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Short Note

First Humpback Whale Movement Between Ecuador and the South Sandwich Islands: Redefines the Easternmost Migration Point of Breeding Stock G

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The humpback whales (*Megaptera novaeangliae*) of the Southern Hemisphere migrate long distances from their feeding grounds in Antarctic waters to the tropics (Matthews, 1937). At the end of the feeding season, each population (i.e., stock) migrates latitudinally towards the Equator to its own coastal or insular breeding ground in tropical or near-tropical waters. Seven humpback whale breeding stocks (A to G) and six management feeding areas (Areas I to VI) are recognized by the International Whaling Commission (IWC) (1998). Two breeding populations migrate along South America: Breeding Stock A is found in the coastal waters of Brazil, and Breeding Stock G is found on the west coast of South America from northern Peru to south Nicaragua (Pacheco et al., 2009; IWC, 2011; De Weerdt et al., 2020).

These populations feed in two Antarctic management areas. Feeding Area I goes from 120° to 60° W (IWC, 2005). South Georgia (~54° S, 36° W) and the South Sandwich Islands (~58° S, 26° W) in the Scotia Sea, South Atlantic (Feeding Area II), are known feeding grounds for Breeding Stock A (Stevick et al., 2006; Zerbini et al., 2006, 2020; Engel et al., 2008; Engel & Martin, 2009; Marcondes et al., 2021), whereas the western Antarctic Peninsula (Feeding Area I) is recognized as the main migratory destination for Breeding Stock G (Stevick et al., 2004; Rasmussen et al., 2007; Castro et al., 2008; Acevedo et al., 2017).

While photographic records of individual humpback whales and tracking techniques have allowed scientists to identify migratory movements for each population between its respective feeding and breeding grounds, data on inter-oceanic movements between Breeding Stocks A and G are sparse (Stevick et al., 2013; Félix et al., 2020). Evidence of inter-oceanic migrations (Pomilla & Rosenbaum, 2005; Robbins et al., 2011; Stevick et al., 2011, 2013; Dalla Rosa et al., 2012; Constantine et al., 2014; Riekkola et al., 2018; Félix et al., 2020) as large-scale cultural transmission of song (Garland et al., 2011; Schall et al., 2021) and mtDNA studies (Baker et al., 2013; Rosenbaum et al., 2017) suggest a possible overlap of breeding stocks in feeding grounds (Castro et al., 2008; Dalla Rosa et al., 2012; Amaral et al., 2016; Marcondes et al., 2021; Schall et al., 2021).

Identifying and understanding distribution patterns, habitat selection, and the extent to which these stocks may mix is of great importance for the establishment of effective conservation and management strategies (Gaston, 2003; Garrigue et al., 2015).

We report herein the first match between South Sandwich Island (Feeding Area II) and Ecuador (Breeding Stock G). In this study, photographs of 2,131 identified humpback whales from the Pacific Whale Foundation's catalogue off the Ecuadorian coast were compared to photographs of 23 individuals identified in the South Georgia and South Sandwich Islands. Catalogues from South Georgia and the South Sandwich Islands were obtained by the Instituto Baleia Jubarte/Humpback Whale Institute in Brazil. An individual humpback whale (ID code IS106_0700 in the Instituto Baleia Jubarte's catalogue) was photographed on 21 January 2006 at 56° 16' S, 027° 32' W off Isla Zavodovski, one of the South Sandwich Islands. The same individual (ID code EC1457 in the Pacific Whale Foundation's catalogue) was resighted on 7 August 2008 at 01° 17.333' S and 081° 02.037' W in the marine area of Machalilla National Park, Ecuador (Figure 1), a well-studied key breeding and nursing habitat for Stock G (Scheidat et al., 2000; Félix & Haase, 2001; Castro & Gonzales, 2002).

Humpback whale IS106_0700 was in a group of two individuals. They swam in shallow water, approximately 30 to 40 m. They remained on the

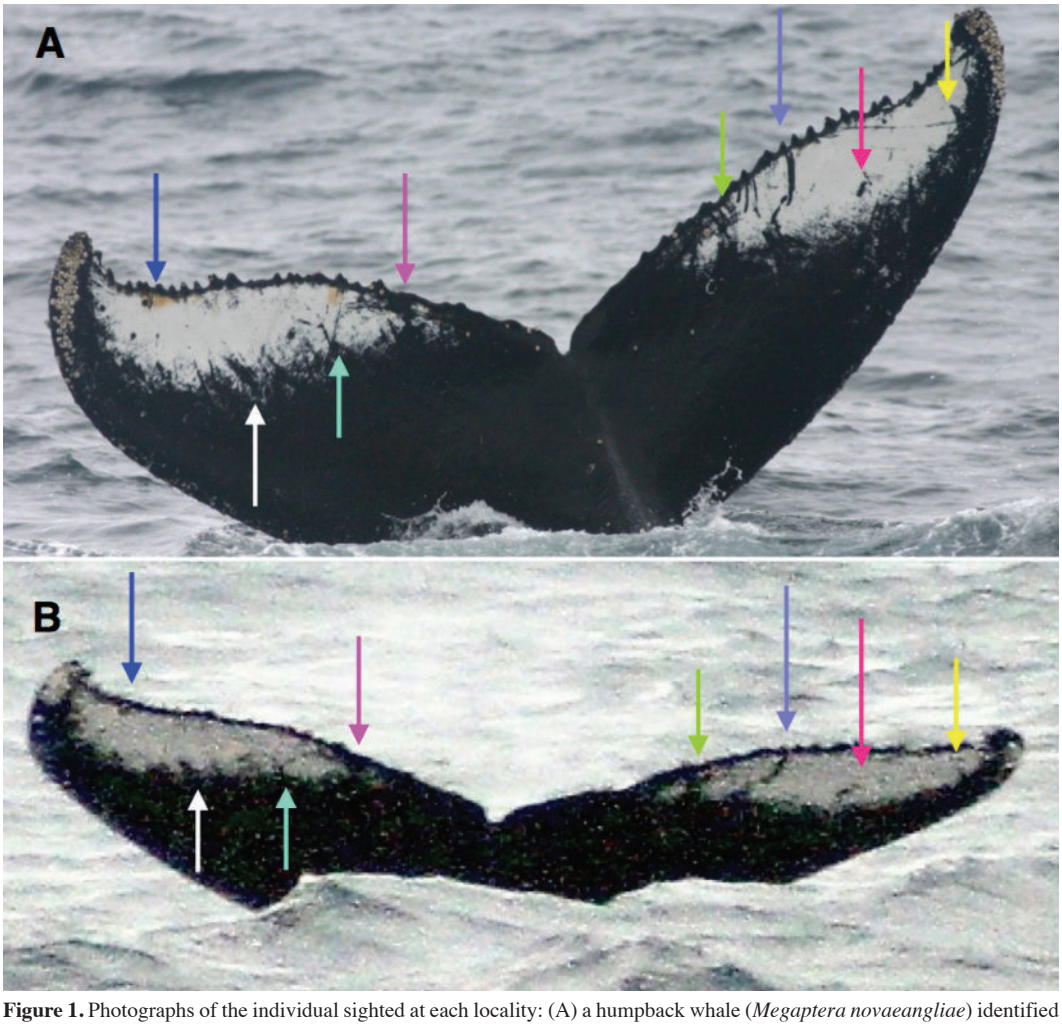

Figure 1. Photographs of the individual sighted at each locality: (A) a humpback whale (*Megaptera novaeangliae*) identified as IS106_0700 was photographed on 21 January 2006 at 56° 16' S, 027° 32' W off Isla Zavodovski, one of the Sandwich Islands and near South Georgia Island; and (B) a humpback whale identified as EC1457 was resighted on 7 August 2008 at 01° 17.333' S and 081° 02.037' W in the marine area of Machalilla National Park, Ecuador. The colored arrows compare the main marks of the whale, which corroborate that it is the same animal.

surface with the peduncle and tail hardly visible. No krill or feeding behavior was observed. There were several groups around, and they remained close to the coast (40 m) throughout the observation. In Ecuador, the humpback whale was a member of a whale pod of three adults involved in courtship behavior observed from 1115 to 1128 h during a whale-watching trip. The shortest migratory distance between these locations is around 8,900 km, and the maximum is 10,000 km (Figure 2). The average migration distance of individuals corresponding to Breeding Stock G to the Antarctic Peninsula, their corresponding feeding ground, is around 8,000 km (Stone et al., 1990). The current longest inter-ocean migration record is between 9,800 to 10,000 km (Stevick et al., 2011).

This observation constitutes the first long-distance resighting of a humpback whale to be documented between Ecuador and Feeding Area II, and it redefines the easternmost migration point of Breeding Stock G. These results, along with previous sightings of individuals from Breeding Stock G near the South Orkney Islands at the limit between the Scotia and Weddell Seas (Castro et al., 2008; Dalla Rosa et al., 2012; Marcondes et al., 2021), support the hypothesis of overlap between Feeding Areas I and II. This overlap has also been documented between Feeding Areas II and III (Amaral et al., 2016; Marcondes

Figure 2. Map of locations where the humpback whale was photographed: (A) 56° 16' S, 027° 32' W off Isla Zavodovski, one of the Sandwich Islands, UK; and (B) 01° 17.333' S, 081° 02.037' W in the marine area of Machalilla National Park, Ecuador. Includes details of Breeding Stocks A and G and Feeding Areas I and II in the Antarctic.

et al., 2021), and poses the question of how and why this overlap may be occurring, as well as its possible implications and effects on population structure.

Gene flow between breeding grounds has already been supported by the report of inter-oceanic movement of humpback whales (Stevick et al., 2013). Evidence of movement between different populations of western and eastern South Atlantic Breeding Stocks A and B (Darling & Sousa-Lima, 2005; Rosenbaum et al., 2009), and between the Antarctic Peninsula and American Samoa (Robbins et al., 2011) showed that longitudinal migrations between humpback whale populations do occur, but it is not known whether they are exceptional or perhaps becoming more regular than hitherto.

Although recent studies of genetic structure among feeding aggregations in the Southern Hemisphere suggest strong site fidelity of Breeding Stock G towards the Antarctic Peninsula (Amaral et al., 2016; Cypriano-Souza et al., 2017), genetics and acoustic studies deduced that this site fidelity is conditioned by prey availability, suggesting that feeding areas can be occupied by multiple populations (Rosenbaum et al., 2017; Schall et al., 2021). While these findings support the interchange of individuals due to an overlap of breeding stocks in their summer feeding grounds, it should be noted that the boundary between feeding grounds could either act as a sporadic gene flow location between two breeding stocks that are significantly differentiated or be part of a greater overlap between feeding grounds, possibly constituting a frequent and significant area for genetic exchange. Although our results prove the migration of an individual from the feeding grounds historically recognized as those of Breeding Stocks A and G, more re-observations (photo-identifications) or exchanges between these two humpback whale populations are needed to determine feeding ground ranges and to identify possible overlapping areas.

Another plausible reason for an extended migration route is the availability of prey on the feeding grounds: as winter sea-ice periods are shortening in the Western Antarctic Peninsula (Parkinson, 2002; Atkinson et al., 2004), there is a reduction in the Antarctic krill population (Atkinson et al., 2004). This may cause Breeding Stock G humpback whales to migrate further east to obtain resources, possibly to areas near South Georgia where there is normally a higher krill density (Atkinson et al., 2004). This increase in foraging range may be blurring traditional feeding area boundaries and resulting in an overlap between Feeding Areas I and II.

As humpback whale populations are recovering after being severely depleted between the 18th and 20th centuries (Andriolo et al., 2006, 2010; IWC, 2008; Pavanato et al., 2017; Wedekin et al., 2017; Zerbini et al., 2019), this increase, paired with a changing spatial availability of krill due to global warming, could be forcing some individuals to look for new feeding or breeding areas due to competition and to reclaim historical (pre-whaling) feeding grounds. The same may also be occurring in other feeding areas.

Although more information is needed to fully understand migration mechanisms and population distributions, our findings suggest an overlap of Feeding Areas I and II, supporting recommendations by Dalla Rosa et al. (2012) and Rosenbaum et al. (2017) to extend the longitudinal boundary between these areas. We suggest revising the boundaries of feeding areas, considering that there should not be a longitudinal line or boundary; instead, shared overlap areas for humpback whales of the southern stock in the Antarctic should be identified and defined.

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