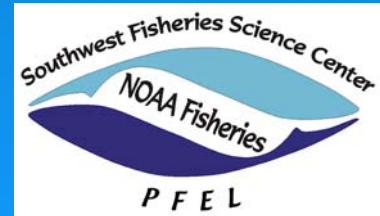


AN OCEANOGRAPHIC BASIS FOR IDENTIFYING BIOLOGICAL HOT SPOTS

FB Schwing, SJ Bograd, C Wilson, PM Stegmann
B Block
D Costa



NOAA/NMFS/SWFSC, Pacific Fisheries Environmental Lab
Hopkins Marine Station, Stanford Univ.
Long Marine Lab, Univ. California, Santa Cruz



North Pacific Hot Spots



North Pacific Hot Spots



RATIONALE

- Define oceanographic cues for biological “hot spots”
- Conduct census of ocean hot spots
- Compare regional, temporal, species, gender, behavioral differences in their use
- Identify stability and predictability of hot spots in the future
- *Map habitat utilization of ocean by species, based on biologging, in situ, and remotely sensed information*

OUTLINE

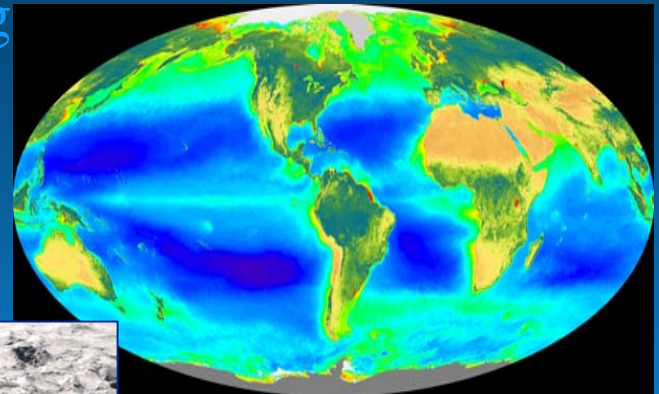
- Tagging of Pacific Pelagics
- Ocean Features and their Variability
- Linking Animal Tracks with Ocean Features
- Animal Oceanographers for the Global Ocean Database
- *Advance from Correlation to Mechanisms of Hot Spots*



Tagging of Pacific Pelagics (TOPP) A Census of Marine Life Pilot Project

B. Block, D. Costa, S. Bograd and R. Kochevar

www.toppcensus.org



Block *et al.* 2003
Acta Oceanographica





TOPP Objectives

- What is the spatial correlation between processes and predators?
 - Do APEX predators use the marine environment in similar ways?
 - » Shared migration corridors?
 - » Common elements to critical habitats?
- What is the critical habitat of these organisms?
 - Define critical habitats with potential to develop MPA
- Capture the imagination of the public
 - Interpret the importance and complexity of the pelagic environment relative to APEX predators

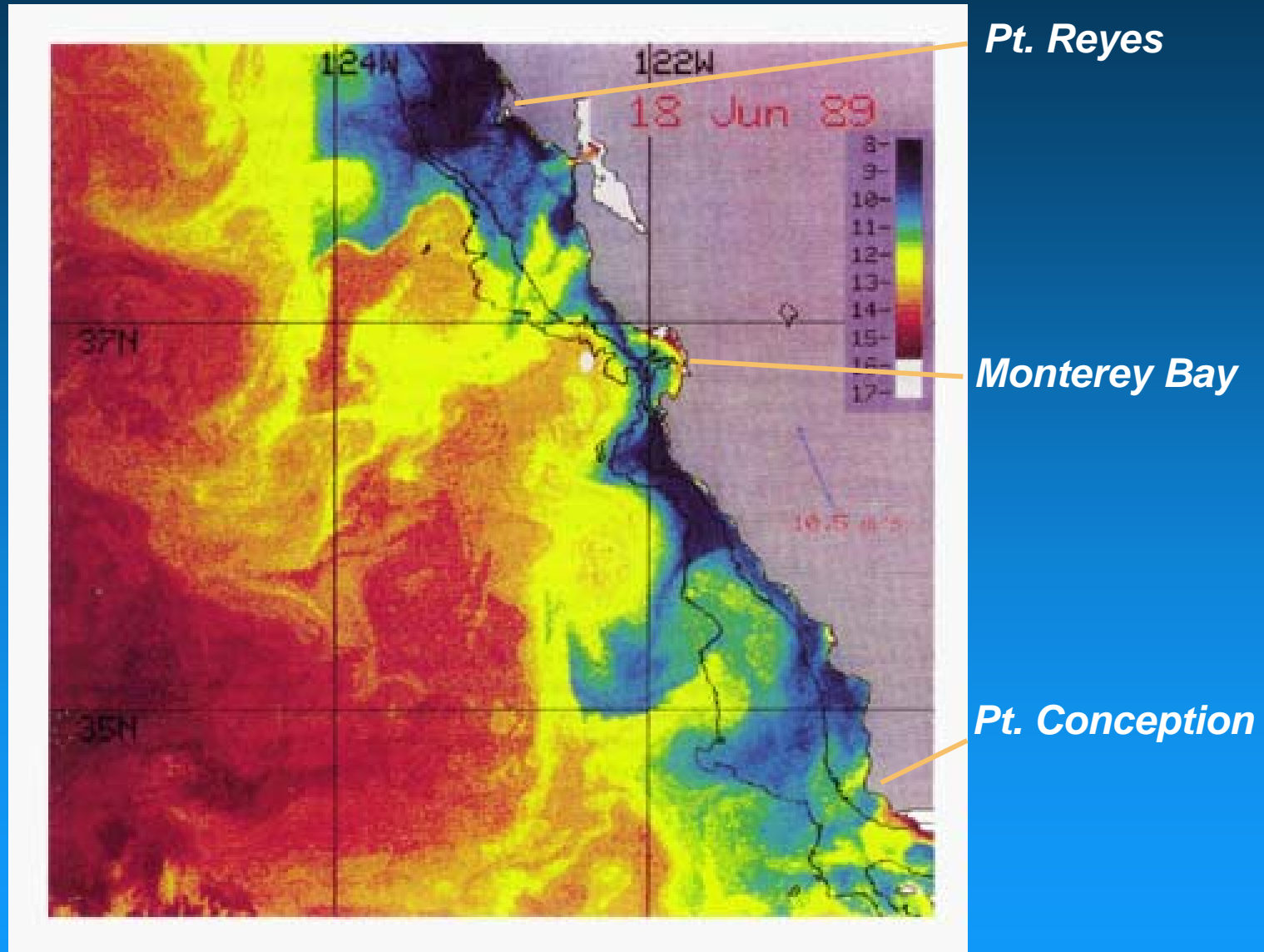
TOPP Oceanographic Samplers

- **Albatross**
 - SST N Pacific
- **Elephant Seals**
 - Archival and satellite linked CTD
 - Pelagic N Pacific
- **California Sea Lions**
 - Archival and satellite linked CTD
 - California Current
- **Salmon sharks**
 - Satellite and Archival TD
 - N Pacific and coastal zone
- **Bluefin tuna**
 - Archival and satellite linked TD
 - Pelagic N Pacific

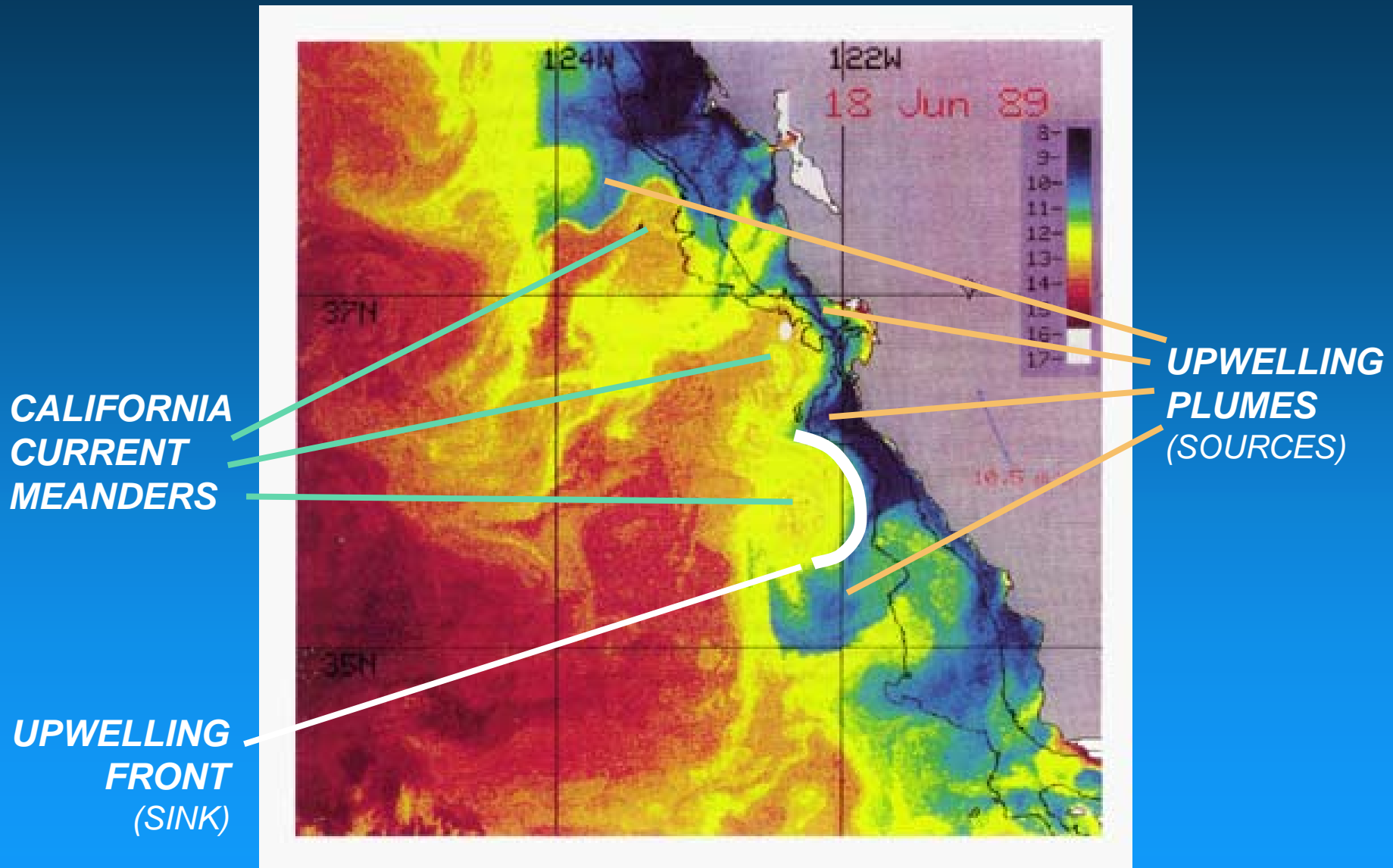
22 tagged species

COASTAL OCEAN FEATURES

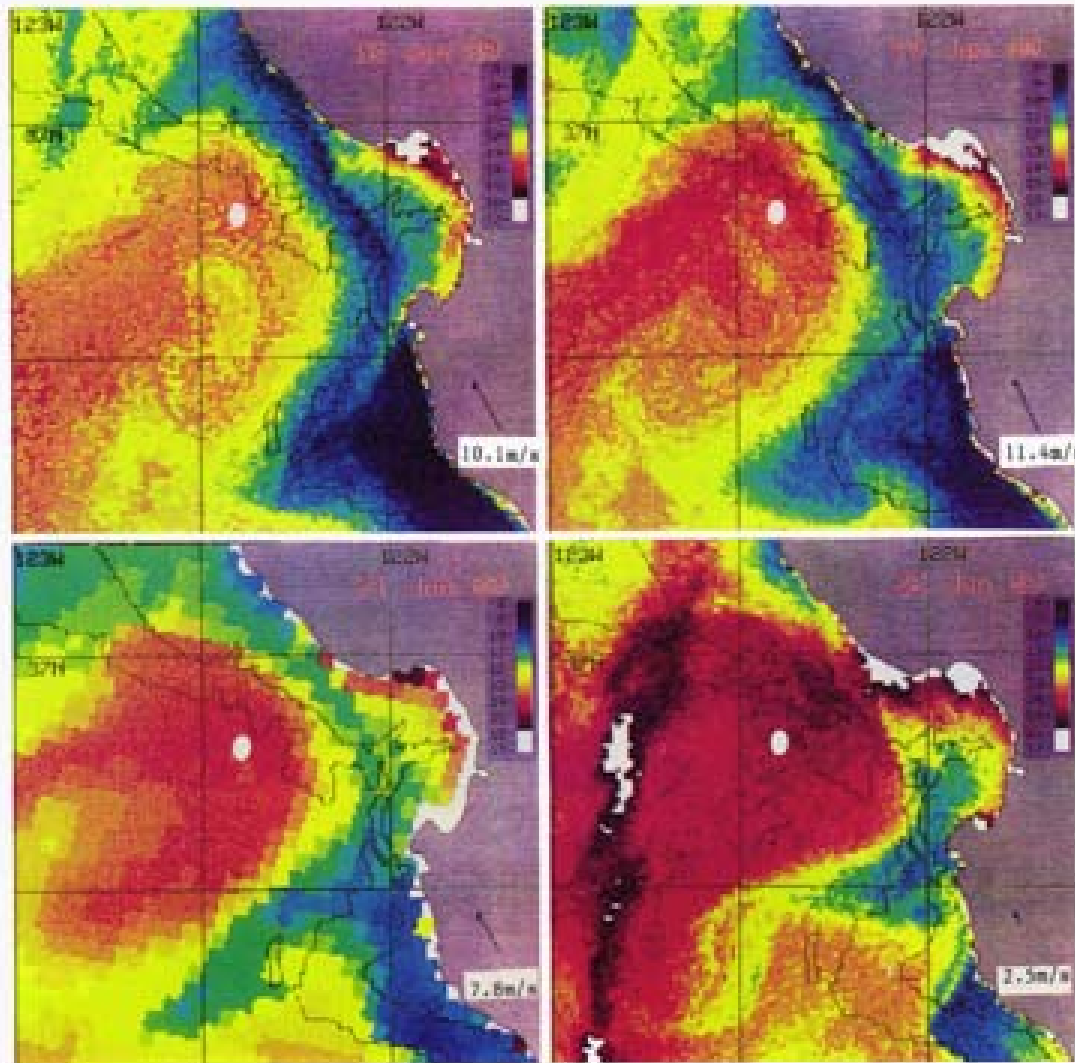
SST
red (warm),
blue (cool)



COASTAL OCEAN FEATURES



Coastal Hot Spots



18-22 June 1989

Hot spots may be persistent but variable

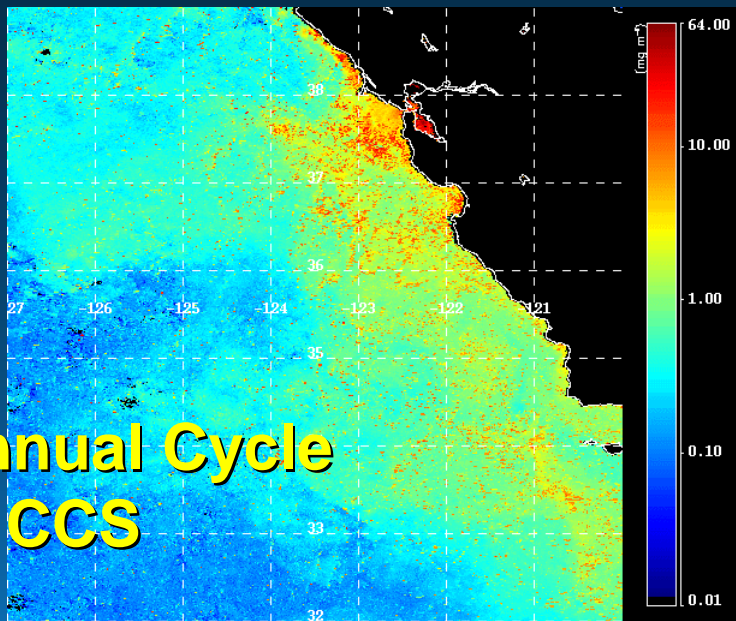
May not be fixed in space

Relaxation of upwelling

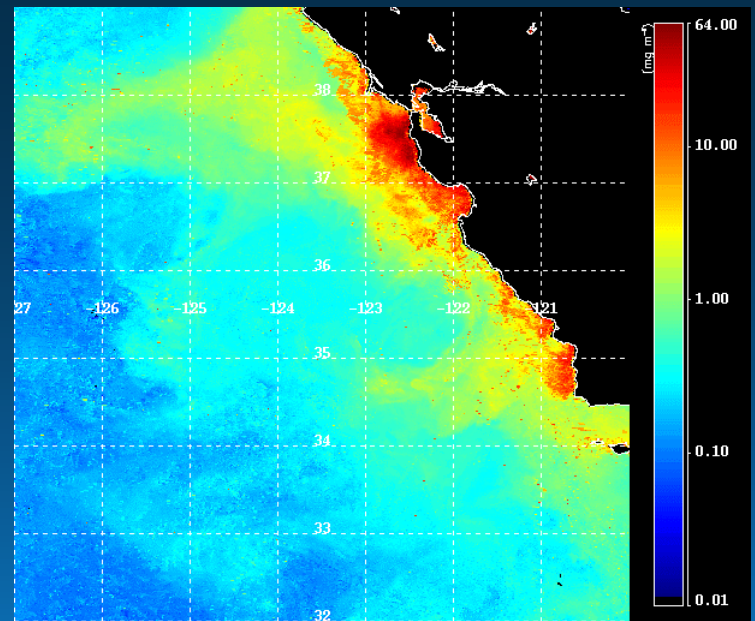
- Rapid response to wind
- Infrequent (ca. 10-30 day)
- Short-lived

(from Rosenfeld et al. 1994)

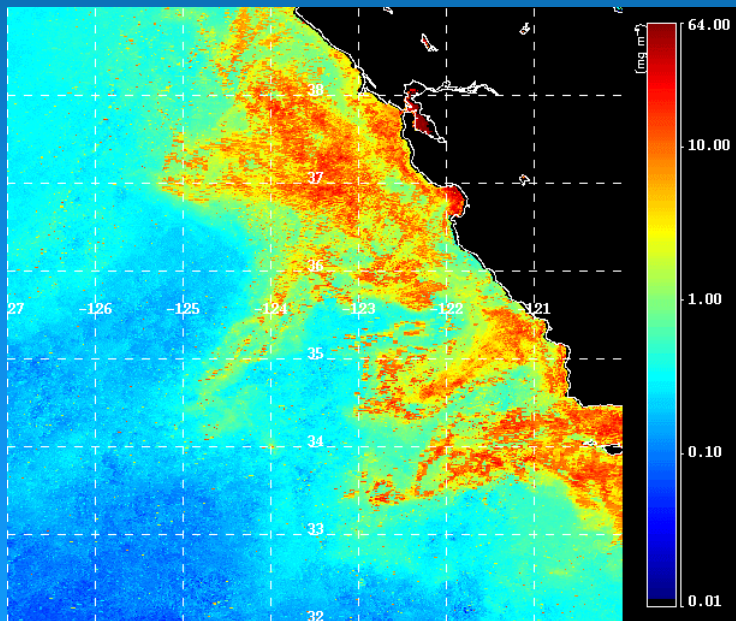
Annual Cycle of CCS



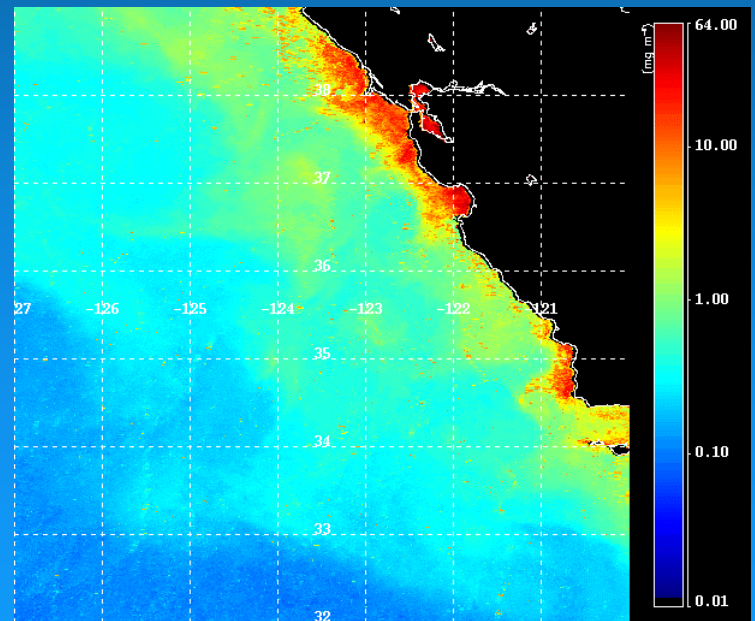
January 1999



April 1999

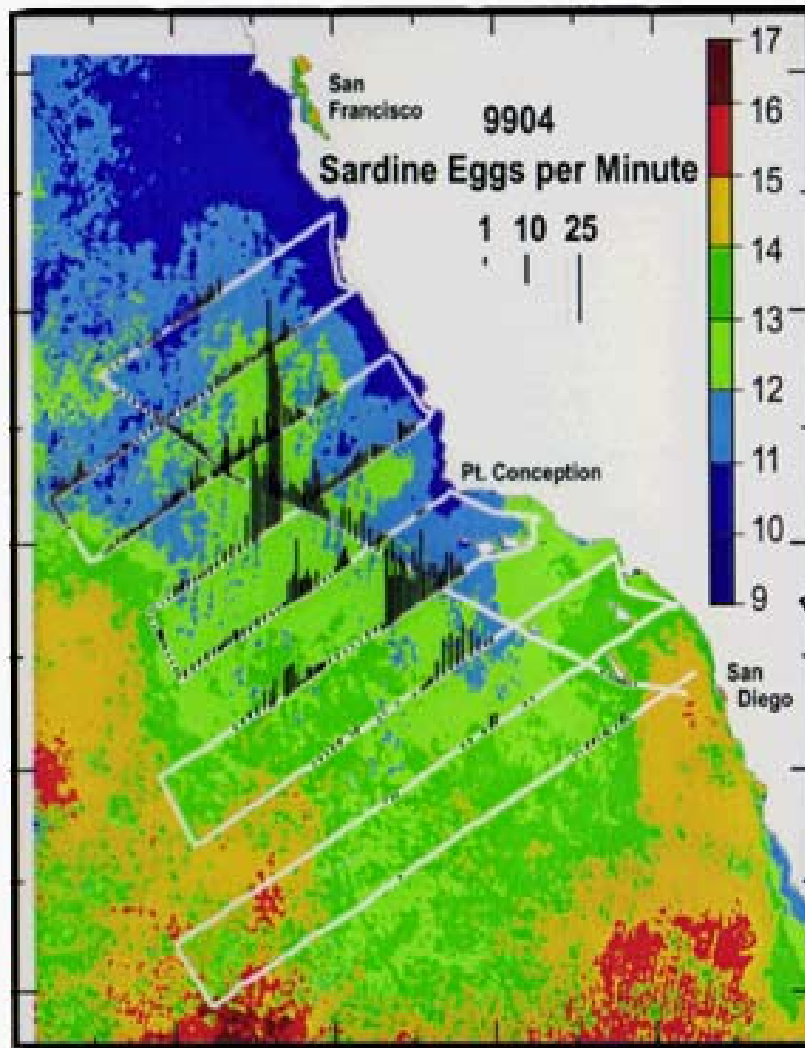
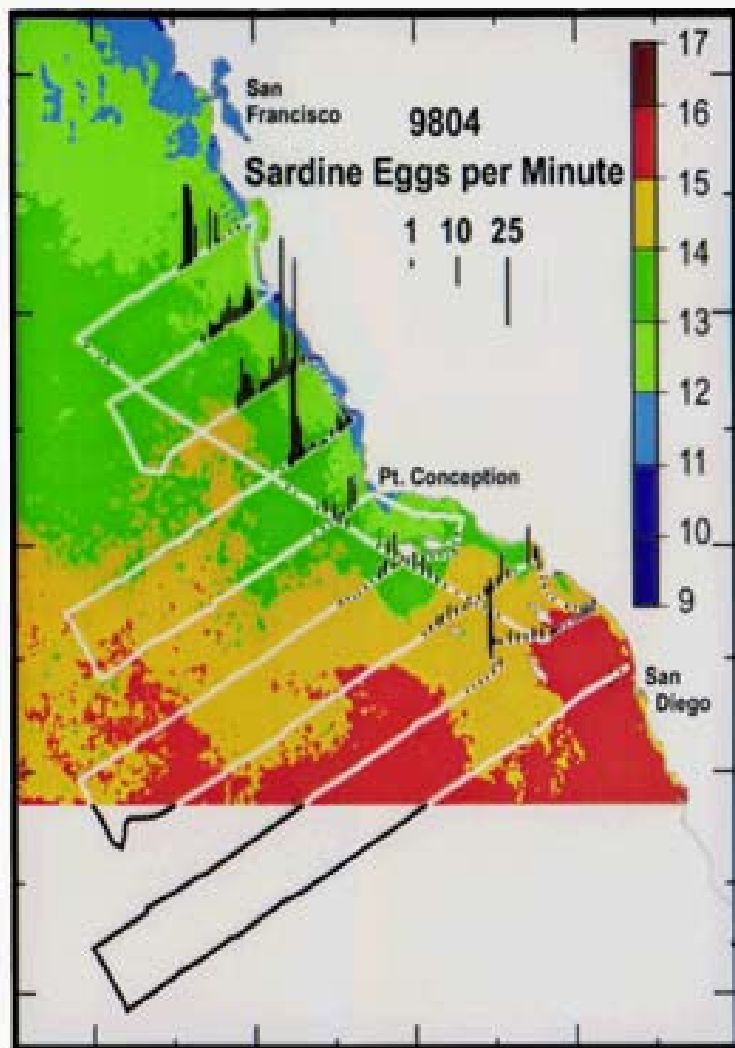


July 1999

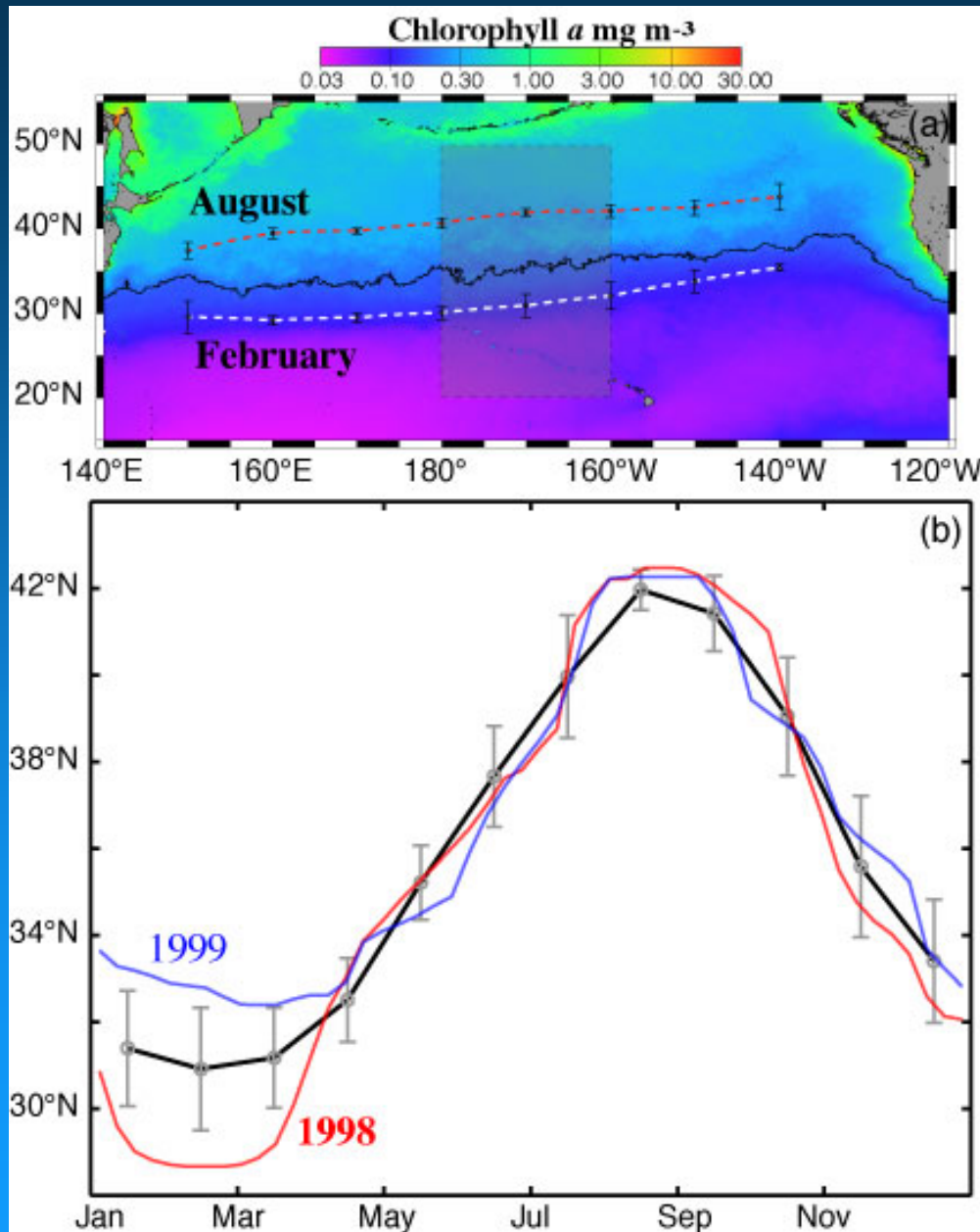


October 1999

Year-to-Year Differences in Ocean and Biological Features

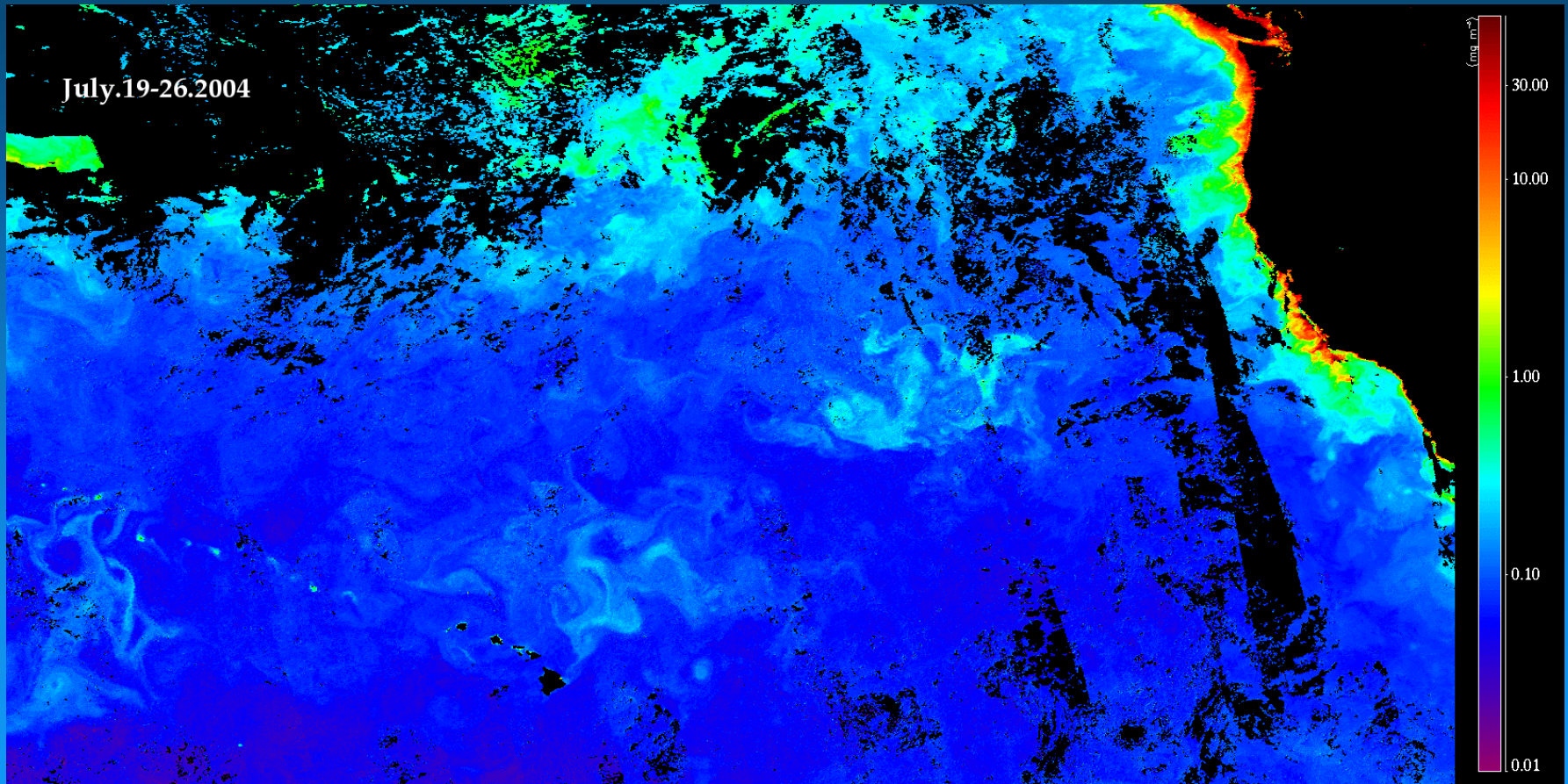


Transition Zone Chlorophyll Front



- *Greater North Pacific*
- *Complex habitat*
- *Seasonal variability*
- *Interannual variability*

Large-scale Ocean Features

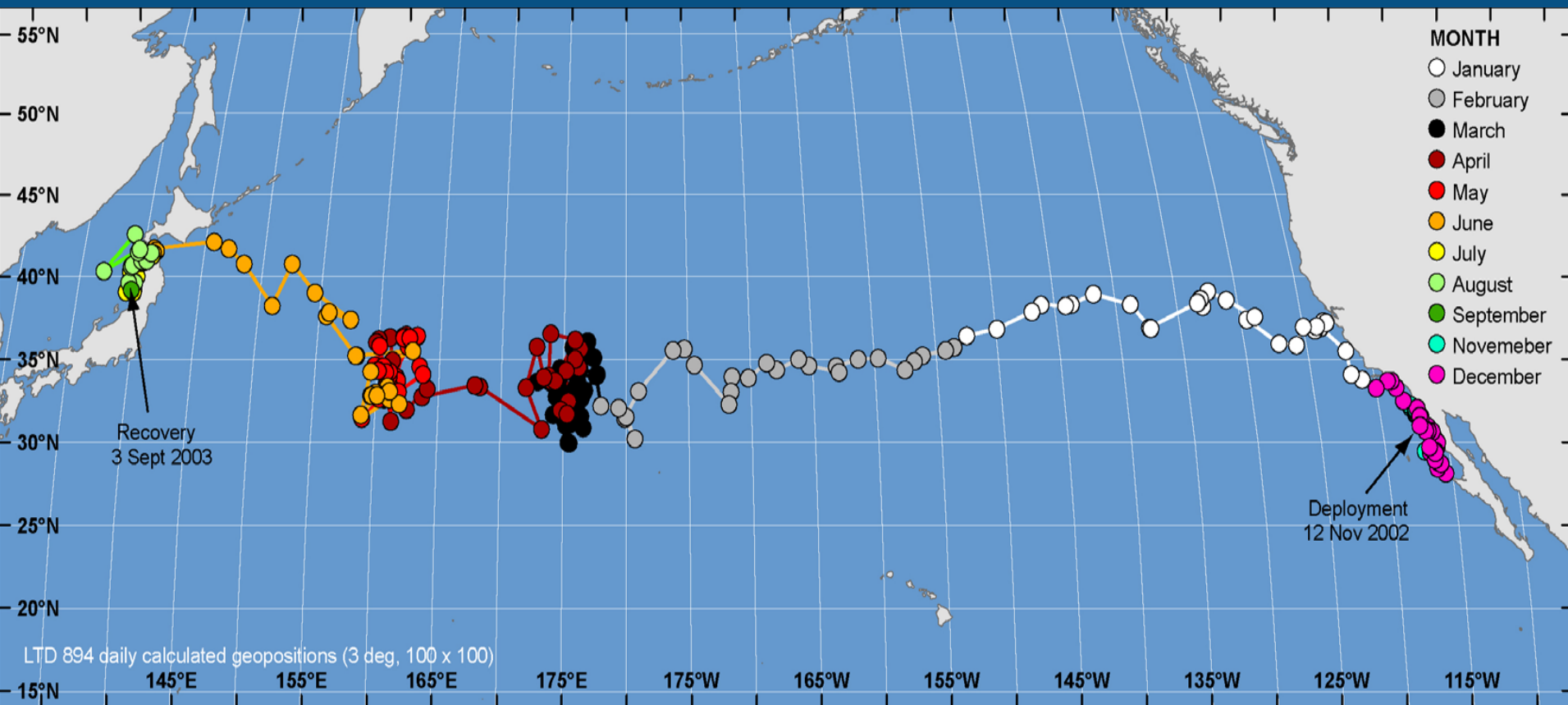


Ocean Cues for Biological Hot Spots

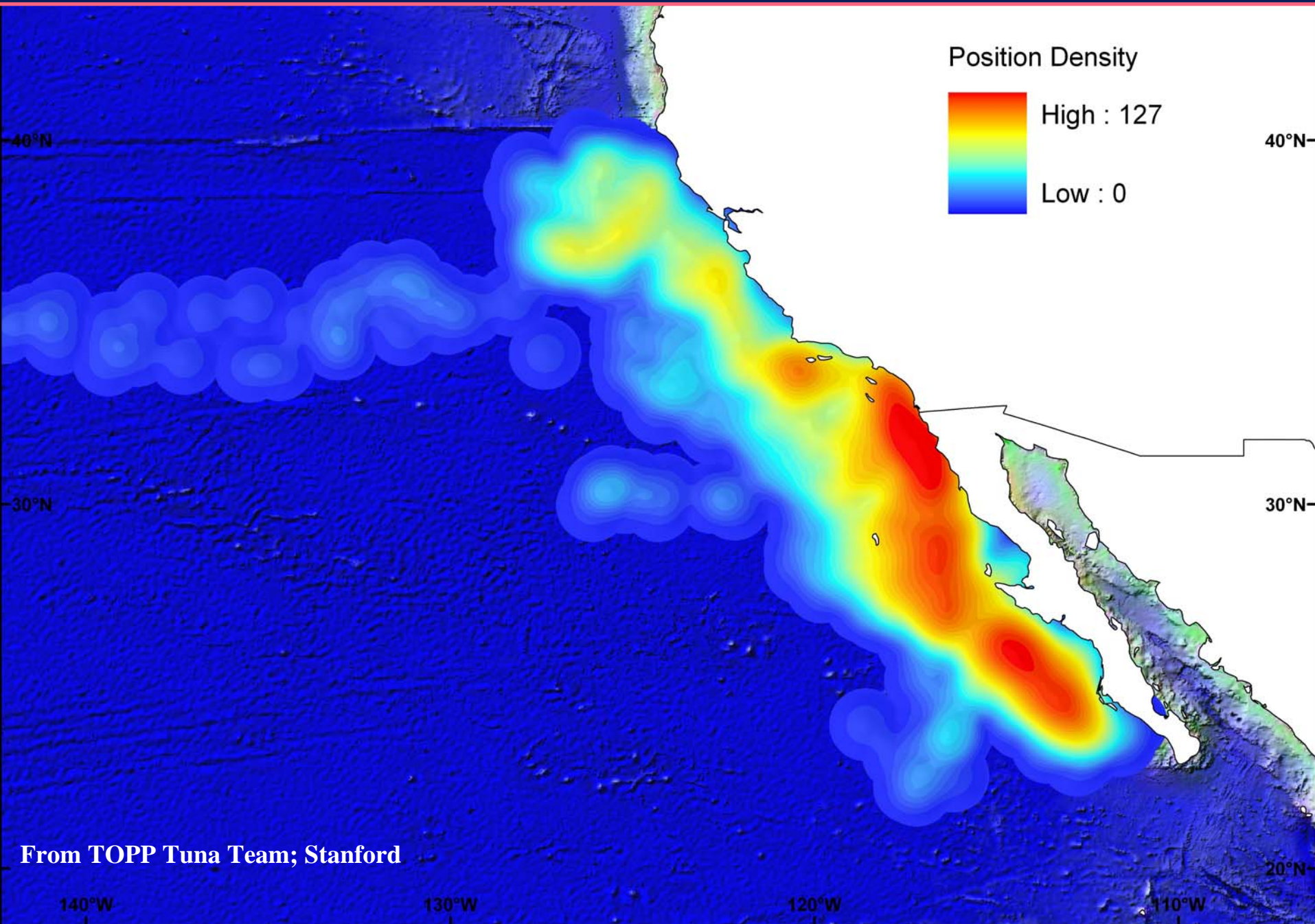
- *Ocean temperature*
 - *Ocean currents*
 - *Visible fronts*
 - *Prey concentration*
-
- *Eddies*
 - *Fronts*
 - *Currents, convergences, upwelling*

A Trans-Pacific Archival Record

November 2002- September 2003, 35 kg Pen Released Bluefin Tuna

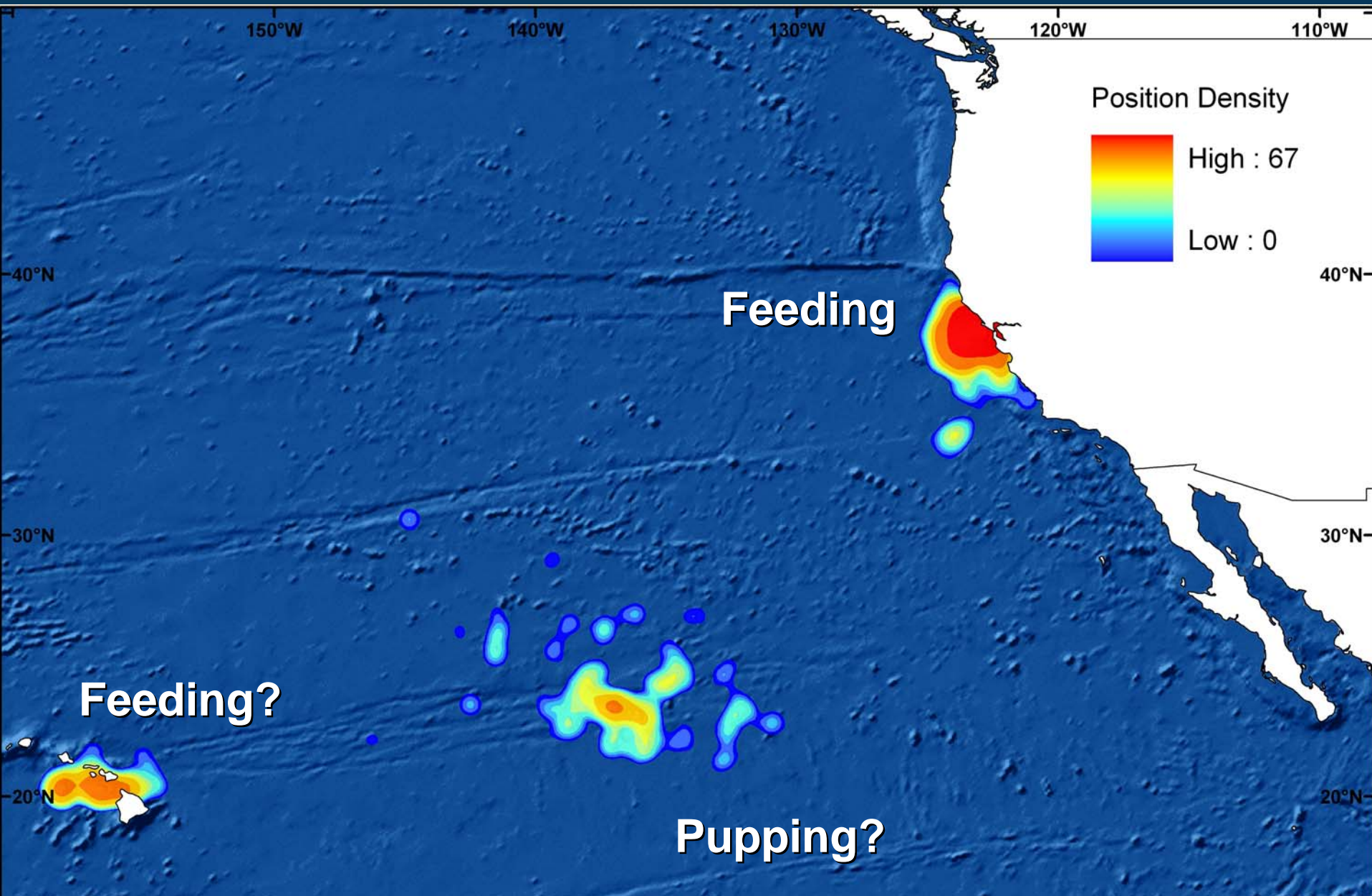


Pacific Bluefin Tuna Hot Spots

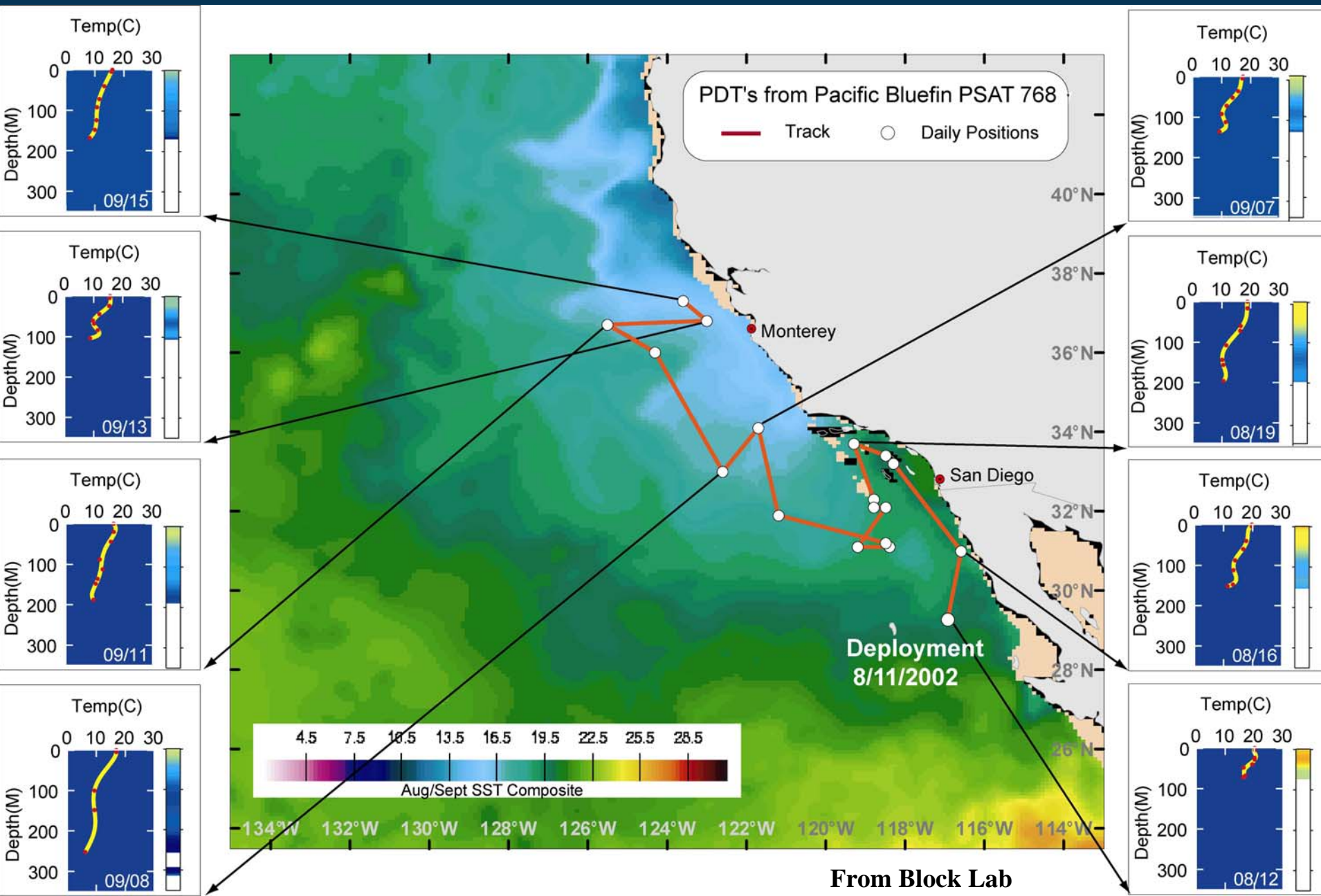


From TOPP Tuna Team; Stanford

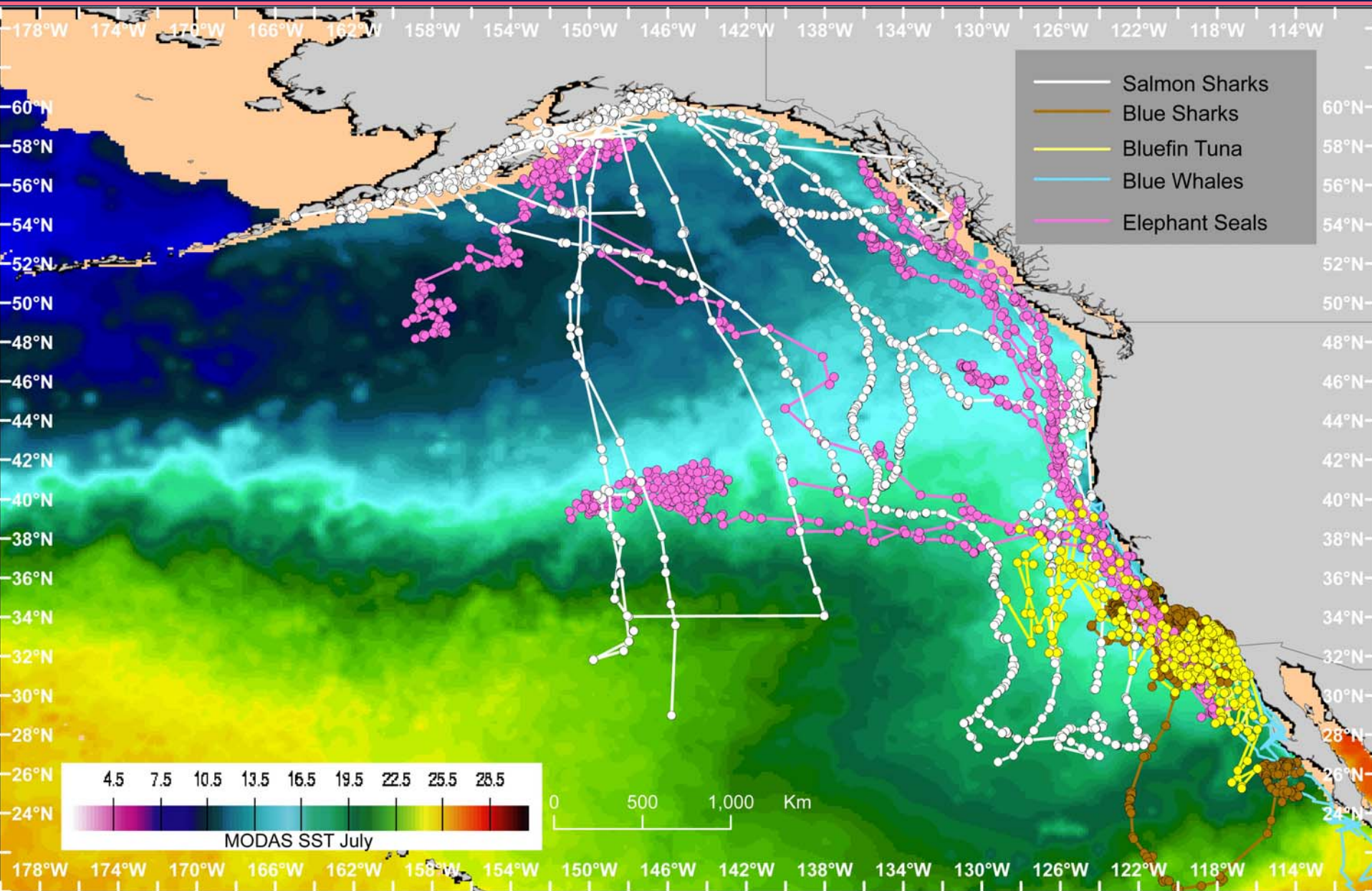
Adult White Shark Hot Spots



Linking Biological Tracks to Environmental Conditions



Identifying Pelagic Hot Spots



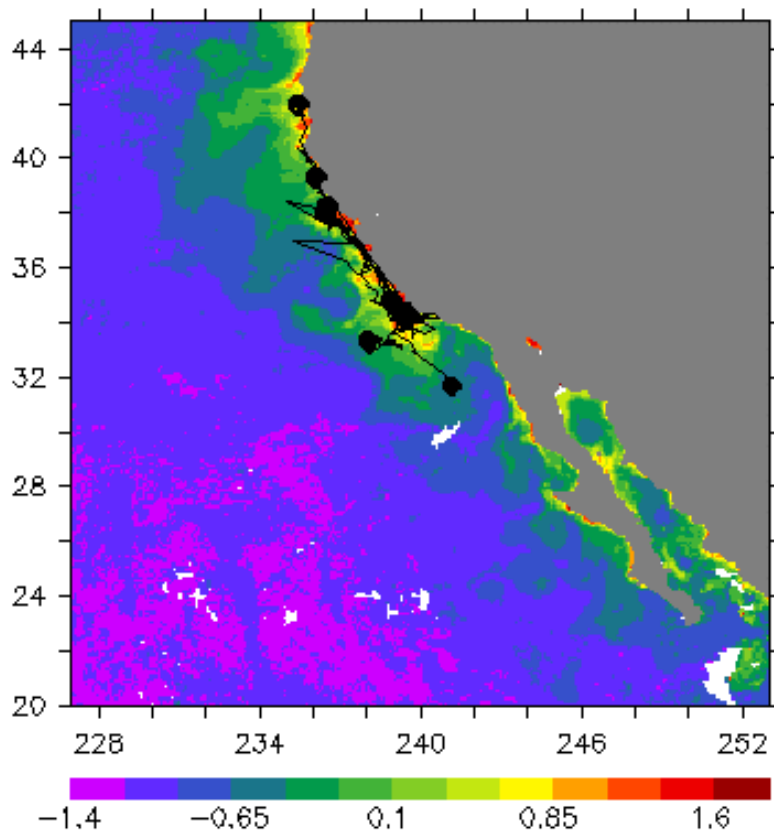
From TOPP Data Management Team, Stanford

Blue Whale

Humpback Whale

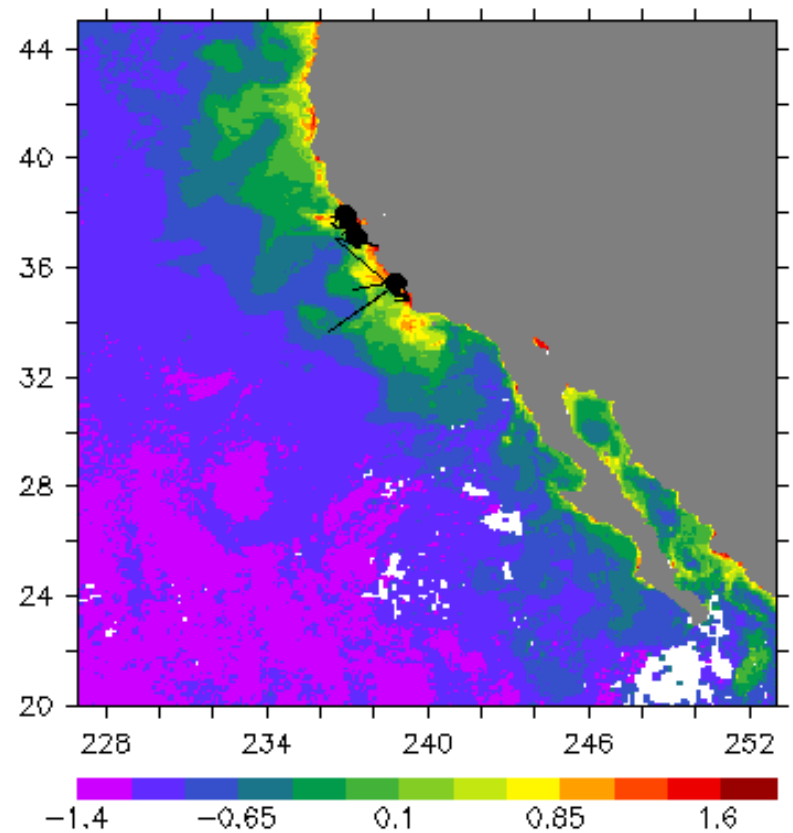
5-Sep-2004

MODIS: 27-AUG-2004 to 4-SEP-2004



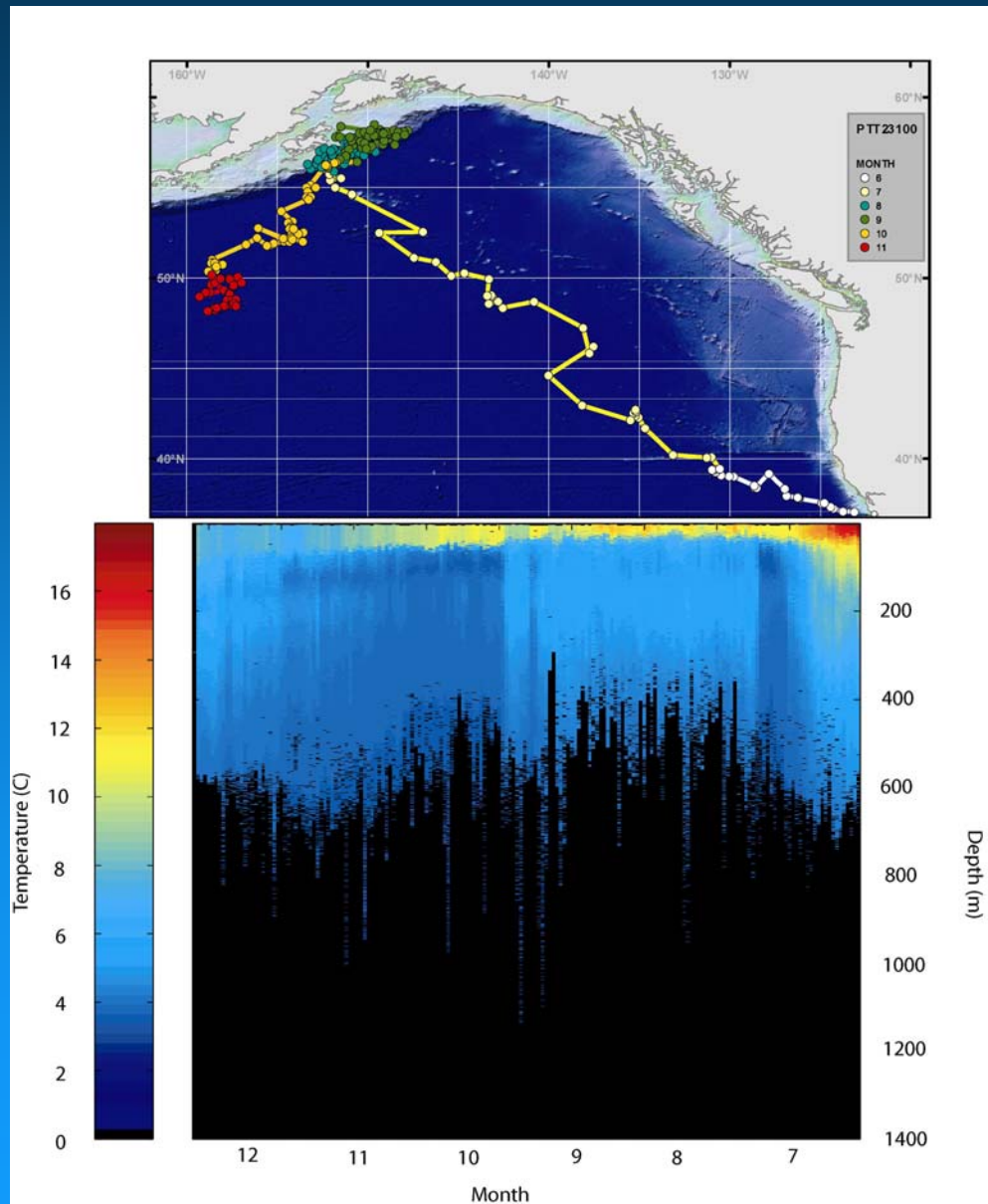
10-Sep-2004

MODIS: 31-AUG-2004 to 8-SEP-2004



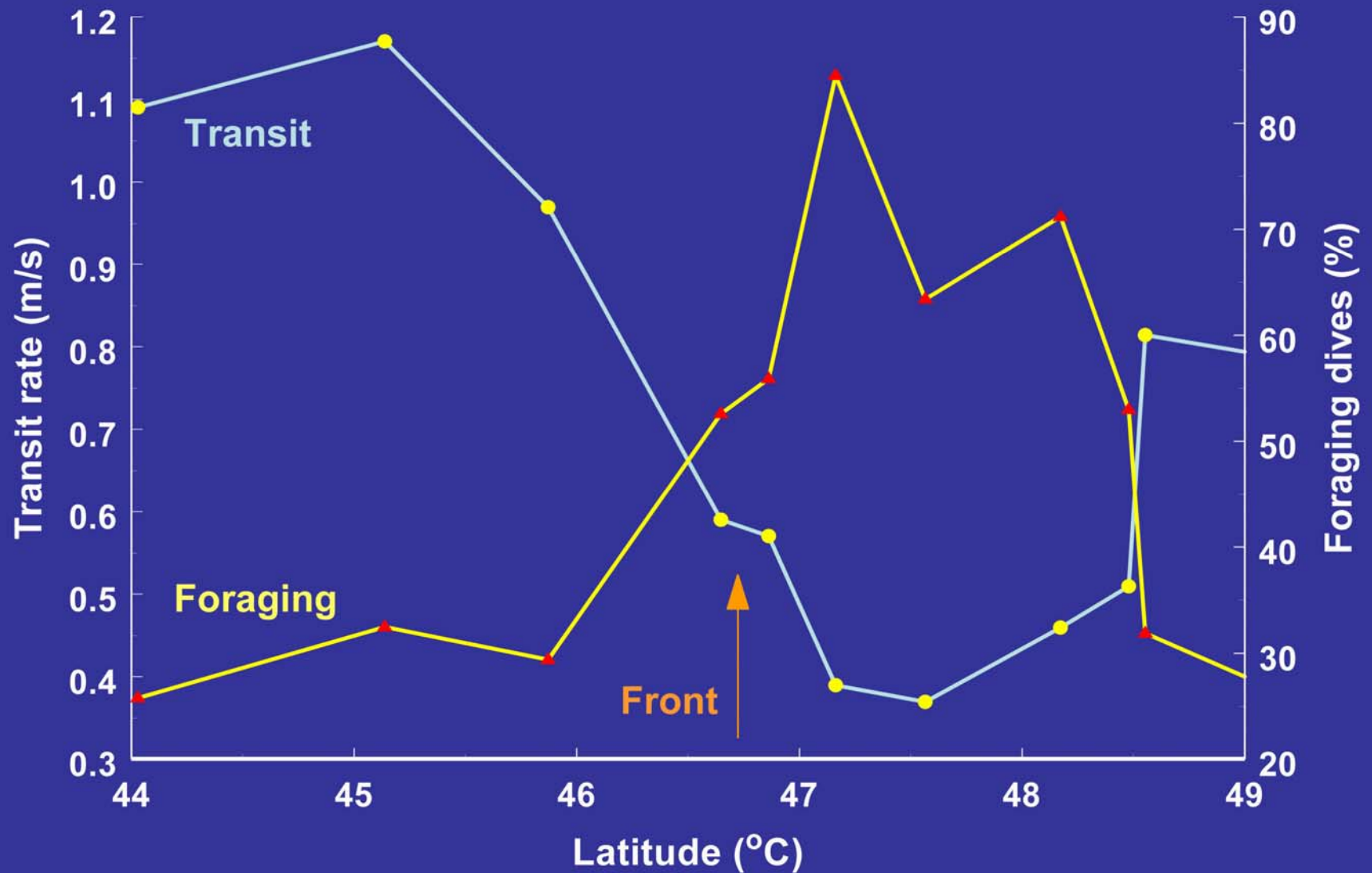
From TOPP Cetacean Team, Stanford/PFEL

Elephant Seals as Oceanographers

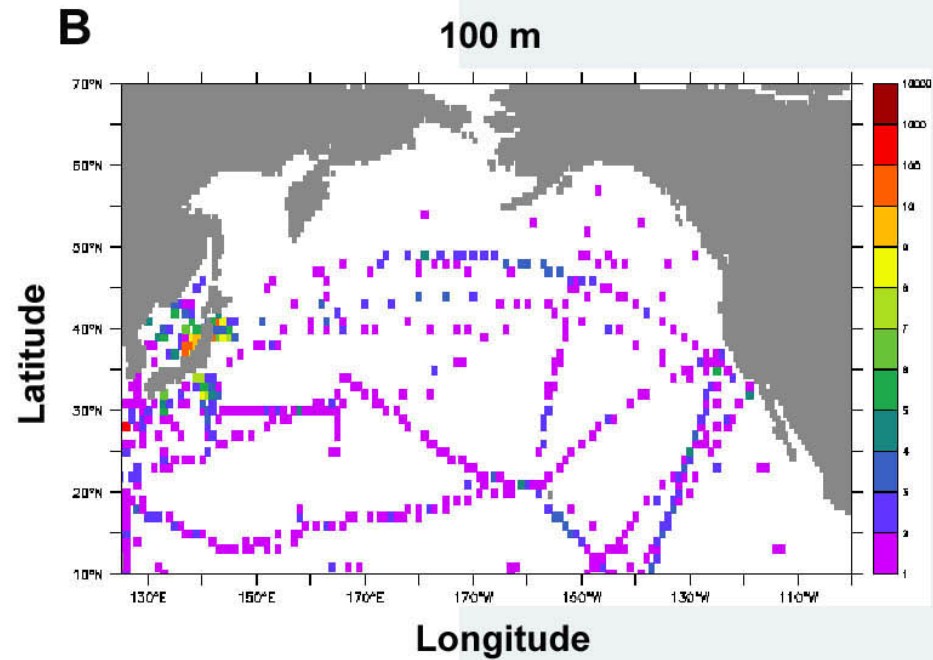
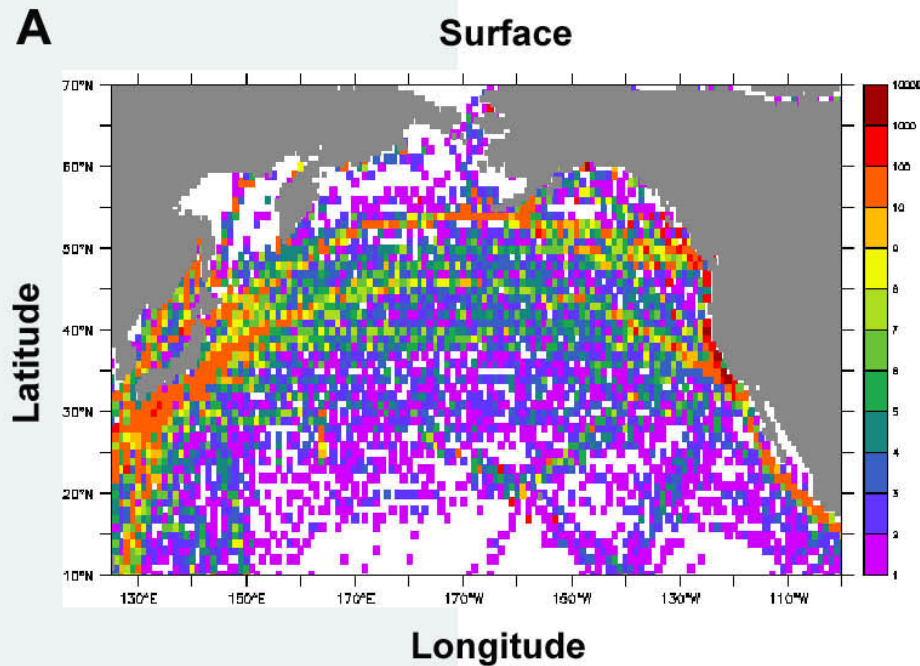


From Costa Lab, UCSC

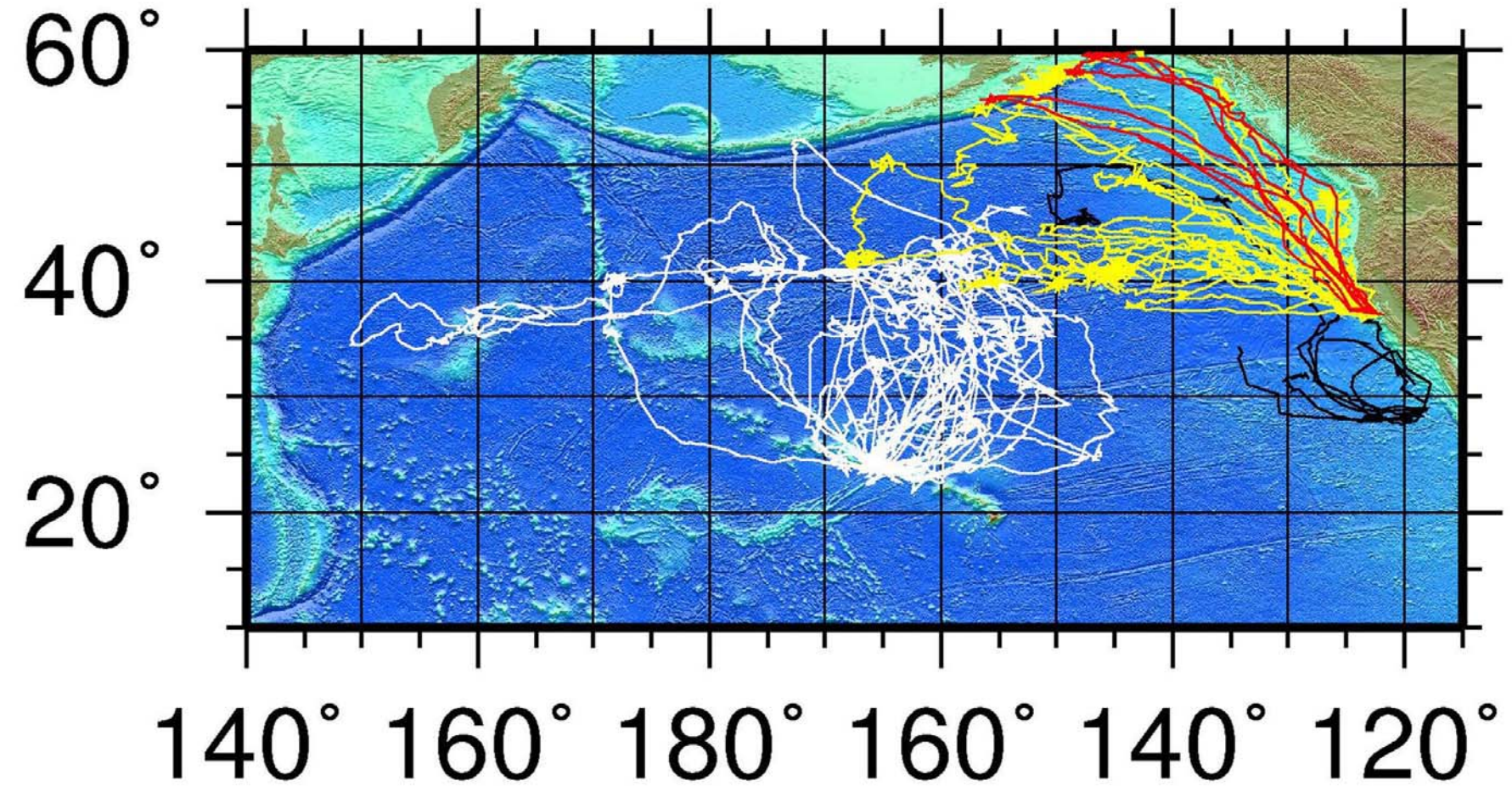
Elephant seal Behavior Associated with Front



Temperature Profiles of North Pacific September 2000

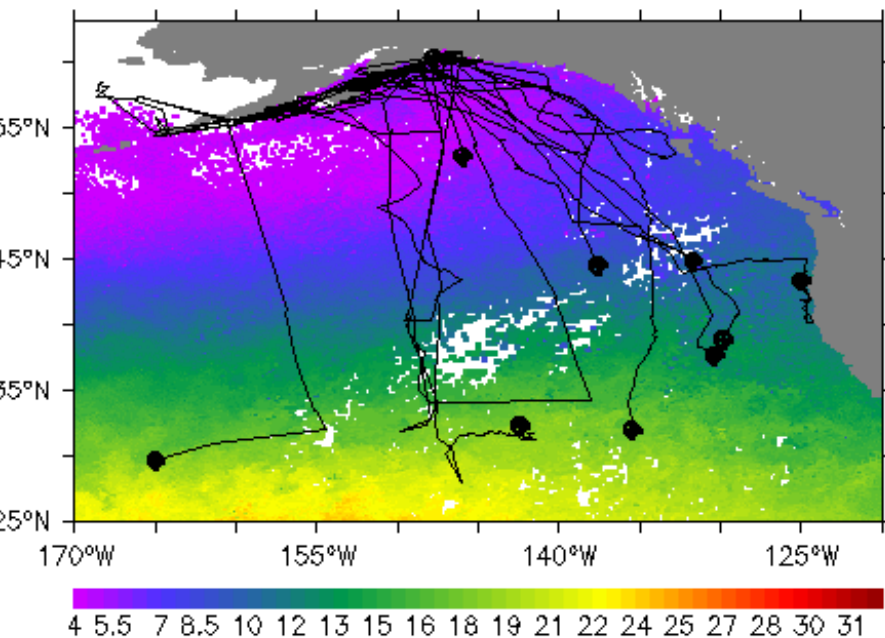


Animal Loggers Cover the North Pacific

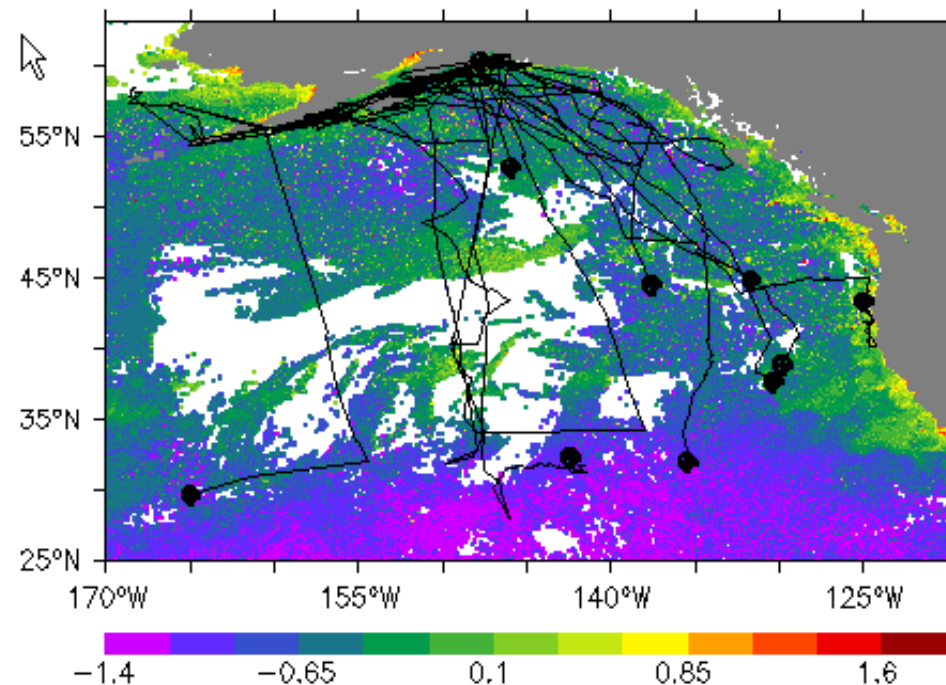


Salmon Sharks on SST and MODIS Live Daily!

AVHRRgac: 2-MAR-2004 to 10-MAR-2004



MODIS: 29-FEB-2004 to 8-MAR-2004



From TOPP Shark Team, Stanford/PFEL

What is the Oceanographic Basis for Biological Hot Spots ?

- Identify hot spots from animal tracks
- Identify ocean characteristics of hot spots
- Census of ocean features
 - Stability and predictability of hot spots*
 - Distribution of utilized and unutilized features*
- Understand multi-species utilization of ocean habitat
 - Behavioral changes associated with hotspots*
 - Cues animals actually detect*
 - Inter-, intra-species interactions, utilization*
- Develop and test models for predicting animal abundance and distribution based on ocean features
- Contribute oceanographic data to global ocean data base

Advance from Correlation to Mechanisms of Hot Spots

The background of the slide is a photograph showing a large fish, possibly a Pacific halibut, being held by a person's hand on a blue boat. The fish is silvery with a dark stripe along its side and a prominent dark eye. The boat's blue tarp and white rope are visible in the foreground.

Acknowledgements

- The Block Lab - HMS
- UC-Santa Cruz
- PFEL - D. Foley
- Monterey Bay Aquarium
- PIFSC - J. Polovina, E. Howell
- ONR NOPP
- Sea Grant
- NOAA Ocean Exploration
- Moore Foundation
- Monterey Bay Aquarium Foundation
- Packard Foundation
- Sloan Foundation
- NOAA NMFS

Comparison of Technologies

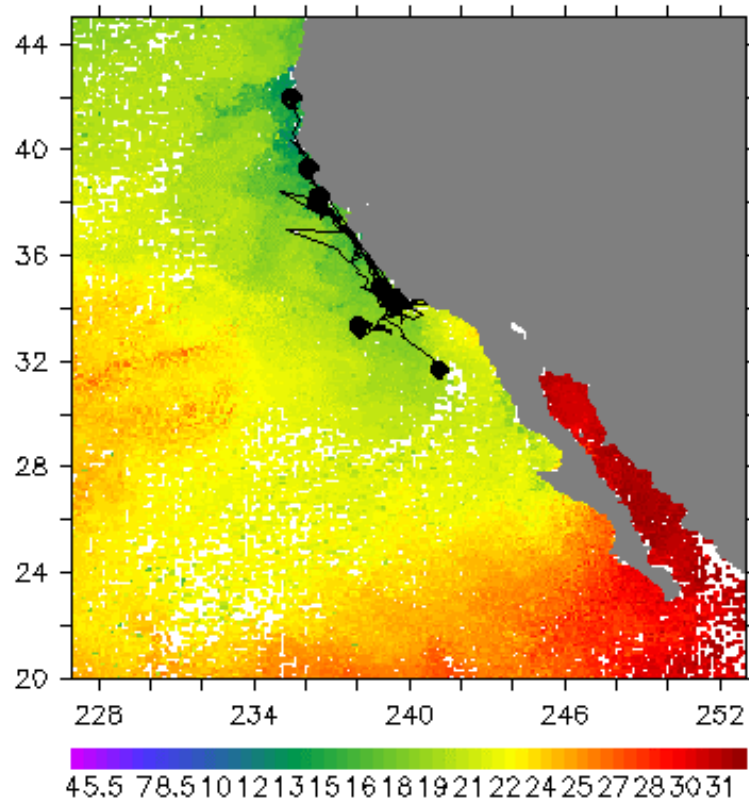
- **WOCE Collected 40,000 XBT profiles 1990-98**
- **ARGO will collect 3,000 profiles every 10 days (1 profile per 10 days per float) or 100,000 CTD profiles per year**
- **1 Argo float will provide 100 profiles**
- **One elephant seal collects 60 per day or 5 per day satellite linked**
- **100 seals deployed for 6 months = 1.2 million CTD profiles of North Pacific**

Blue Whale

Humpback Whale

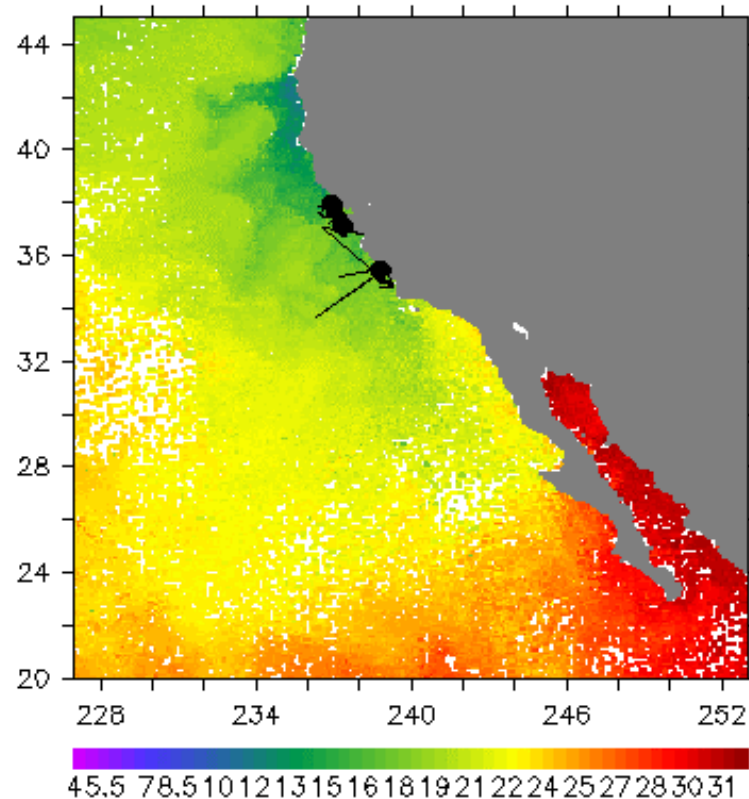
5-Sep-2004

AVHRR: 26-AUG-2004 to 3-SEP-2004



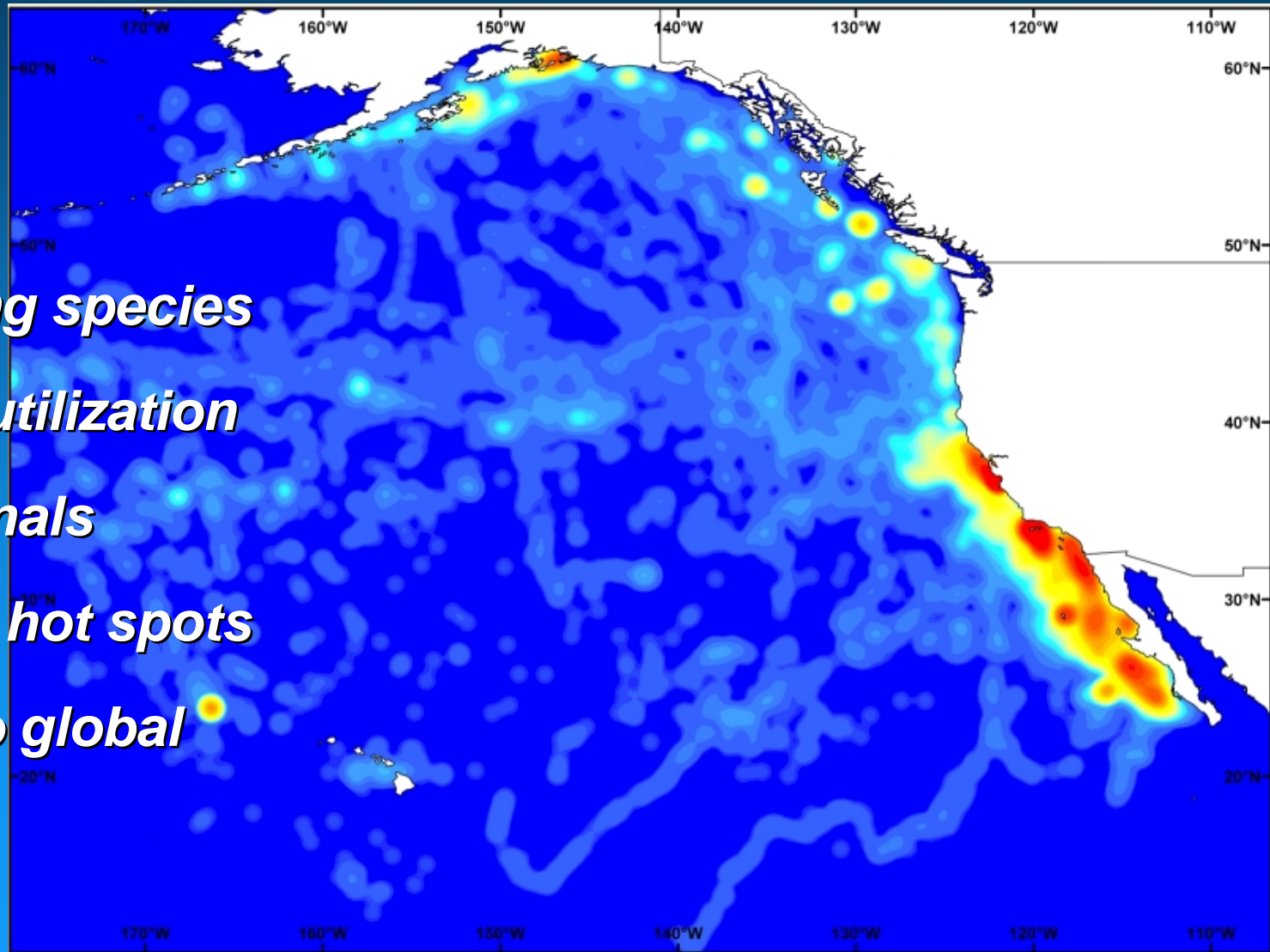
10-Sep-2004

AVHRR: 1-SEP-2004 to 9-SEP-2004



Tagging of Pacific Pelagics: Identifying Physical-Biological Hot Spots

- *22 bio-logging species*
- *Map habitat utilization*
- *ID ocean signals*
- *Variability of hot spots*
- *Contribute to global database*



TOPP Species

- **Air Breathing Vertebrates**

- N. Elephant seal

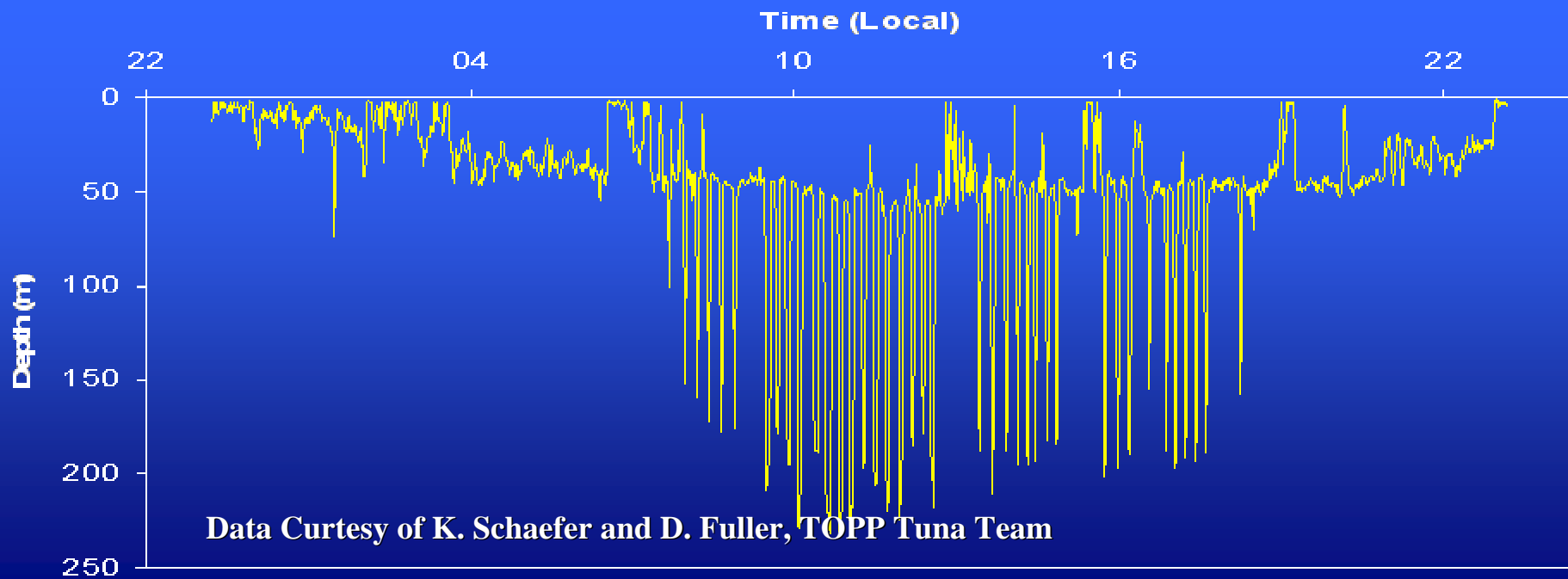
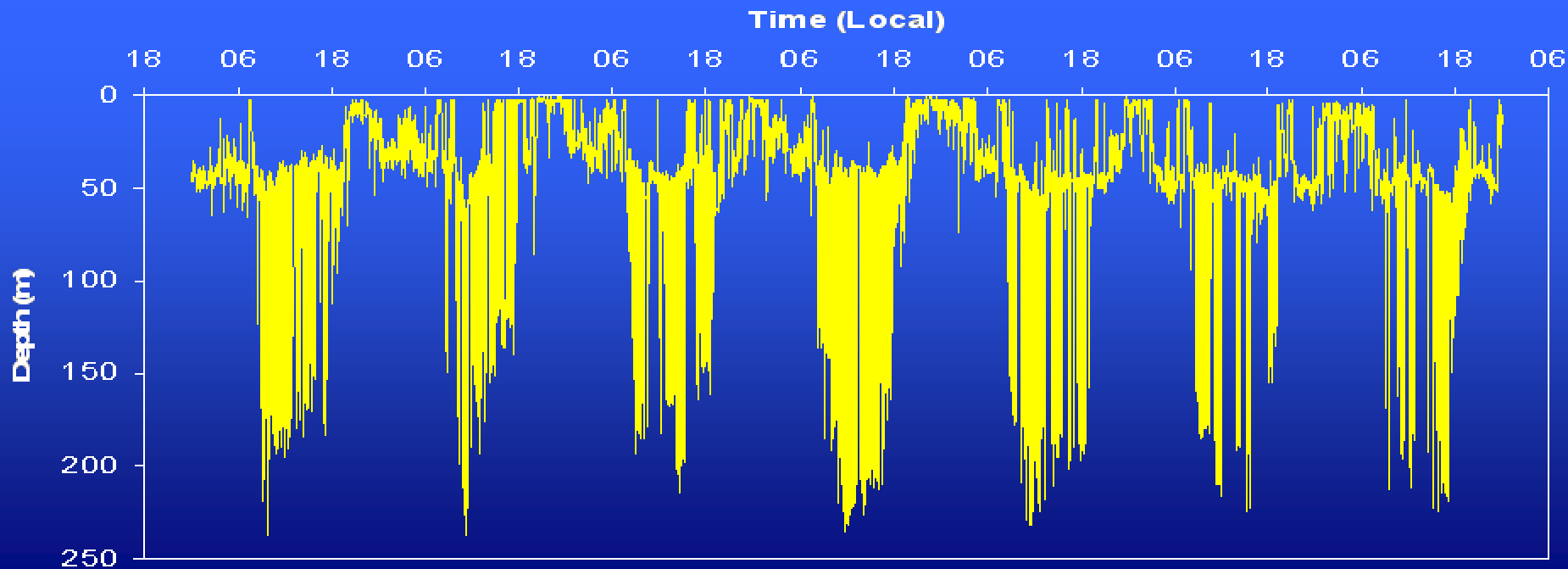
- Leatherback Turtle
 - Loggerhead Turtle
 - Black footed Albatross
 - Laysan Albatross
 - Blue whale
 - Humpback whale
 - Fin Whale
 - California sea lion
 - Sperm whale
 - **Shearwaters**

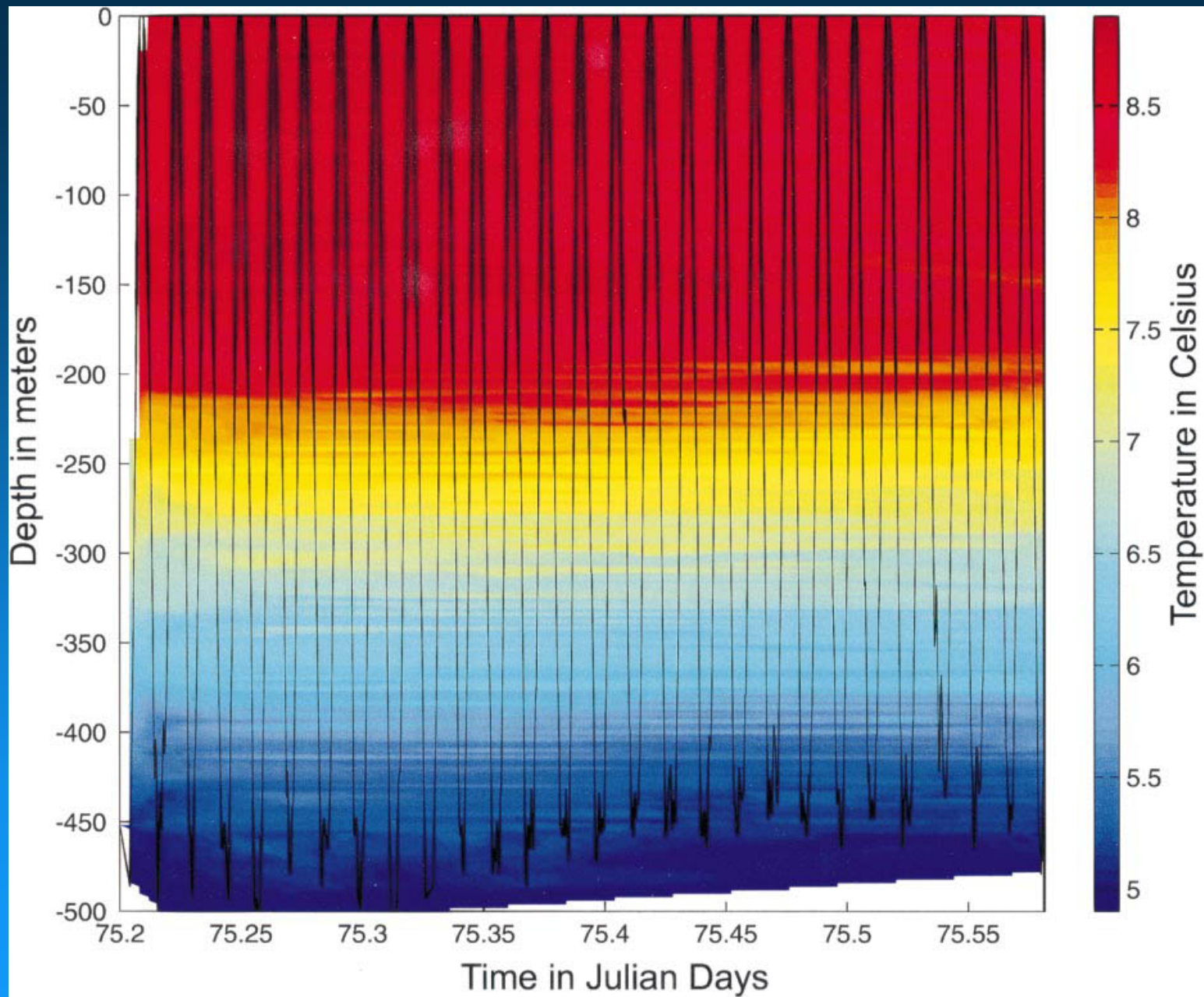
- **Fishes and Squid**

- Pacific *Bluefin tuna*

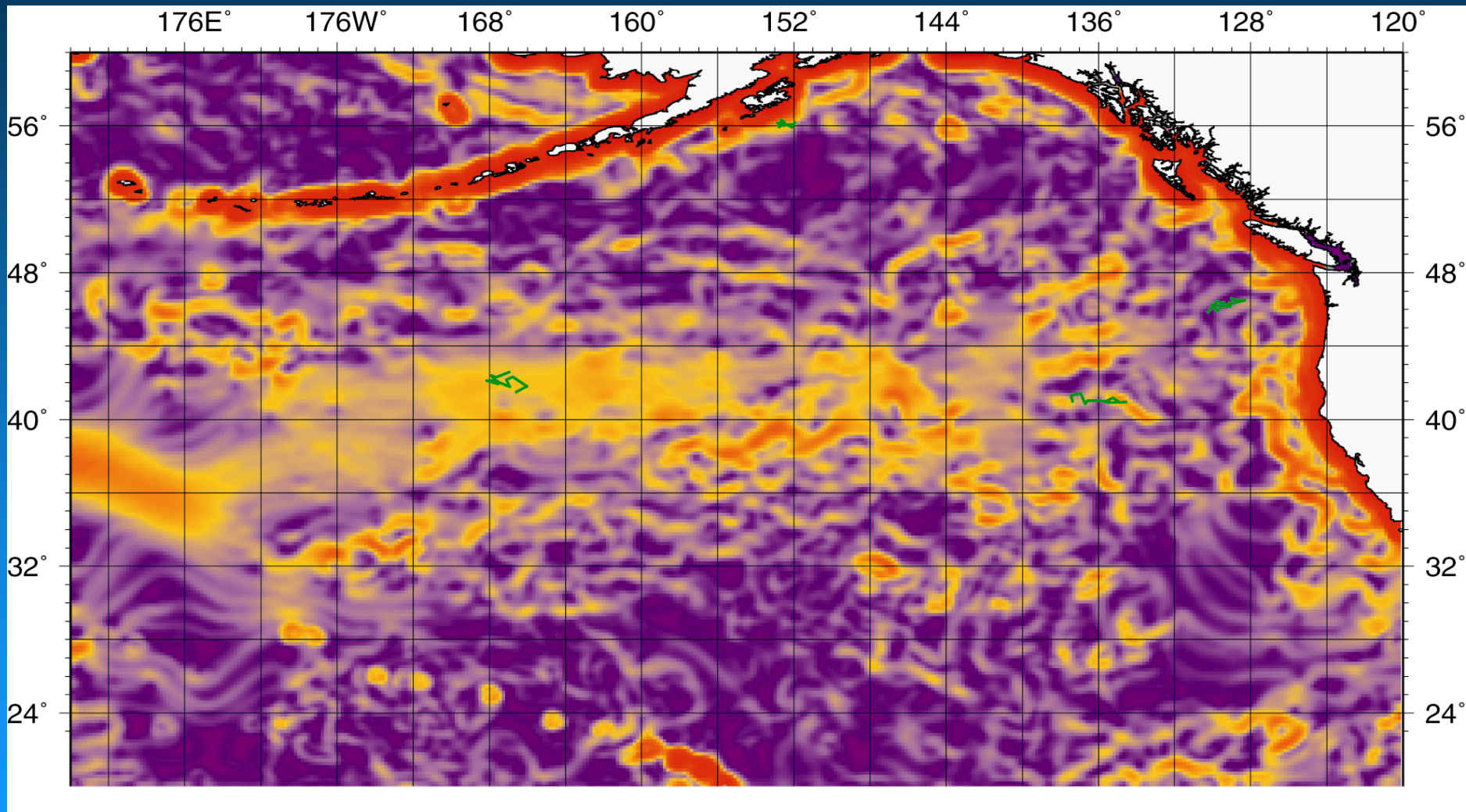
- Blue shark
 - Salmon shark
 - Yellowfin tuna
 - Albacore tuna
 - Dosidicus* squid
 - White shark
 - Mola
 - Thresher shark
 - Basking & whale sharks**
 - Swordfish/Marlin**





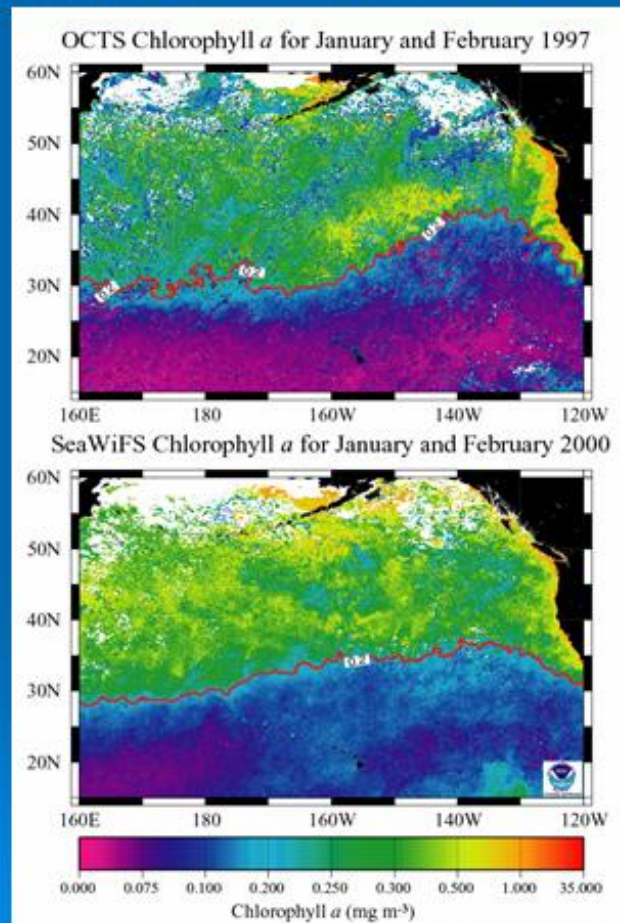


Elephant Seal Foraging in SST Gradient Field



North Pacific Transition Zone Chlorophyll Front

TRANSITIONAL ZONE CHLOROPHYLL FRONT TZCF



Polovina et al. (2001)

- TZCF affected by El Niño
- Key forage habitat
- Migratory corridor for:
 - turtles
 - albacore tuna
 - albatross
- Changes in location affect:
 - International fisheries
 - Gear interaction with endangered turtles
 - Productivity NW Hawaiian islands