

Short Note

Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*) Repeatedly Self-Confining in a Traditionally Built Basin Off Jeju Island, Republic of Korea

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Coastal aquaculture activities overlap with the habitats of various marine predators such as sea birds, seals, and dolphins (Schreiber et al., 2002; Kemper et al., 2003; Bearzi et al., 2009). In such areas, predatory species have been reported to interact with the aquaculture systems regularly (Methion & López, 2019). Such interactions seem to be associated with food resource availability. The establishment of aquaculture systems leads to the aggregation of wild fish, primarily because of the large quantities of unconsumed food originating from the facilities (Tuya et al., 2006; Fernandez-Jover et al., 2007). Consequently, considerable amounts of organic matter with high nitrogen and phosphate contents are found at the dumping sights which, in turn, attract prey species (Karakassis et al., 2000; Würsig & Gailey, 2002; Kemper et al., 2003).

Aquaculture is a major economic activity in Jeju Island, South Korea, especially with olive flounder (*Paralichthys olivaceus*), which is the flagship fish species and the second-largest export item in Jeju Island after semiconductors (Sohn et al., 2019). In a small village in the east of Jeju Island, Haengwon-ri, there is an inland aquafarm complex where 27 companies specializing in olive flounder aquaculture share an intake pipe and a sewer (Figure 1). The emitted content from the aquafarm complex reaches the open shore after two steps of outdoor systems: the sedimentary pool → Wondam → open water. The

sedimentary pool connected to the complex is a fishing spot in Jeju Island filled with olive flounders emitted from the fish tanks. Adjacent to the sedimentary pools and outdoor filtering system of the aquafarm complex is a small basin called *Wondam* (Figure 2). *Wondam*, meaning “stone wall” in Jeju Korean dialect, is a traditional fishing method used throughout Korean waters. The Sejong Chronicles from the 15th century describe the fishing method: stone walls built on the shore to trap fish via tidal action throughout the whole peninsula, including Jeju island (Lee, 2006; Hilty, 2011; Ril et al., 2020). Currently, the traditional fishing method is not widely used by the fishers, but the *Wondam* stone wall structures remain around the shoreline of Jeju Island. Herein, we report an unusual case of multiyear, repeated, and prolonged visits by an Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) to a specific *Wondam*.

The Indo-Pacific bottlenose dolphin is a widely distributed species inhabiting tropical and temperate coastal areas (Song, 2014; Wang, 2018). In South Korea, it only inhabits the coastal waters of Jeju Island year-round and is mainly spotted within 500 m from the shore in the northeast and northwest coasts (Kim et al., 2015). In coastal and estuarine habitats, dolphin populations tend to establish small and localized groups, exhibit high site fidelity, and feed on dispersed prey (Fury & Harrison, 2008; Wang, 2018). Some studies have demonstrated that aquaculture systems near such

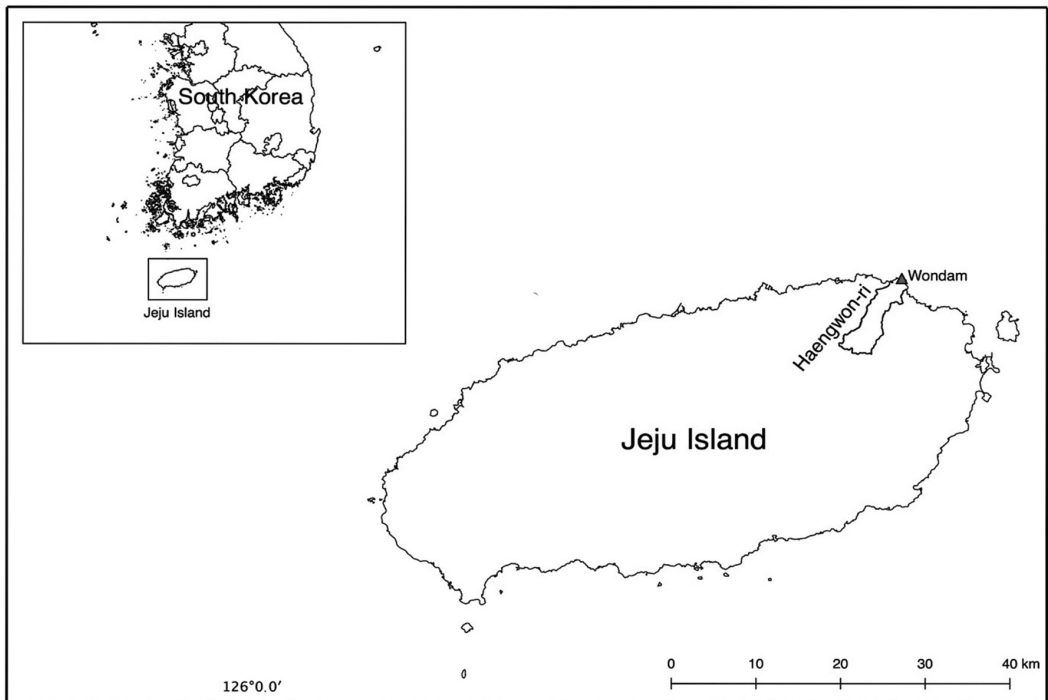


Figure 1. Location of the Wondam study site in Jeju Island, South Korea



Figure 2. A close aerial view of Haengwon Inland fish farm and the Wondam. The large inland fish farm complex dumps its emission into the sedimentary pool, and then the emission is filtered out to the Wondam. (Photo taken by a drone)

types of habitats function as foraging habitats for dolphins and influence both habitat selection and foraging techniques. For example, on the northwestern coast of Spain, one of the world's major seafood markets, aquaculture leads to high prey density, and dolphins are more likely to be spotted foraging inside aquaculture areas than outside aquaculture areas (López & Methion, 2017; Methion & López, 2019). However, since dolphins are social animals that display fission-fusion social structures in which individuals' associations within groups vary spatiotemporally (Connor et al., 2000), most studies have focused on the social group aspects, with numerous studies carried out on solitary individuals in different oceans globally (Lockyer, 1978; Santos, 1997; Müller et al., 1998; Eisfeld et al., 2010; Tsuji et al., 2017). However, the reasons for the individual differences remain unclear.

Since August 2015, several Indo-Pacific bottlenose dolphins have been spotted around the aquaculture farms in Haengwon-ri, Jeju Island. The dolphins feed on discarded fish and other marine species, such as the gray mullet (*Mugil cephalus*), chub mackerel (*Scomber japonicas*), horse mackerel (*Trachurus trachurus*), and Japanese halfbeak (*Hyporhamphus sajori*), which are attracted by feed pellets discarded from the fish farms or naturally

trapped in the Wondam. When the high tides completely submerge the Wondam, five to 20 dolphins swim around or inside it and sometimes some of them become trapped during the ebb tide. As the sea level increases, most individuals swim back to the ocean and join other individuals. However, in November 2016 and September 2017, one individual stayed within the confined area alone for more than 2 days. The dolphin was identified as an adult male, JTA065, registered in the Marine Animal Research and Conservation (MARC) catalog from South Korea. Based on its speckle patterns, JTA065 was estimated to be over 20 years of age, as speckles increase in number and density with an increase in maturity (Krzyszczczyk & Mann, 2011; Figure 3).

Sequential observations of the same individual, JTA065, were made for 4 years, from September 2015 to September 2019. It was observed at the Wondam every year; however, only in 2016 and 2017 did it enclose itself for more than a week during each visit (Table 1). At other times, it stayed for only 1 or 2 days. When JTA065 was present at the Wondam, at least one experienced observer was stationed at above-ground observation points to monitor its breathing patterns, verify surface activities, and assess health conditions (Table S1; supplemental tables for this short note are available in the "Supplemental Material" section of the *Aquatic*

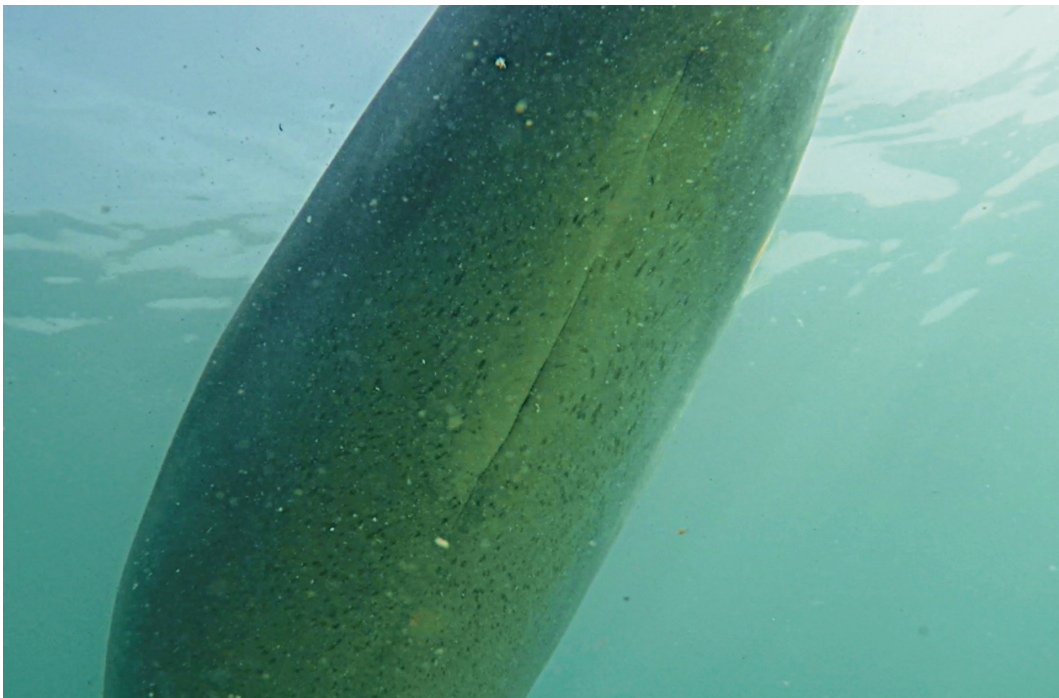


Figure 3. Ventral region of JTA065, an Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) swimming inside the Wondam, showing a urogenital opening

Mammals website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147).

Unmanned aerial vehicles (UAVs) with cameras (Phantom 4 and Mavic Pro; DJI, Shenzhen, China) were used when weather permitted. For a closer inspection of the individual's underwater behavior, a trained scuba diver went underwater with a GoPro HERO3 camera (GoPro Inc., San Mateo, CA, USA), without making direct contact, thus minimizing interference with the natural activities of JTA065. In the video that was recorded, JTA065 mostly moved forward or swam in circles (this video is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147). The observed foraging behavior was also analyzed and could be classified into three distinct categories: (1) hunting for olive flounder swimming on the surface, (2) swimming around rocky shores and seagrass beds to look for prey hiding in crevices, and (3) crater feeding with its rostrum to hunt buried prey (Figure 4). To verify that JTA065 was not trapped due to tide height, we checked both minimum and maximum tide heights in the days it stayed at the Wondam (Table S2;

www.badatime.com). We assumed that the minimum high tide (~190 cm) during the self-confined period was enough for JTA065 to enter or exit the Wondam. Therefore, according to the tidal information, JTA065 could have left the Wondam but opted to remain within the enclosed area.

Predation risk and food availability are the two primary factors influencing dolphin habitat selection (Heithaus & Dill, 2002). Dolphins also tend to exhibit strong site fidelity to habitats where dolphins can easily exploit prey, which minimizes the energy spent hunting (López, 2006; Cribb et al., 2013). Because dolphins are opportunistic predators, they feed whenever prey is available (Eierman & Connor, 2014). A proportion of the olive flounder at the Wondam in the present study is typically found motionless between rocks or floating at the surface—an easy prey for dolphins. When waters recede, many fish species and sometimes even squids are trapped inside the Wondam. Some successful feeding behaviors consisted of JTA065 floating or waiting in one area inside the Wondam and capturing prey as it floated by. Such an example demonstrates how energy efficient it is to catch prey inside the Wondam; there is no need for active hunting. Additionally, because the Wondam is a stone wall that works as a physical

Table 1. Dates and durations of the stays of JTA065 at the Wondam from 2015 to 2019

Date of entering the Wondam	Date of leaving the Wondam	Duration of stay ($n = \text{days}$)
20 August 2015	20 August 2015	> 1
8 September 2016	9 September 2016	1
5 November 2016	17 November 2016	12
18 September 2017	19 September 2017	1
24 October 2017	18 November 2017	25
22 June 2018	23 June 2018	1
3 September 2018	5 September 2018	2
12 August 2019	13 August 2019	1



Figure 4. The foraging behaviors of JTA065 at the Wondam: (a) hunting olive flounder (*Paralichthys olivaceus*) at the surface and (b) swimming around seagrass beds to look for prey; and (c) an olive flounder buried in the sandy bottom.

boundary for the dolphin to capture and corner prey, containing a sea bottom consisting of mostly bare sand with few hideouts, the fish density in the area is relatively high, and the prey are exposed. Therefore, dolphins foraging in the Wondam have increased feeding opportunities, leading to higher food intake rates similar to previous studies (Würsig, 1986; Benmessaoud et al., 2017).

Approximately 350 fish farms were operating in Jeju Island in 2019 according to the nation's open data portal. The impact of the facilities on the dolphins depends on an individual's site fidelity; however, environmental conditions, such as shifts in oceanographic conditions across seasons, migration of fish species, or shifts in wind and water currents, also alter dolphin foraging strategies and their fidelity to specific habitats (Hubard et al., 2004; de la Paz et al., 2020; Haughey et al., 2020). Exploiting easy prey near the aquaculture is beneficial to dolphins when food is scarce; however, there are potential negative impacts on individuals and populations if they visit such sites over the long term. First, such areas may not be appropriate foraging habitats for dolphins considering hygiene factors. In such areas, they are directly exposed to wastewater from inland aquaculture complexes, which contains leftover food pellets, dead or sick fish, and, more importantly, chemicals used in the aquaculture farms (e.g., antibiotics). The study area was a famous fishing spot, but it was designated as a no-fishing zone in 2020 due to the exposure and public shaming by a social media account (Jin, 2020) of the poor conditions of the olive flounders in the area and increased litter density. Second, the probability of direct contact with humans increases in such sites. During the study period, some fishers were observed throwing caught fish towards the confined individual dolphin in an attempt to feed it. In addition, locals attempted to swim close to the confined dolphin. Such proximity to the wild dolphin and attempted interactions pose direct and indirect risks. Direct risks include incidental injury and an increased stress level which can lead to aggressive behaviors towards humans (Scheer, 2010), while indirect risks include entanglement and ingestion of recreational fishing gear and exposure to noise disturbance or water pollution (Kemper et al., 2003; Powell & Wells, 2010; Methion & López, 2019). Therefore, when any dolphin is enclosed inside the Wondam, local authorities should limit human presence in the surrounding area. Furthermore, strict management of aquaculture water quality is required to facilitate the maintenance of the health of the Indo-Pacific bottlenose dolphins, as well as of all of the marine fauna that call inshore areas in Jeju Island their home.

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