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

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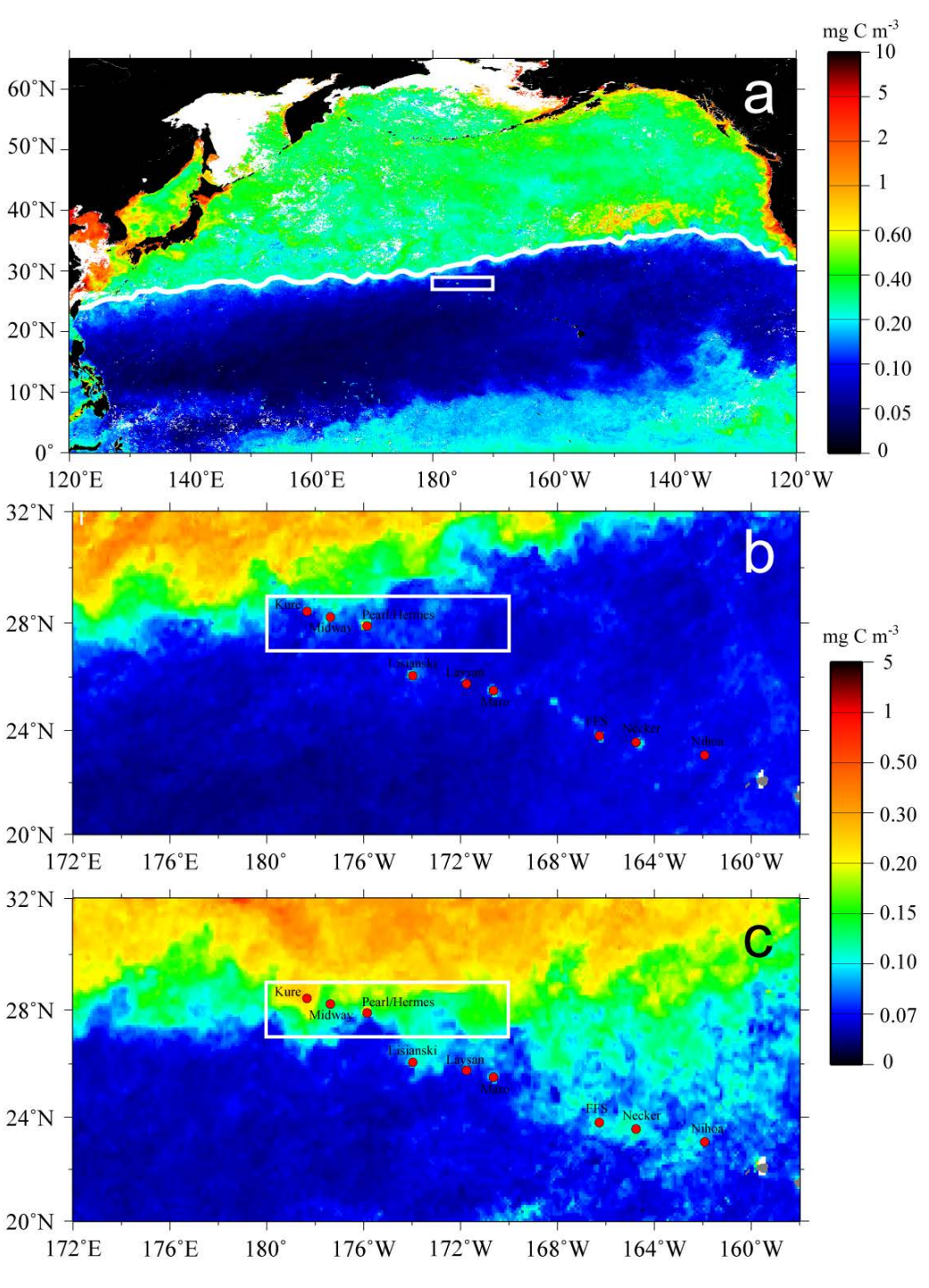
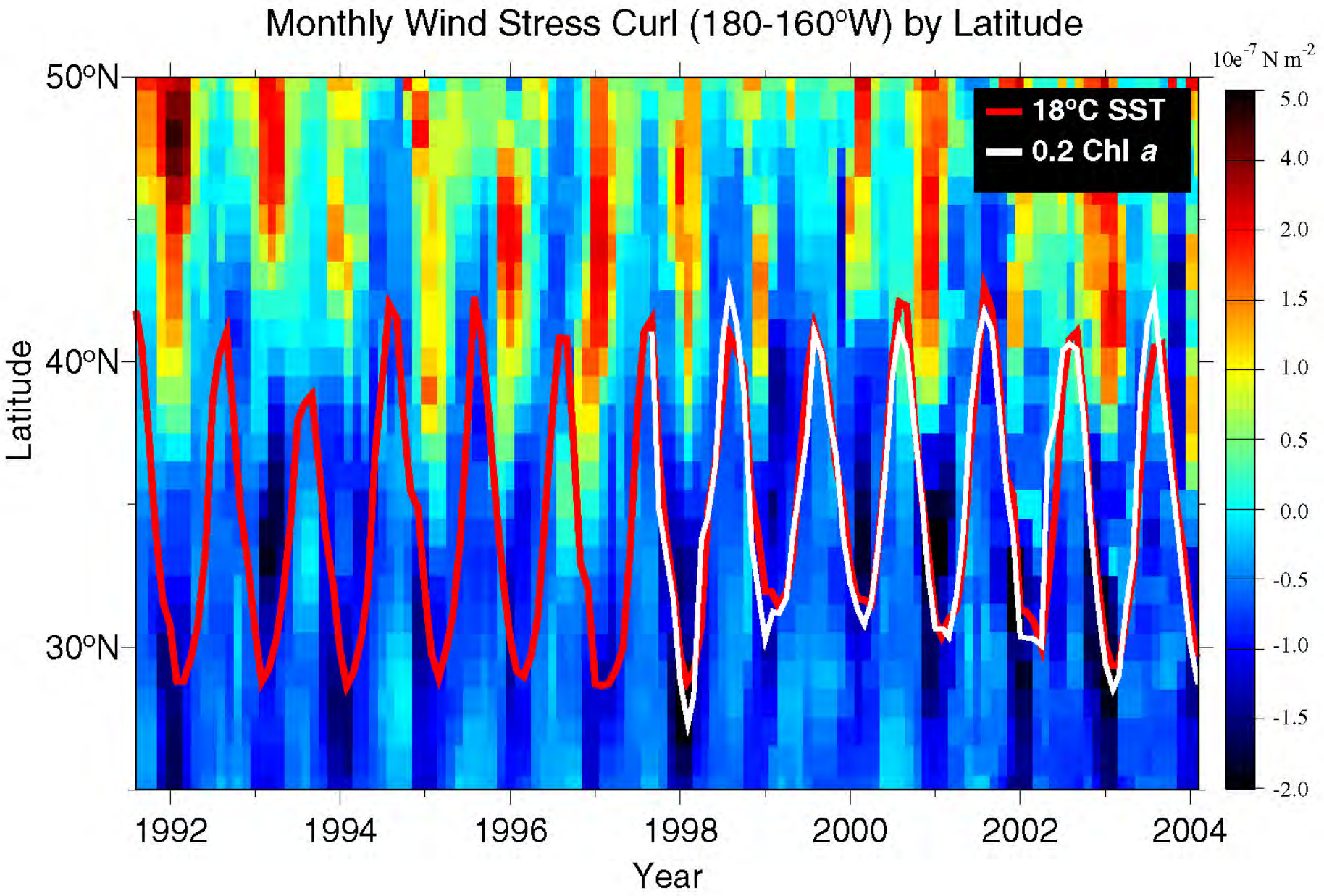
Satellite-derived winter surface chlorophyll in March 2000 (top, middle) and March 2004 (bottom) provide an example of interannual variation in northward extent oligotrophic waters.



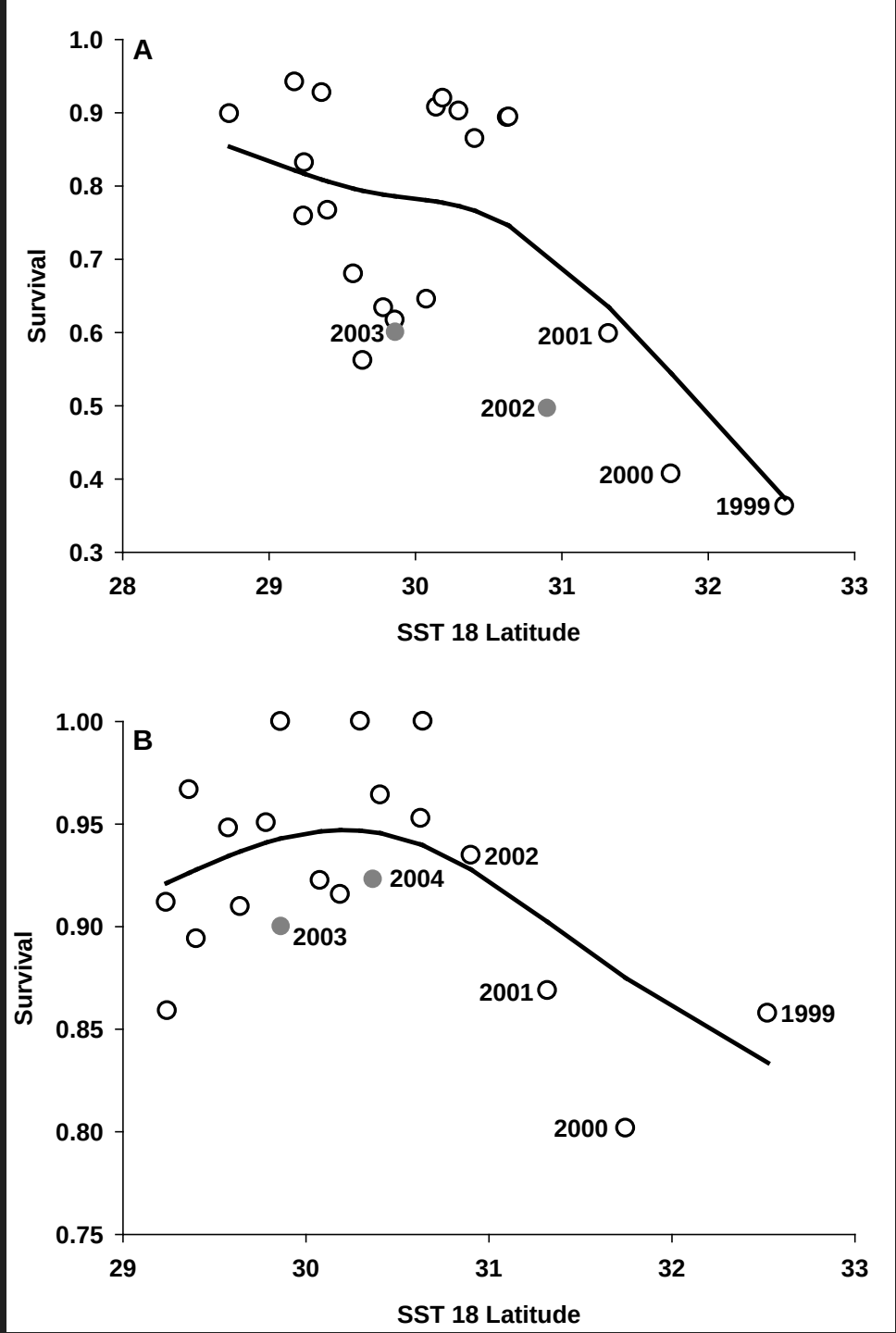
Wind Stress Curl, Surface Chlorophyll *a*, and 18ºC SST for180-160ºW



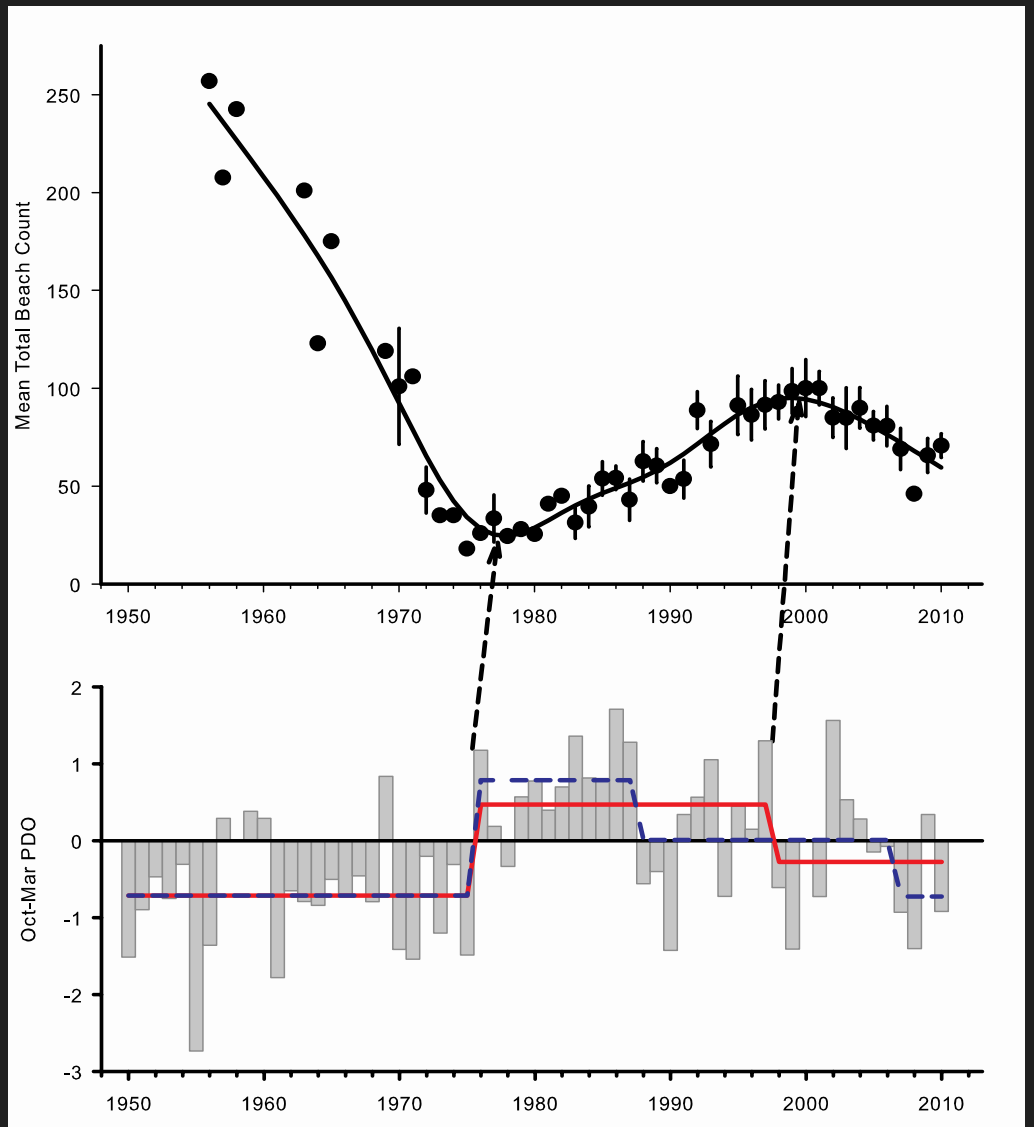
Survival of Hawaiian Monk Seals at northern atolls as a function of the position of the 18º SST isotherm, a proxy for the TZCF, 1985-2003

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

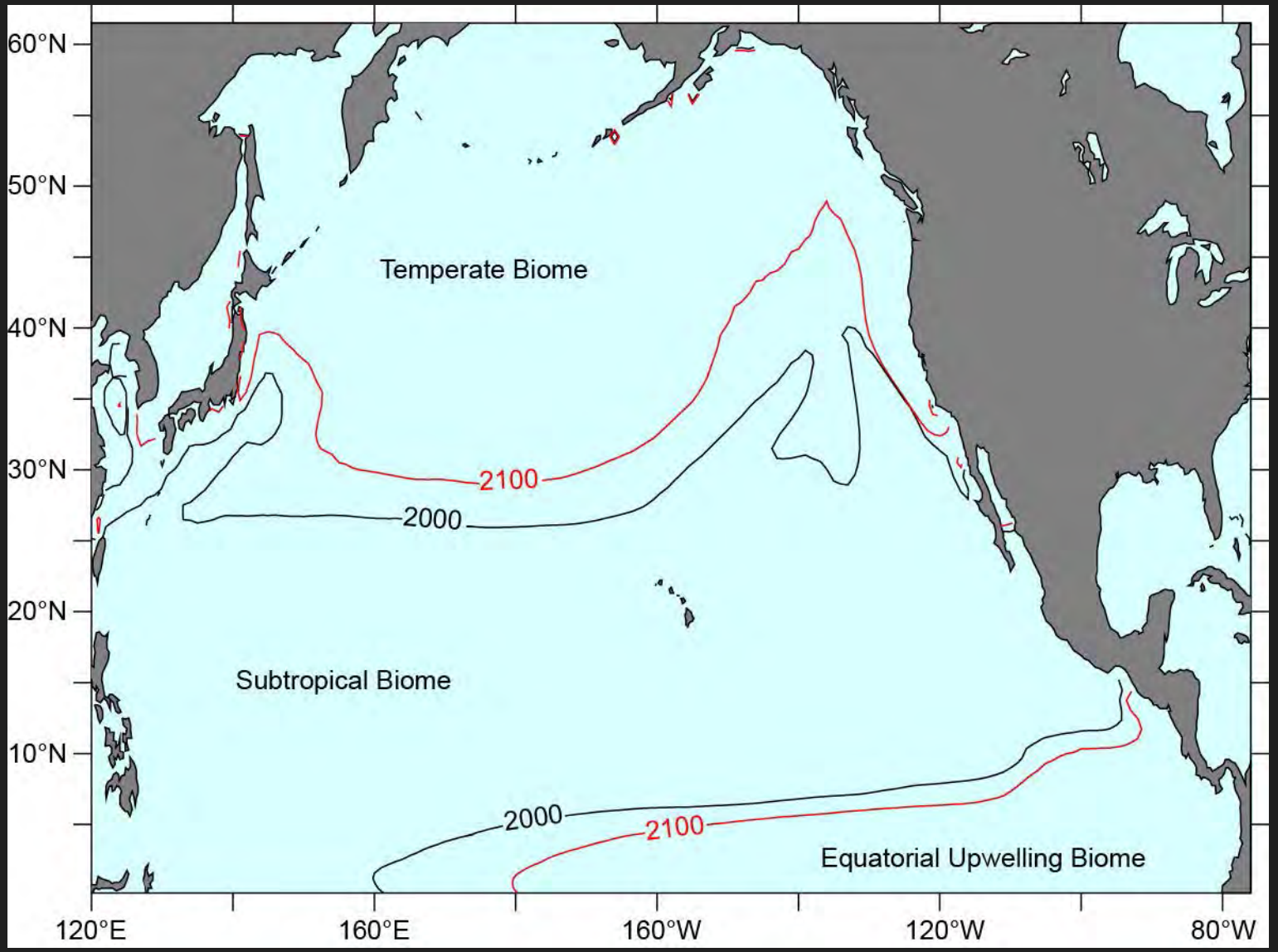
Reduced wind-stress curl

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

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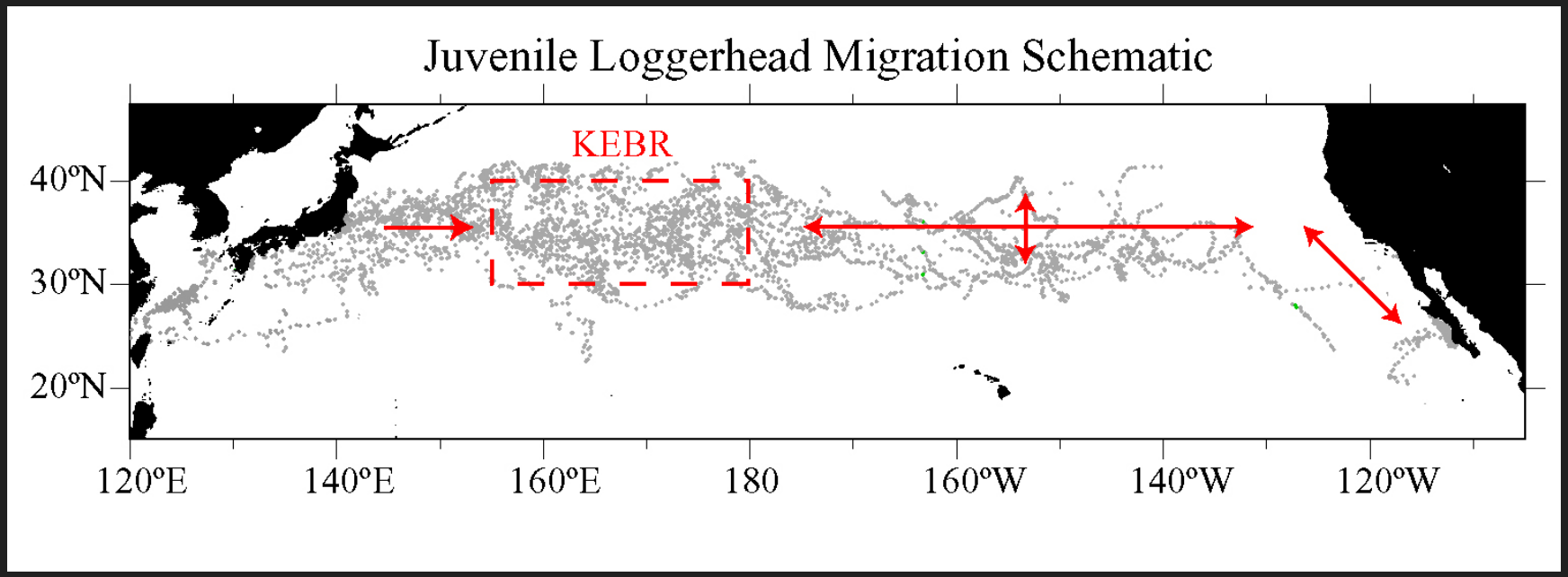
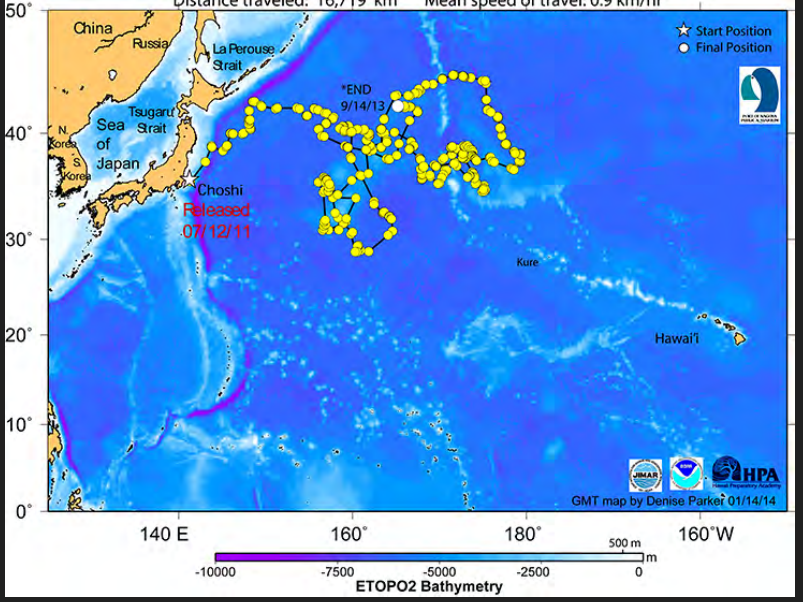
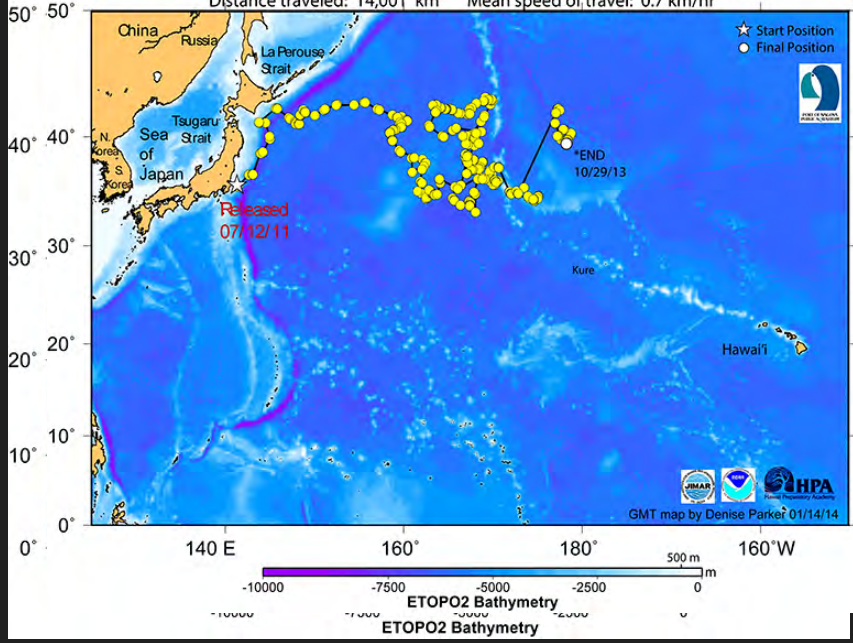

Juvenile Loggerhead Migration Schematic
KEBR
40°N
30°N
20°N
120°E
140°E
160°E
180
160°W
140°W
120°W

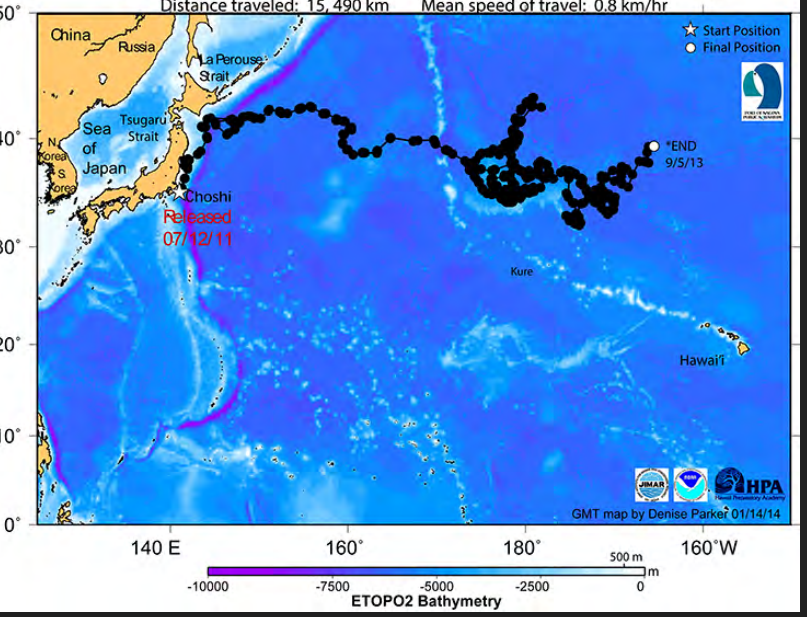
FINAL MAP:
2011-2013 movement of juvenile loggerhead turtle "27", ID 19595
released offshore of Boso Point, Japan hatched and raised by the Port of Nagoya Public Aquarium
SPOT5 transmitter 4/116 SCL: 39.1 cm Days transmitting: 795 days
Distance traveled: 16,719 km Mean speed of travel: 0.9 km/hr



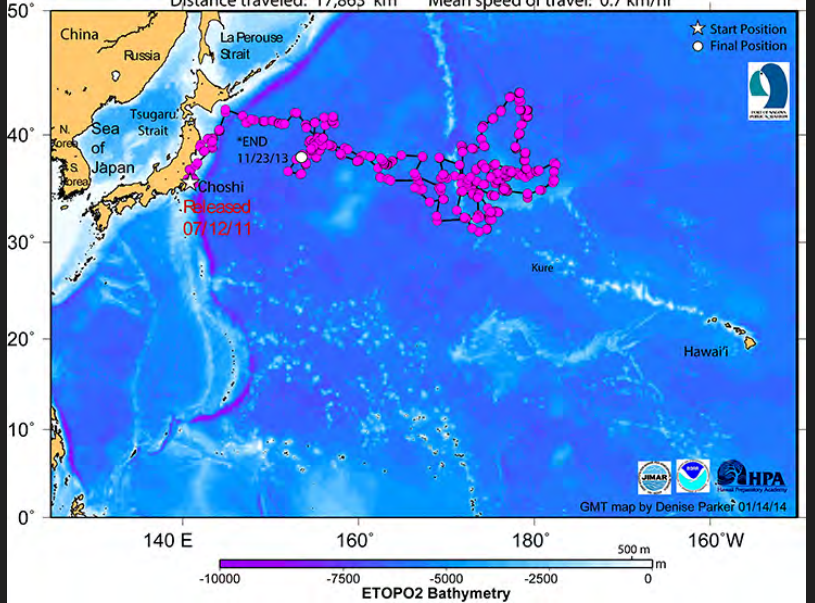
FINAL MAP:
2011-2013 movement of juvenile loggerhead turtle "15", ID 22151
released offshore of Boso Point, Japan hatched and raised by the Port of Nagoya Public Aquarium
SPOT5 transmitter 4/116 SCL: 34.9 cm Days transmitting: 840 days
Distance traveled: 14,001 km Mean speed of travel: 0.7 km/hr



FINAL MAP:
2011-2013 movement of juvenile loggerhead turtle "34", ID 42714
released offshore of Boso Point, Japan hatched and raised by the Port of Nagoya Public Aquarium
SPOT5 transmitter 4/116 SCL: 36.6 cm Days transmitting: 786 days
Distance traveled: 15, 490 km Mean speed of travel: 0.8 km/hr



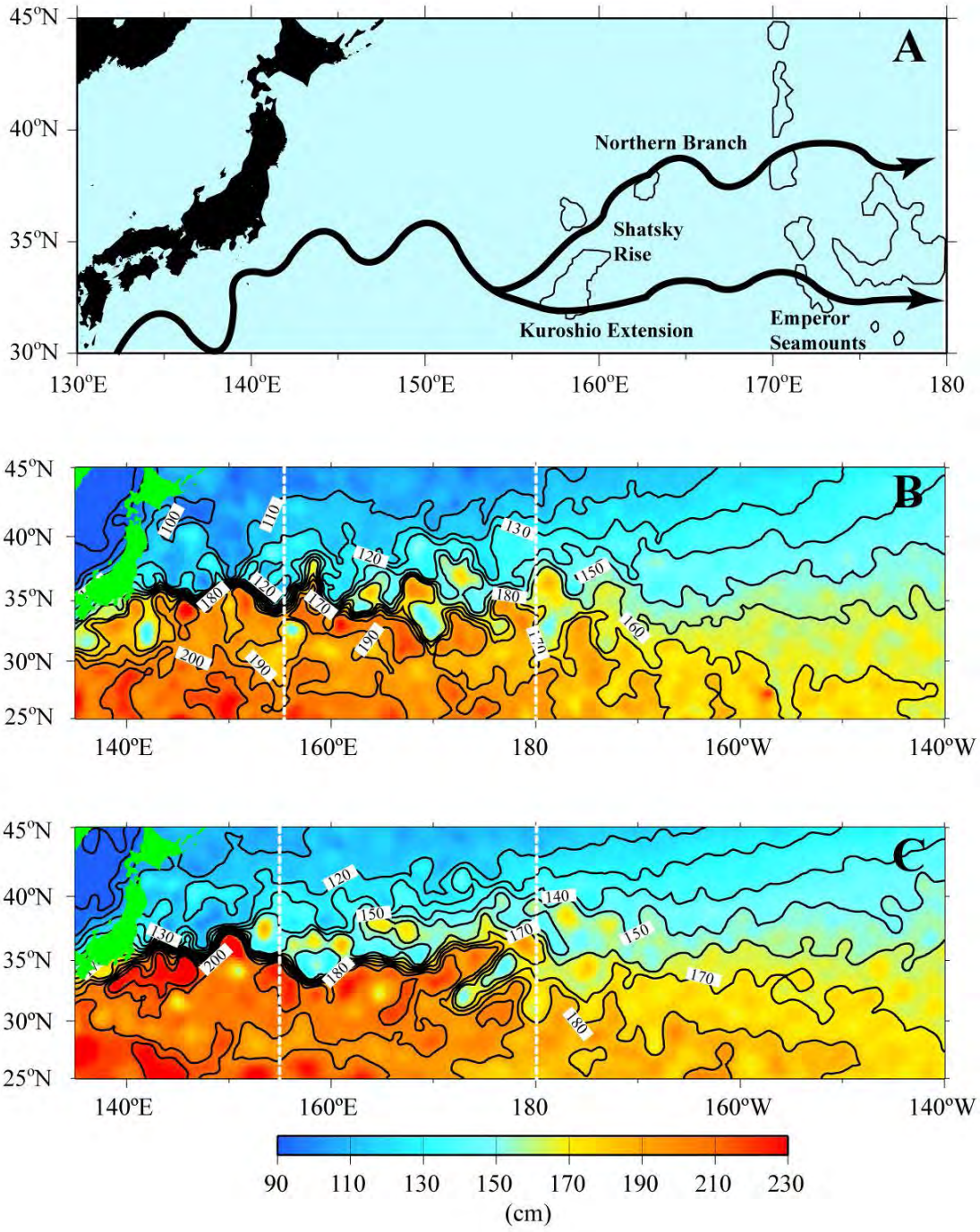
FINAL MAP:
2011-2013 movement of juvenile loggerhead turtle "12", ID 23002
released offshore of Boso Point, Japan hatched and raised by the Port of Nagoya Public Aquarium
SPOT5 transmitter 4/116 SCL: 37.4 cm Days transmitting: 865 days
Distance traveled: 17,863 km Mean speed of travel: 0.7 km/hr



Schematic of the Kuroshio Extension Bifurcation region (A)

AVISO altimetry for March 2003

AVISO altimetry for September 2003

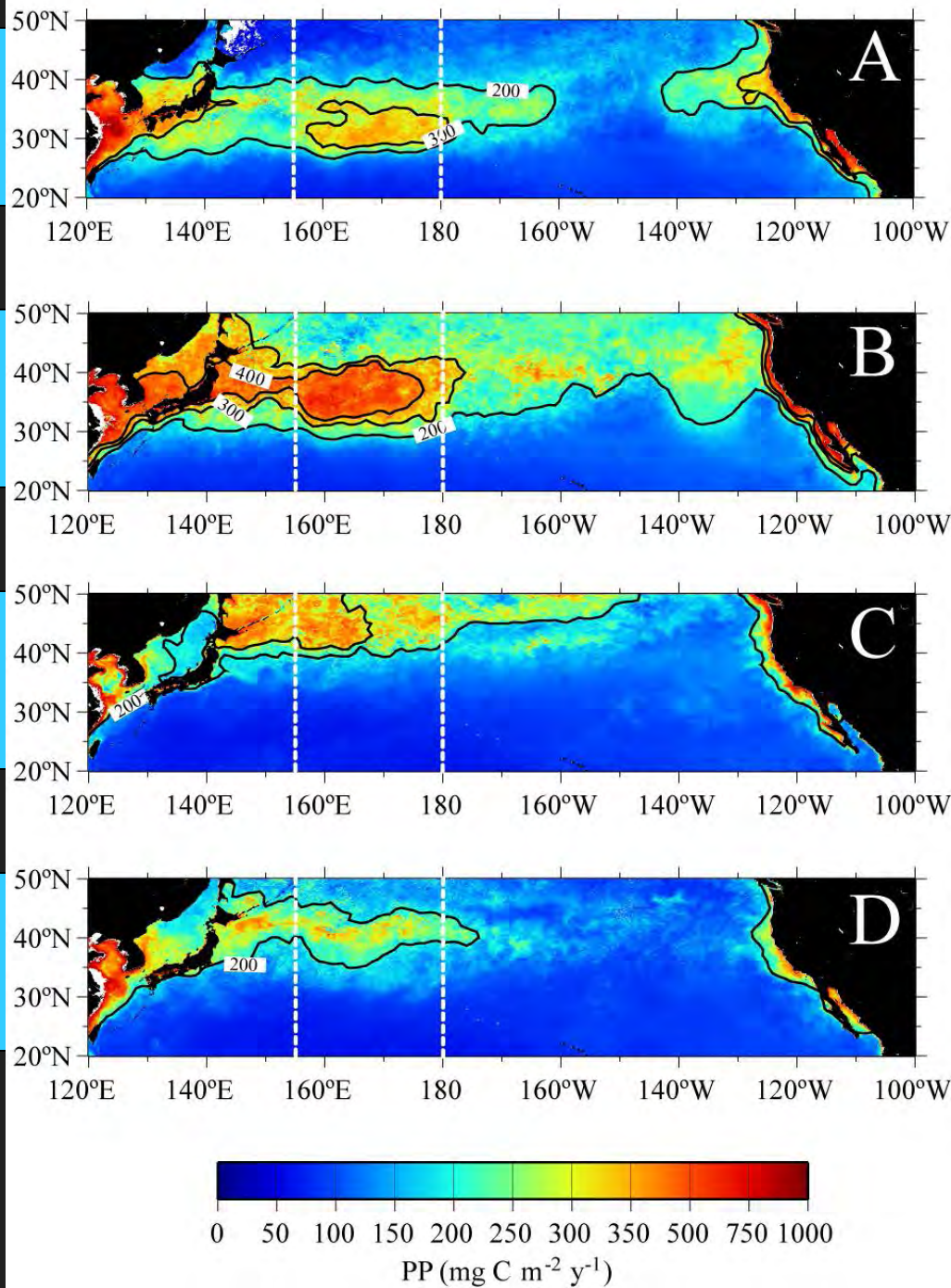


MODIS primary productivity (BF model) for Quarter 1 2003

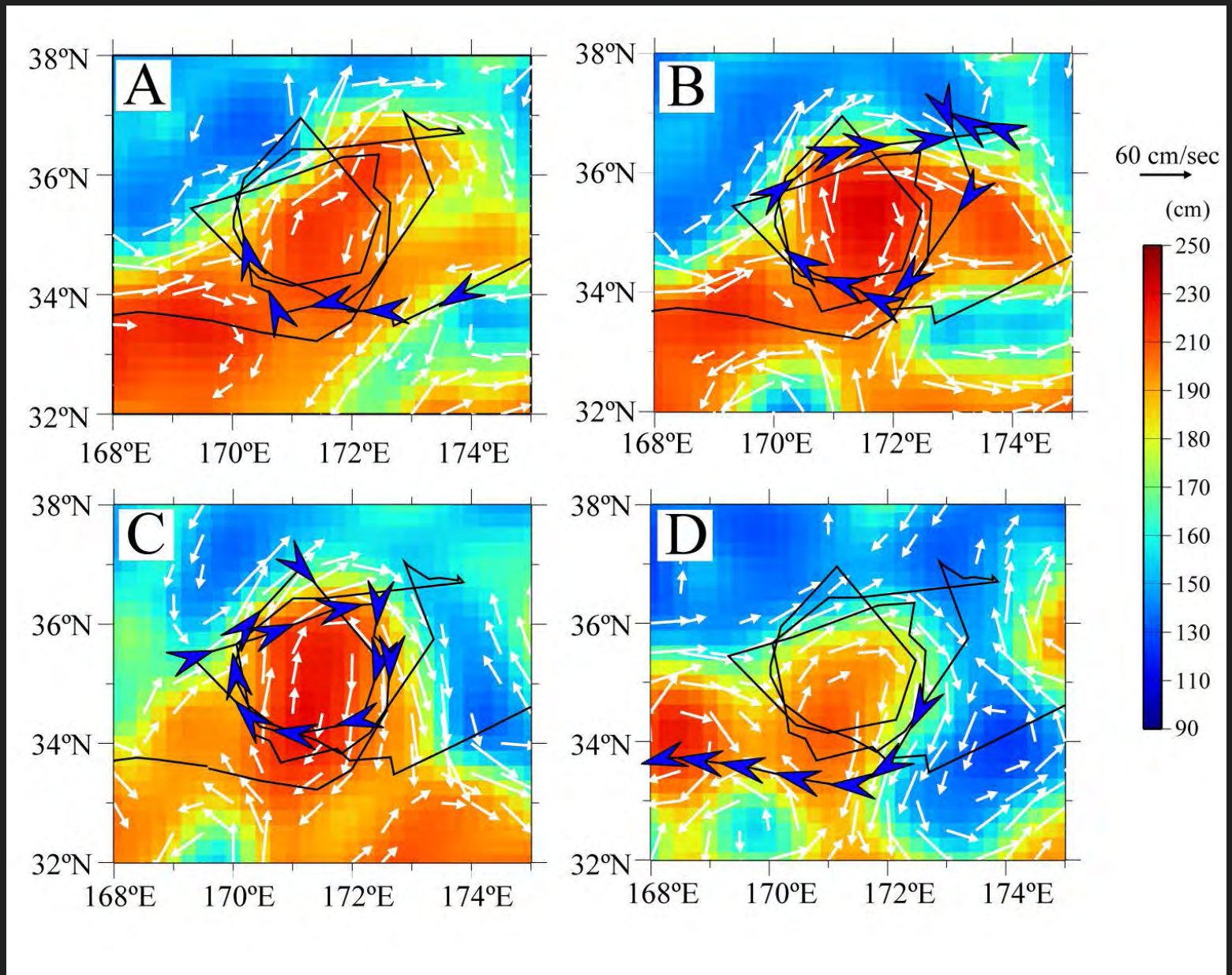
MODIS primary productivity (BF model) for Quarter 2 2003

MODIS primary productivity (BF model) for Quarter 3 2003

MODIS primary productivity (BF model) for Quarter 4 2003

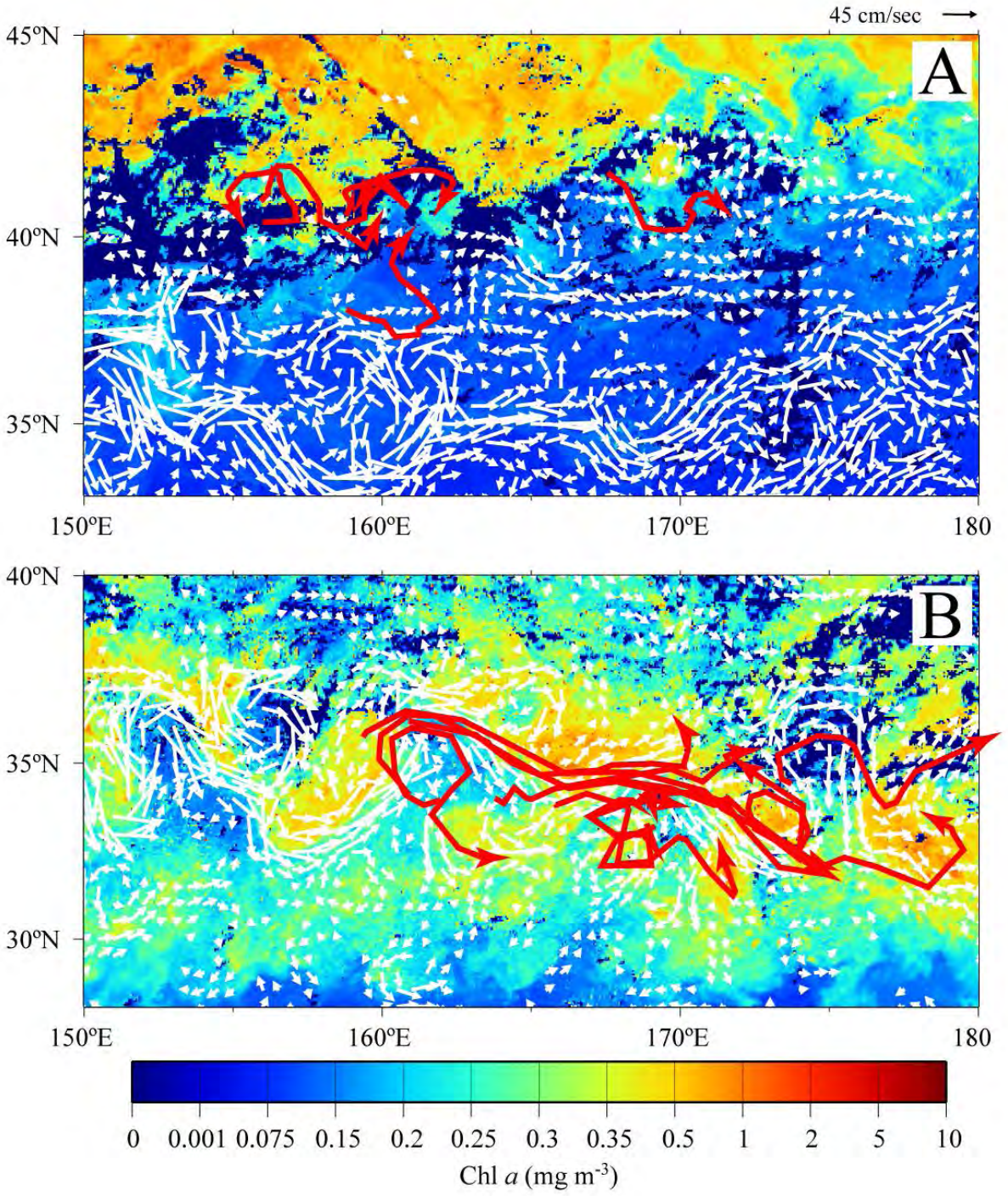


Loggerhead track over SSH and geostrophic currents for October 2003 (A), November 2003 (B), December 2003 (C), and January 2004 (D)

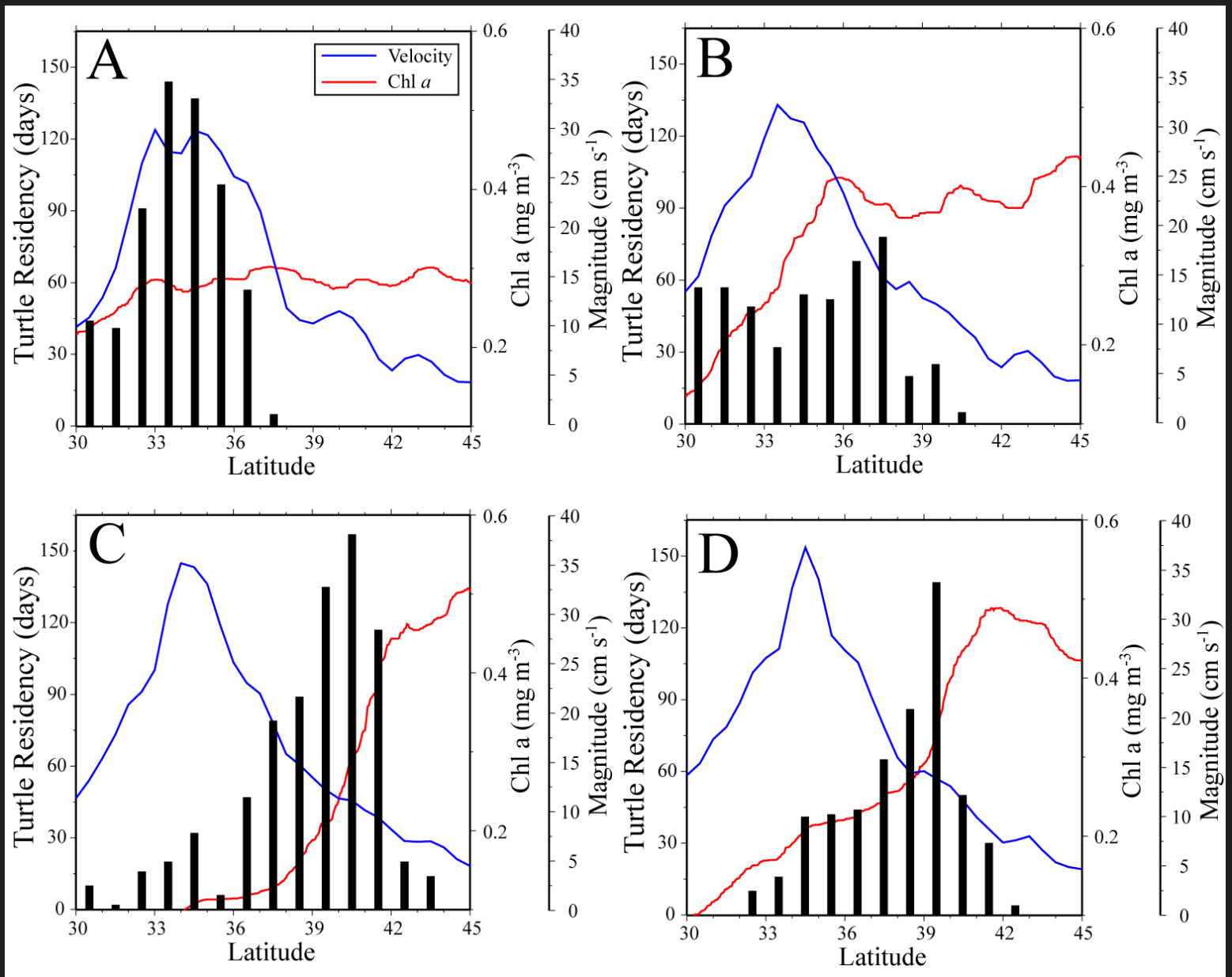


Geostrophic currents and ocean color for September 6-13, 2003

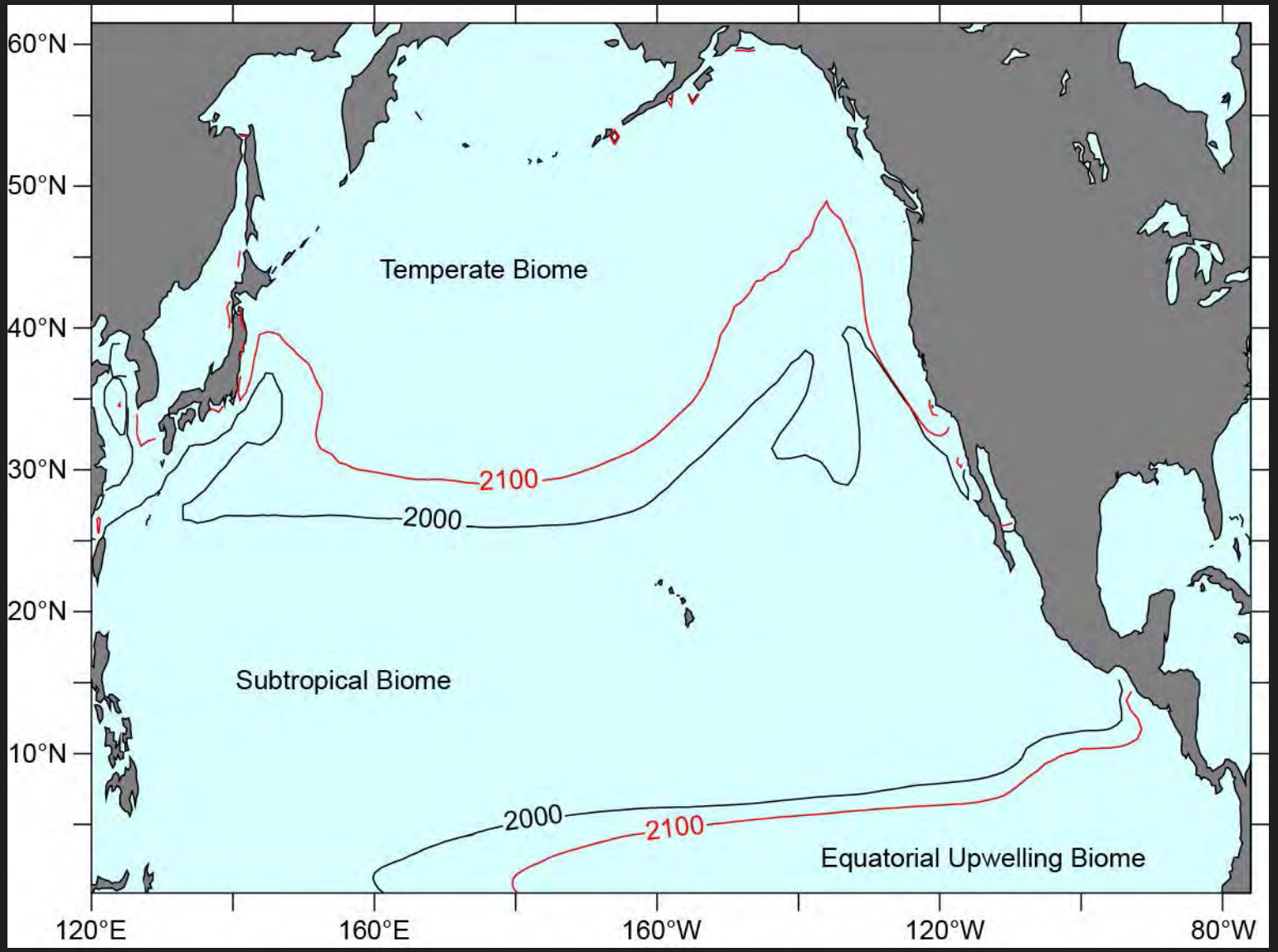
Geostrophic currents and ocean color for March 5-12, 2004



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 increasing on other, possibly less productive, forage habitats