Integrating Satellite Data into Ecosystem-based Management of Living Marine Resources

Cara Wilson

NOAA • NMFS • SWFSC
Environmental Research Division
Pacific Grove, CA

Integrating Satellite Data into Ecosystem-based Management of Living Marine Resources

Bograd, Brodziak, Methot, Shotwell et al.

NOAA • NMFS

Integrating Satellite Data into Ecosystem-based Management of Living Marine Resources

- A joint NASA/NOAA workshop held at MBARI, Moss Landing, CA, May 3-5, 2006
- Primary objective was to demonstrate the potential for satellite data to support and enhance NOAA's Ecosystem-based Management of LMRs.
- Representation from each of NOAA/NMFS's six regional science centers
- Four pilot projects were developed

Integrating Satellite Data into Ecosystem-based Management of Living Marine Resources

PROJECTS

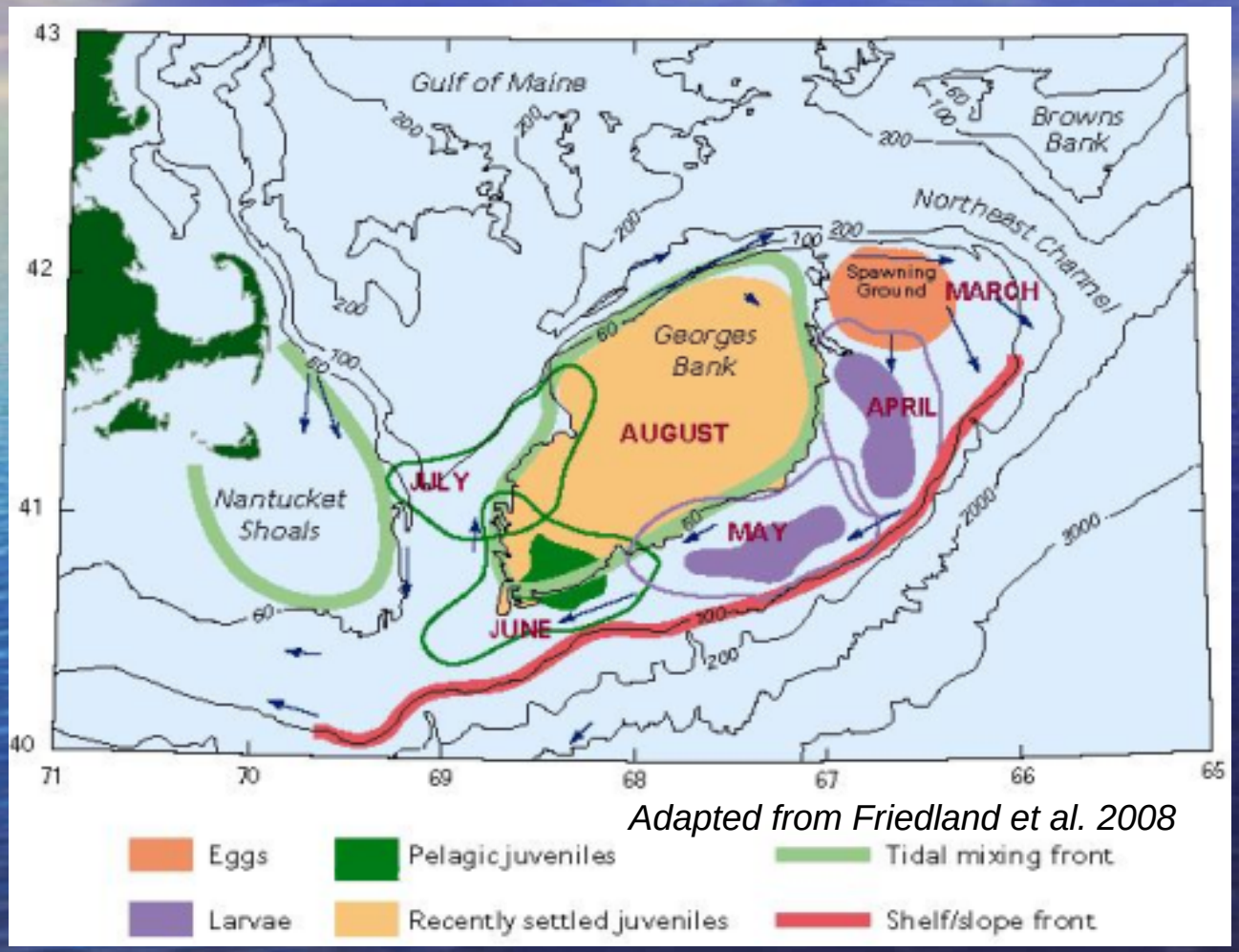
- Using satellite data to improve short-term recruitment predictions for Georges Bank cod (*Gadus morhua*) and haddock (*Melanogrammus aiglefinus*) stocks
  PI: Jon Brodziak (PIFSC)
- Reducing uncertainty in Alaskan sablefish recruitment estimates
  PI: Kalei Shotwell (AFSC)
- Integrating environmental, fisheries, and electronic catch tag data to characterize essential turtle habitat in areas of significant bycatch
  PI: Steven Bograd (SWFSC with PIFSC & NEFSC)
- Improving rebuilding plans for overfished west coast fish stocks through inclusion of climate information
  PI: Rick Methot (NWFSC)

Project: Georges Bank Cod & Haddock

Using Satellite Data to Improve Short-Term Recruitment Predictions

Jon Brodziak PIFSC

General Distribution of Georges Bank Cod and Haddock Early Life History Stages

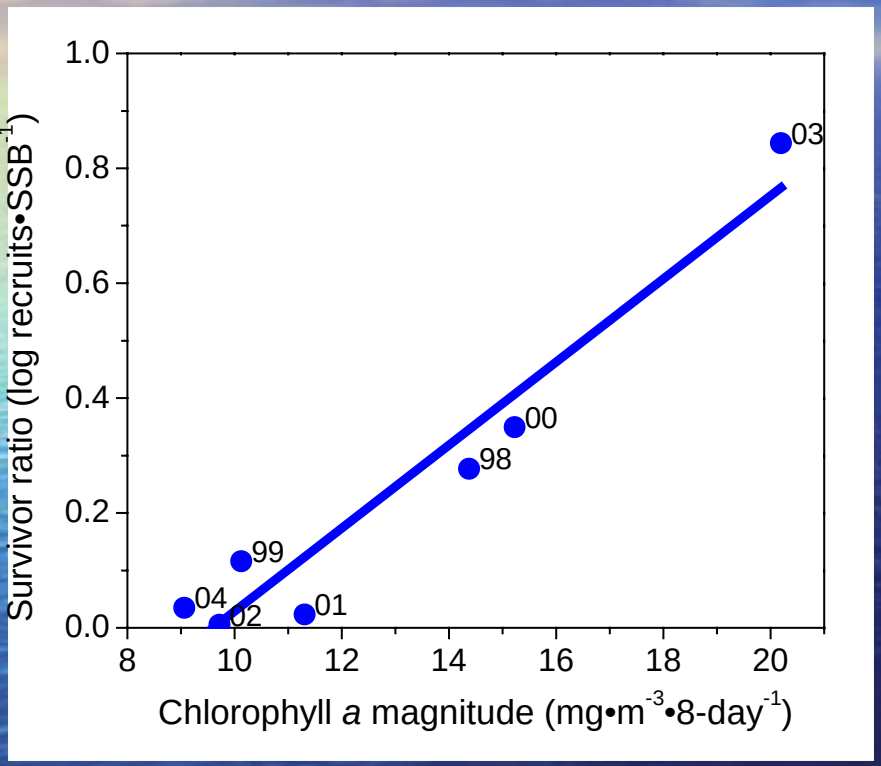


Adapted from Friedland et al. 2008

What determines recruitment strength of marine fish stocks?
Early life history survival? Spawner abundance and condition ?

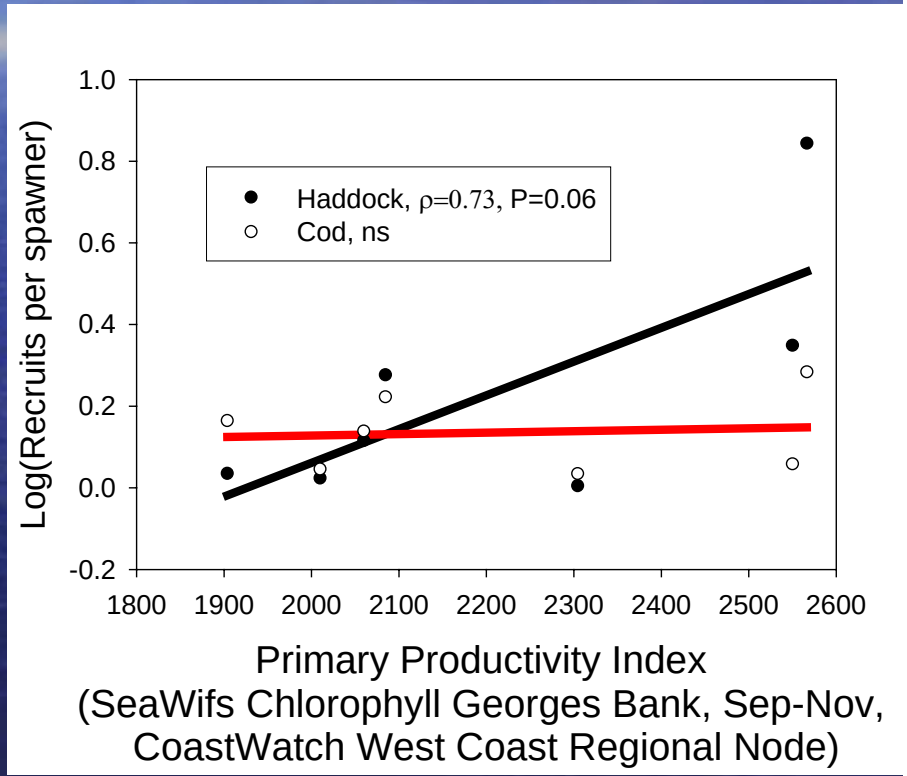
Project: Georges Bank Cod & Haddock

Fall Bloom Hypothesis: Food abundance enhances parental condition and reproductive output



Friedland et al. Does the fall phytoplankton bloom control recruitment of Georges Bank haddock through parental condition? *Can. J. Fish. Aquat. Sci*., in press

Primary Productivity Index: Bottom-up forcing affects fall feeding prior to spring spawning



- Significant positively correlated PP signal across three spatial scales: subregional, Georges Bank region (shown), and superregional
- No signal for Cod

Work in Progress

- Is there a detectable spring bloom effect on survival ratios?
  - Possibly for cod but low N
  - Interannual variation in onset of spawning
  - Dynamic time stratification
- Are wind stresses important relative to other effects?
  - Need to access wind stress measurements
  - QuikSCAT
  - COADS
- Modeling environmental forcing using GAMs to discern shape of nonlinear effects
- Modifying age-structured projection model AGEPRO to incorporate multiple environmental predictors
- Next, Pacific tunas & billfishes…

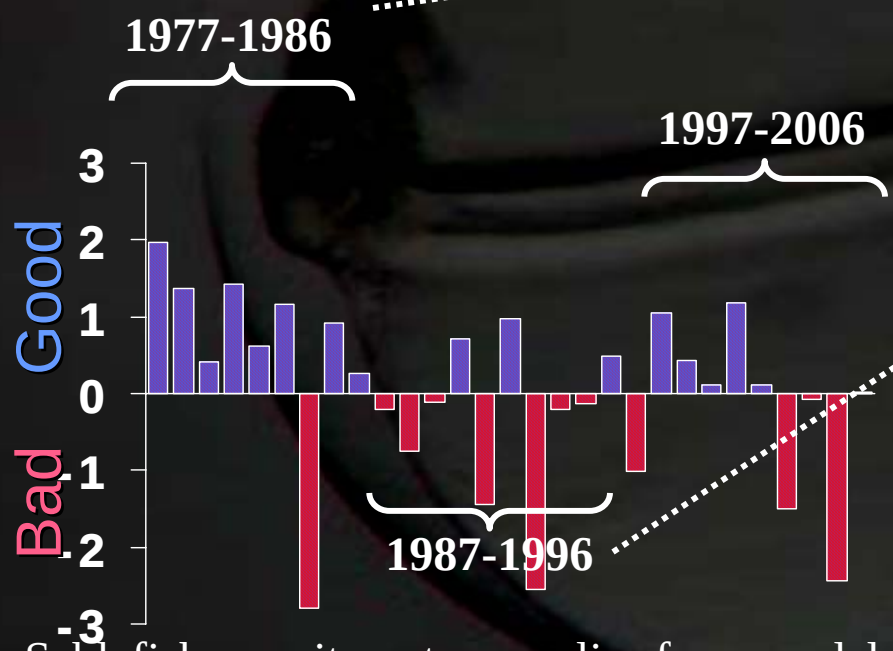
Alaskan Sablefish Project

Authors: S. Kalei Shotwell & Dana H. Hanselman

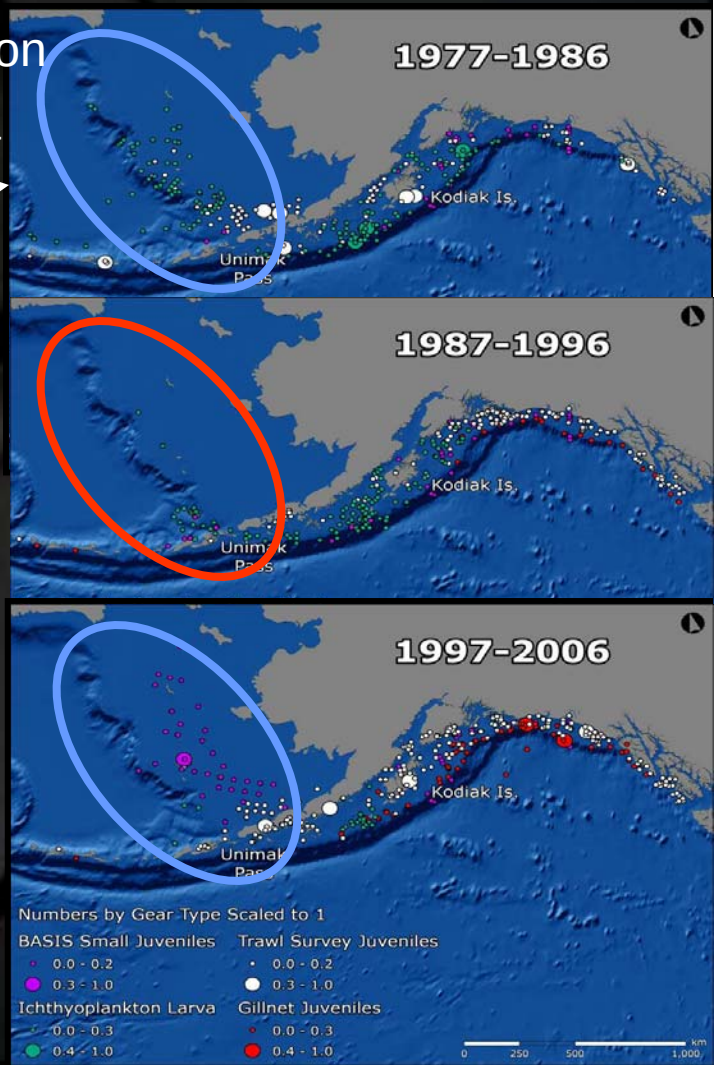
- Sablefish (*Anoplopoma fimbria*)
  - Fast growing, wide distribution, highly valuable commercial species
  - Adults generally at 200+ meters in continental slope, gullies, fjord
- Early life history (ELH) largely unknown
  - Spawning at depth (400+m), larvae swim to surface, collect at shelf break
  - Juveniles move nearshore to overwinter, then offshore in summer
  - Reach adult habitat and recruit to fishery or survey in 4 to 5 years
- Recruitment calculated in age-structured model
  - Recruitments are estimated as two year-olds
  - Estimates for most recent years are highly variable with large uncertainty and excluded from model projections
- Objective
  - Evaluate ELH data and explore integrating satellite derived environmental time series into the sablefish stock assessment to reduce recruitment uncertainty

Early Life History

- Collected historical ELH survey data and compared to model recruitment
- Model recruitment estimates show high autocorrelation
- Potential decadal regimes, supported by survey data



Sablefish recruitment anomalies from model



Next Steps:

- Identify dominant environmental mechanisms
  - High spatial and temporal variability detected in the ELH surveys imply influence of physical mechanisms on sablefish recruitment
  - Potential mechanisms include:
    - Mesoscale eddy entrainment: variability in food availability
    - Gulfwide freshwater discharge: variability in mixed layer, iron input
  - Use environmental time series developed from satellite data
    - AVHRR Pathfinder V5, front probability, Alaska Stream position
    - Multi-mission altimetry, eddy kinetic energy, eddy position
    - Coastal freshwater discharge northern Gulf of Alaska
- Incorporate into stock assessment model as time series
  - Early detection of recruitment trends
  - Increase efficiency in harvest decisions
  - More reliable future projections

Satellite-derived SST frontal analysis for fisheries management

Ed Armstrong[1], C. Holt[2], R. Methot[4], A. Punt[3], N. Mantua[3] & B. Holt[1]

1 NASA JPL/ California Institute of Technology

2 Fisheries and Oceans Canada

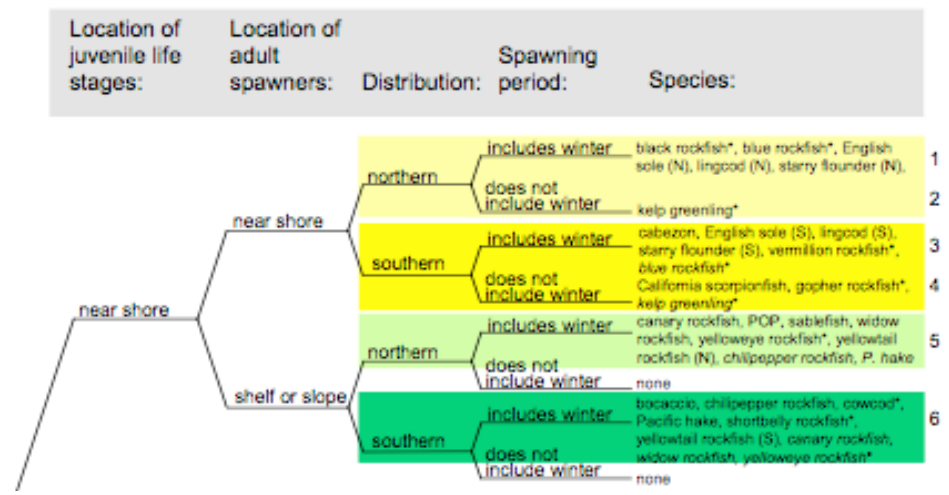
3 University of Washington

4 NOAA NMFS

Goal: Identify biological, chemical, and physical indicators of conditions in the California Current that have influences long-term trends in recruitment of west coast groundfish species

Fish species

- **Black rockfish: 1985-2001**
- **Lingcod N: 1985-2000**
- **English Sole: 1985-2002**
- **Starry Flounder N: 1985-2001**
- **Cabezon N: 1985-2003**
- **Cabezon S: 1985-2003**
- **Lingcod S: 1985-1999**
- **Starry Flounder S: 1985-2003**
- **Canary Rockfish: 1985-2006**
- **Sablefish: 1985-2006**
- **Widow rockfish: 1985-2003**
- **Chilipepper rockfish: 1985-2006**
- **Pacific ocean perch (rockfish): 1985-2002**



Species classified into groups with similar ecological characteristics and geographic distributions

Commercially viable species with long life spans >50 years.

Background

- Various hypothesis on recruitment investigated
  - Variability of the west coast Spring Transition (upwelling commences)
  - Fine scale temporal variability of SST
  - Fine scale spatial variability of SST
- Stock assessment model (NOAA Stock Synthesis II) used to generate recruitment estimates from historical observations of fish catch and surveys

Spring Transition hypothesis

Recruitment success increases when the timing of larval life stages coincides with early spring transition

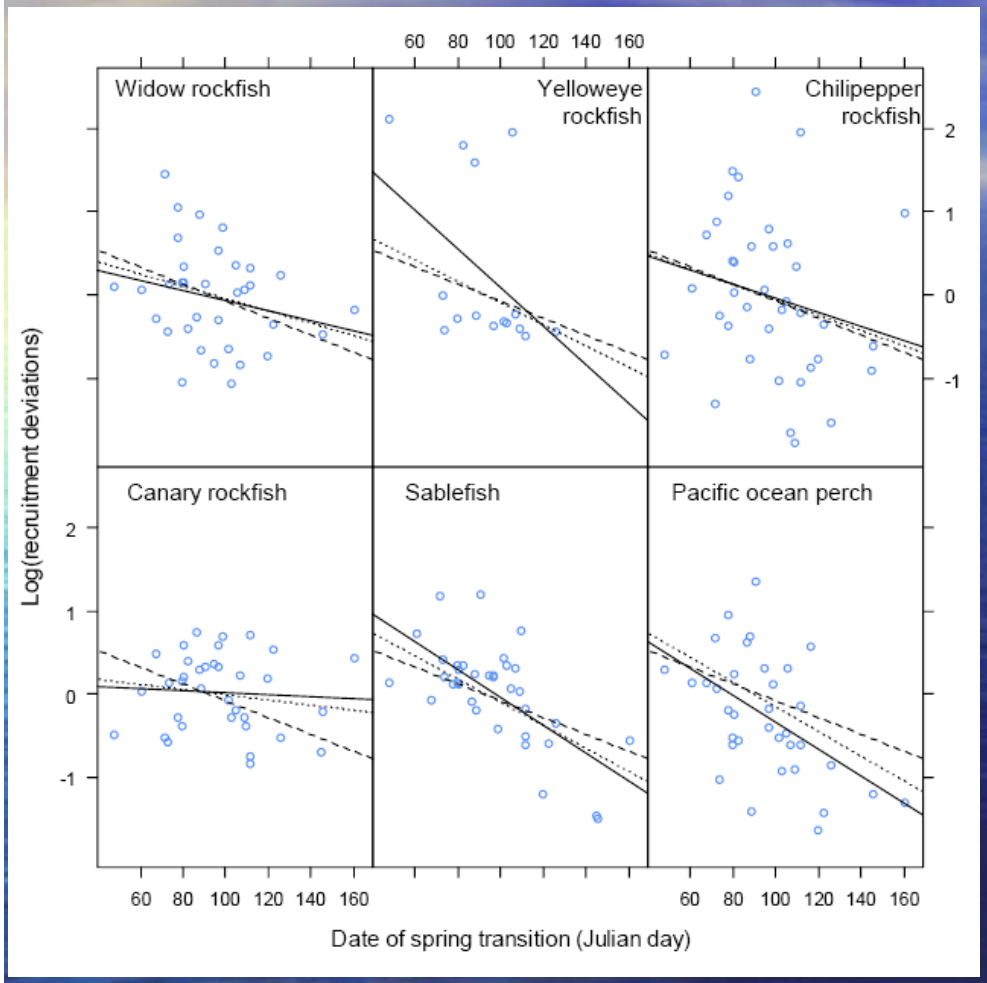
Small scale variability hypothesis

Recruitment is affected by small scale oceanic variability

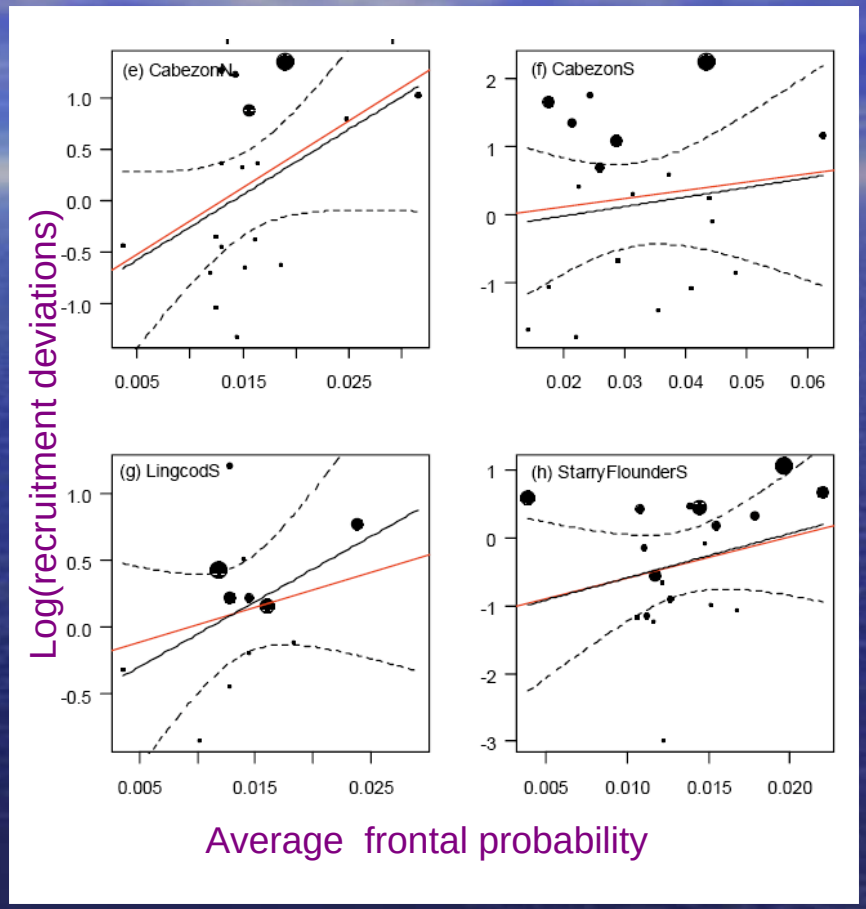
- Temperature fronts, eddies, upwelling centers add habitat complexity and prey availability
- Goal: Use satellite SST gradients as a proxy for these

Project: West Coast Groundfish

Spring Transition hypothesis



Small scale variability hypothesis



Earlier ST linked to higher recruitment, but not significant

Higher recruitment linked to higher front probability, but not significant

Summary

- Both the Spring Transition dates and frontal probability maps correlation to recruitment estimates were not significant at 5% level
  - But some trends were enticing, especially for nearshore spawn/settle species
- Higher resolution SST products such 4 km Pathfinder SST could provide confirmation on possible relationships
  - Long time series is critical
- Additional products such as sea surface height, satellite derived currents, ocean color will also be investigated

Distribution, Movements, and Behaviors of Critically Endangered Eastern Pacific Leatherback Turtles: Conservation Implications for an Imperiled Population

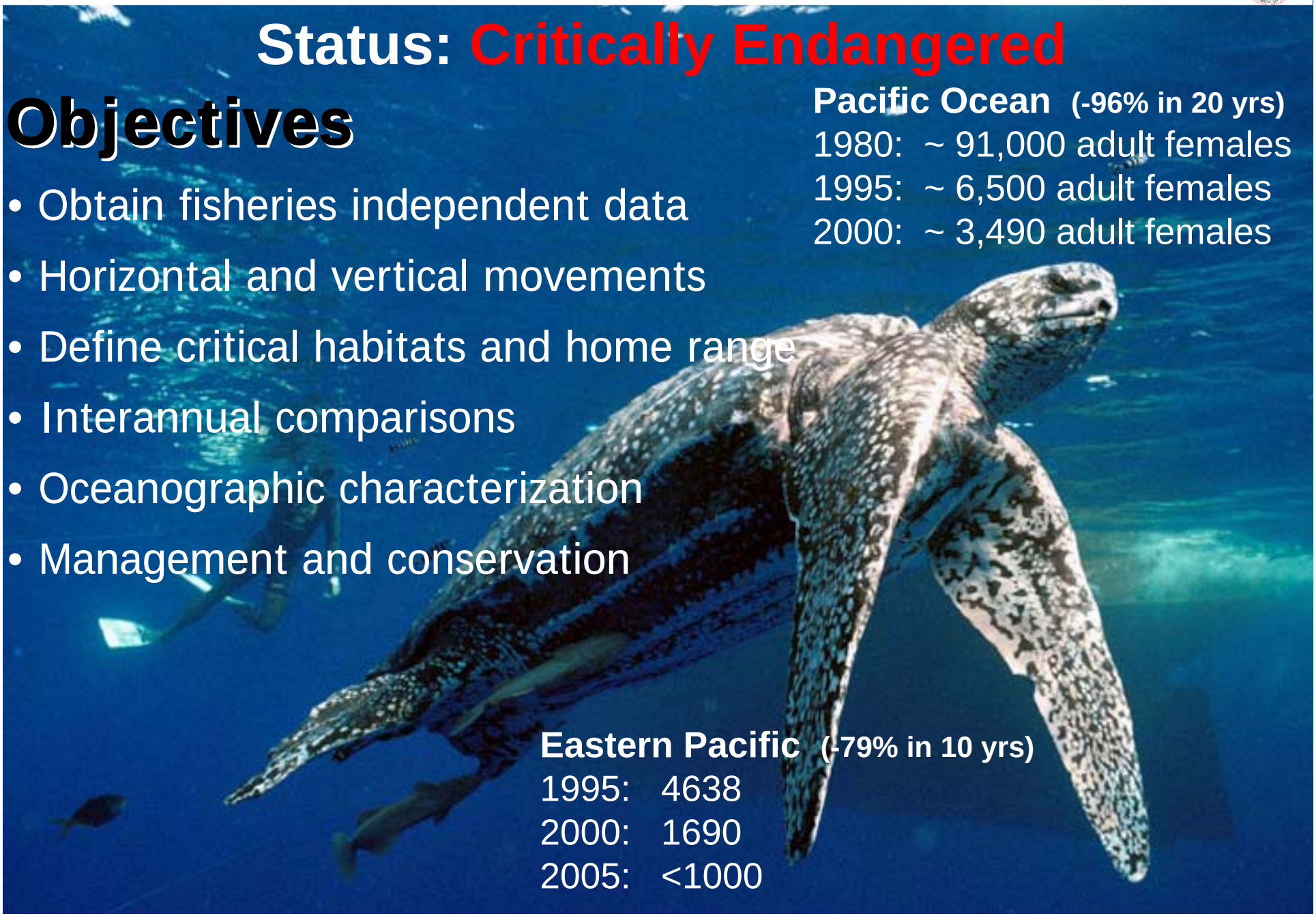
Shillinger, Palacios, Bailey, Bograd
Block Lab, Stanford University
NOAA-SWFSC-ERD

Status: Critically Endangered

Objectives

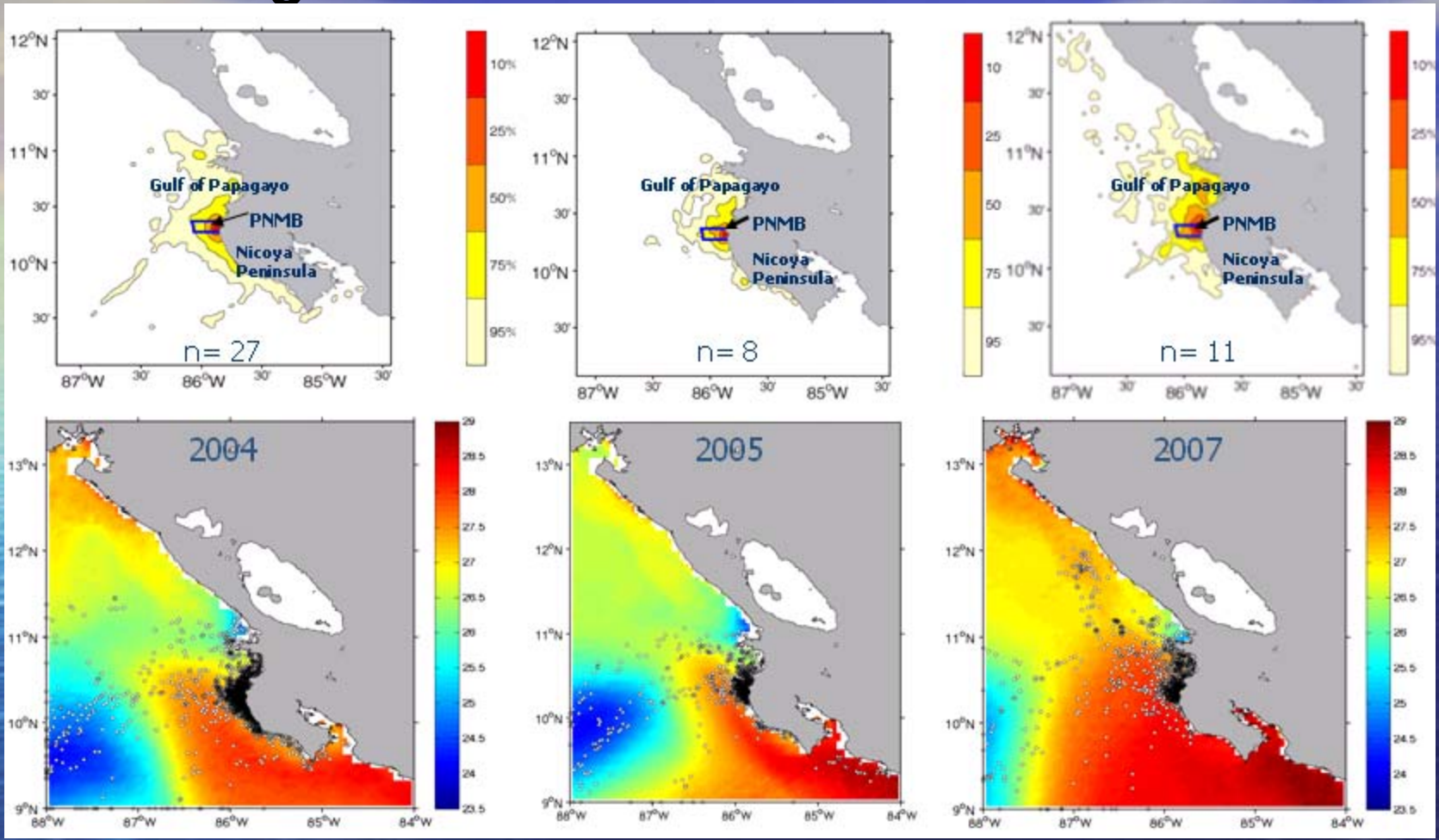
- Obtain fisheries independent data
- Horizontal and vertical movements
- Define critical habitats and home range
- Interannual comparisons
- Oceanographic characterization
- Management and conservation

Pacific Ocean (-96% in 20 yrs)
1980: ~ 91,000 adult females
1995: ~ 6,500 adult females
2000: ~ 3,490 adult females



Eastern Pacific (-79% in 10 yrs)
1995: 4638
2000: 1690
2005: <1000

Internesting Movements and SST



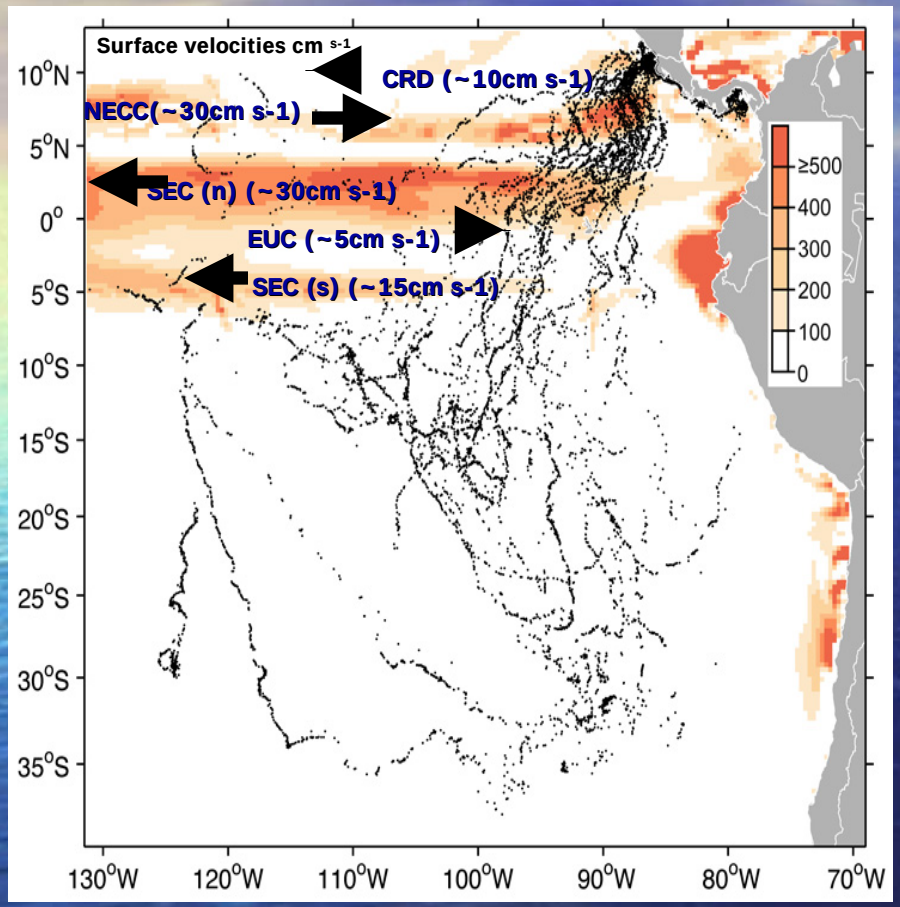
2004
Papagayo upwelling disrupts warm CRCC
Mean depth: 19 m
Mean duration: 9.20 min

2005
Strong Papagayo upwelling (coldest year)
Warm (strong) CRCC
Mean depth: 17.5 m
Mean duration: 9.14 min

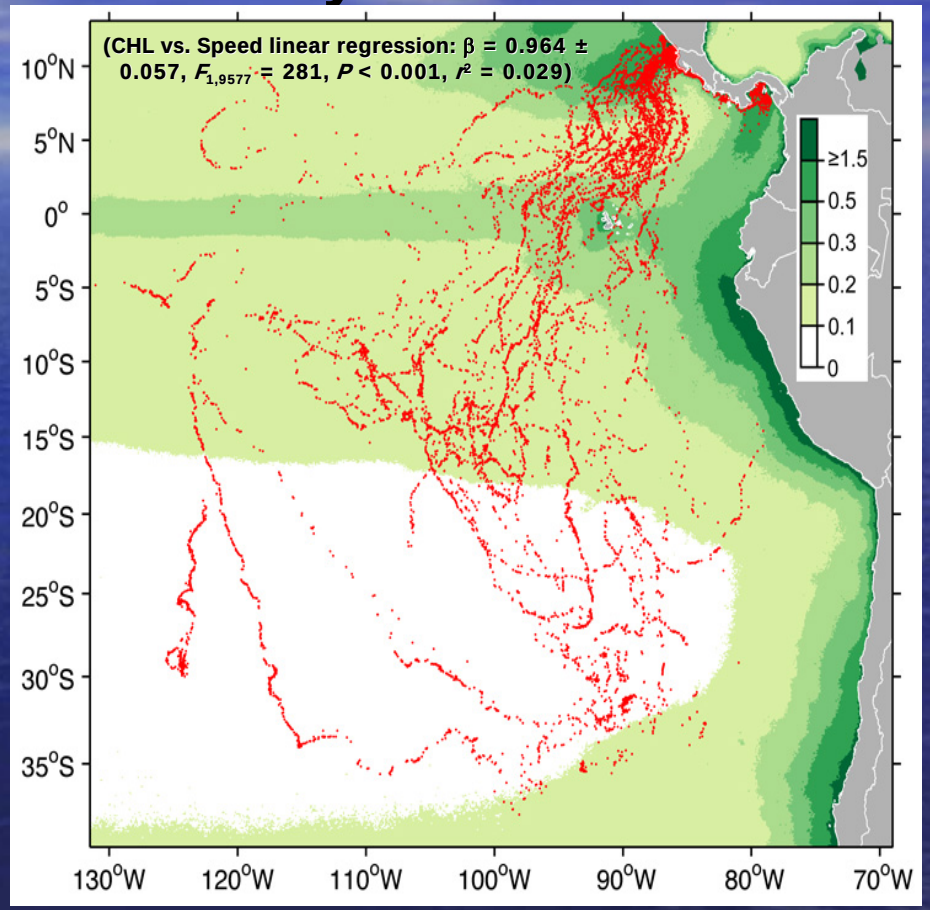
2007
Weak Papagayo upwelling
Warmest (stronger) CRCC
Mean depth: 26.29 m
Mean duration: 12.26 min

Project: Sea Turtles

Mean Kinetic Energy ($cm^2\ s^{-2}$)



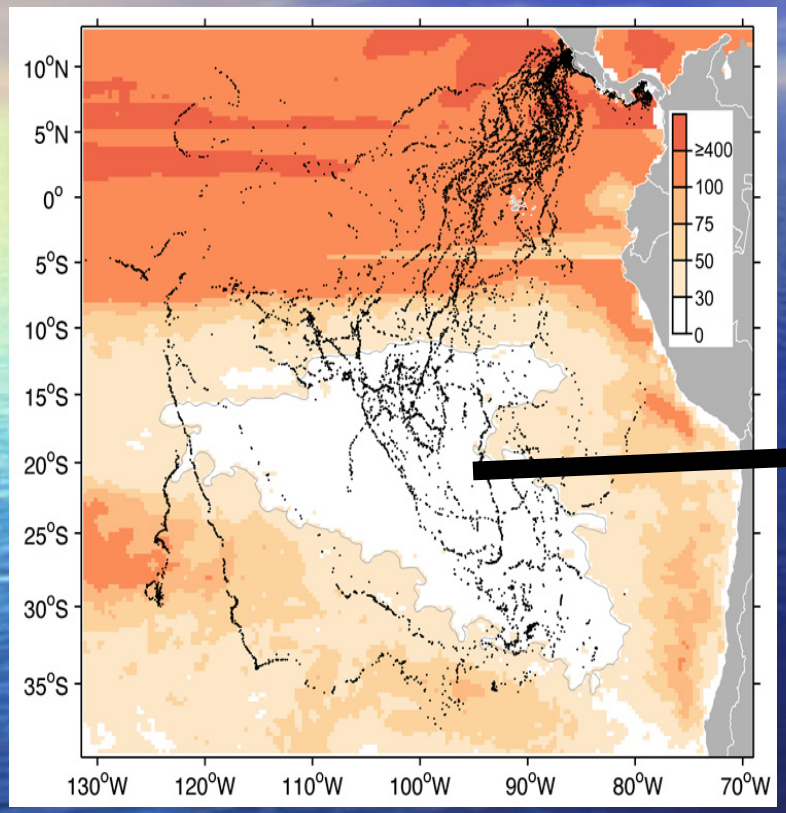
Chlorophyll ($mg\ m^{-3}$) 10 year SeaWiFS

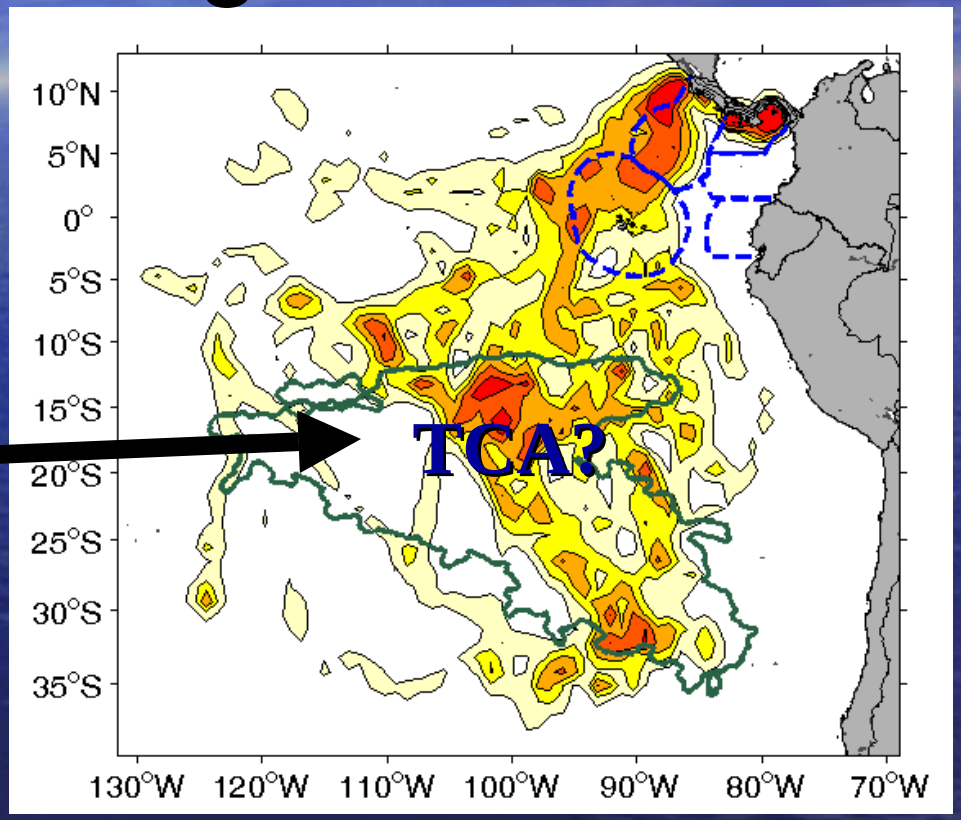


2. Turtles [illegible] of [illegible] currents

3. [illegible] of [illegible] density productivity

Turtle Conservation within EEZ's and on the High Seas?





Green contour enclosing a region with lowest climatological eddy kinetic energy (>30 cm^2/s^2) in the South Pacific Gyre.

1. South Pacific Gyre: reduced mean flow but eddy motions and eddy currents remain
2. A "golden" for turtles resistance, still cut a find food
3. Resource depleted South Pacific
4. Unsecured

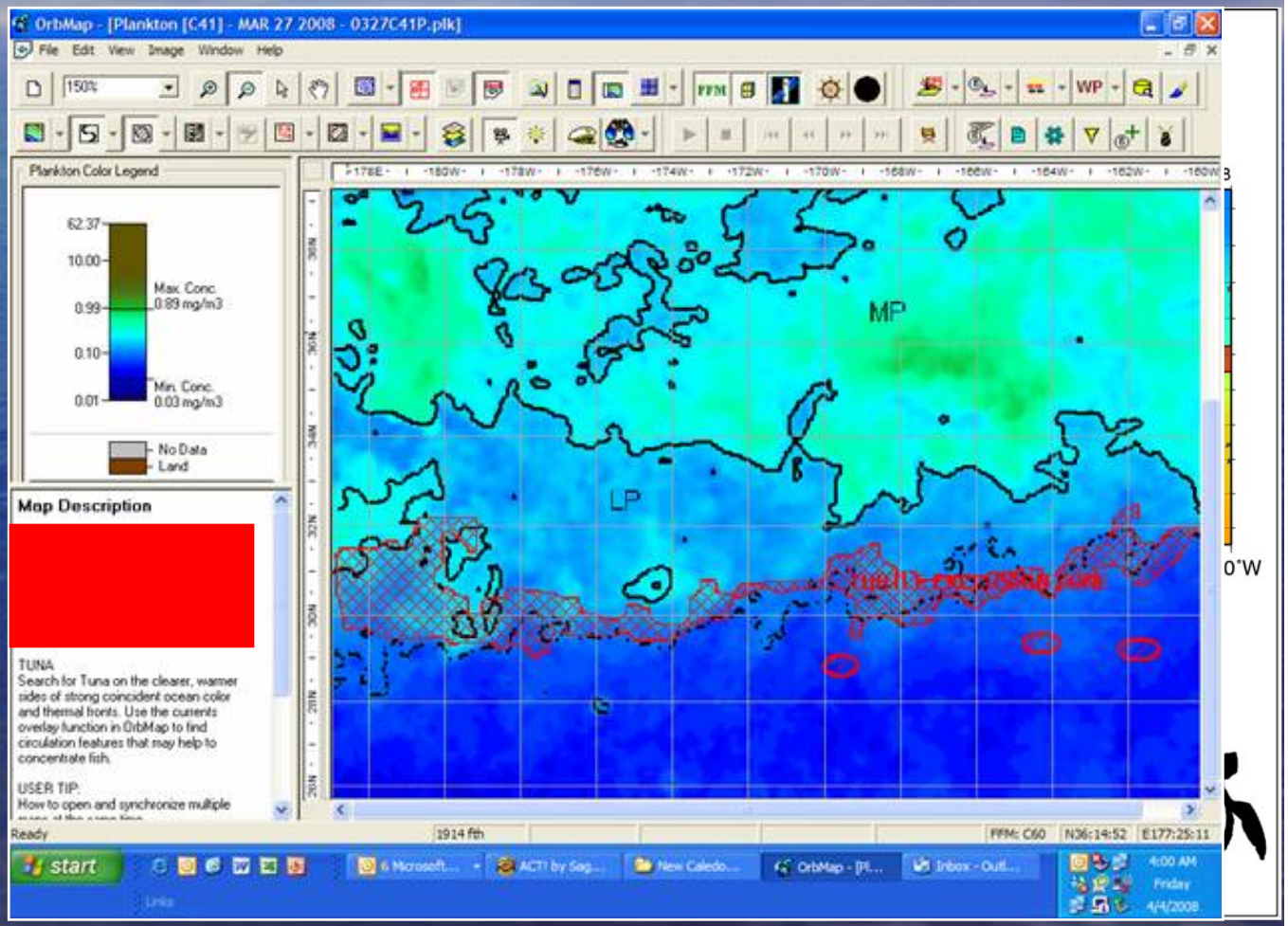
PIFSC TurtleWatch

Based on NESDIS SST (GAC 4 km 3 day average) and JPL Geostrophic Currents (9 km 7 day)

Provided daily by email to industry/managers and hand carried to fishers

Vietnamese version

GeoEye version



We're just getting started.....

ESRI ArcGIS™

&

Satellite data

MISSION: IMPOSSIBLE?

Not anymore!!

EDC™ Environmental Data Connector

an extension for connecting ArcGIS to Thredds/OPeNDAP

- Allows easy selection, and importation of any dataset served by Thredds/OPeNDAP into ArcGIS 9.2
- Developed by Applied Science Associates, Inc.
- Funded by NOAA's Satellite R&O project
- Free distribution

www.pfeg.noaa.gov/products/EDC

Questions??? cara.wilson@noaa.gov

EDC™ Environmental Data Connector

u

- Provides the front-end capabilities of the EDC independent of ArcGIS
- Provides a GUI to browse THREDDS catalogs or OPENDAP directories, to subset the selected data in space and time, and to download the data as a netcdf file
- The EDC Standalone Module will work on any computer with Java 1.5

www.pfeg.noaa.gov/products/EDC

Questions??? cara.wilson@noaa.gov

EDC™ Environmental Data Connector

an extension for connecting ArcGIS to Thredds/OPeNDAP

Rationale:

The continuity, global coverage, and high temporal and spatial resolution of satellite data make it an important tool for monitoring and characterizing marine ecosystems, but data have been largely inaccessible for those working with GIS tools, such as fisheries scientists and marine resource managers.

www.pfeg.noaa.gov/products/EDC

Questions??? cara.wilson@noaa.gov