Augmenting Argo: characterizing sub-surface conditions in the Northeast Pacific at a time of extreme oceanographic variability

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Project Summary

The Northeast Pacific Ocean is a dynamic and biologically productive system that sustains a complex community of marine predators. Cool, nutrient-rich waters fuel high levels of productivity while physical features (fronts, eddies, etc.) create concentrated regions of foraging habitat with sufficient biomass to sustain large populations of apex predators (Whitney et al. 2005, Palacios et al. 2006). The Transition Zone Chlorophyll Front (TZCF), located between the subarctic and subtropical gyres in the central North Pacific, is of particular ecological relevance, providing reliable foraging habitat for large predators, including seabirds, pinnipeds, turtles, and predatory fish (Polovina et al. 2001, Block et al. 2011). These dynamic oceanographic features are subject to fluctuations caused in part by ocean-climate oscillations such as the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) (Etnoyer et al. 2004, Polovina et al. 2015), which impact the biological community and have consequences on the foraging success of top predators (Costa et al. 1991, Crocker et al. 2006)

Current oceanographic conditions in the Northeast Pacific are unprecedented; this region is experiencing the strongest ENSO event since 1997-98, and positive PDO anomalies over the last year suggest a potential phase shift in this oscillation. Simultaneously, a large-scale mass of anomalously warm water (the “Blob”) has persisted around the eastern TZCF since late 2013. We are just beginning to understand the full magnitude of these combined phenomena and the implications at both the physical and biological levels. For example, Whitney et al. (2015) documented an extreme depression in chlorophyll content in early 2014 corresponding with anomalously warm sea surface temperatures. Similarly, there have been a variety of unusual species distributions and behaviors, from jellyfish to tuna (Bond et al. 2015), suggesting substantial impacts at the ecosystem level.

A key component in understanding current conditions is quantifying the thermal content and density structure of the water column, particularly in areas that are biologically critical. Currently, the primary mechanisms for collecting data on sub-surface water properties are the Argo float network, gliders, and oceanographic cruises that target specific regions. While these mechanisms provide high-quality measurements, their coverage is relatively sparse both spatially and temporally. Advances in tagging technology have enabled the use of animals as ocean-sensing platforms, facilitating the collection of additional temperature and salinity data from the world’s oceans (Boehme et al. , Boehme et al. 2010, Charrassin et al. 2010, Costa et al. 2012). Conductivity-temperature-depth (CTD) tags attached to animals complement more traditional methods because they collect data at biologically relevant temporal and spatial scales.

In the past 11 years, our laboratory has performed over 120 CTD tag deployments on northern elephant seals (*Mirounga angustirostris*), generating a comprehensive baseline of ocean conditions across their migratory range. Northern elephant seals are ideal platforms for collecting oceanographic data because they are wide-ranging across the Northeast Pacific, and exhibit a continuous, deep-diving pattern while at sea (Figure 1) (Le Boeuf et al., 1988; Robinson et al., 2012). This deep-diving pattern not only enables the collection of high-density CTD casts from depths up to 1000 m, but also provides a window into mesopelagic food webs. The use of northern elephant seals as ocean-sensing platforms is therefore an elegant complement to the data collected by Argo floats, nearly doubling the total number of CTD casts and dramatically increasing the density of measurement within biologically-relevant areas, particularly the TZCF (Figure 2). Oceanographic data collected by northern elephant seals will be invaluable in characterizing current ocean conditions in the North Pacific, and understanding the impacts of climate patterns on biological communities. In addition our 11 year baseline that constitutes more than 400 individual tracks of adult female elephant seals will allow us to examine the response of a large marine predator to an ENSO event.

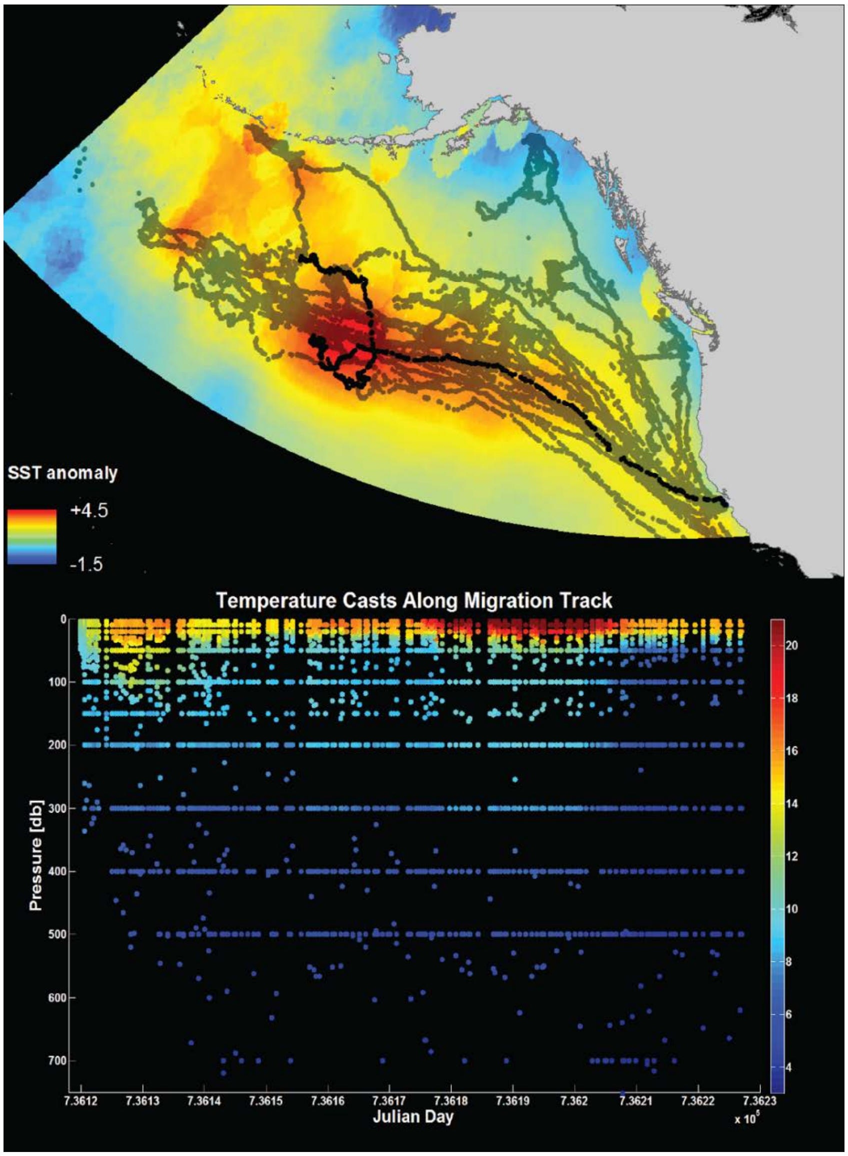

Figure 1. Tracks of 24 northern elephant seals between June and October 2015 overlaid on sea-surface temperature (SST) anomalies in the North Pacific Ocean (top). A temperature cast from a single elephant seal (highlighted track from the top panel) carrying a CTD tag is shown in the lower panel, with pressure (depth) on the y axis and time on the x-axis.

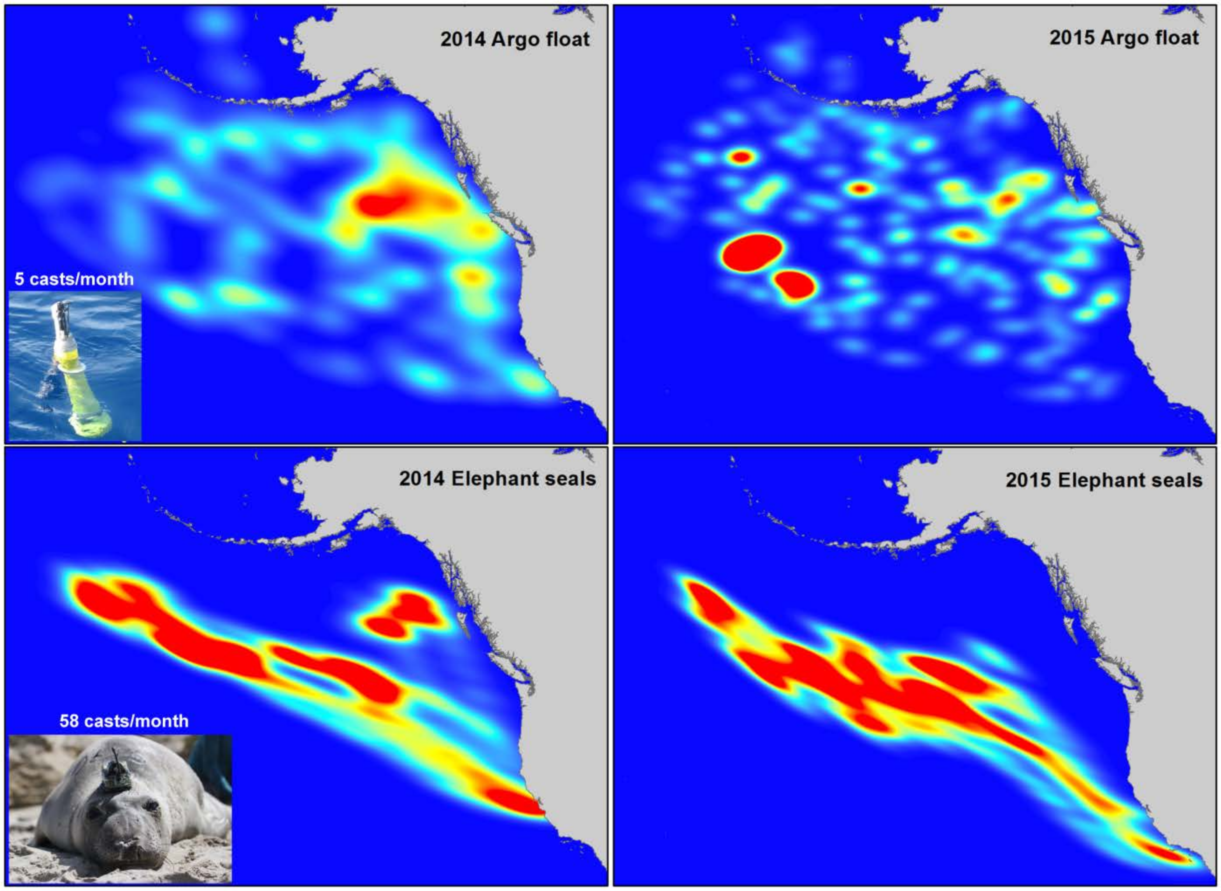

Figure 2. Density of Argo float and northern elephant seal CTD casts in 2014 (June to January) and 2015 (June to September). Argos floats (n = 125) collected 3,050 casts in 2014 and 3,080 in 2015. Northern elephant seals (n = 10 per year) collected 2,178 casts in 2014 and 2,500 casts in 2015. The average number of casts per month per instrument across both years is shown for each type of instrument.

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