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Short Note

Consequences Potentially Related to a Meteorological Event on a Resident Group of Bottlenose Dolphins (*Tursiops truncatus*) from the Mexican Pacific

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The bottlenose dolphin (*Tursiops truncatus*) is one of the most studied species within the Order Cetacea (Wells & Scott, 2009). This species usually inhabits temperate and tropical marine waters, mainly along coastal shorelines around the world (Wells & Scott, 2009), with typical group sizes of two to 15 individuals (Shane et al., 1986). Dolphins adapt their feeding preferences through behavioral plasticity, which allows them to use several resources depending upon the season or geographical space (Fernández et al., 2013). Thus, dolphin behavior reflects the conditions of the different regions they visit to fulfill their physiological needs, and dolphins are, therefore, considered marine ecosystem sentinels (Moore, 2008; Ansmann et al., 2012).

Some bottlenose dolphin groups engage in different kinds of movements such as seasonal migrations, particular movements within a home range, and combinations of infrequent long-range movements and periodic short-range displacements (Wells & Scott, 1999). Still, coastal bottlenose dolphins probably represent the principal species of resident populations (Martínez-Serrano et al., 2011; Fearnbach et al., 2012; Morteo et al., 2012), with the capacity to move or adapt when the ecological characteristics of the habitat change (Holt, 2003). Therefore, if a shift in prey resources occurs and less prey are available, dolphins are likely to follow available prey or search prey out in other habitats (Wilson et al., 1997, 2004), with traversed distances that can range from 100 to 800 km along coastal areas (Wells et al., 1990; Maze & Würsig, 1999; Delgado-Estrella, 2002). Varying habitat boundaries may be delimited by water temperature, salinity, and depth, among other environmental parameters (Wells & Scott, 2009).

Tropical storms or hurricanes are considered environmental disturbances because they can affect the habitat and animals within some particular coastal areas (Smith et al., 2013). Such is the case of the following events cited in Glynn et al. (1964): in 1947, a hurricane in the Gulf of Mexico destroyed major parts of the inshore oyster reef fauna (Engle, 1948); in 1961, a hurricane washed a great amount of sea grass onto the Biscayne Bay shore (Thomas et al., 1961); and in 1962, a hurricane caused high fish and invertebrate mortality in North Florida Bay (Tabb & Jones, 1962). Hurricanes, depending on their strength, represent events that can also destroy or damage urban infrastructure causing the entry of suspended particles to the water column (Kruczynski & Fletcher, 2012), which affect marine fauna. The effects of these meteorological events on cetaceans are not well studied due to their unpredictable occurrence (Bassos-Hull & Wells, 2007; Smith et al., 2013); however, various short-term (e.g., displacement, injury, or death) and long-term (e.g., habitat degradation, prey decrease, damage to critical habitats, health problems, and changes in social structure) effects can occur (Langtimm & Beck, 2003; Elliser & Herzing, 2011). Also, severe weather disturbances could lead to cetacean mass strandings (Mignucci-Giannoni et al., 1999).

Knowledge of cetacean residency patterns is an important tool for conservation and management of local populations (Parra et al., 2006). Shane et al. (1982) suggested that bottlenose dolphins with a permanent or established home range, such as resident populations, can be sensitive to environmental disturbances that occur in their area. The following four examples demonstrate the potential direct effects (negative or positive) of hurricanes on resident dolphins: (1) Rosel & Watts (2008) reported seven dolphins outside their usual habitat in the Gulf of Mexico off Louisiana during the 2005 hurricane season; (2) Miller et al. (2010) found an increase in reproductive rates in the dolphin population in Mississippi Sound, likely due to an increase in prey density following the sharp decline of commercial fishing efforts after Hurricane Katrina; (3) Fearnbach et al. (2011) reported many dolphins from Little Bahama Bank showed fresh shark bite wounds during summer months from 1992 to 2007, immediately after a hurricane, presumably because high waves and storms made the shallow waters uninhabitable for dolphins so they spent more time in deeper waters and, therefore, were more exposed to predators such as sharks; and (4) Smith et al. (2013) observed short- and long-term effects on dolphin foraging patterns in Mississippi Sound following Hurricane Katrina.

The potential effect of variable weather or other environmental disturbances on dolphins along the coast of the Mexican Pacific Ocean are unknown, and local studies of bottlenose dolphin ecology are non-existent. Regional tour operators in Barra de Navidad and Melaque, Jalisco, however, have observed a bottlenose dolphin group for the past 15 years; their anecdotal reports suggest this dolphin group might be a resident population in Tenacatita Bay, Jalisco (Rogelio Flores & Rafael Flores, pers. comm., 1 March 2011). The estimated bottlenose dolphin group size was eight. The aim of this short note is to report on an interaction potentially related to a meteorological event for this particular group of bottlenose dolphins.

To monitor these bottlenose dolphins, researchers from the University of Colima conducted monthly photo-identification surveys between March 2011 and May 2012, using a 9-m boat with a 75-hp outboard engine. When dolphins were sighted, the group's position was determined using a hand-held GPS (*Garmin map76CS*), and standard datasheets were completed with information including the date, time of day, group size, and activities (e.g., traveling, resting, socializing, or foraging; Vaughn et al., 2007). We stayed with each group to take pictures of natural marks and scars on dorsal fins, following Urian & Wells (1996), using a digital camera (Canon EOS 50D) with 100-300-mm lens. For photo-identification, we selected images that possessed sharp definition (in-focus images); were oriented perpendicular to the dolphin; and showed the complete dorsal fin to distinguish its form, notches, and scars (Urian et al., 2015). A photographic catalogue was created and allowed comparisons among individuals using the software *ACDSee Pro*, Version 3.

During the study period, 13 coastal surveys (approximately once per month) were conducted into Tenacatita Bay exclusively to monitor this dolphin group. Most of the surveys (n = 9; 70%) were conducted at the end of each month; only four surveys were not conducted at the end of a month because of bad sea conditions to sail. Survey time of day varied between 1000 and 1600 h, with each survey about 2 h in duration; even so, dolphins were observed immediately on each survey's start in the same area.

During surveys conducted between March and October 2011, eight adult dolphins and one

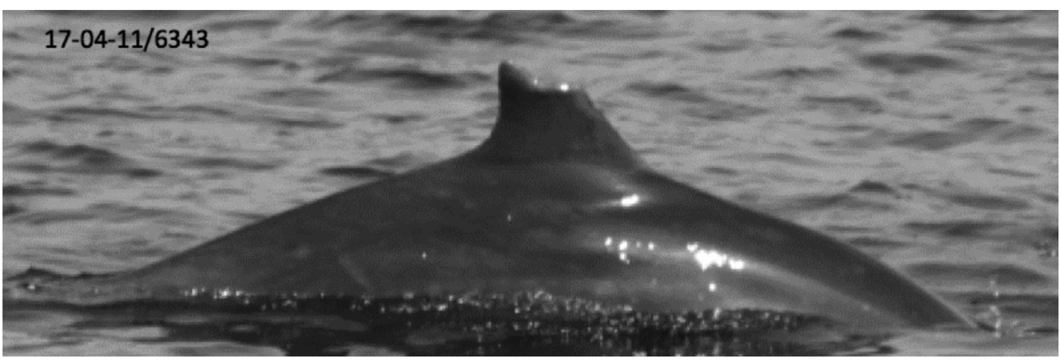

Figure 1. Bottlenose dolphin (*Tursiops truncatus*; ID#2) with truncated dorsal fin was sighted in Tenacatita Bay in Jalisco (during April-October 2011), and then in Puerto Angel Bay in Oaxaca, Mexico (once in April and once in May 2012). (*Photo credit:* Christian D. Ortega-Ortiz, Grupo Universitario de Investigación de Mamíferos Marinos [GUIMM], Universidad de Colima)

newborn calf were identified and resighted on every survey. One dolphin had a distinctly truncated dorsal fin with the top one third missing (ID#2; Figure 1). A biopsy of skin tissue was collected to conduct molecular analysis at the Molecular Ecology Laboratory of Universidad Autónoma de Baja California to identify this individual's gender (Bérubé & Palsbøll, 1996). This female dolphin was photo-recaptured five times during the 2011 study period: in March, April, May, July, and October. We calculated this dolphin's home range with a mean Propinquity Analysis to delimit its potential areas of geographical distribution, based on the Minimal Distances Tree concept and the Graph and Closer

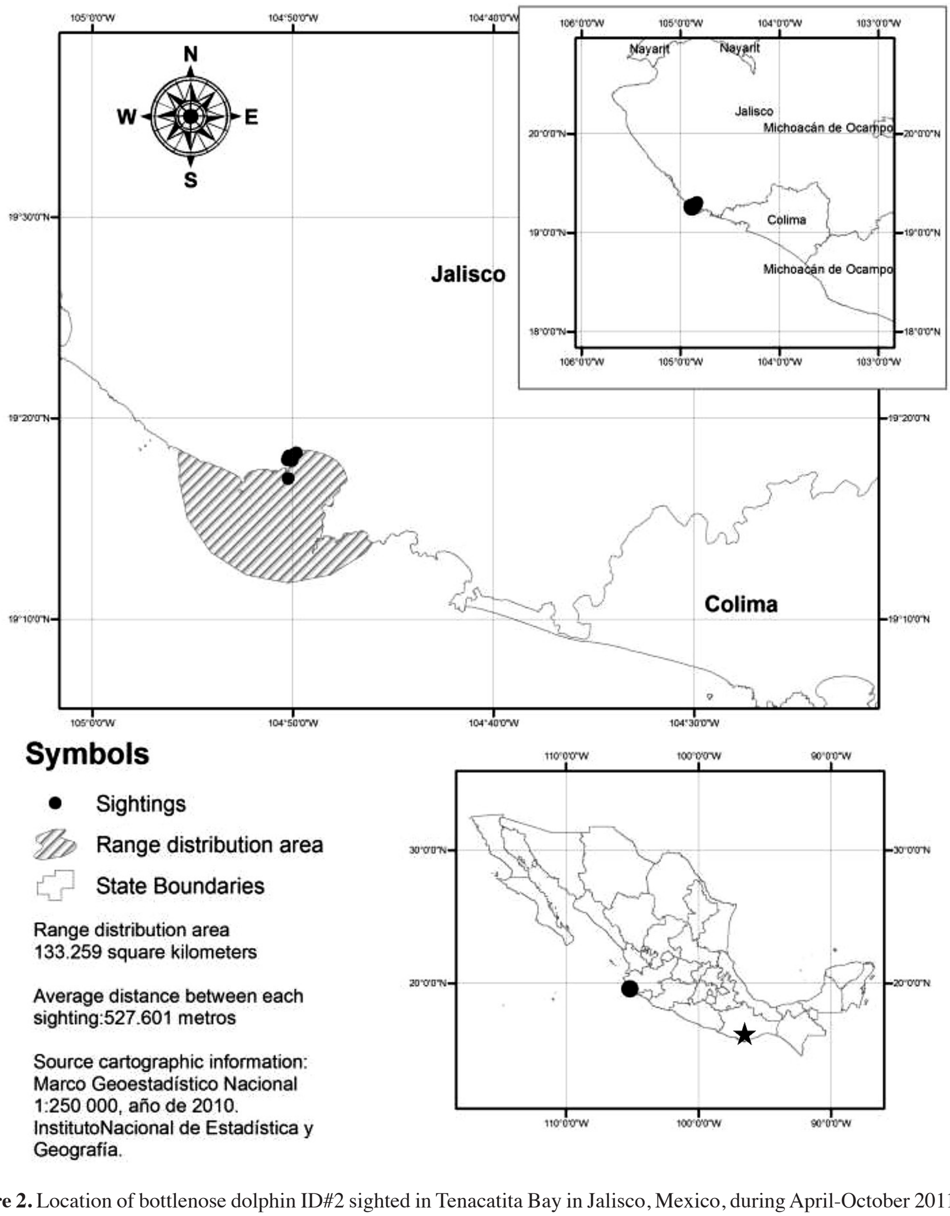

Figure 2. Location of bottlenose dolphin ID#2 sighted in Tenacatita Bay in Jalisco, Mexico, during April-October 2011. Note the probable distribution range from the Propinquity Analysis is 133 km². In addition, the black star symbol on the bottom map indicates sightings of this dolphin on 30 April and 12 May 2012 in coasts from Oaxaca, Mexico.

Neighborhood theories (Rodríguez & Escalante, 2008). This calculation indicated the potential distribution range for this dolphin in Tenacatita Bay as 133 km^2 (Figure 2), a narrow area that corroborated the individual's assumed residency (Martinez-Serrano et al., 2011).

Hurricane Jova hit the coast of Jalisco on 12 October 2011, with an intensity of sustained winds at 165 $km \cdot hr^{-1}$, placing it as a Category 2 on the Saffir-Simpson Hurricane Wind Scale (Brennan, 2012). Hurricane Jova generated the largest amount of rain received in the region that year (374.4 mm in 24 h) (Bravo-Lujano & Hernández-Unzón, 2011), which led to important changes in the coastal zone (Lazos-Chavero et al., 2017; Tapia-Palacios et al., 2017). Turbidity throughout the water column inside the Tenacatita Bay, probably caused by terrestrial runoff, was observed for several days after the hurricane. Coincidentally, from April 2011 to May 2012, we were monitoring oceanographic parameters in the bay and obtained temperature profiles from CTD casts taken monthly from a sampling station located in the middle of the bay. In the first 15 m depth, atypical colder water (20 to 22°C) was observed during October-November 2011 (Figure 3); this temperature range is more commonly recorded between winter and spring (March-April) because of coastal upwelling by local winds (Salas et al., 2006; Kono-Martínez et al., 2017). The occurrence of these colder temperatures is suggestive of coastal zone changes potentially caused by Hurricane Jova.

After Hurricane Jova, monthly vessel surveys and data collection continued through May 2012, although the regularly identified dolphin group was no longer sighted. On 30 April and 12 May 2012, the dolphin ID#2 was observed alone at Puerto Angel Bay in Oaxaca, Mexico, which is located ~950 km south of Tenacatita Bay (Figure 2). Then, on 31 July 2012, lifeguards reported this same dolphin floating dead very close to Zicatela Beach in Puerto Escondido, a distance of approximately 70 km north of Puerto Angel. The carcass had lacerations over much of the body likely caused by drifting fishing nets that were removed by tour operators, lifeguards, and volunteers (Figure 4). The seven other members of this bottlenose dolphin group were not seen in Oaxaca. Following this female's carcass sighting, our research group conducted surveys from 2012 to 2013 to continue monitoring marine mammals in the Colima–Jalisco region. Only six surveys were conducted in Tenacatita Bay, with no sightings of ID#2's conspecifics. However, in March 2014, tour operators and our research group again observed five members of this dolphin group, in addition to an unidentified adult and a calf, in Tenacatita Bay.

This short note provides information about a range extension by a female dolphin (ID#2) that is probably one of the longest distances (~950 km) recorded for a resident bottlenose dolphin as compared with the species' common range patterns (100 to 800 km; Wells et al., 1990; Maze &

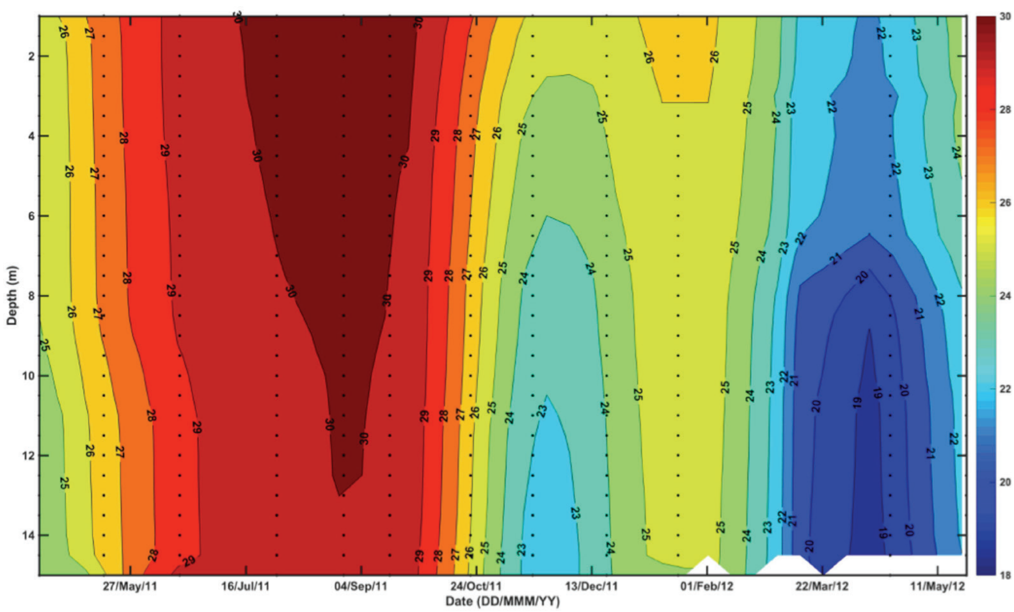

Figure 3. This temperature profile was obtained from Conductivity Temperature Depth (CTD) casts taken during April 2011 through May 2012 to 15 m depth at the same point in the middle of Tenacatita Bay in Jalisco, Mexico.

Figure 4. Bottlenose dolphin ID#2 carcass found close to Zicatela Beach in Puerto Escondido, Oaxaca, Mexico, in July 2012. Lacerations caused by fishing nets were visible on several parts of the body. (*Photo credit:* Francisco Villegas Zurita, Instituto de Ecología, Universidad del Mar, Puerto Ángel, Oaxaca, México)

Würsig, 1999; Delgado-Estrella, 2002; Lynn & Würsig, 2002). This report also provides support that meteorological phenomena such as hurricanes can disturb coastal regions, which likely impacts dolphins and may lead to a change in home range or displacement to other areas that can be temporary or permanent.

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