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Rest, nurture, sex, release, and play: diurnal underwater behaviour of the spinner dolphin at Fernando de Noronha Archipelago, SW Atlantic

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Abstract

At Fernando de Noronha Archipelago in the South West Atlantic, spinner dolphins (*Stenella longirostris*) regularly congregate in large groups in a bay with clear, shallow water, allowing their behaviour to be observed and recorded at close quarters. We present an overview of the diurnal underwater activity of the Noronha spinners while in the bay. Apart from well-known types of behaviour such as resting, mating, and playing, we present and illustrate others such as suckling, defaecating, and vomiting which are less well-known and documented. Heterospecific interactions and associations are also discussed. An ecologically new role for cetaceans, as a food supplier for reef fishes, is herein proposed for the Noronha spinners.

Resumo

No Arquipélago de Fernando de Noronha, Atlântico Sul Ocidental, golfinhos-rotadores (*Stenella longirostris*) congregam-se regularmente em grandes grupos numa baía rasa com água de boa visibilidade, o que permite sua observação a curta distância. Apresentamos aqui uma síntese sobre a atividade subaquática diurna dos rotadores de Noronha na baía. Ao lado de comportamentos bem conhecidos, como descanso, acasalamento e jogo, apresentamos e ilustramos alguns comportamentos pouco conhecidos e/ou documentados, como amamentar, defecar e vomitar. Interações e associações heteroespecíficas são também relatadas. Uma nova função ecológica para cetáceos, a de provedor de alimento para peixes recifais, é aqui proposta para os rotadores de Noronha.

Zusammenfassung

Am Fernando-de-Noronha-Archipel im Südwestatlantik versammeln sich die Ostpazifik-Delphine *Stenella longirostris* gewöhnlich in großen Gruppen in einer Bucht mit klarem, flachem Wasser, sodass man ihr Verhalten aus nächster Nähe beobachten und aufzeichnen kann. Es wird ein Überblick über ihre Unterwasser-Aktivitäten am Tage in dieser Bucht gegeben. Außer den üblichen Verhaltensweisen wie Ruhe, Paarung und Spiel werden auch einige in Wort und Bild vorgestellt, die weniger bekannt und seltener dokumentiert sind – z.B. Säugen, Kotabgabe und Erbrechen. Auch werden zwischengeschlechtliche Kontakte und Gruppierungen besprochen. Außerdem wird auf eine bisher unbeachtete Rolle der Wale hingewiesen, nämlich als Nahrungsgeber für Korallenfische.

Résumé

A l'archipel Fernando de Noronha, dans le sud-ouest atlantique, les dauphins de l'espèce *Stenella longirostris* se rassemblent régulièrement en grands groupes, dans une baie d'eau claire, peu profonde, permettant d'observer et d'enregistrer de très près leur comportement. Nous présentons une vue d'ensemble de l'activité sous-marine diurne des dauphins de Noronha dans la baie. A part les types de comportement bien connus, comme le repos, l'accouplement et le jeu, nous en présentons d'autres, comme l'allaitement, la défécation et le vomissement qui sont moins connus et documentés. Les interactions hétérospécifiques et les associations sont également commentées. Nous y proposons, pour les dauphins de Noronha, un nouveau rôle écologique pour des Cétacés, à savoir: de fournisseurs de nourriture pour les poissons récifaux.

Sommario

Nell'arcipelago Fernando de Noronha dell'Atlantico sudoccidentale, la stenella (*Stenella longirostris*) si rac-

coglie regolarmente in grandi gruppi in una baia caratterizzata da acque limpide e poco profonde, consentendo l'osservazione e la registrazione del suo comportamento naturale. Viene qui presentata una visione d'insieme dell'attività diurna della specie durante la sua permanenza nella baia di Noronha. Oltre ad aspetti del comportamento già noti come il riposo, l'accoppiamento e il gioco, ne vengono presentati e illustrati altri come il momento della poppata, la defecazione e il vomito che sono molto meno documentati. Sono anche discusse interazioni eterospecifiche e associazioni e viene proposto un nuovo ruolo ecologico per i cetacei, in particolare per la stenella di Noronha, come fonte di cibo per pesci di scogliera.

Introduction

From the behavioural viewpoint, Spinner dolphins (*Stenella longirostris*, Delphinidae) are among the best studied cetacean species. However, most of the current knowledge of these marine mammals derives from studies on the Pacific populations in Hawaii (review in Norris *et al.*, 1994). Studies of the behaviour of West Atlantic populations are scarce and published in local journals (e.g., Lodi & Fiori, 1987; Silva Jr. *et al.*, 1996). These last deal mostly with the behaviour of surfacing dolphins, as well as providing data on their frequency and permanence in the bay, as observed from the land. In addition, the above-mentioned studies are published in Portuguese, which limits their accessibility.

At the Fernando de Noronha Archipelago, off north-east Brazil in the equatorial West Atlantic, great concentrations of spinner dolphins are found at the site known as the Baía dos Golfinhos (Dolphins' Bay). The site is regularly visited by groups of up to about 2000 spinners which include adults of both sexes, and juveniles (Silva Jr. *et al.*, 1996). In the bay, the dolphins exhibit different types of behaviour such as aerial display and resting, as well as social interaction which includes copulation and nursing (Lodi & Fiori, 1987; Silva Jr. *et al.*, 1996). The clarity of the water and the fact that large numbers of spinners enter the bay all year round (Silva Jr. *et al.*, 1996) favour observation of their underwater behaviour at close quarters. Groups of spinner dolphins congregate in the bay during the morning and early afternoon, the first individuals arriving mostly between 0600-0700 h to rest and socialise. The last lot of dolphins leave between 1300 and 1600 h to feed in the open sea (Silva Jr. *et al.*, 1996). A further advantage of Dolphins' Bay is that it is part of a reserved area of the Fernando de Noronha National Marine Park: People and boats are not allowed and researchers are only permitted to enter the bay under strict regulation.

There follows an overview of the diurnal underwater activity of Noronha spinners in the bay. We give a general, qualitative (sometimes quantitative) view of their behaviour, and also touch on three topics con-

cerning other animals which occur in the bay: 1) Reaction to other similar-sized or larger marine vertebrates; 2) Association between reef fish and the dolphins. 3) The role played by the spinners in the behaviour of these fishes.

Methods

All observations were made in the south-west Atlantic in the Fernando de Noronha National Marine Park off north-east Brazil. Fernando de Noronha Archipelago (03°50'S, 32°25'W) lies about 345 km east of the São Roque Cape in north-eastern Brazil (see Maida & Ferreira, 1997 and Carleton & Olson, 1999, for map and description). Observation sessions were mostly carried out at the Baía dos Golfinhos, a 15-25 m deep bay about 3 km wide (Lodi & Fiori, 1987; Silva Jr. *et al.*, 1996). The bottom of the bay is an open sandy area dotted with patchy reef formations similar to those found in Kealakekua Bay, Hawaii, another place where dolphins congregate and rest (Norris & Dohl, 1980; Wells & Norris, 1994).

The dolphins' behaviour was observed directly, and photographed, and videotaped while snorkelling and skin diving (e.g., Pryor & Shallenberger, 1991; Silva Jr. *et al.*, 1996). The dolphins were given 1-3 min to get used to the divers before starting observation. The sessions lasted from 10 to 90 min. Focal animal and all occurrence samplings were used for direct observation: in which all instances of specific actions such as copulating or defaecating were recorded over a given period (Altmann, 1974; Lehner, 1996). The best time for observation was in the morning, since during the afternoon the dolphins gradually left the bay (e.g., Silva Jr. *et al.*, 1996; Sazima *et al.*, 2003; see also Lammers, 2004 for Hawaii).

Most of the behavioural records for which we have quantitative data were made between May 1994 and May 1995 and comprised 31 hours of direct observation over a total of 41 diving days. Further behavioural records were made during photo identification and other studies between June 1998 and June 2004, comprising 173 hours of observation (e.g., Sazima *et al.*, 2003; Silva-Jr & Sazima, 2003) in a total of 202 diving days. We also analysed 8 hours of videotapes recorded during the above periods. In some cases it was necessary to identify individual dolphins (e.g., when a given dolphin carried a diskfish couple – see Silva Jr. & Sazima, 2003). For this we used photo identification, a well known procedure for the study of small cetaceans making use of natural marks such as fin shapes, nicks, scars, and pigment patterns (Würsig & Jefferson, 1990), used to identify spinners in the Pacific (Norris *et al.*, 1994) and the West Atlantic (Silva Jr. *et al.*, 1996). Dolphins were sexed according to their external features: the males have a conspicuous genital protuberance and females possess two obvious mammary slits (Norris *et al.*, 1994). Age groups were assessed by proportional lengths: Indi-

viduals measuring up to 2/3 of a fully grown adult's total length were counted as calves (Silva Jr. *et al.*, 1996). A calf was always seen in close proximity to an adult, possibly its mother.

Photographs and video recordings are on file at the Centro Golfinho Rotador in Fernando de Noronha, and video samples and scanned photographs at the Museu de História Natural, Universidade Estadual de Campinas (ZUEC record collection). Sounds were recorded with a SONY® DSR-PD15 3CCD DVCAM professional underwater digital camcorder housed in an AMPHIBICO® dual hydrophone aluminium waterproof case with a 24 kHz upper frequency limit. Sonograms were produced by a Macintosh® computer coupled to the MacRecorder® Sound System 2.0.5, using 8-bit resolution, a 22 kHz sampling frequency, and FFT with 256 points.

Results

Resting behaviour – Groups of dolphins rested while cruising slowly near the bottom, close to each other, mostly in a regular, tight formation. Resting groups ranged in size from 3 to 25 individuals (mean 12.6; SD = 4.86; N = 102). From time to time all the members of the small groups ascended together - if small (Fig. 1) – and, if the group was large, rose singly in turn, surfaced to breathe, then descended to the

bottom, always in formation and 'zigzagging' from the bottom to the surface and vice-versa. Immersion during rest time ranged from seven to 200 sec (mean= 164.67 sec; SD + 43.56; N = 193). Resting groups cruised back and forth within the bay, usually without any obvious route pattern.

Nursing behaviour – Parental care was recorded on most occasions when the dolphins occupied the bay. Most of the time the calves remained close to females that were probably their own mothers (Fig. 2). The females touched the calves' back and flippers with their own flippers, Soft noises (burst-pulse signals, cf. Lammers *et al.*, 2003) were habitually emitted by the females in the direction of the calves, especially when they appeared distressed or when they returned from their frolicking (see playing behaviour). These apparently 'soothing' noises were accompanied by touching by the females and vice versa.

Suckling began when a calf would position itself at its mother's side whilst nudging the mammary slit with the tip of its beak (Fig. 3). The calf's glottis was seen to move as the milk was taken from the mammary slit by suckling movements. Whilst the calf was suckling its eyes remained wide open, the tongue appeared to move and the sternohyoid muscle was contracting. After suckling at one side of the mammary slit, the calf moved to the opposite side. Suckling lasted between



Fig. 1. A resting group of spinner dolphins (*Stenella longirostris*) swimming in formation at cruising speed, about to surface for breathing. Note the tongue of one dolphin hanging out of its open mouth. Photo by J. M. Silva Jr.



Fig. 2. A nursing spinner dolphin female and a calf shortly after breathing at surface (above); a female and a still suckling juvenile swimming side by side (below). Photos by J. M. Silva Jr. (above) and I. Sazima (below).

five and 20 sec (mean = 11.25; SD + 4.34; N = 16). Twice we recorded the calf taking milk which was squirted from the mammary slit, as if the liquid were taken through an “invisible” pipe. Once a calf was recorded taking mouthfuls of milk ejected from the mammary slit as into the water. Suckling calves ranged from the newborn (identifiable by their neonatal skin folds) to juveniles up to about 130 cm in length.

Mating behaviour – Mating was recorded all year round, copulation being most frequent early in the morning (0800-0930h), as well as before the dolphins left the bay. Although we recorded single males copulating with a female (N = 13), mating subgroups formed by 2-5 mature males were more commonly seen (N = 26). Besides male/female couples and mating groups of a few males and one female, we also recorded large mating groups comprising up to 20 females and 80 males, with all the males trying to copulate with the females in these very large groups. The large groups were particularly noisy, emitting loud whistles, clicks, and burst-pulsed signals (Fig. 4). Before copulating, a male would gently touch the

female’s flipper or body with his own flippers, then rubbing, nudging or gently biting her genital slit with his beak (Fig. 5), and sometimes biting her flippers. A male subgroup would surround a female (Fig. 6), with each male trying to copulate with her in turn. The number of simultaneously courting males ranged between one and ten (mean= 4.48; SD + 2.4; N = 64). To copulate, the male positioned himself below the female with his belly up (Fig. 6). During penetration, about half of the penis’ length was inserted. The mean penetration time was 16.18 sec (SD + 6.66; N = 91). A male subgroup would remain with a single female for up to 35 min, with the males copulating repeatedly.

The females avoided the males in about 90% of the records (N = 91) by swimming faster than the male as that positioned himself to copulate, or by rolling her body to assume a lateral or supine posture with belly up, as well as adopting a vertical posture with her beak out of the water. All these tactics proved effective in avoiding penetration. Males within large mating groups showed aggressive behaviour towards each other, such as opening their beaks, biting each other



Fig. 3. A juvenile spinner dolphin about to suckle, nudging the female's genital slit with its beak. Photo by J .M. Silva Jr.

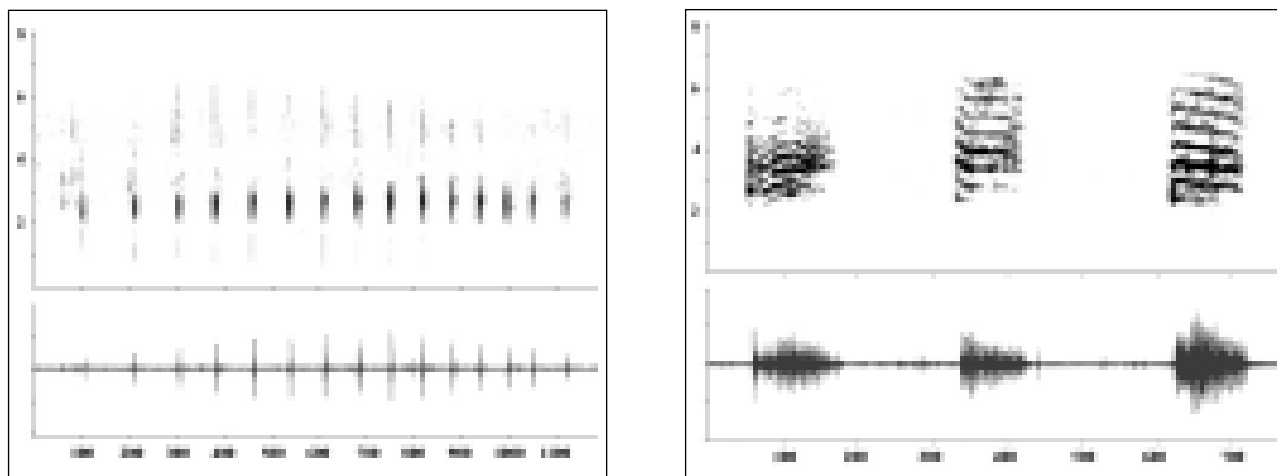


Fig. 4. Sounds produced by the spinner dolphin, a click (left) and a series of three burst-pulses (right). A sonogram and an oscillogram are shown for each sound. The numbers on vertical axes show frequency (in kHz) and those on horizontal axes show time (in milliseconds) for each type of sound. Figures by L. O. Giassom.

and leaving distinct regular scratches on the skin, as well as bumping. We recorded no aggressive behaviour amongst males in small mating groups.

In a six male-one female group, one of the males copulated more than the other five, achieved about 50% of the total number of copulations within the group. This particular male nudged the genital slit of the female, copulated, and then nudged her genital slit again after each copulation, behaviour not recorded for any other male in our study. In an eight males-two female group, one male was prevented from copulating – with any female – by two other males who interposed themselves between that male and the females, whilst emitting loud clicking and

burst-pulses as well as butting it from time to time. This particular male (individual 041) had a laterally twisted, contorted beak.

Pre mating-like behaviours, such as nudging or biting the genitals were recorded between males, females, and even juveniles (see playing behaviour). Mating-like behaviour such as belly-to-belly posture and rubbing genitals against each other were recorded for adult males (N = 6). Intromission of the penis of one male into the genital slit of the other male was recorded during this posture (N = 4).

Eliminative behaviour – We recorded two types of eliminative behaviour: defaecating and vomiting. Defaecating occurred haphazardly all the time the dol-



Fig. 5. A spinner dolphin male nudging the genital slit of a female with its beak. Photo by J. M. Silva Jr.



Fig. 6. A group of spinner dolphin males surrounding a female, one male (upside down) copulating. Photo by J .M. Silva Jr.

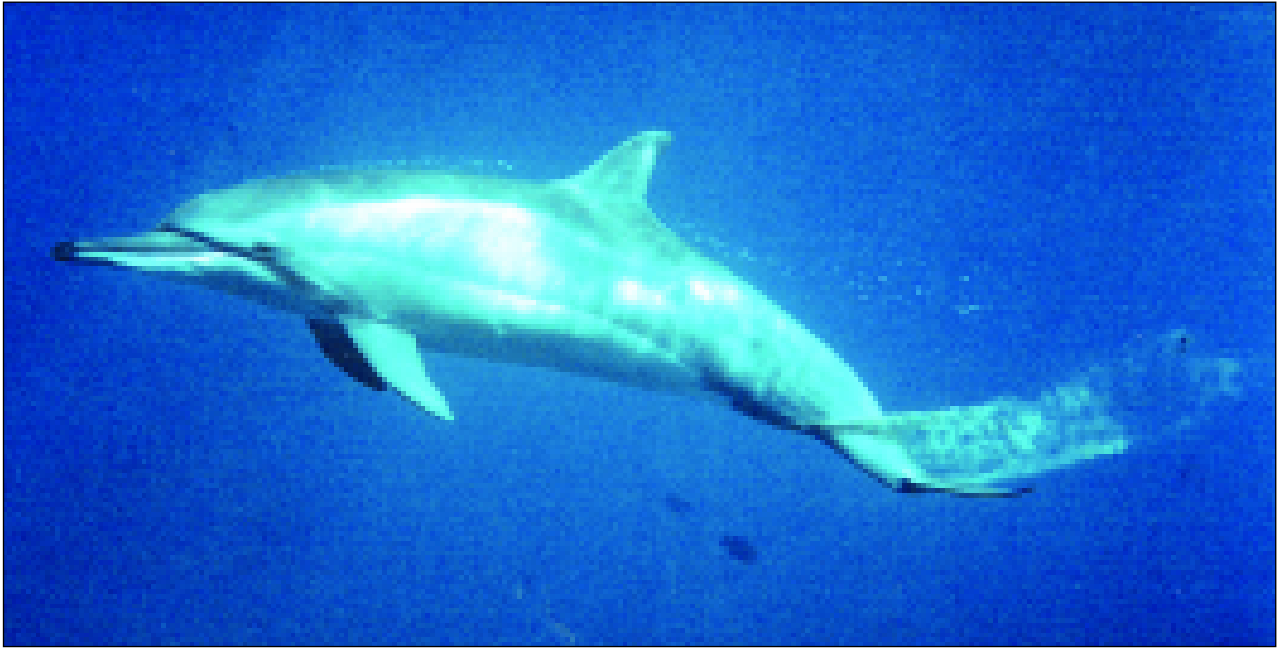


Fig. 7. A spinner dolphin voiding a cloud of particulate faeces. Note the sigmoid curve directed backwards formed by the hind-body on evacuation. Photo by J. M. Silva Jr.



Fig. 8. A spinner dolphin taking water before vomiting. Note open mouth and distended throat. Photo by J. M. Silva Jr.

phins stayed within the bay. Shortly before defaecating, a dolphin would bend its body into a slight sigmoid curve directed backwards (Fig. 7) and then eliminated a variable amount of faeces, which formed a cloud in the water (see Sazima *et al.*, 2003). When the quantity of faeces was small, the dolphin defaecated without noticeable changes in behaviour while cruising or swimming. The faeces were eliminated irre-

spective of the dolphin's position within the group, i.e., a dolphin about to defaecate did not separate from the rest of the group. As a result the spinner's faeces passed over the individuals behind it in the group. The faeces often consisted of mixture of particulate and/or-amorphous matter, often together with some fluid and this resulted in a spinner eliminating its faeces over the individuals following behind.



Fig. 9. Two spinner dolphins playing with a piece of seaweed (*Sargassum* sp.), one of them holding the “toy” on its left flipper. Photo by J. M. Silva Jr.



Fig. 10. Two male spinner dolphins chasing a Caribbean reef shark (*Carcharhinus perezii*). Photo by J. M. Silva Jr.

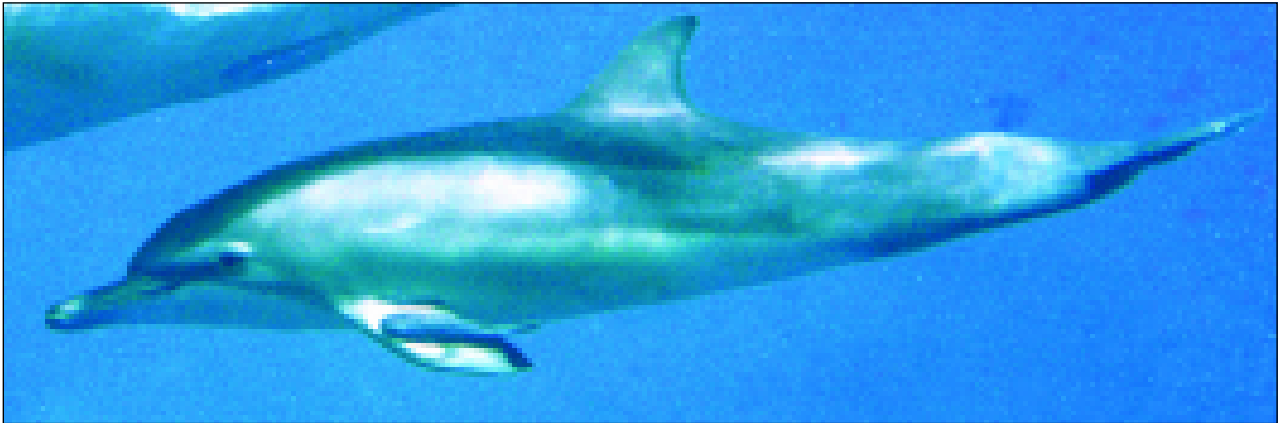


Fig. 11. A juvenile whalesucker (*Remora australis*) attached to the left flipper of a spinner dolphin calf. Note abraded skin on the fluke's upper side. Photo by J. M. Silva Jr.



Fig. 12. A recruit-of-the-year whalesucker attached to the throat of a spinner dolphin (above), and two adult fish on the belly and flank of another (below). Photos by I. Sazima (above) and J. M. Silva Jr. (below).



Fig. 13. A group of black durgons (*Melichthys niger*) picking up particulate spinner dolphin faeces. Photo by I. Sazima.

Vomiting was not as common a behaviour as defaecation, the ratio of defaecation to vomiting events varying between 3:1 and 20:1 (see Sazima *et al.*, 2003). Water and rarely air was taken in before vomiting occurred. While swimming with its mouth open, the dolphin took in a mouthful of water (Fig. 8), which caused its throat and mouth floor to bulge. Occasionally the dolphin's tongue hung out of its mouth during the intake of water (Fig. 1). Six distinct phases of vomiting behaviour are described and illustrated by Silva Jr. *et al.* (2004), with the entire sequence lasting about eight to fourteen seconds. Vomiting was generally preceded by a short burst of speed, after which the dolphin usually bent its body in a slight sigmoid curve directed forwards (lateral movements of the hind body might occur at times), and vomited with its mouth wide open. Vomiting was apparently related to a previous night's feed on meal rich in squid, as the vomit included pieces of squid and beaks, as well as particulate or amorphous material (see Silva Jr. *et al.*, 2004 for details), and live roundworms (*Anisakis* sp., Anisakidae). We never recorded a vomit consisting only of fish meal.

It was observed that a number of reef fish species fed on faeces and vomit. This behaviour will be discussed later in heterospecific interactions and associations.

Playing behaviour – The most commonly recorded type of play was when calves practised adult behaviour patterns such as manoeuvring, leaping, as well as swimming in sudden burst of speed away from adult females (possibly their mothers). The calves practised their playing in open areas, generally circled by some of the individuals of the group including an adult female, possibly the mother. While playing, the calf's wiggling, tilting, and other movements were exaggerated, and it quickly beat its tail and changed its course repeatedly. The calves also chased each other, touched each other's bodies or flippers, and engaged in bouts of what resembled brief sequences of the adult pre-mating behaviour, including genital touching with their beaks.

A particular play type was recorded for both juveniles and adults, which consisted of taking a piece of floating seaweed (mostly *Sargassum* sp.). A dolphin would take a piece of seaweed and hold it on its flipper for



Fig. 14. A group of black durgons following a group of resting spinner dolphins cruising at low speed. Photo by J. M. Silva Jr.

a while (Fig. 9), then release it and place it on the other flipper, or its tail or beak. A dolphin may play repeatedly in this way with the same piece of seaweed, or let it drift away after holding it on the flipper for a while or after a tail pass. During the play, the dolphin would not have any problems balancing and holding on to the seaweed, irrespective of its manoeuvring within the group. If then dropped, the same piece of seaweed may be taken by a following or flanking dolphin, which would play with it for a while in the same way. We also recorded two dolphins playing together with the same piece of seaweed, each of them taking its turn, up to about 10 times over the study period. Sometimes two or three dolphins in an observed group carried a seaweed piece each.

'Mock' chasing of fishes was displayed by both juvenile and adult dolphins. One play subject was the black durgon (*Melichthys niger*, Balistidae) which the dolphins chased for short distances (up to 1-2 m) touching it briefly with their beaks, causing the fish to flee. As durgons are the most commonly associated with spinner dolphins in the bay, (see below) they

appear to serve as convenient play objects. Only once we recorded a young adult chasing then catching a black durgon. The fish tried to escape by flapping and was released shortly afterwards. On release, the freed fish was unharmed and did not flee from the dolphin. We also recorded dolphins chasing yellow jacks (*Caranx bartholomaei*, Carangidae), heading towards single fish and pursuing them for a while before they fled. Jack chasing was displayed mostly by young adults.

Heterospecific interactions and associations –

We recorded two types of heterospecific interactions, both of them agonistic. When four pantropical spotted dolphin (*Stenella attenuata*) entered the bay, it was already occupied by about 350 spinners. The spotted dolphins were closely grouped and swam synchronously changing direction suddenly while being chased by groups of about 10-15 spinners. The spinners displayed several types of agonistic behaviour towards the spotted dolphins, such as the emission of loud echolocation clicks and burst-pulsed signals, sigmoid-shape posture (see Johnson & Norris, 1994),

mouth agape and belly bumping the spotted dolphins with their beaks. In turn the spotted dolphins displayed threatening behaviour and assumed sigmoid postures as they fled.

The second type of agonistic encounters involved reef sharks (*Carcharhinus perezi*, Carcharhinidae) that entered the bay. These sharks are common at Fernando de Noronha and display a versatile behavioural repertoire (e.g., Sazima & Moura, 2000). Agonistic encounters did not occur every time a shark entered the bay, nonetheless the dolphins seemed aware of their presence. If a shark swam towards a female with a calf or a group of females with calves, it was almost immediately chased out of the bay. A signal that a group of males was about to chase a shark was the emission of high frequency sounds, seen as vibration of the dolphin's melon and sometimes rapid waving of the head. The adoption of a sigmoid posture by one or more dolphins could follow, the males then swimming straight at the shark (Fig. 10). At the dolphins' approach, the shark would immediately flee without retaliating, usually out of the bay. Sharks chased by dolphin male groups ranged 80-180 cm in total length.

Spinner dolphins appear to be wary of large sharks. Once we recorded all groups of spinners (about 350 individuals) suddenly leaving the bay at great speed. Soon after, we saw a large reef shark (more than 2m long) swimming close to the surface. It manoeuvred closely around us (two observers) then darted away and returned three times until we approached the shore.

We recorded two types of fish association with the spinners in the bay. One of them was hitch hiking by the whalesucker (*Remora australis*, Echeneidae), a diskfish commonly attached to Noronha spinners (Silva Jr. & Sazima, 2003). Whalesuckers were recorded on calves (Fig. 11) as well as on adults. These fish were recorded on spinners all year round. Their lengths ranged from 3 to 52 cm and there were up to three of them per dolphin (Fig. 12).

A guild of 12 plankton-eating reef fishes, including the ubiquitous black durgons (*Melichthys niger*) fed on spinner faeces and vomit (Fig. 13). When resting and cruising at low speed the spinners were closely followed by several durgons (Fig. 14), a behaviour probably related to the prospect of the fish being in position when the dolphins would begin to defaecate (see Sazima *et al.*, 2003 for details).

Discussion

Behaviour recorded for the Noronha spinner dolphin is in general similar to that reported in dolphins studied in Hawaii (Norris & Dohl, 1980; Norris *et al.*, 1994; Lammers, 2004), predictably including resting, mating, and playing. Other behavioural patterns reported here are poorly documented in the Hawaiian spinner but we have no reason to believe there would be a great difference.

Resting behaviour – We know of no underwater studies on the resting behaviour of spinner dolphins. However, comparisons may be obtained from land-based studies on the spinner dolphin and a few other delphinids (e.g., Würsig & Würsig, 1980; Würsig *et al.*, 1994; Goley, 1999). Dive formation and the behaviour of resting groups are very similar for spinners in Hawaii and Fernando de Noronha (Würsig *et al.*, 1994; present study), dusky dolphins (*Lagenorhynchus obscurus*) in Patagonia (Würsig & Würsig, 1980), and Pacific white-sided dolphins (*L. obliquidens*) in captivity (Goley, 1999). This similarity probably indicates a behavioural trait for small to medium-sized dolphin species that live and travel in groups.

Mean submersion time for the Hawaiian spinner while resting is 120 sec (Würsig *et al.*, 1994), and the 'dive/travel slow' (= resting behaviour) submersion time for the bottlenose dolphin (*Tursiops truncatus*) in Northern Adriatic Sea ranges from 31-375 sec (mean = 121.2 sec; SD±65.1; N= 298) (Bearzi *et al.*, 1999), another figure similar to that obtained by Norris *et al.* (1994) and both of them slightly shorter than that we recorded for the Noronha spinner (mean= 164 sec).

Nursing behaviour – The spatial relationship we recorded for calves and females in Noronha seems to be common behaviour in small to medium sized dolphins, as indicated in the reports on *S. longirostris* and *T. truncatus* in captivity (Tavolga & Essapian, 1957; Johnson & Norris, 1994; Gubbins *et al.*, 1999).

Ours seems to be the first description and documentation of suckling for a free ranging dolphin species (see overview in Whitehead & Mann, 2000). Suckling behaviour of the Noronha spinners does not differ markedly from that reported for captive specimens of the same species from Hawaii (Johnson & Norris, 1994), and for the bottlenose dolphin (Cockroft & Ross, 1990). The postures adopted by the calf in relation to the female are very similar, and suckling time for captive spinners ranges from 5 to 20 sec with a mean of 9 sec (Johnson & Norris, 1994) – almost the same time we recorded. However, suckling time for the bottlenose dolphin seems considerably shorter, ranging from 3-9 sec with a mean of 5.6 sec, although this behaviour may vary with the calf's growth (Cockroft & Ross, 1990).

Mating behaviour – The mating behaviour of the Noronha spinner, including 'caresses' and copulating postures, is very similar to that reported for the Hawaiian spinner (Wells & Norris, 1994). Thus, average mating groups of the Noronha and Hawaiian spinners are the same (2-6 individuals), although the Noronha spinner may form much larger mating groups of up to about 50-100 individuals. This difference is most probably related to the total number of spinners present in the same place at the same time (up to about 70 in Hawaii and about 2000 in Noronha).

The intromission behaviour of the Noronha spinner (e.g., about half of the penis being inserted in the

female's vagina) is similar to that reported for captive *T. truncatus* (Tavolga & Essapian, 1957). Intromission time reported for the bottlenose dolphin is said to be 'not more than ten seconds' (Tavolga & Essapian, 1957), a little shorter than the average of about 16 seconds that we recorded for the Noronha spinner.

The frequency with which females try to deter males attempting copulation is most probably related to mate choice by the females. Even if most of the females of gregarious cetacean species have access to a great number of potential mates, there is evidence for choice of mates by females, which may be an important determinant for reproductive success (Whitehead & Mann, 2002). The dolphins' great manoeuvrability allows a female to outmanoeuvre males in several ways (Mesnick & Ralls, 2002; present study) and thus to make choices between potential mates. Even the high mating success we recorded for one particular male (see below) seems mostly related to the female's choice.

Of interest is the copulation success of one particular male in a mating group, and the prevention by others of copulation by another particular male: 1) It seems that some females would favour particular males whose behaviour seems more stimulating, and thus would increase the mating success of these 'inventive' males; 2) males within a group would recognize males that looked odd or behaved strangely and would coordinate efforts to deter the mating attempts of such 'defective' individuals.

The male-male mating-like behaviour, including penis intromission, may be an aggressive display of dominance of one individual over the other, as suggested by Psarakos *et al.* (2003), and recorded for the pantropical spotted dolphin (Herzing & Johnson, 1997). Since the social structure of spinner dolphins is regarded as a transitory and fluid one ('fission-fusion' groups, see Lammers, 2004) in which roles alternate between individuals and coalitions or groups (Norris & Johnson, 1994), the pre-mating and mating-like behaviour between males and between females may also function to establish some particular bonds, and thus may be more common than our records indicate. Another, very speculative explanation (although one that cannot be entirely ruled out) is that the involved individuals derive some pleasant tactile sensation from this non reproductive, mating-like behaviour.

Eliminative behaviour – Defaecating behaviour in free-ranging dolphins is presently recorded only for the Noronha spinner (Sazima *et al.*, 2003) and the bottlenose dolphin (Shinohara *et al.*, 1999). The major difference between these two species is that spinners commonly eliminate their faeces over individuals to their rear within the group, whereas bottlenose dolphins seldom display this behaviour, the defaecating individual withdrawing a little from other members of the group (Shinohara *et al.*, 1999; Sazima *et al.*, 2003). Thus, for the two most studied delphinid

species, this behaviour seems to differ mostly by the position of the defaecating individual within a group

Vomiting behaviour for free-ranging dolphins was unreported until recently (Silva Jr. *et al.*, 2004), and thus no comparisons are possible. Vomiting in Noronha spinners appears to be related to meals rich in squid (Silva *et al.*, 2004), and perhaps its further benefit is to rid the dolphin of rid of stomach dwelling roundworms. Both the faeces and vomit are fed upon by reef fishes (see below). The large numbers of durgons shown in figure 2 of Sazima *et al.* (2003), may represent the fish feeding on a very rich vomit instead of faeces as originally indicated.

Playing behaviour – Adult-like behaviour by calves is already known in free-ranging spinners and other dolphin species (e.g., Johnson & Norris, 1994; Bel'kovich, 1991). Playing with objects such as pieces of seaweed is known for other free ranging dolphin species, including spinners (Johnson & Norris, 1994) and dusky dolphins (Würsig, 2002). Although Würsig (2002) emphasizes that playing with objects is an activity in which the socialising sense is transferred to the object, the toy trading and apparently interactive playing with pieces of seaweed pieces recorded for the Noronha spinner indicates that the seaweed might be regarded as an instrument for interaction between the dolphins.

We know of no reports of dolphins playing with non-food fishes like those recorded here for black durgons, although dusky dolphins play with gulls (*Larus dominicanus* and *L. maculipennis*) which are mouthed gently and briefly dragged underwater, then released unharmed (Würsig, 2002). However, tossing food fishes into the air is known in bottlenose dolphins (Bel'kovich, 1991). Mock or play chasing after fishes is apparently unrecorded for spinner dolphins, although some dolphin species are known to interact with turtles (pulling their tail or legs) and sharks (imitating their movements) (Würsig, 2002).

Heterospecific interactions and associations – Agonistic encounters between spinners and pantropical spotted dolphins were described recently, these encounters being behaviourally complex and highly variable (Psarakos *et al.*, 2003), which renders their analysis of limited value until additional data are gathered. Our single record, however, is consistent with the idea that there is a high potential for aggressive interactions between these two dolphin species, especially when one is outnumbered by the other (Psarakos *et al.*, 2003).

Aside from the agonistic encounter between spinners and spotted dolphins reported here, we recorded from a land based observation post a female humpback whale (*Megaptera novaeangliae*) and her calf in front of the Dolphins' Bay escorted by about 50 spinners forming a semicircle that 'closed' the access of the whales to the bay. The spinners escorted the two whales for about 5 min, during which time they

reached the open sea. On another occasion three humpbacks arrived at the bay and some 500 spinners deserted the area, coming back only after the whales left the bay. These two records indicate a potential for agonistic interactions between spinners and whales in the Dolphins' Bay.

Sharks are known to prey on small to medium sized dolphins, including species of *Stenella* (see reviews in Heithaus, 2001; Maldini, 2003). Dolphins chasing and harassing sharks is a long held view, although there are few documented instances of this behaviour (Wood *et al.*, 1970). Our underwater observations indicate that this is the case indeed, although shark chasing seems to occur under particular circumstances, e.g., defence of calves. Defence against sharks may be related to the apparently high survival rate of dolphins as indicated by healed shark bites on living individuals (e.g., Corkeron *et al.*, 1987; Wells & Scott, 2002). However, Maldini (2003) argues otherwise, i.e., that mutilated and scarred dolphins are survivors of unsuccessful shark attacks. The agonistic sigmoid posture adopted by the Noronha spinner is also recorded for the Hawaiian spinner, and is regarded as mimicking the shark's intra specific threat posture (Johnson & Norris, 1994). Even if we found the Noronha spinners displaying a similar posture, we have no evidence that the shark perceives the spinner's signal as a threat. Our record of a large reef shark moving close to the water surface and the sudden fleeing of all spinners from the bay indicates that the shark was foraging after dolphins, and possibly due to its large size and position in the water column it was not chased. A similar flight response is recorded for a group of nine bottlenose dolphins approached by a 2.5-3.0 m long great white shark, *Carcharodon carcharias* (Connor, 1996).

Spinner dolphin/reef fish associations are reported for Dolphins' Bay only (Lodi & Fiori, 1987; Lodi, 1998; Sazima *et al.*, 2003). The whalesucker association with spinners is currently under study, and a brief report on the attachment duration of a diskfish couple to a particular dolphin individual was recently published (Silva Jr. & Sazima, 2003). Besides hitch hiking, the whalesucker probably benefit further from the association by feeding on spinners' offal, increasing its mating chances, and gaining protection from predators (Katona & Whitehead, 1988; Sazima *et al.*, 2003; Silva Jr. & Sazima, 2003).

Spinners' faeces and vomit are a rich and predictable food source in the Dolphins' Bay, and are feed upon by a guild of 12 reef fish species (Sazima *et al.*, 2003). The most ubiquitous offal eater is the black durgon, which probably learned to recognize a dolphin about to eliminate and to follow it (Sazima *et al.*, 2003).

Spinner dolphins unquestionably have an ecological role in Dolphin's Bay, that of a rich food source supplier (see below).

Remarks

The clarity of the water in Dolphin's Bay provided exceptionally favourable conditions for underwater observation. We regard the previously unknown and/or poorly documented types of behaviour reported here and elsewhere (e.g., Sazima *et al.*, 2003; Silva Jr. & Sazima, 2003; Silva Jr. *et al.*, 2004) most probably occur at other sites occupied by spinner dolphins. However, vomiting behaviour, which we recorded with some frequency at Fernando de Noronha, appears to occur rarely, if at all, in the Hawaiian populations (see Silva Jr. *et al.*, 2004). Nevertheless, other behaviours and/or associations probably are more widespread occurrences. For instance, we predict that dolphins' offal eating by a reef fish guild would be recorded at sites other than Fernando de Noronha Archipelago, provided that adequate conditions are locally available (Sazima *et al.*, 2003), and the same holds for the dolphin/whalesucker bond (Silva Jr. & Sazima, 2003).

We add here a new role for cetaceans to those already discussed in overviews about the ecological importance of these mammals and their role in aquatic ecosystems (Katona & Whitehead, 1988; Bowen, 1997). The new role is that of a food supplier for reef fishes via faeces and vomits. The Noronha spinners apparently sustain a sizeable population of black durgons in the Dolphins' Bay, besides supplying additional food for a guild of 11 other, mostly plankton eating reef fish species (Sazima *et al.*, 2003).

As it stands, underwater observation proves a valuable tool to understand some of the behaviour for which a close proximity with the dolphins is needed (see Pryor & Norris, 1991; Norris *et al.*, 1994 for examples and discussion). The Dolphins' Bay at Fernando de Noronha Archipelago and its spinners still wait for additional, refined and variably focused studies, including sound production related to the behavioural repertoire perceptible while underwater (see Herzog, 1996; Lammers *et al.*, 2003).

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References

- Altmann, J. 1974. Observational study of behavior: sampling methods. *Behaviour*, **49**: 227-265.

- Bearzi, G., Politi, E. & G. Notorbartolo di Sciara.** 1999. Diurnal behavior of free-ranging bottlenose dolphins in the Kvarneric' (Northern Adriatic Sea). *Marine Mammal Science*, **15** (4): 1065-1097.
- Bel'kovich, V. M.** 1991. Herd structure, hunting, and play bottlenose dolphins in the Black Sea. In: *Dolphin societies: discoveries and puzzles* (Eds. K. Pryor & K.S. Norris.): 17-77. University of California Press, Berkeley.
- Bowen, W. D.** 1997. Role of marine mammals in aquatic ecosystems. *Marine Ecology Progress Series*, **158**: 267-274.
- Carleton, M. D. & S. L. Olson.** 1999. Amerigo Vespucci and the rat of Fernando de Noronha: a new genus and species of Rodentia (Muridae: Sigmodontinae) from a volcanic island off Brazil's continental shelf. *American Museum Novitates*, **3256**: 1-59.
- Cockroft, V. G. & G. J. B. Ross.** 1990. Observations on the early development of a captive bottlenose dolphin calf. In: *The bottlenose dolphin* (Eds. S. Leatherwood & R. R. Reeves): 461-478. Academic Press, San Diego.
- Connor, R. C.** 1996. Approach by great white shark elicits flight response in bottlenose dolphins. *Marine Mammal Science*, **12** (4): 602-606.
- Corkeron, P. J., Morris, R. J. & M. M. Bryden.** 1987. Interactions between bottlenose dolphins and sharks in Moreton Bay, Queensland. *Aquatic Mammals*, **13** (3): 109-113.
- Goley, P. D.** 1999. Behavioral aspects of sleep in Pacific white-sided dolphins (*Lagenorhynchus obliquidens*, Gill 1865). *Marine Mammal Science*, **15** (4): 1054-1064.
- Gubbins, C., McCowan, B., Lynn, S. K., Hooper, S. & D. Reiss.** 1999. Mother-infant spatial relations in captive bottlenose dolphins, *Tursiops truncatus*. *Marine Mammal Science*, **15** (3): 751-765.
- Heithaus, M. R.** 2001. Predator-prey and competitive interactions between sharks (order Selachii) and dolphins (suborder Odontoceti): a review. *Journal of Zoology, London*, **253**: 53-68.
- Herzing, D. L.** 1996. Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, *Stenella frontalis*, and bottlenose dolphins, *Tursiops truncatus*. *Aquatic Mammals*, **22** (1): 61-79.
- Herzing, D. L. & C. M. Johnson.** 1997. Interspecific interactions between Atlantic spotted dolphins (*Stenella frontalis*) and bottlenose dolphins (*Tursiops truncatus*) in the Bahamas, 1985-1995. *Aquatic Mammals*, **23** (1): 85-99.
- Johnson, C. M. & K. S. Norris.** 1994. Social behaviour. In: *The Hawaiian spinner dolphin*. (Eds. K. S. Norris, B. Würsig, R. S. Wells & M. Würsig): 243-286. University California Press, Berkeley.
- Katona, S. & H. Whitehead.** 1988. Are Cetacea ecologically important? *Oceanography and Marine Biology Annual Review*, **26**: 553-568.
- Lammers, M. O.** 2004. Occurrence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores. *Aquatic Mammals* **30** (2): 237-250.
- Lammers, M. O., Au, W. W. L. & D. L. Herzing.** 2003. The broadband social acoustic signaling behavior of spinner and spotted dolphins. *Journal of Acoustical Society of America*, **114**: 1629-1639.
- Lehner, P. N.** 1996. *Handbook of ethological methods*. Cambridge University Press, Cambridge, 672 pp.
- Lodi, L.** 1998. Comensalismo entre peixes recifais do Arquipélago de Fernando de Noronha e golfinhos-rotadores, *Stenella longirostris*. *Biotemas*, **11**: 127-132.
- Lodi, L. & B. Fiori.** 1987. Observações sobre o comportamento do golfinho-rotador; *Stenella longirostris* (Cetacea, Delphinidae) na Ilha de Fernando de Noronha – Brasil. *Anais da 2ª Reunião de Trabalho de Especialistas em Mamíferos Aquáticos da América do Sul*: 60-68.
- Maida, M. & B. P. Ferreira.** 1997. Coral reefs of Brazil: an overview. *Proceedings of the International Coral Reef Symposium*, **8**: 263-274.
- Maldini, D.** 2003. Evidence of predation by a tiger shark (*Galeocerdo cuvieri*) on a spotted dolphin (*Stenella attenuata*) off O'ahu, Hawai'i. *Aquatic Mammals*, **29** (1): 84-87.
- Mesnick, S. L. & K. Ralls.** 2002. Mating systems. In: *Encyclopedia of marine mammals* (Eds. W. F. Perrin, B. Würsig & J. G. M. Thewissen.): 726-733. Academic Press, San Diego.
- Norris, K. S. & T. P. Dohl.** 1980. Behavior of the Hawaiian spinner dolphin, *Stenella longirostris*. *Fishery Bulletin*, **77**: 821-849.
- Norris, K. S., Würsig, B., Wells, R. S. & M. Würsig.** (Eds.), 1994. *The Hawaiian spinner dolphin*. University of California Press, Berkeley, 408 pp.
- Pryor, K. & K. S. Norris** (Eds.). 1991. *Dolphin societies: discoveries and puzzles*. University of California Press, Berkeley, 397 pp.
- Pryor, K. & I. K. Shallenberger.** 1991. Social structure in spotted dolphins (*Stenella attenuata*) in the tuna purse seine fishery in the eastern tropical Pacific. In: *Dolphin societies: discoveries and puzzles* (Eds. K. Pryor & K.S. Norris.): 161-196. University of California Press, Berkeley.
- Psarakos, S., Herzing, D. L. & K. Marten.** 2003. Mixed-species associations between Pantropical spotted dolphins (*Stenella attenuata*) and Hawaiian spinner dolphins (*Stenella longirostris*) off Oahu, Hawaii. *Aquatic Mammals*, **29** (3): 390-395.
- Sazima, I. & R. L. Moura.** 2000. Sharks (*Carcharhinus perezii*), cleaned by the goby (*Elacatinus randalli*), at Fernando de Noronha Archipelago, Western South Atlantic. *Copeia*, **2000** (1): 297-299.
- Sazima, I., Sazima, C. & J. M. Silva Jr.** 2003. The cetacean offal connection: feces and vomits of spinner dolphins as a food source for reef fishes. *Bulletin of Marine Science*, **72**: 151-160.

- Shinohara, M., Kishida, T. & E. Kawa.** 1999. Defecating behavior of wild bottlenose dolphins, *Tursiops truncatus*. *13th Biennial Conference on the Biology of Marine Animals*: 172.
- Silva Jr. J. M., Silva F. J. L. & J. A. Pereira.** 1996. O comportamento do golfinho rotador em F. de Noronha. *Anais 14 Encontro Anual de Etologia, Sociedade Brasileira de Etologia*: 251-262.
- Silva Jr. J. M., Pandolfo, L. J. & I. Sazima.** 2004. Vomiting behavior of the spinner dolphin (*Stenella longirostris*) and squid meals. *Aquatic Mammals*, **30** (2): 271-274.
- Silva-Jr, J. M. & Sazima, I.** 2003. Whalesuckers and spinner dolphins bonded for weeks: does host fidelity pay off? *Biota Neotropica*, **3** (2): 1-6.
- Tavolga, M. C. & F. S. Essapian.** 1957. The behavior of the bottle-nosed dolphin (*Tursiops truncatus*): mating, pregnancy, parturition and mother-infant behavior. *Zoologica*, **42** (1): 11-31.
- Wells, R.S. & K. S. Norris.** 1994 The island habitat. In: *The Hawaiian spinner dolphin*. (Eds. K. S. Norris, B. Würsig, R. S. Wells & M. Würsig): 31-53. University California Press, Berkeley.
- Wells, R. S. & M. D. Scott.** 2002. Bottlenose dolphins *Tursiops truncatus* and *T. aduncus*. In: *Encyclopedia of marine mammals* (Eds. W. F. Perrin, B. Würsig & J. G. M. Thewissen.): 942-945. Academic Press, San Diego.
- Whitehead, H. & J. Mann.** 2000. Female reproductive strategies of cetaceans. In: *Cetaceans societies: field studies of dolphins and whales*. (Eds. J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead): 219-246. The University of Chicago Press, Chicago.
- Wood, F. G. Jr., Caldwell, D. K. & M. C. Caldwell.** 1970. Behavioral interactions between porpoise and sharks. *Investigations on Cetacea*, **2**: 264-277.
- Würsig, B.** 2002. Playful behaviour. In: *Encyclopedia of marine mammals* (Eds. W. F. Perrin, B. Würsig & J. G. M. Thewissen): 942-945. Academic Press, San Diego.
- Würsig, B. & T. A. Jefferson.** 1990. Methods of photo-identification for small cetaceans. In: *Individual recognition of cetaceans: use of photo-identification and other techniques to estimate population parameters* (Eds. P.S. Hammond, S. A. Mizroch & G. P. Donovan): 43-52. International Whaling Commission, Cambridge.
- Würsig, B., Wells, R. S. & K. S. Norris.** 1994. Food and feeding. In: *The Hawaiian spinner dolphin*. (Eds. K. S. Norris, B. Würsig, R. S. Wells & M. Würsig): 216-231. University California Press, Berkeley.
- Würsig, B. & M. Würsig.** 1980. Behavior and ecology of dusky dolphin, *Lagenorhynchus obscurus*, in the South Atlantic. *Fishery Bulletin*, **77** (4): 871-890.