## Supplementary Tables and Figures

Table S1. Documented interactions between marine mammals and large-scale climatic phenomena.

| Species | Location | Response | Citation |
|---|---|---|---|
| Northern elephant seal *Mirounga angustirostris* | Central California | Decline in pup weaning mass, increase in foraging effort through warm sea temperatures caused by recurrent strong El Niño periods and positive PDO conditions. | Le Boeuf & Crocker (2005) |
| California sea lion *Zalophus californianus* | San Miguel Island, CA | Decline in pup survival rate during El Niño, increase during La Niña with sea temperature. | DeLong et al. (2017) |
| Hawaiian monk seal *Monachus schauinslandi* | Northwestern Hawaiian Islands | Pup body condition and survival positively impacted by El Niño events. | Antonelis et al. (2003) |
| Multiple | Bering Sea | Species redistribution around the area due to warmer SSTs from 1997 El Niño. | Tynan (1999) |
| Blue whale *Balaenoptera musculus* | Eastern North Pacific | Variation in spatial distribution in response to ENSO and PDO. | Burtenshaw et al. (2004), Calambokidis et al. (2009) |
| Fish-eating killer whales *Orcinus orca* | Eastern North Pacific | Documented in smaller group sizes after negative PDO periods, likely due to decreases in primary prey availability. | Lusseau et al. (2004) |
| Common dolphin *Delphinus delphis* | Central Gulf of California | Sighted at much higher rates during the 1983 El Niño event than the 1985 La Niña event, and at intermediate levels during 1984 neutral period. | Tershy et al. (1991) |
| Common dolphin *Delphinus delphis* | New Zealand, Monterey Bay California | Both likely due to shifts in prey distribution- used waters closer to shore during La Niña in New Zealand, increased abundance in California. | Neumann (2001), Benson et al. (2002) |
| Common dolphin *Delphinus delphis* | Eastern Tropical Pacific | Shifted their distribution west of their historically known range during the La Niña event of 1988. | Reilly & Fiedler (1994) |
| Common bottlenose dolphins *Tursiops truncatus* | California | Underwent major range expansion after the 1982-83 El Niño event. | Wells et al. (1990) |
| Dusky dolphins *Lagenorhynchus obscurus* | Peru | An El Niño event that coincided with the collapse of their main prey resulted in a shift in diet of females, found through changes in tooth mineral quality. | Manzanilla (1989) |
| Dall's porpoise *Phocoenoides dalli* | Monterey Bay CA | Found in higher densities before an El Niño event than during it. | Benson et al. (2002) |

| Species | Location | Response | Citation |
|---|---|---|---|
| Sperm whale *Physeter macrocephalus* | California | Feeding success varies between ENSO phases. | Whitehead & Rendell (2004) |
| Longman's beaked whale *Indopacetus pacificus* | Western Indian Ocean | Two strandings noted farther south than any others during El Niño years in areas influenced by warm currents. | Anderson et al. (2006) |

Table S2. All killer whale sightings within the ranges of the resident beaked whale species, as well as the MEI value and ENSO period that they occurred within. Unpublished or non-Cascadia Research sources are contributed sightings from citizen scientists.

| Month/ Year | Season | Island | MEI Value | ENSO Phase (Flavor) | Source |
|---|---|---|---|---|---|
| 07/94 | Spring | W Hawai‘i Island | 0.9 | El Niño (CP) | Baird et al. (2006) |
| 08/94 | Summer | W Hawai‘i Island | 1 | El Niño (CP) | Baird et al. (2006) |
| 01/96 | Fall | W Hawai‘i Island | -0.8 | La Niña | Baird et al. (2006) |
| 01/98 | Fall | W Hawai‘i Island | 2.2 | El Niño (EP) | Baird et al. (2006) |
| 01/98 | Fall | W Hawai‘i Island | 2.2 | El Niño (EP) | Baird et al. (2006) |
| 02/00 | Fall | W Hawai‘i Island | -1.2 | La Niña | Baird et al. (2006) |
| 02/01 | Fall | W Hawai‘i Island | -0.4 | Neutral | Baird et al. (2006) |
| 05/01 | Spring | W Hawai‘i Island | -0.5 | La Niña | Baird et al. (2006) |
| 09/01 | Summer | W Lāna‘i | -0.8 | La Niña | Baird et al. (2006) |
| 05/03 | Spring | W Hawai‘i Island | -0.2 | Neutral | Cascadia Research |
| 04/04 | Winter | E Lāna‘i | -0.3 | Neutral | Baird et al. (2006) |
| 06/09 | Spring | W Hawai‘i Island | 0.3 | Neutral | Masa Ushioda |
| 11/13 | Fall | W Hawai‘i Island | -0.2 | Neutral | Cascadia Research |
| 11/13 | Fall | W Hawai‘i Island | -0.2 | Neutral | Russ Andrews |
| 11/13 | Fall | W Hawai‘i Island | -0.2 | Neutral | Cascadia Research |
| 07/16 | Spring | W Hawai‘i Island | -0.2 | Neutral | Cascadia Research |
| 07/16 | Spring | N Maui | -0.5 | La Niña | PIFSC |
| 07/16 | Spring | W Hawai‘i Island | -0.5 | La Niña | PIFSC |
| 07/16 | Spring | W Hawai‘i Island | -0.5 | La Niña | Cascadia Research/PIFSC |
| 10/16 | Summer | S Moloka‘i | -0.5 | La Niña | Tabitha Pupuhi |
| 05/17 | Spring | W Hawai‘i Island | -0.3 | Neutral | Alicia Franco |
| 05/17 | Spring | W Hawai‘i Island | -0.1 | Neutral | Multiple Contributors |
| 05/19 | Spring | W Hawai‘i Island | 0.2 | Neutral | Alicia Franco |
| 04/20 | Winter | W O‘ahu | -0.7 | La Niña | Alex Reinprecht |
| 04/20 | Winter | W Hawai‘i Island | -0.1 | Neutral | Seth Conae |
| 07/20 | Spring | W Hawai‘i Island | -0.9 | La Niña | Jason Lafferty |
| 01/21 | Fall | W Hawai‘i Island | -1.2 | La Niña | Colby Kauffman |
| 08/21 | Summer | W Hawai‘i Island | -1.3 | La Niña | Big Island Divers |
| 08/21 | Summer | W Hawai‘i Island | -1.3 | La Niña | Multiple Contributors |
| 09/21 | Summer | E Hawai‘i Island | -1.4 | La Niña | via KHON2 News |
| 08/22 | Summer | W Hawai‘i Island | -1.8 | La Niña | Cascadia Research |
| 08/22 | Summer | W Hawai‘i Island | -1.8 | La Niña | Captain Zodiac |
| 09/22 | Summer | W Hawai‘i Island | -1.8 | La Niña | Cascadia Research |

Table S3. GAM summary output for goose-beaked whales, comparing differences between sighting rates across seasons, MEI, NPGO, and PDO.

| Parametric Terms | Estimate | SE | p-value |
|---|---|---|---|
| Intercept (Fall) | -3.4 | 0.2 | <0.001 |
| Spring | -0.9 | 0.3 | 0.005 |
| Summer | -0.3 | 0.3 | 0.180 |
| Winter | -0.9 | 0.4 | 0.012 |
| Smooth Terms | edf | chi.sq | p-value |
| MEI | 0.2 | 0.3 | 0.254 |
| NPGO | <0.001 | 0 | 0.797 |
| PDO | <0.001 | 0 | 0.668 |
| % Deviance Explained | 16.0 | | |

Table S4. GAM summary output for Blainville's beaked whales, comparing differences between sighting rates across seasons, MEI, NPGO, and PDO.

| Parametric Terms | Estimate | SE | p-value |
|---|---|---|---|
| Intercept (Fall) | -4.6 | 0.3 | <0.001 |
| Spring | 0.2 | 0.4 | 0.611 |
| Summer | -0.04 | 0.4 | 0.922 |
| Winter | 0.7 | 0.4 | 0.079 |
| Smooth Terms | edf | chi.sq | p-value |
| MEI | 0.6 | 1.4 | 0.127 |
| NPGO | 0.1 | 0.1 | 0.288 |
| PDO | <0.001 | 0 | 0.638 |
| % Deviance Explained | 11.7 | | |

Table S5. GAMM summary output for goose-beaked whale range-use ratios, comparing differences across both grouped seasons and ENSO periods, with a random effect for individual tag ID. For this model, seasons were grouped due to limited sample size across all four oceanographic seasons.

| Parametric Terms | Estimate | SE | p-value |
|---|---|---|---|
| Intercept (Summer/Fall) | -2.5 | 0.2 | <0.001 |
| Winter/Spring | 0.3 | 0.4 | 0.415 |
| Smooth Terms | edf | chi.sq | p-value |
| MEI | 0 | 0 | 0.666 |
| Tag ID (random intercept) | 3.3 | 5.9 | 0.083 |
| % Deviance Explained | 22.9 | | |

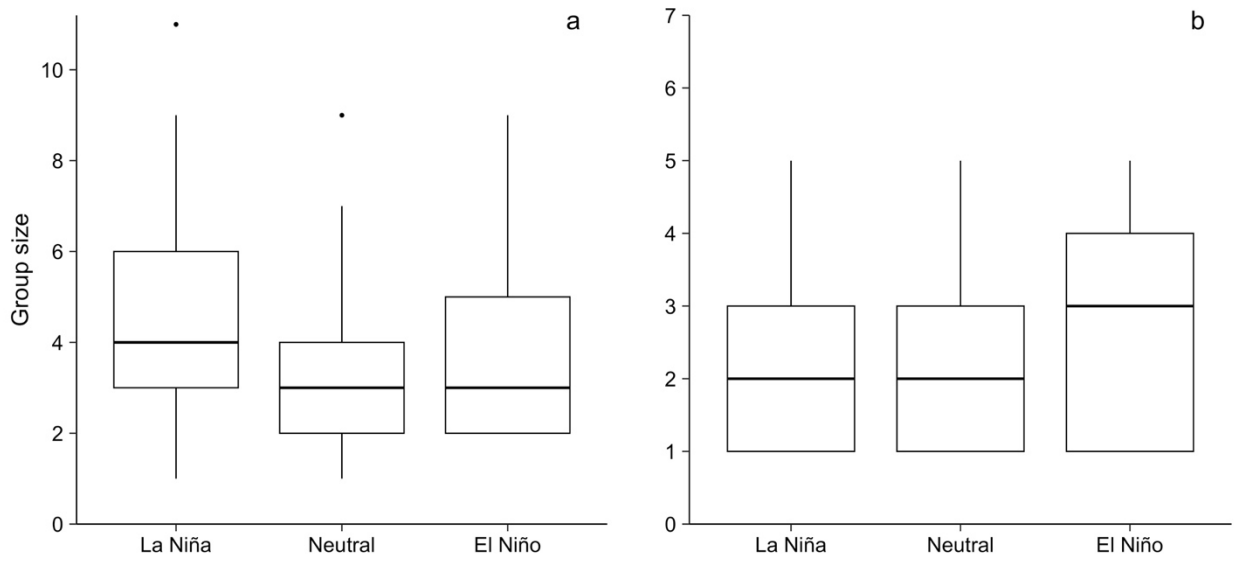


Figure S1. Group size values between ENSO phases for Blainville's beaked (a) and goose-beaked- (b) whales. Note that the Y-axis scales differ for each graph.

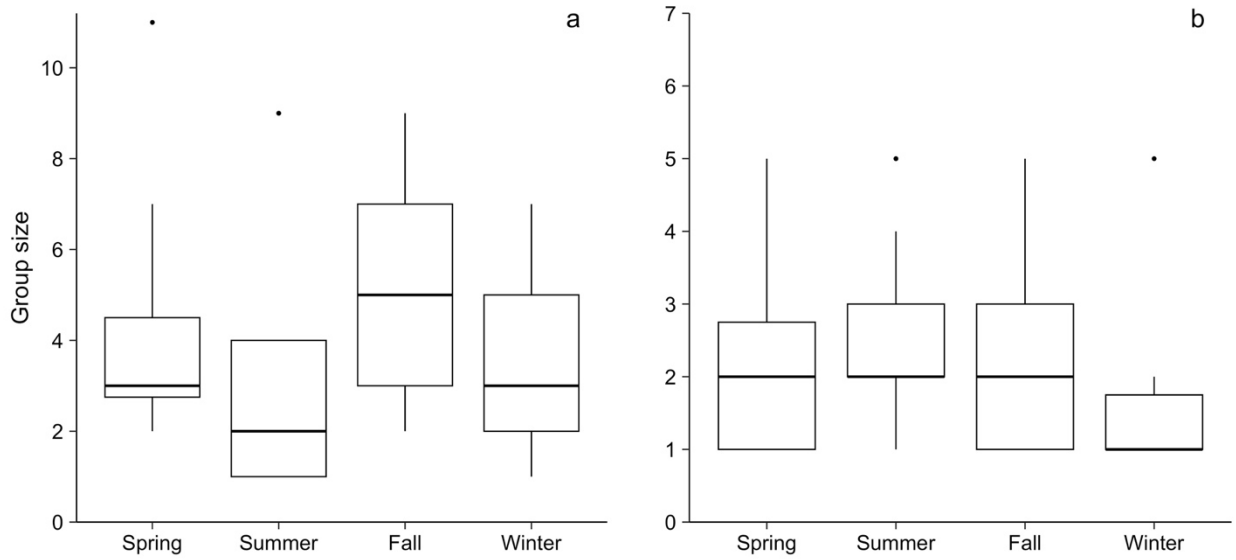


Figure S2. Group size values between season for Blainville's (a) and goose-beaked (b) whales. Note that the Y-axis scales differ for each graph.

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