



Vocalizations associated with pectoral fin contact in bottlenose dolphins (*Tursiops truncatus*)



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ABSTRACT

Pectoral fin contact in bottlenose dolphins represents one form of tactile communication. Acoustic communication associated with pectoral fin contact is an additional level of communication that may change or enhance the tactile message between two individuals. In this study, we examine vocalization types associated with pectoral fin contact in a group of captive bottlenose dolphins (*Tursiops truncatus*). From 2006 to 2009, vocalizations potentially associated with 748 pectoral fin contacts were examined: whistles, click trains and overlap of whistles and click trains were documented when associated with fin contact. Dolphins were also documented not vocalizing when exchanging pectoral fin contacts. Call type associated with pectoral fin contact was compared for the proportion of the type of pectoral fin contact, vocalizer sex, initiator and receiver roles, and gender pair. Overall, vocalizations differed significantly by vocalizer role as *rubber* or *rubbee*, initiator, and sex. Receivers and *rubbees* clicked and used overlap vocalizations more frequently, and males produced overlap vocalizations more frequently. These results suggest that whistles may be used to initiate pectoral fin contact or show preference for a particular partner, while click trains may be used to show disinterest in pectoral fin contact or to signal the end of a contact. Examining vocalizations produced in conjunction with tactile contact is a relatively new approach in the study of individual dolphin behavior and may be useful for understanding dolphin social alliances and social preferences for various individuals within a population.

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1. Introduction

The exchange of information via signals (i.e., communication) has been studied in many species of delphinid, including common bottlenose dolphins (*Tursiops truncatus*, Overstrom, 1983), Indo-Pacific bottlenose dolphins (*Tursiops aduncus*, Sakai et al., 2003, 2006), Atlantic spotted dolphins (*Stenella frontalis*, Dudzinski, 1996, 1998; Dudzinski et al., 2009b, 2010), and Hawaiian spinner dolphins (*Stenella longirostris*, Ostman, 1994). Bottlenose dolphins use a variety of vocalizations, tactile behaviors, and postures to convey information. Non-vocal auditory signals may include jaw claps, tail slaps, breaches and leaps (Shane, 1990; Norris et al., 1994; Dudzinski et al., 2009b).

1.1. Types of vocalizations

Dolphin vocalizations are divided into two broad categories: amplitude-modulated calls or clicks and frequency-modulated tones or whistles (Herman and Tavolga, 1980; Tyack, 1986a, 1986b; Au, 1993). Echolocation, or clicks with a fundamental frequency

ranging from 120 to 140 kHz, is very directional and has been described for several delphinid species, including bottlenose dolphins (Caldwell et al., 1965; Tyack, 1976; Herman and Tavolga, 1980), common dolphins (*Delphinus delphis*, Caldwell and Caldwell, 1968), Hawaiian spinner dolphins (Norris et al., 1985; Ostman, 1994), killer whales (*Orcinus orca*, Bain, 1986; Ford and Fisher, 1986), and pilot whales (*Globicephala macrorhynchus*, Weilgart and Whitehead, 1990). Whistles present a lower fundamental frequency, typically less than 22 kHz, are omni-directional and have been studied significantly more than pulsed calls for many species; these acoustic signals also lend themselves to quantitative measurement because of their narrow-band, frequency-modulated character and a fundamental frequency that resides within the range of most commercially available recording gear (Caldwell and Caldwell, 1965; Tyack, 1976; Caldwell et al., 1990; Wang et al., 1995). Whistles generally range from 0.5 to 2.5 s in duration, but length can vary considerably among species and individuals (Caldwell et al., 1990).

1.2. Non-acoustic communication

Tactile contact is frequently observed between dolphins, and involves, for example, rubbing bodies, rubbing against a surface in the environment, or rubbing a part of the body on

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another individual (Pryor, 1990). Pectoral fin contact is an affiliative behavior involving touching or rubbing part of one dolphin's body and another dolphin's pectoral fin (Sakai et al., 2006; Dudzinski et al., 2009a, 2010). Pectoral fin contact has been studied in Indo-Pacific bottlenose dolphins (Mann and Smuts, 1998, 1999; Sakai et al., 2003, 2006; Dudzinski et al., 2009a), bottlenose dolphins (Tavolga and Essapian, 1957; Samuels et al., 1989; Tamaki et al., 2006; Dudzinski et al., 2010), Commerson's dolphins (*Cephalorhynchus commersonii*, Johnson and Moewe, 1999), spinner dolphins (Norris et al., 1994), Atlantic spotted dolphins (Dudzinski, 1996, 1998; Dudzinski et al., 2009a), belugas (*Delphinapterus leucas*, Smith et al., 1992), and sperm whales (*Physeter macrohynchus*, Whitehead and Weilgart, 2000). Pectoral fin contact is often observed during play, sexual contexts, maternal interactions, or general social contexts, and may strengthen social bonds between individuals (Dudzinski et al., 2009a, 2010).

1.3. Association of dolphin behavior with vocalizations

While much research has been conducted on cetacean vocalizations, less information has been gathered on sounds that might be produced in association with particular individual behaviors. This scarcity of detail is likely related to difficulties of conducting behavioral studies on highly mobile animals in a marine environment while synchronously recording their sounds. Clark (1982) found an association between certain calls and close, physical social interactions in southern right whales (*Eubalaena australis*). Sjare and Smith (1986) examined vocalizations and behavioral activity in belugas using the broad behavioral categories of feeding, resting, and socializing. Vocalizations included clicks and whistles, and vocal rates were generally higher during social interaction than during directed swimming, resting behavior, or alarm situations (Sjare and Smith, 1986).

In North Atlantic pilot whales (*Globicephala melas*), greater click activity was associated with feeding and surface active behavior (Weilgart and Whitehead, 1990); whistles seemed to function as calls to maintain contact with group members and coordinate movements of the herd (Weilgart and Whitehead, 1990). Hector's dolphins (*Cephalorhynchus hectori*) use complex click trains more commonly in large groups, suggesting they have a social communicative function (Dawson, 1991); high pulse rate sounds were more common in aerial and aggressive contexts than in more restful activity states (Dawson, 1991).

Only a few studies have examined the association between a particular sound and an individual dolphin's behavior. Caldwell and Caldwell (1967) observed a high-energy sound associated with fright in captive bottlenose dolphins; they observed that a "crack" sound occurred when the animals were displaying flight, tight schooling and hyper-excitability. Overstrom (1983) described pulsed emissions that accompanied aggressive displays in bottlenose dolphins. He found that dolphins displayed an open-mouthed posture accompanied by violent head motions and pulse-type vocalizations, often accompanied by jaw claps. Herzing (1996) examined vocalizations associated with general behaviors of Atlantic spotted dolphins and bottlenose dolphins: 10 types of vocalizations were generally associated with underwater behaviors. Particular vocalizations were linked to various behaviors, including foraging and feeding behavior, excitement or anxiety, courtship, aggressive behavior, and sexual play (Herzing, 1996, 2000). Connor and Smolker (1996) examined a male vocalization called a "pop", a narrow-band low frequency pulse associated with female consortship in the bottlenose dolphin population in Monkey Mia, Australia.

Table 1

Population dynamics for the RIMS dolphin group during these four years of study (2006–2009). C = calf, J = juvenile, S = subadult, A = Adult, M = male, F = female.

Year	Age				Sex	
	C	J	S	A	M	F
2006	5	1	2	8	8	8
2007	5	4	2	7	9	9
2008	3	4	5	7	10	9
2009	6	5	2	11	12	12

1.4. Goals of this study

This study examined the vocalizations associated with pectoral fin contact exchanges between individual bottlenose dolphins with the specific goals to quantify the types of sounds that may accompany this tactile behavior, to examine whether particular vocalizations are commonly associated with pectoral fin contact and to examine whether different vocalizations are associated with different vocalizer categories, such as sex or role, or with different combinations of dolphin pairs, such as sex or age-classes. Understanding the role of specific vocalizations within the context of this particular behavior will reveal more information about dolphin relationships and social structure. Examining the association between tactile and acoustic communication could indicate more details about the role of these signals in securing relationships in a fission-fusion society.

2. Methods

2.1. Study site and population

Four years of data were analyzed (2006–2009) from a longitudinal data archive collected at the Roatan Institute for Marine Science (RIMS), located at Anthony Key Resort, Roatan, Honduras (DCP Data Archive 2006–2009; Dudzinski et al., 2010). The dolphin facility is located inside a fringing reef in a natural lagoon that encloses about 300 m² in surface area. The sea floor is covered with sand, seagrass beds and natural coral. Bottlenose dolphins in this captive population range in age from neonate to 30+ years; the social dynamic is similar to that observed for wild bottlenose dolphins (Kogi et al., 2004; Connor et al., 2006); during the four years included in this study, their study group ranged in size from 16 to 24 dolphins, with a roughly 1:1 female:male sex ratio annually (Table 1).

2.2. Video data collection

Behavioral data were collected using focal animal and all-occurrence sampling (Altmann, 1974); video data were collected during underwater swims using a mobile video/acoustic system (Dudzinski et al., 1995). Identified individual dolphins were selected for follow, based upon which dolphin(s) were readily in view of the camera and observer (see Dudzinski et al., 2010 for protocol details). Limiting factors to data collection included visibility conditions, weather, sea state, and facility schedule and availability. Event sampled pectoral fin contacts between dolphins that were documented from 2006 to 2009 were analyzed for associated dolphin vocalizations. (For more detailed information on the pectoral fin contact data collection, see the methods of Dudzinski et al., 2009a, 2009b, 2010.)

2.3. Acoustic data collection

Using previously collected data on pectoral fin contact (Dudzinski et al., 2010), 20 s audio segments (beginning 10 s prior to fin contact start, ending 10 s after contact start, and including

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