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Short Note

A New Case of Interoceanic Movement of a Humpback Whale in the Southern Hemisphere: The El Niño Link

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Extensive seasonal migrations by humpback whales (*Megaptera novaeangliae*) have been well documented for decades (Kellogg, 1929; Dawbin, 1966; Clapham & Mead, 1999). Unlike other more oceanic whales with complex seasonal patterns, such as blue (*Balaenoptera musculus*), sei (*B. borealis*), and even Bryde's (*B. edeni*) whales (Jefferson et al., 2015), the presence of humpback whales in destination areas in high and low latitudes are predominantly regular and predictable. Based on their breeding areas, the International Whaling Commission (IWC) recognizes seven different stocks of humpback whales in the Southern Hemisphere, assigned as Breeding Stocks A to G (IWC, 1998). Genetic studies largely support this separation, although a certain level of gene flow between the different stocks exists (Olavarría et al., 2007; Rosenbaum et al., 2017).

The east and west coasts of South America are each respectively home to one of these southern humpback whale stocks. Animals from Breeding Stock A (BSA) reproduce on the southern coast of Brazil, mainly around Abrolhos Bank in the western South Atlantic Ocean (16° to 19° 30' S) (Martins et al., 2013), while whales from Breeding Stock G (BSG) reproduce from northern Peru (4° S) to southern Nicaragua in the Eastern Pacific Ocean (11° 16' N) (Acevedo et al., 2017; De Weerdt et al., 2020). BSA has its feeding grounds in the Southern Ocean around South Georgia and the South Sandwich Islands (54° 31' S, 37° 24' W) (Zerbini et al., 2006; Engel & Martin, 2009), while the feeding grounds of the BSG are found primarily around the Antarctic Peninsula (65° S, 63° W) and extend eastward as far as the south of the South Orkney Islands (60° 54' S, 46° 40' W) (Dalla Rosa et al., 2012). A small part of BSG does not reach Antarctic Peninsula waters and remains in the inland waters around the southern tip of South America (Gibbons et al., 2003; Acevedo et al., 2013). The connectivity between breeding and feeding areas of both stocks has been well documented through satellite tracking (Zerbini et al., 2006; Félix & Guzmán, 2014), photo-identification of individual whales (Stevick et al., 2004, 2006; Acevedo et al., 2017), and genetics (Cypriano-Souza et al., 2010; Félix et al., 2012). Both stocks share a few mitochondrial DNA haplotypes, indicating recent interbreeding (Engel et al., 2008; Félix et al., 2012).

Although long-term migratory fidelity between breeding and feeding sites is well known in humpback whales, some individuals deviate from this pattern. This has been related to large-scale ocean–atmospheric events (Stevick et al., 2013), changes in prey distribution (Chittleborough, 1959), and probably other lesser-known ecological processes driven by climate change (Askin et al., 2017). In the North Pacific, individuals have been recorded visiting different breeding areas between Hawaii and Japan (Salden et al., 1999) and between Mexico and Hawaii (Forestell & Urbán, 2007; Darling et al., 2019). This has also been reported in the Southern Hemisphere, with individual whales recorded in multiple breeding areas within Oceania and between Oceania and the eastern South Pacific (Garrigue et al., 2002, 2007; Kaufman et al., 2011; Steel et al., 2018).

Less frequent is the migration of animals visiting breeding areas between different ocean basins. To our knowledge, three previously documented cases of exceptional movements exist: (1) a genetic match of a male humpback whale biopsy sampled in the Indian Ocean and the South Atlantic Ocean (Pomilla & Rosenbaum, 2005), (2) a female humpback whale between Brazil (western South Atlantic Ocean) and Madagascar (western Indian Ocean) (Stevick et al., 2010), and (3) another female between Puerto Cayo, Ecuador (eastern South Pacific Ocean) and Abrolhos, Brazil (western South Atlantic Ocean) (Stevick et al., 2013). Such extraordinary movements were detected thanks to interoceanic scientific research collaborations and the large datasets generated in those breeding grounds.

Herein, we present a new case of the interoceanic movement of a humpback whale recorded during the breeding season in two different ocean basins. The individual with ID code MSB#0775 was seen twice at Salinas in Ecuador (2° 09' S, 81° 01' W): first on 1 August 2006, and then again on 13 July 2008 in the same location. This individual, assigned with ID code IBJ#4479 in a Brazilian catalogue, was subsequently observed on 6 August 2016 in Abrolhos Bank, Brazil (17° 52' S, 39° 05' W). The individual was recognized by the unique coloration pattern on the ventral side of its flukes (see Katona et al., 1979; Figure 1) and then detected by a fully automated image recognition system comparing 35,000 individual humpback whales in 82,000 encounters within the Happywhale platform (Cheeseman & Southerland, unpub. data). The shortest distance between both breeding areas is 11,600 km (Figure 2). The discovery was made thanks to the collaborative effort of multiple research groups sharing their fluke catalogs through international repositories that promote data sharing for a better understanding of migratory movements of the species (i.e., CEQUA and Happywhale). Such repositories have also developed informatics tools for more efficient comparison of large volumes of compiled photographs.

When individual MSB#0775/IBJ#4479 was sighted for the first time in 2006 in Ecuador, it was accompanied by another whale. On the second occasion, this whale was part of a small competitive group of three animals. Sloughed skin was collected for genetic analysis from two of the three animals in this group, including one that was most likely MSB#0775. In both cases, animals were determined to be males (F. Félix, unpub. data). In Brazil, the individual was seen as part of a group of two individuals. The absence of a calf swimming in close association with this individual during the three sightings also suggests the whale was probably male.

Because of the scarce number of records, such interoceanic movements are likely to be

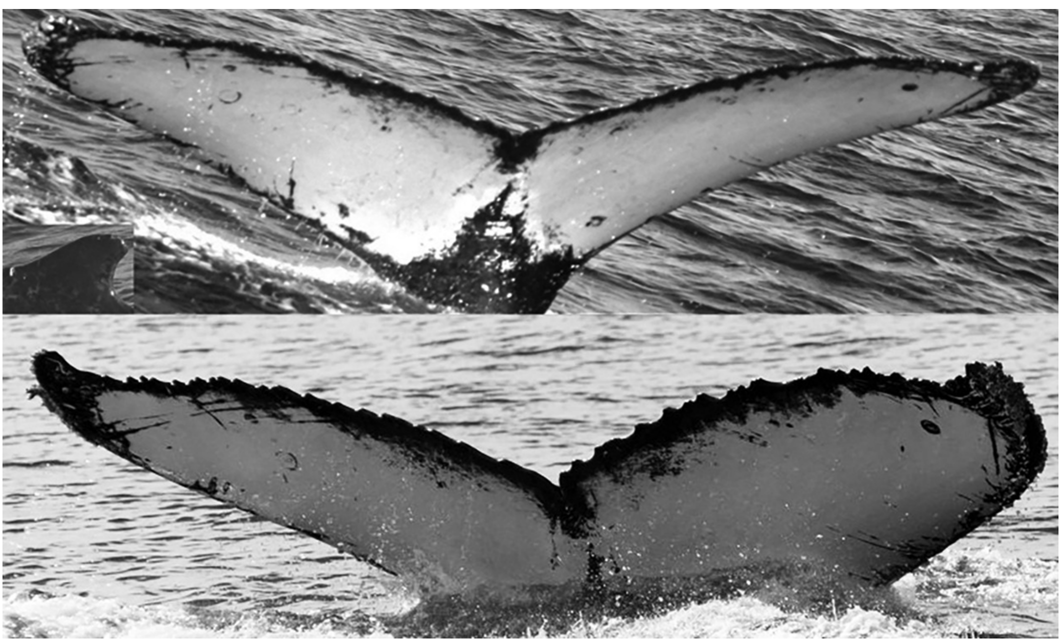

Figure 1. Individual MSB#0775 (top) recorded in Ecuador in 2006 and 2008, and IBJ#4479 (bottom) recorded in Brazil in 2016

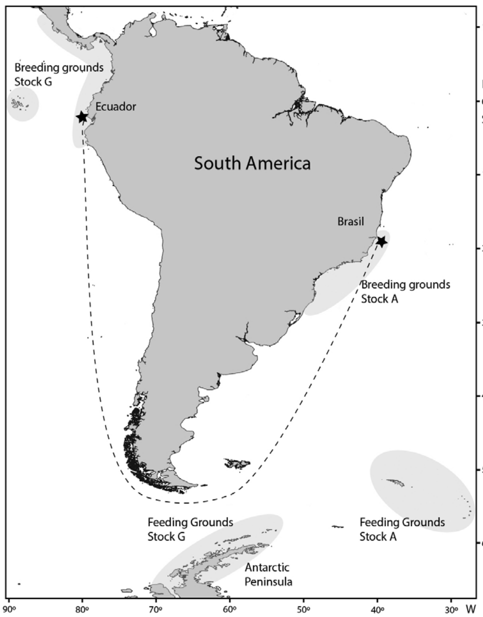

Figure 2. Map showing the sighting sites of individual MSB# 0775/IBJ#4479; the dashed line connects Salinas in Ecuador and Abrolhos Bank in Brazil.

associated with vagrant animals that become vectors for genetic exchange between the different stocks (Olavarría et al., 2007; Engel et al., 2008; Baker et al., 2013). The two cases of interoceanic movements between the eastern South Pacific and the western South Atlantic have two aspects in common: (1) both whales were first recorded in Ecuador, which suggests these animals were born in the BSG; and (2) both records in Brazil occurred during the second year of strong El Niño events (1997-1998 and 2015-2016). While the records in Brazil support a link between the climate event and the interoceanic movement of humpback whales from the BSG, as suggested by Stevick et al. (2013), the ENSO effect should be considered with caution. In the second case, 8 years elapsed since the last sighting in Ecuador. The whale could have shifted from the BSG to the BSA breeding ground at any time within this period. Such movement would occur, as in the case reported by Stevick et al. (2013), due to perturbations in the eastern South Pacific ecosystem (e.g., Barber & Chávez, 1983; Fiedler, 2002).

The impacts of this large-scale phenomenon extend into Antarctic waters (Yuan, 2004; Dalla Rosa, 2010), affecting the availability of food for whales in their traditional feeding areas of the Antarctic Peninsula as ENSO is a primary driver of the euphausiid cycle in the north Antarctic Peninsula ecosystem (Loeb & Santora, 2015). During periods of extreme environmental conditions, such as those that occur during warm ENSO years and the subsequent cold period "La Niña," encounter rates of humpback whales in the Bransfield and Gerlache Straits decreased in response to reduced prey biomass and altered prey distribution (Dalla Rosa, 2010). Such atypical summer conditions would affect humpback whale distribution by causing them to move greater distances than usual, presumably in search of more abundant and readily available prey. Depending on the species, krill density due to climatic variability caused by ENSO may have a lag between 1.75 and 3.75 years (Loeb & Santora, 2015). Thus, changes produced by ENSO would not manifest immediately at breeding grounds but would lag for several years (Félix & Haase, 2001; Seyboth et al., 2016).

In the Hawaiian waters of the North Pacific, Cartwright et al. (2019) demonstrated a major reduction in humpback whale sightings and reproductive rates plausibly correlated with the years following a shift in the Pacific Decadal Oscillation (PDO) oceanographic cycle. Large-scale oceanographic events, such as ENSO and PDO, may create multi-year shifts in prey availability, shifting migratory behavior choices away from established patterns of site fidelity.

In addition to environmental perturbations, such as major ENSO events, substantial trophic changes have occurred in the Antarctic in recent decades. Factors influencing these changes include the decrease of krill density and distribution due to the climate-driven reduction of ice cover (Atkinson et al., 2019) and the removal of krill biomass due to the recovery of some humpback whale stocks (e.g., Zerbini et al., 2019). Recovery of whale stocks may lead to expanding their summer feeding ground range, greater summer overlap between breeding stocks, and increasing opportunities to join different migratory groups heading northwards. These large-scale environmental changes appear likely to continue with climate warming and may increase the incidence of long-distance movement in humpback whales on both the feeding and breeding ranges, thus influencing migratory behavior and gene flow in Antarctic whale stocks. However, the precise mechanisms that may influence a shift in the breeding destinations remain unknown, and, therefore, it is not possible to say with certainty if environment, social or demographic cues, or some combination thereof, are responsible for this exceptional behavioral migratory response.

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