

Changes in timing of whale migration in California explain increasing numbers of deadly entanglements.

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We documented changes in the overall abundance and timing of migration of humpback (*Megaptera novaeangliae*), blue (*Balaenoptera musculus*), and gray (*Eschrichtius robustus*) whales observed from the Farallon Islands, California. These changes are increasing the exposure of whales to crab pot and trap fishing gear off central California, and these changes appear to underlie increased entanglement rates in recent years.

We hypothesized that changes in the number of whale sightings, timing of migration, and residency time off central California were driven by both local oceanography and basin-scale climate conditions. Wind-driven upwelling and overall productivity in the California Current System is driven by atmospheric circulation that is influenced by the El Niño Southern Oscillation, the Pacific Decadal Oscillation, and the North Pacific Gyre Oscillation.

Using 25 years of daily whale counts collected from Southeast Farallon Island, we

developed generalized linear models to assess trends and identify environmental drivers of changes in whale sightings, timing of migration, and residency time. We validated these models, confirming their ability to forecast whale sightings and timing of migration

Whale sightings have significantly increased over time for all species. Foraging migration (northward migration and arrival time) has been occurring earlier for all species, particularly for humpback and blue whales and was significantly influenced by El Niño. Breeding migration (southward migration and departure time) showed little to no change. Humpback entanglements were correlated with early arrival to and longer residency in central California.

Actions to decrease the temporal overlap between whales and pot/trap fishing gear, particularly during El Niño years are encouraged to decrease the risk of entanglements.

Main Points

Humpback, blue and gray whale sightings have increased over time.

Northward whale migration and arrival time to central California is occurring earlier and influenced by El Niño

Entanglements in fishing gear for humpback whales are correlated with early arrival and longer residency.

Ingman K, Hines E, Mazzini PLF, Rockwood RC, Nur N, Jahncke J (2021) Modeling changes in baleen whale seasonal abundance, timing of migration, and environmental variables to explain the sudden rise in entanglements in California. *PLoS ONE* 16(4): e0248557. <https://doi.org/10.1371/journal.pone.0248557>