The Hawaiian monk seal and North Pacific loggerhead sea turtle as sentinel of climate change

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Satellite-derived winter surface chlorophyll in March 2000 (top, middle) and March 2004 (bottom) provide an example of interannual variation in northward extent oligotrophic waters.
Wind Stress Curl, Surface Chlorophyll a, and 18ºC SST for 180-160ºW

Monthly Wind Stress Curl (180-160ºW) by Latitude

- 18ºC SST
- 0.2 Chl a
Survival of Hawaiian Monk Seals at northern atolls as a function of the position of the 18° SST isotherm, a proxy for the TZCF, 1985-2003

A: 1&2 yr old pups
B: 3&4 yr old pups
Pearl and Hermes monk seal beach count and PDO
Projected Climate Changes for N Pacific over the 21st Century

- Basin-wide warming
- Tropical easterlies weaken
- Westerlies and polar easterlies weaken and shift poleward
- Reduced wind-stress curl
- Weakened vertical velocities and increased stratification
- Nutrient redistribution

Rykaczewski and Dunne 2010, Sarmiento et al. 2004, Vecchi et al. 2006, Yin 2005
Biome Boundaries at beginning and end of the 21st Century
Monk Seals in northern atolls

- Currently monk seal pup survival has a bimodal distribution - high with + PDO and low with – PDO.

- However as the TZCF southern position shifts poleward as westerlies weaken and shift poleward due to climate change it no longer reaches the atolls even in +PDO and the relationship between PDO and pup survival will break down. Monk seal pup survival reverts to a unimodal distribution with a low mean level
Schematic of the Kuroshio Extension Bifurcation region (A)

AVISO altimetry for March 2003

AVISO altimetry for September 2003
MODIS primary productivity (BF model) for Quarter 1 2003

MODIS primary productivity (BF model) for Quarter 2 2003

MODIS primary productivity (BF model) for Quarter 3 2003

MODIS primary productivity (BF model) for Quarter 4 2003
Loggerhead track over SSH and geostrophic currents for October 2003 (A), November 2003 (B), December 2003 (C), and January 2004 (D)
Geostrophic currents and ocean color for September 6-13, 2003

Geostrophic currents and ocean color for March 5-12, 2004
Frequency distributions for loggerhead turtles released from Japan by latitude
Biome Boundaries at beginning and end of the 21st Century
Loggerhead sea turtles

Use the Kuroshio Extension Current (KEC) as a key forage habitat when high chlorophyll and currents coincide.

Under climate change, high chlorophyll waters will shift poleward due to increased vertical stratification in the KEC region. If the KEC also shifts north the forage habitat should remain intact. However if the KEC remains stationary, loggerhead turtles will need to rely increasingly on other, possibly less productive, forage habitats.