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Long-Distance Movements of Indo-Pacific Bottlenose Dolphins (*Tursiops aduncus*) and Habitat Preference of Two Species of Bottlenose Dolphins in Eastern Kyushu, Japan

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Abstract

The Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) was first confirmed in the coastal waters of the Oita Prefecture in eastern Kyushu, Japan. Boat-based sighting surveys and opportunistic observations for this species were conducted during the survey periods of 56 d between June 2002 and December 2004 in the Oita region. There were five sightings of this species in April, May, and November in 2003 and December in 2004—two groups consisting of more than a dozen dolphins and three solitary dolphins. Seven individuals of these sightings were identified by dorsal fins. Among them, five individuals were confirmed as having been previously identified in Kagoshima Bay in southern Kyushu, suggesting that individual dolphins might travel over hundreds of kilometers. These five dolphins were considered temporary migrants to the Oita region because we could find them only in the spring of 2003. During the boat-based sighting surveys, the common bottlenose dolphin (*T. truncatus*) were found only in November for two consecutive years. These dolphins may be temporary, possibly seasonal visitors to the region. These two species used different water depth ranges in the same bay, indicating that the two species preferred different habitats. A single sighting in 2009 of *Tursiops* sp. in waters adjacent to the Oita Prefecture, Seto Inland Sea, is also reported.

Key Words: bottlenose dolphin, *Tursiops aduncus*, *Tursiops truncatus*, Japan, habitat preference, long-distance movements

Introduction

The Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) is distributed in coastal and near-shore waters of the Indian and western Pacific Oceans (Jefferson et al., 2008). This species typically inhabits lagoons, estuaries, embayments, and open coastal waters (Chilvers & Corkeron, 2003; Stensland et al., 2006; Dulau-Drouot et al., 2008; Fury & Harrison, 2008; Gross et al., 2009). Genetic differentiation is found even between neighboring populations (Natoli et al., 2008; Särnblad et al., 2011), suggesting the existence of many isolated populations in the distribution areas.

Small-isolated populations of Indo-Pacific bottlenose dolphins are found in Japanese waters (Shinohara, 1998; Shirakihara et al., 2002; Kogi et al., 2004; Nanbu et al., 2006; Mori & Yoshioka, 2009; Funasaka et al., 2011; Figure 1). Geographic differences in whistle acoustic parameters and genetic differentiations were found among populations (Hayano et al., 2004; Morisaka et al., 2005). A new location was recently confirmed to be a possibly regularly used habitat for this species: around Torishima Island (Hayano et al., 2010; Morisaka et al., 2010; Figure 1). According to the Marine Mammals Stranding Database of the National Museum of Nature and Science in Tokyo (http://svrsh2.kahaku.go.jp/drift/e; accessed 6 March 2012) and stranding records of the Cetaceans Research Institute in Tokyo (www.icrwhale.org/zasho.html#translate-en; accessed 12 March 2012), stranding records of Indo-Pacific bottlenose dolphins have increased in regions located apart from the usual range over which members of this species have been regularly observed. These could indicate the existence of undiscovered populations

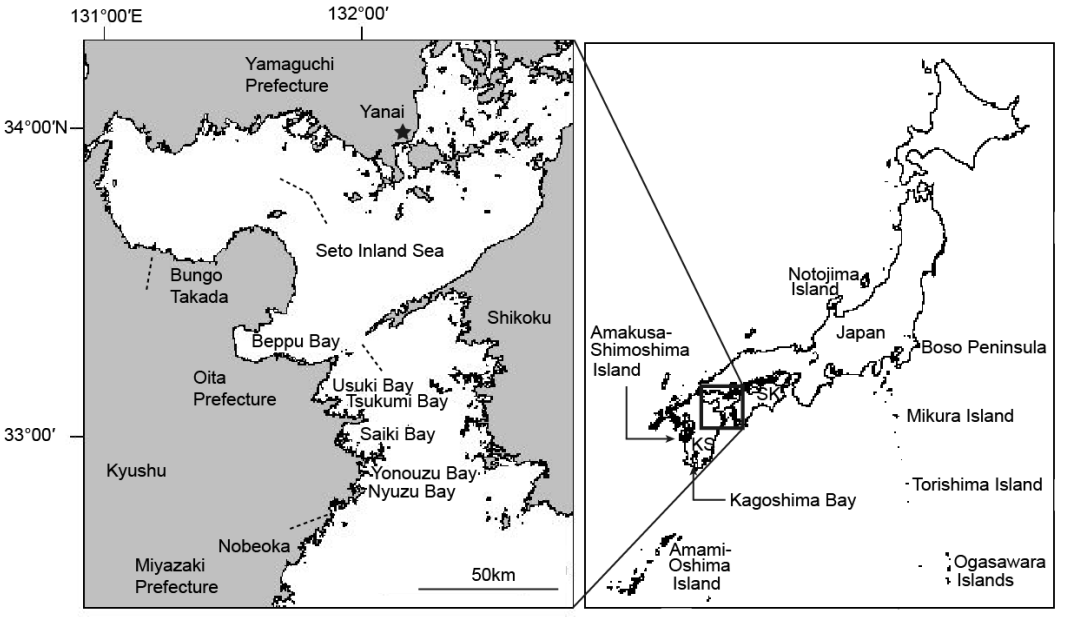

Figure 1. Map of the study area in eastern Kyushu and Japan; Indo-Pacific bottlenose dolphins have been found around Mikura Island, Torishima Island, Ogasawara Islands, Boso Peninsula, Notojima Island, Amakusa-Shimoshima Island, Amami-Oshima Island, and in Kagoshima Bay (Shinohara, 1998; Shirakihara et al., 2002; Fujita, 2003; Kogi et al., 2004; Nanbu et al., 2006; Mori & Yoshioka, 2010; Morisaka et al., 2010; Funasaka et al., 2011). Dotted line indicates the prefectural boundary; KS = Kyushu; SK = Shikoku; and ★ = Tozaki.

of Indo-Pacific bottlenose dolphins or the expansion of their range from known habitats.

Information related to sightings of unknown species of dolphin in the coastal waters of Oita in Kyushu, western Japan, was provided to the authors (specifically to KS) in 2002. No records of Indo-Pacific bottlenose dolphins were previously reported in that region, despite the presence of resident individuals of this species in both western and southern Kyushu (Shirakihara et al., 2002; Nanbu et al., 2006). Surveys were required to determine whether the dolphins were Indo-Pacific bottlenose dolphins or other dolphin species. Our goal is to confirm the occurrence of Indo-Pacific bottlenose dolphins in the Oita region and to know the origin and ranging pattern of these individuals by comparing photo-ID records from populations of this species in Kyushu.

Materials and Methods

The study area was located in eastern Kyushu, western Japan (Figure 1). At the beginning of the surveys in the Oita region, we interviewed fishermen, ship crews, and anglers from Bungo Takada to Nobeoka at the northern end of Miyazaki Prefecture to obtain the clues to the discovery of Indo-Pacific bottlenose dolphins. From interview responses and the location of the homeport of the chartered fishing boat (12 m long and equipped with 450 hp engine), we determined Usuki and Tsukumi Bays in the Oita Prefecture as the main area for boat-based sighting surveys. The surveys were conducted for 17 d on calm sea conditions (Beaufort Sea State ≤ 2) between June 2002 and December 2004 (Table 1). During most of the surveys, two experienced observers searched for dolphin groups with naked eyes from the bow of the boat. Binoculars (×8) were used when sighting cues like splashes were found. The boat left the port on the northern coast of Usuki Bay in the morning and went south along the coast. The survey course was set about 300 m from the coast (total length was about 50 km). When a dolphin group was sighted, the species was identified. If the group was made up of Indo-Pacific bottlenose dolphins or common bottlenose dolphins, it was tracked as a focal group for as long as possible. We distinguished common bottlenose dolphins from Indo-Pacific bottlenose dolphins by their distinct blaze lateral to the dorsal fin as described by Hale et al. (2000). Common bottlenose dolphins have a more falcate dorsal fin, a shorter rostrum, and larger body length (Jefferson et al., 2008). Boat positions (within 100 m from the group) were automatically logged using a GARMIM eTrex

Vista HCx GPS. Water depth was extracted from the digital maps of *Marine Explorer*, Version 4.0 (Environment Simulation Laboratory Co. Ltd., Kanagawa, Japan).

Dorsal fin photos were taken using CANON EOS film and digital cameras equipped with a 100-300 mm zoom lens for individual identification. Individual Indo-Pacific bottlenose dolphins were identified using natural marks along the dorsal fin (Würsig & Jefferson, 1990). Photographs of the fin were compared to the photo-identification catalog of the Amakusa population (which contains 300 individuals) created previously by the authors (Shirakihara et al., 2002; Shirakihara & Shirakihara, in press) and to those of the Kagoshima Bay population (which contains 25 individuals), created by Nanbu et al. (2006). The distance between Amakusa and Oita, when measured along the coast, was about 700 km. Those between Oita and Kagoshima, and Kagoshima and Amakusa were about 600 km and 300 km, respectively.

During our stay in Oita, we frequently visited fishing villages along the coast from Beppu Bay to Nyuzu Bay to obtain a clue that might lead to the discovery of Indo-Pacific bottlenose dolphins when the boat-based sighting surveys were not feasible due to bad weather conditions. We could find five groups of the dolphins from land during these visits (Table 1). We observed two groups from a boat that was hired on the spot and three groups from a coastal sea wall and aqua farm facility. We attempted to obtain photographs for all of these opportunistic observations.

For the same purpose, we requested reports of dolphin sightings to the crew of the *R/V Hoyo* (from the Oita Prefectural Agriculture, Forestry and Fisheries Research Center), which conducts biological/oceanographic surveys for fisheries almost every day in the coastal waters of the Oita Prefecture (for the boundaries of the prefecture, see Figure 1). When the crew saw a dolphin group, time, latitude/longitude, water depth, and a rough estimate of group size were recorded. We did not ask them to identify the species because distinguishing between two species of bottlenose dolphins as well as identification of the Delphinidae species was difficult for most of the crew. According to the Marine Mammals Stranding Database of the National Museum of Nature and Science in Tokyo (http://svrsh2.kahaku.go.jp/drift/e; accessed 6 March 2012) and the Stranding Records of the Institute of Cetacean Research in Tokyo (www.icrwhale.org/zasho.html#translate-en; accessed 8 March 2012), there was a possibility of occurrence of multiple species of Delphinidae around the Oita region: rough-toothed dolphin (*Steno bredanensis*), common bottlenose dolphin (*T. truncatus*), long-beaked common dolphin (*Delphinus capensis*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and Risso's dolphin (*Grampus griseus*). Sighting reports on dolphin groups were collected between November 2002 and February 2006. The reported dolphin groups were categorized as two types. One was "small coastal groups" that appeared in shallow waters, which fulfilled two conditions: (1) group size ≤ 10 individuals and (2) depth of the sighting position ≤ 20 m. Groups that did not fulfill both conditions were designated as "other groups."

There are few records of free-ranging bottlenose dolphins in waters adjacent to the Oita Prefecture in the Seto Inland Sea (Figure 1). TI found the

Table 1. Summary of surveys in Oita

Year	Month	Survey days	No. of SS[a]	No. of OB[b]	No. of OL[c]
2002	June	1	0		
	Sept	4	0		
	Nov	2	2		
2003	March	4	1		
	April	6	2	1	
	May	2	1		
	Aug	3	2		
	Sept	5	2		
	Nov	4	2	1	
2004	March	4	2		
	May	8	1		
	July	1	0		
	Aug	7	1		
	Dec	5	1		3
Total		56	17	2	3

[a] Number of boat-based sighting surveys in Usuki and Tsukumi Bays

[b] Number of observations from a boat which was conducted after sighting of Indo-Pacific bottlenose dolphins from land

[c] Number of observations of this species from land

dolphins from the shore and took photographs to confirm the species.

Results

Boat-Based Sighting Surveys

From the boat-based sighting surveys, we confirmed Indo-Pacific bottlenose dolphins, common bottlenose dolphins, and long-beaked common dolphins (Table 2). Long-beaked common dolphins were recorded at 33° 09' N, 131° 55' E.

Indo-Pacific bottlenose dolphins were found on 2 May 2003 in Tsukumi Bay. The group was observed at about 2 km west from the location where the species was first confirmed 5 d previously by opportunistic observation (Figure 2). The group moved southwest along the coast and stayed there for a long time. The dolphins stayed close to each other and repeatedly performed synchronized diving. Feeding activity was observed at least twice. Group size was estimated to be 15 to 20 individuals, including a mother-and-calf

Table 2. Dolphin groups sighted in the Oita region

Species	Date	Location	Group size
T. aduncus	27 April 2003	Tsukumi Bay	12-13
T. aduncus	2 May 2003	Tsukumi Bay	15-20
T. aduncus	8 November 2003	Yonouzu Bay	1
T. aduncus	21 December 2004	Nyuzu Bay	1
T. aduncus	22 December 2004	Nyuzu Bay	1
T. aduncus?	23 December 2004	Nyuzu Bay	1
T. truncatus	29 November 2002	Tsukumi and Usuki Bay	150
T. truncatus	7 November 2003	Tsukumi and Usuki Bay	200
D. capensis	4 August 2003	Tsukumi and Usuki Bay	40

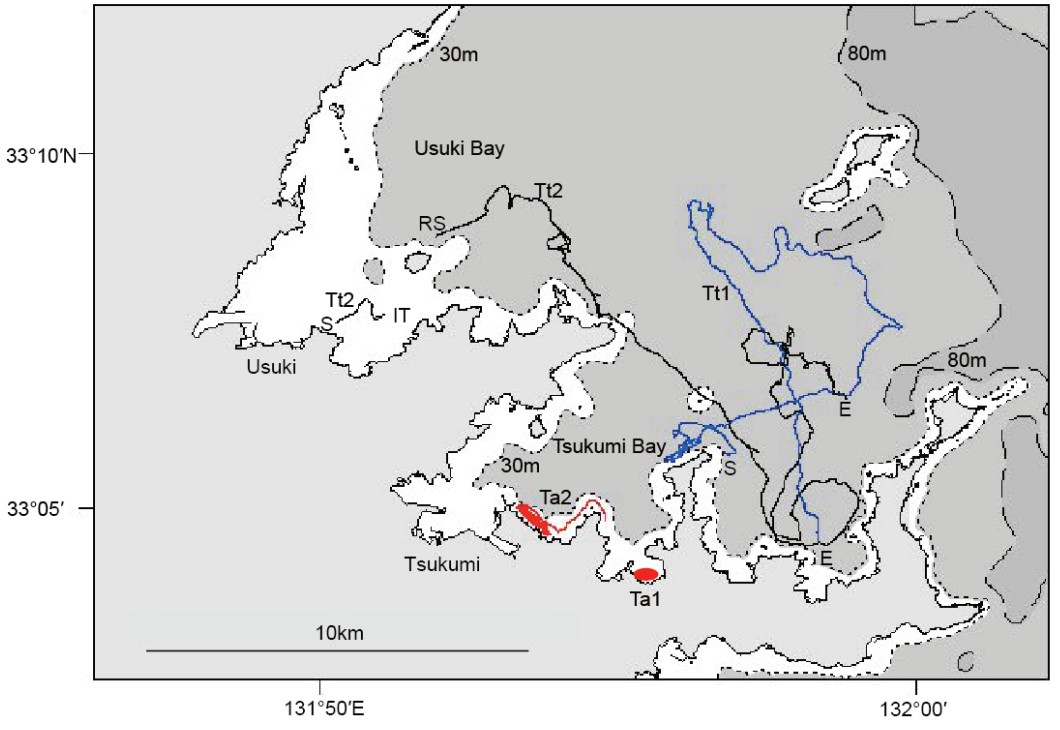

Figure 2. Movements of dolphin groups: Ta1, Indo-Pacific bottlenose dolphins on 27 April 2003; Ta2, Indo-Pacific bottlenose dolphins on 2 May 2003 (red line); Tt1, common bottlenose dolphins on 29 November 2002 (blue line); and Tt2, common bottlenose dolphins on 7 November 2003 (black line). Tracking started in the south and ended in the east; position recording was interrupted at IT due to a GPS malfunction and restarted at RS.

pair, with large and smaller dolphins swimming side by side consistently. Seven individuals were identified. Six of these individuals were confirmed to be from the group documented 5 d earlier (see below). The group found in the boat-based sighting surveys was tracked for 7.5 h.

Two groups of common bottlenose dolphins were confirmed from the sighting surveys. On 29 November 2002, a group of common bottlenose dolphins consisting of approximately 150 individuals was located at 1030 h east of the tip of a peninsula in Tsukumi Bay and was followed for 6 h (Figure 2). The second common bottlenose dolphin group (~200 individuals) was detected in Usuki Bay on 7 November 2003 at 0900 h in < 30 m depth, and it was tracked for 8.5 h.

Both the common bottlenose dolphin groups entered water < 30 m deep but spent most of their time in deeper areas, between water 30 to 80 m deep (Figure 3). In contrast, the Indo-Pacific bottlenose dolphin group spent most of its time in shallow water < 10 m deep.

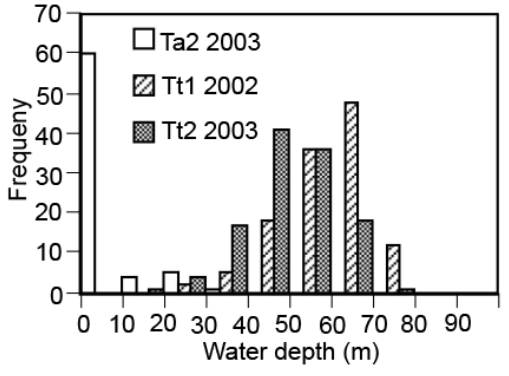

Figure 3. Frequency of the occurrence of dolphin groups by water depth; depth at the occurrence was measured every 3 min.

Boat- and Land-Based Opportunistic Observations

Indo-Pacific bottlenose dolphins were first sighted in Tsukumi Bay on 27 April 2003 (Figure 2). The group was observed from land just before sunset. We approached them by a boat that was hired at a fishing port near the spot to determine the species. On the basis of the dorsal fin scars, six individuals were identified among 12 to 13 individuals in the group. They seemed to forage at the inner part of this small bay.

We documented three solitary Indo-Pacific bottlenose dolphins: one was found in Yonouzu Bay (32° 55' N, 131° 59' E) in November 2003, and another two were found in Nyuzu Bay (32° 52' N, 131° 59' E) in December 2004. The individual found in Yonouzu Bay lacked clear notches on the edge of the dorsal fin. Photos were not clear enough to make individual identification of solitary dolphins observed in Nyuzu Bay possible. Therefore, we could not confirm them for re-identification.

Comparison of Dorsal Fin

Among the seven identified individuals of Indo-Pacific bottlenose dolphins, five were found in the photo-identification catalog of the Kagoshima Bay population. These individuals were repeatedly (4 to 14 times) photographed in the northern area of Kagoshima Bay between 1999 and 2001 (Nanbu et al., 2006).

R/V Hoyo *Observation Data*

From observations by the crew of the *R/V Hoyo*, "small coastal groups" of dolphins were documented from February to July, with a concentration of occurrence in 2003 (Table 3). All but one was found in Usuki and Saiki Bays (Figure 4). In contrast, "other groups" were sighted year-round in a wide range. The mean group size was 6.3 individuals (range = 2 to 10, n = 12, SD = 2.6) for "small coastal groups" and 49.8 individuals (range = 2 to 1,000, n = 51, SD = 140.1) for "other groups." The mean depth where the group was sighted was 15.5 m (range = 10 to 20, n = 12, SD = 3.7) for "small coastal groups" and 61.2 m (range = 10 to 117, n = 49, SD = 30.3) for "other groups." The "small coastal groups" might include

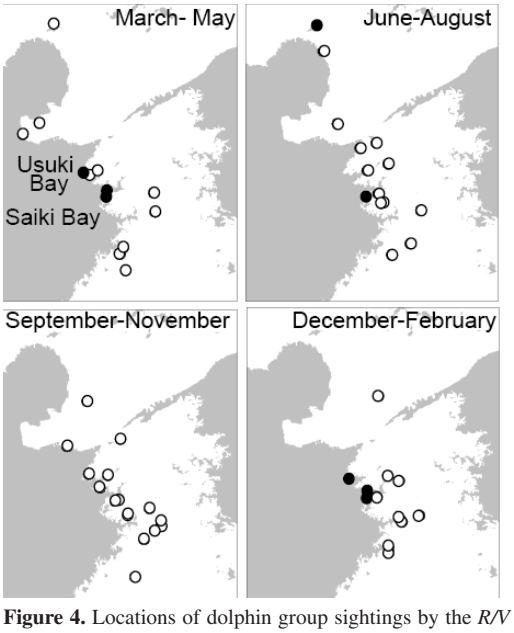

Figure 4. Locations of dolphin group sightings by the *R/V Hoyo* crew between November 2002 and February 2006; black and white circles indicate the positions of "small coastal groups" and "other groups," respectively.

Table 3. Summary of sighting reports by the crew of *R/V Hoyo* from the Oita Prefectural Agriculture, Forestry and Fisheries Research Center

	Small coastal groups						Other groups					
	2002	2003	2004	2005	2006	Total	2002	2003	2004	2005	2006	Total
Jan								3	1		3	7
Feb		4			1	5		1	1	2		4
March		1				1		1				1
April		2				2			3	2		5
May		1				1		3	1	1		5
June		2				2			2	1		3
July				1		1		1	2	2		5
Aug								2	2			4
Sept								1	6			7
Oct								1		2		3
Nov							2	1	1	2		6
Dec							1			1		2
Total		10		1	1	12	3	14	19	13	3	52

Indo-Pacific bottlenose dolphins on the basis of the survey results mentioned above.

Bottlenose Dolphins in Waters Adjacent to the Oita Region, Seto Inland Sea

At 1100 h on 4 December 2009, two groups of *Tursiops* sp. were observed at about 25 to 30 m from shore at Tozaki in Yanai, Yamaguchi Prefecture by TI (Figure 1). Each group consisted of about 10 individuals. The distance between the groups was 20 to 30 m. They moved to the east, and then turned around to the west. Headfirst reentry leaps higher than 5 m in the air were frequently observed. We could not confirm that the dolphins were Indo-Pacific bottlenose dolphins.

Discussion

Indo-Pacific bottlenose dolphins were first confirmed in the Oita region in eastern Kyushu, Japan, from the boat- and land-based surveys in this study. We also succeeded in the tracking of two large groups of common bottlenose dolphins for two consecutive years in bays where Indo-Pacific bottlenose dolphins occurred. Common bottlenose dolphins appeared a few kilometers away from an area that was used intensively by Indo-Pacific bottlenose dolphins. However, the inshore and shallow water < 30 m deep were occupied exclusively by Indo-Pacific bottlenose dolphins; common bottlenose dolphins spent most time in 30 to 80 m depths, suggesting that the two species prefer different types of habitat. This was consistent with survey results in other locations where both species were found (Miyashita et al., 1995; Hale et al., 2000; Dulau-Drouot et al., 2008). Both appeared to be distributed year-round in specific areas (Hale et al., 2000; Dulau-Drouot et al., 2008). In the Oita region, we found common bottlenose dolphins in November and Indo-Pacific bottlenose dolphins in April, May, November, and December, thus suggesting the temporary occurrence of both species in this region.

The resident population of Indo-Pacific bottlenose dolphins seems to remain in a smaller geographic area and can be found with little effort in areas such as Mikura Island and in the Amakusa Shimoshima-Island population (Shirakihara et al., 2002; Kogi et al., 2004). In this study, after spring 2003 when we first observed Indo-Pacific bottlenose dolphins in the Oita region, no groups were again sighted except solitary individuals, though we repeatedly searched for dolphins. Information on the exact location where the dolphins could usually be found was not obtained during the interviews with people resident to the area. The *R/V Hoyo* crew frequently observed "small coastal groups" from February to July 2003, a period which coincided with our findings of two groups of Indo-Pacific bottlenose dolphins. If resident individuals of Indo-Pacific bottlenose dolphins were settled in this region, people living in Oita would see the dolphins more frequently. The encounter rate with the dolphins was quite low. Thus, we consider the Indo-Pacific bottlenose dolphins we found not to be residents in this region.

Five individuals identified in the Oita region came from Kagoshima Bay in southern Kyusyu. These dolphins are thought to be temporary migrants that had strayed from their usual habitat in Kagoshima Bay because the dolphins were frequently confirmed in the Kagoshima Bay surveys (59 times) between 1999 and 2001 (Nanbu et al., 2006). If the dolphins selected the Oita region as new habitat, we would have found them more often. Ranging patterns for this species are variable;

identified individuals have exhibited long-distance movements > 300 km or they were not found in adjacent areas (Chilvers & Corkeron, 2003; Möller et al., 2007; Reisinger & Karczmarski, 2010). A record of long-distance movements (over 100 km) by identified resident Indo-Pacific bottlenose dolphins exist from Mikura Island to the Boso Peninsula (Fujita, 2003). Further study is needed to clarify the ranging patterns of Kagoshima Bay dolphins and whether they go back and forth between Kagoshima Bay and other areas such as the Oita region.

Common bottlenose dolphins found in temperate and tropical marine waters around the world represent several ranging patterns: seasonal migrations, year-round home ranges, periodic residency, and a combination of occasional long-range movements and repeated local residency (Wells & Scott, 2009). In Japanese waters, the dolphins occur south of southern Hokkaido in the Pacific Ocean and in the Sea of Japan (Miyashita, 1993; Yoshioka, 2009), and seasonal migration has been suggested (Tanaka, 1987). In the Oita region, two groups of the species sighted in November for two consecutive years were tracked for several hours. They stayed within an area of approximately 100 km^2 in Tsukumi and Usuki Bays. The group sighted on 7 November 2003 was not found in the sighting survey 2 d later, which suggested this group moved out of the area. Most of the strandings and sightings of *Tursiops* sp. have been reported from September to November and from February to May in the Oita region and its adjacent waters, including Seto Inland Sea (Kasuya & Kureha, 1979; Kuwano et al., 2011; R. Kuwano, pers. comm., 8 July 2011). TI sighted bottlenose dolphin groups in December in Seto Inland Sea. More data with reliable species identification are required in order to draw conclusions about the occurrence patterns of common bottlenose dolphins in the Oita region, but the groups we found may be temporary or seasonal visitors to the region.

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