Short Note

A Beluga (*Delphinapterus leucas*) off the West Coast of Baja California Sur, Mexico: The Southernmost Record Far from Its Typical Distribution Area

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Belugas (Delphinapterus leucas) have a nonhomogeneous distribution around the Arctic circle, including subarctic waters. A population substructure of this species has been proposed, related to different attributes of its ecology, including its "apparent" dependence on coastal areas, which has shaped their current patterns of migration, dispersal, and other patterns (O'Corry-Crowe et al., 1997, 2018; Lowry et al., 2019). While the named "Arctic populations" are migratory, with some completing annual cycles greater than 6,000 km, the named "subarctic populations" can exhibit substantial overlapping in their winter and summer ranges (Richard et al., 2001; Suydam et al., 2001; Hobbs et al., 2005; Citta et al., 2016; O'Corry-Crowe et al., 2018).

In Alaska, five stocks have been delimited for belugas, which present differentiation in their mtDNA, little overlap in their summer distributions, and different population trends. One of these is the Eastern Chukchi Sea Stock which has the largest population size ($\approx 20,000$ individuals), while the Cook Inlet Stock has the smallest population size (279 individuals) (Lowry et al., 2019; Shelden & Wade, 2019). Tag analysis of the Cook Inlet Stock showed that these belugas are a resident stock, remaining within the Cook Inlet area, even during the fall and winter months (O'Corry-Crowe et al., 2018; Shelden et al., 2018). In Bristol Bay, there is a link between the seasonal distribution of the two species. During salmon migration, beluga movements were restricted to river inlets, but beluga habitat use expanded after the salmon

runs had ended, becoming more extensive during the winter months when they moved beyond the inner bays (when ice conditions allowed), although tagged belugas never moved into open water outside Bristol Bay (Citta et al., 2016). The Eastern Chukchi Sea Stock presents seasonal migrations, and it has been documented that adult males can move > 2,000 km (Suydam et al., 2001; O'Corry-Crowe et al., 2018).

Belugas are sometimes seen singly, although they commonly occur in groups of two to ten, and particularly adult males usually form groups of six to 20 individuals (Colbeck et al., 2013; O'Corry-Crowe, 2018, 2020; McGuire et al., 2020).

On 2 October 2020, the fisherman staff of Exportadora de Sal and park rangers from the National Commission of Natural Protected Areas (CONANP), belonging to the El Vizcaino Biosphere Reserve, reported the discovery of a beluga floating at the entrance to the Guerrero Negro lagoon, located along the west coast of the state of Baja California Sur, Mexico (Figures 1 & 2). Shortly after, due to the action of the tides, the beluga was displaced towards the dune known as "El Satan," located in the southwest part of the mouth that gives access to the lagoon in the coordinates N 27.891° W 114.209° (Figure 2). Once the beluga beached, the CONANP personnel, with permission from PROFEPA (Mexican government agency in charge of attending to and coordinating actions to respond to marine mammal strandings), measured the total length of the beluga (4.25 m); and a small sample of tissue, including skin and fat, was taken.



Figure 1. The upper panel shows the area where the Western Alaska beluga stocks are distributed. The black circle indicates the approximate distribution area of the Cook Inlet Stock, the black oval indicates the approximate area of the Bristol Bay Stock, and the dotted rectangle indicates the approximate area of the Eastern Chukchi Sea Stock. The black square indicates Guerrero Negro, Baja California Sur, Mexico, where the stranding of a beluga (*Delphinapterus leucas*) was documented on 2 October 2020. The black triangles indicate the southernmost sightings recorded for belugas on the west coast of North America.



Figure 2. The upper left panel shows the dead floating beluga observed at the entrance to Guerrero Negro lagoon. The rest of the photos show the beluga already stranded in the area known as "El Satan," at the entrance to Guerrero Negro lagoon, on 2 October 2020.

The next day, members of the stranding network traveled 770 km from La Paz to Guerrero Negro to try to recover the beluga, take samples, and perform a necropsy. Unfortunately, due to the strong change of tide, the beluga was no longer there, and an intense aerial and aquatic search was carried out. Still, it was no longer possible to relocate the animal, so a necropsy could not be performed, and only a small piece of skin was stored at -40°C. Although there was a report that the beluga had been seen alive swimming off Guerrero Negro before stranding, this could not be confirmed with images or video. Still, the stranded beluga was in good condition (fresh/edible), which supports the report of a recent live sighting. The carcass had a normal appearance; the eyes appeared to be recently scavenged, with the presence of fresh blood; and neither the tongue nor the penis was protruded (Figure 2). The "Fresh Dead" characteristics observed in the beluga suggest that it had been dead for a short time. In the photos, it is possible to see that the beluga did not look emaciated, nor did it present any obvious external physical injuries or marks generally associated with interactions with human activities (Figure 2).

To perform genetic analysis, a section of skin was cut and used for DNA extraction using the protocol of Ivanova et al. (2006). A fragment of the control region was analyzed, while another section was dried at 60°C for 36 h for isotopic analysis.

The forward primer TRO-F (5' CCTCCCTAA GACTCAAGGAAG 3'), designed by the Southwest

Fisheries Science Center, and the reverse primer Cet-R (5' GATCTATGTCCTGTRACCATTAA 3'), reported by Blanco-Jarvio et al. (2023), were used to amplify a 757 pb fragment corresponding from the 46 to the 804 pb of the mitogenome's control region of the sequence MW183361 downloaded from GenBank (https://www.ncbi.nlm.nih.gov/genbank). Our sequence was compared with specific mtDNA lineages (or haplotypes) found in the control region (O'Corry-Crowe et al., 2018) to identify the location of the stock identity (Figure 3).

Sex determination was done by a multiplexed PCR with the primers TtSRYR (5' ACCGGCT TTCCATTCGTGAACG 3') (Rosel, 2003) and PMSRYF (5' CATTGTGTGGGTCTCGTGATC 3') (Richard et al., 1994) for the SRY gene amplification; and the primer ZFX0582F (5' ATAG GTCTGCAGACTCTTCTA 3') and ZFX0923R (5' AGAATATGGCGACTTAGAACG 3') (Bérubé & Palsbøll, 1996) for the ZFX gene. All PCR conditions were the same as those reported in Blanco-Jarvio et al. (2023).

The relationships and spatial distribution of the haplotypes were estimated with a TCS network in PopArt (Leigh & Bryant, 2015). For isotopic analysis (indicator of habitat use as part of its foraging habits; Newsome et al., 2007), lipid extraction was performed using a 1:1 chloroform:methanol solution and then dried again. It was homogenized with an agate mortar, and 0.8 to 1.2 mg was weighed using an analytical balance with a precision of 0.001 mg. The sample was placed



Figure 3. The haplotype network of *Delphinapterus leucas* is shown. Circles indicate each haplotype, and the colors indicate the stocks used to build the haplotype network. The beluga whale stranded in Guerrero Negro lagoon presented the H5 haplotype.

in a 3.5×5.0 mm tin capsule and analyzed in a mass spectrometer at CICESE in Ensenada, Baja California, Mexico. The elemental compositions of C and N were estimated based on standards with known values: Vienna Pee Dee Belemnite for carbon and atmospheric N₂ for nitrogen. The proportion of stable isotopes of C and N was represented as delta (δ) with units expressed as parts per thousand (DeNiro & Epstein, 1978).

On the Northeast Pacific coast, there are few records south of the typical beluga range. Considering the gradient from north to south, they were at the following U.S. locations: one in the Salish Sea, Washington, in 1948; three sightings in October 2021 in Tacoma, Washington; one in July 1965 along the coast of California at 37.7° N, 121.9° W (Scheffer & Slipp, 1948; GBIF Secretariat, 2023); and one was sighted along the coast of San Diego, California, on 26 June 2020 (\approx 32.8° N to 117° W). The beluga sighting in San Diego during June 2020 was reported as a male with an approximate length of 4.5 m in apparent good body condition (Goldman, 2020). The sighting off San Diego (26 June 2020) is of particular interest because it was documented 98 d before and ~700 km north of Guerrero Negro, and it was, until then, the southernmost record of this species (Figure 1).

Anomalous dispersal and behavioral changes in belugas related to changes in prey availability, particularly during summer and fall, have been documented to coincide with anomalous ice year changes that have been related to the climate changes occurring in the Arctic, particularly in the Chukchi and Beaufort Seas (Quakenbush et al., 2015; Hauser et al., 2017; Choy et al., 2020; Mayette et al., 2023). During 2019-2020, an intense marine heatwave affected several areas of the Northeast Pacific, having an impact on primary productivity and trophic dynamics. This included areas located at 60° N and even further north. These effects were less notable in the continental shelf area of the west coast of North America compared to the regions of the Aleutian Islands and Bering Sea (Chen et al., 2021), which are considered normal areas for the distribution of belugas (O'Corry-Crowe, 2018).

At the end of summer, belugas in the Arctic have a greater preference for sea surface temperature (SST) waters within the continental shelf in the range between 1° to 10°C, with individuals showing preference for waters between 1° to 8°C, but also being observed in waters of up to 14°C SST (Mayette et al., 2023). During June 2020, the average SST values off the coast of San Diego were 17.5°C (Figure 4); however, in the continental shelf area just before reaching the Channel Islands area (just north of where the beluga was seen), the SST presented values of between 11° to 14°C, which can still be considered within the "known" SST range for this species and, in particular, for a beluga that was recorded singly (Mayette et al., 2023). For the days before the stranding of the beluga, the SST in the area adjacent to Guerrero Negro was between 22° to 24°C, while a SST of 21° to 22°C was registered in the area where the beluga was observed off San Diego. For both cases, it was warmer by around 8°C relative to what is known for this species (Figure 3).

Of beluga stocks in Alaska, the Cook Inlet Stock is the least distant (> 5,000 km) from the peninsula of Baja California, Mexico; the second least distant is Bristol Bay Stock (\approx 6,000 km); while the Eastern Chukchi Sea Stock is located at \approx 7,400 km, considering a coastal route (Figure 1). The size (4.5 m) and sex (male) of the beluga whale sighted along the San Diego coast in June 2020 coincides with the characteristics of the beluga documented in Guerrero Negro, which the photographs confirmed was a 4.25-m-long male (Figure 2).

The genetic pattern of the haplotype sequence amplified here matches with high likelihood within the so-called "clade C" of the mitogenomic analysis carried out by Skovrind et al. (2021)-H5 (Figure 3). This H5 haplotype has been documented in all mtDNA lineages defined by Lowry et al. (2019), including the eastern Chukchi Sea area, Beaufort Sea, Bristol Bay, Cook Inlet, and Sakhalin, but it is the most frequent in Anadyr and the eastern Bering Sea (Figure 3). Although the beluga stock geographically closest to Guerrero Negro with the presence of the H5 haplotype is Cook Inlet, it is known that individuals from this stock show high fidelity to their distribution area. Therefore, we propose that it is highly likely that this beluga whale came from Bristol Bay due to the geographical distance (Figure 1). However, considering the dispersal capabilities of some individuals from different beluga stocks (Suydam et al., 2001; O'Corry-Crowe et al., 2018), it cannot be completely ruled out that the beluga stranded in Guerrero Negro may have come from another of the stocks where the presence of H5 is documented.

The maximum average lengths of male belugas in Arctic populations range between 3.89 to 4.48 m (Luque & Ferguson, 2006), an interval within which the measurement obtained for the male stranded in Guerrero Negro falls (4.25 m), supporting the hypothesis that it was an adult male. The beluga observed in Guerrero Negro did not appear to be emaciated, and one possible explanation for its presence in waters so far from the species' typical congregation areas is that the documented global warming events could affect prey distribution, causing belugas to move beyond their usual ranges (Quakenbush et al., 2015; Hauser et al., 2017; Choy et al., 2020; Mayette et al., 2023).

In the case of vagrant marine mammal species with circumpolar distribution, it has been suggested that records of atypical presence may be due to health problems or poor body condition (Rounsevell & Peberton, 1994; Bester et al., 2017). However, records of different species of marine mammals with circumpolar distribution have been documented in different parts of the world without the cause having been determined. Even in some of those "extreme records," evidence of feeding behavior or a robust body condition has been documented that suggests that the animals had been feeding (Scheinin et al., 2011; Elwen & Gridley, 2013; De Boer et al., 2017; Haelters et al., 2018; Hupman et al., 2019; Elorriaga-Verplancken et al., 2020; Cerrillo-Espinosa et al., 2023; Romero-Tenorio et al., 2023).

In the case of the beluga found in Guerrero Negro, isotopic evidence as an indicator of its foraging habits within a time frame of around 70 d before the sample collection (St. Aubin et al., 1990) yielded mean values of 18.0% ($\delta^{15}N$) and -18.4% $(\delta^{13}C)$. These stable isotope ratios provide information of trophic position and its breadth ($\delta^{15}N$) as well as habitat use across an inshore-offshore gradient (δ¹³C) (Minagawa & Wada, 1984; Fry & Wainright, 1991). However, both isotope ratios also allow inferences to be drawn about habitat use at a larger latitudinal scale (Newsome et al., 2007) due to the inverse relationship between latitude and baseline values of both ratios (Altabet et al., 1999; Aurioles-Gamboa et al., 2006). The value of δ^{13} C (-18.4‰) fell within the range of offshore foraging habits of odontocetes in the Pacific Ocean (Aurioles-Gamboa et al., 2013). This low δ^{13} C value could also be related to a foraging ground in high latitudes because of the positive relationship between low temperatures of seawater and dissolved ¹²C-enriched CO₂ (Goericke & Fry, 1994). However, we suggest that offshore foraging was a stronger factor because its $\delta^{15}N$ value (18.0%) did not correspond to that of a piscivorous odontocete from high latitudes (in its typical distribution), where the denitrification process that 15N enriches the baseline of the trophic web is weaker relative to mid-latitudes (Altabet et al., 1999; Wu et al., 1999). In this regard, $\delta^{15}N$ values of beluga skin that were sampled in their typical northern distribution (around Hudson Bay and Cumberland Sound) fell in between approximately 15.5 and 16.5% (Marcoux et al., 2012; Rioux et al., 2012). Instead, the individual under our analysis fell within the range of piscivorous odontocetes from the Mexican



Figure 4. The upper panel shows the average SST values for June in the region between Guerrero Negro, Baja California Sur, Mexico, and the congregation areas of the five beluga stocks recognized in Alaska, coinciding with the sighting of a beluga whale off the California coast; and the lower panel shows the average SST values for September, which is the month before the beluga whale stranding in waters off Guerrero Negro. Sea surface temperature values were downloaded from the Giovanni-NASA platform (https://giovanni.gsfc.nasa.gov/giovanni).

Pacific that were assessed by Aurioles-Gamboa et al. (2013), where values up to around 18.0% ($\delta^{15}N$) and -20.0 to -18.0% ($\delta^{13}C$) were reached. Therefore, based on the isotope values of this stranded beluga and its relatively good body condition before its stranding, we suggest that this individual foraged within the Pacific latitudinal range of the Baja California Peninsula.

Between 2018 and 2022, several cases of vagrant belugas have been documented, both in the Pacific and the Atlantic Oceans. Considering the rarity of the beluga sighting in waters off San Diego, like that in Guerrero Negro, and the isotopic values and the body condition of the stranded beluga in Guerrero Negro, we suggest a high possibility that it was the same beluga. The biological meaning of this event is not clear, and long-term monitoring will be required to determine if this is an isolated case or if it results from current environmental changes.

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