

# Partnership Research of Marine Turtles at the Pacific Islands Fisheries Science Center: Identifying Loggerhead Pelagic Foraging Ecology



Ecosystems and Oceanography Division (EOD)  
and  
Marine Turtle Research Program (MTRP)



# 赤蠐龟



North Pacific Loggerhead



# Releasing Turtles for Research

海龟放流的研究机会





# PIFSC MARINE TURTLE RESEARCH

## 太平洋島嶼漁業科學中心的海龜研究

- Pelagic ecology of Chinese and Japanese loggerheads for bycatch reduction

台灣與日本赤蠟龜的遠洋生態，以減少混獲



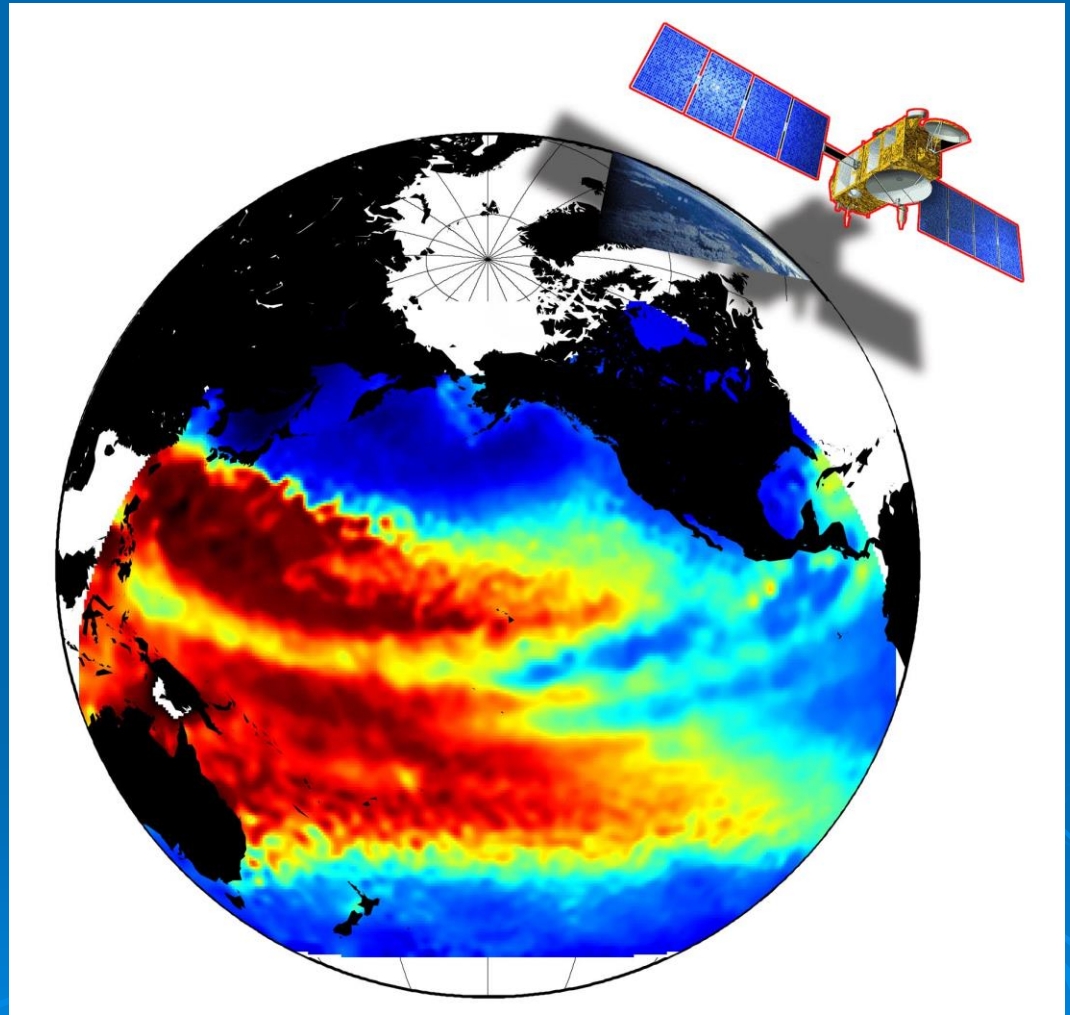
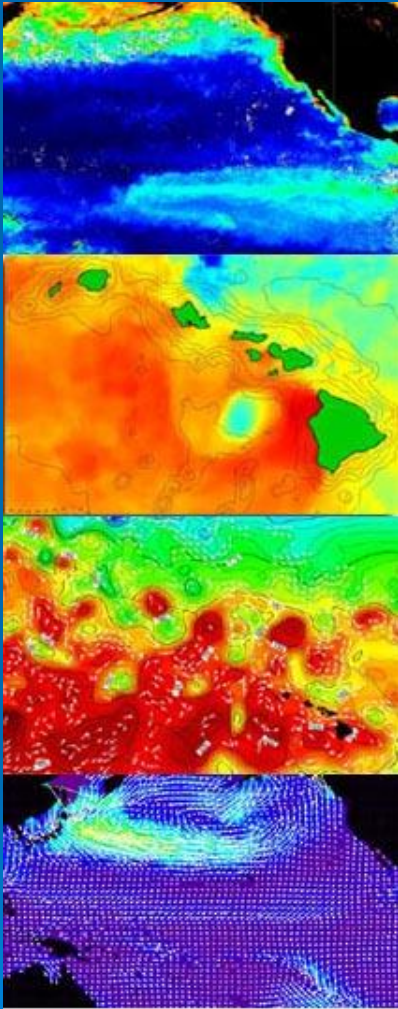




Miniature satellite tags



# Satellite Ocean Imaging











「いしかり」フェリー・オブ・ザ・イヤー  
92～93 11年連続受賞

おかげさまで「いしかり」は、  
船旅専門誌「クルーズ」の  
「読者が選ぶフェリー・オブ・  
ザ・イヤー」を11年連続受賞

NAGOYA

SENDAI

TOMAKOMAI

# 名古屋 ≧ 仙台 ≧ 苫小牧

TOMAKOMAI

ゆとり・優雅・安い船旅

SENDAI

NAGOYA



運賃

平成15年4月1日～7月17日 / 8月25日～平成16年3月31日

ご予約は2ヶ月前から

## 名古屋

隔日運航	翌日
20:00発	17:00着
翌日	隔日運航
09:20着	12:20発

## 仙台

毎日運航	翌日
20:00発	10:45着
翌日	毎日運航
09:20着	19:00発

## 苫小牧











# Choshi City Boso Peninsula

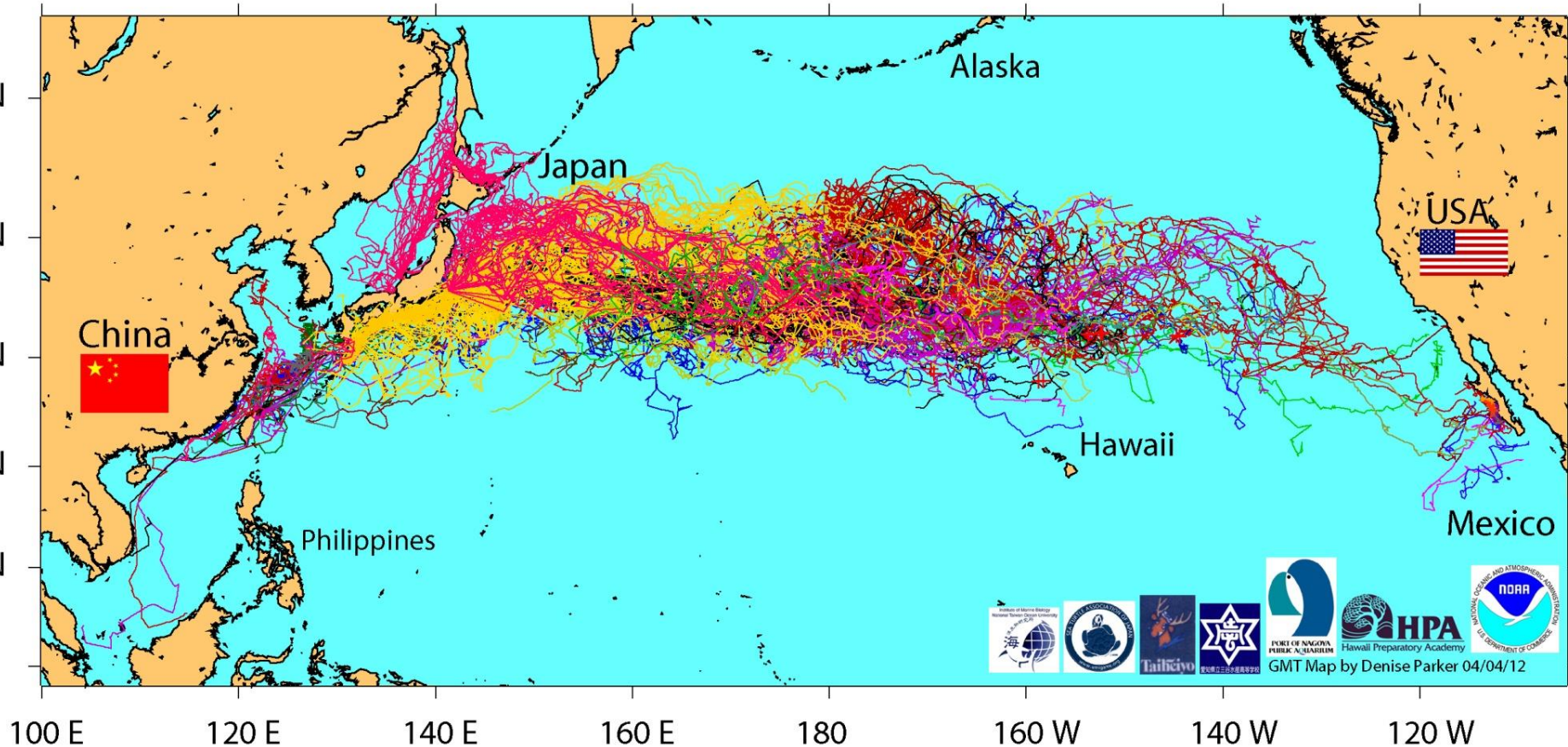






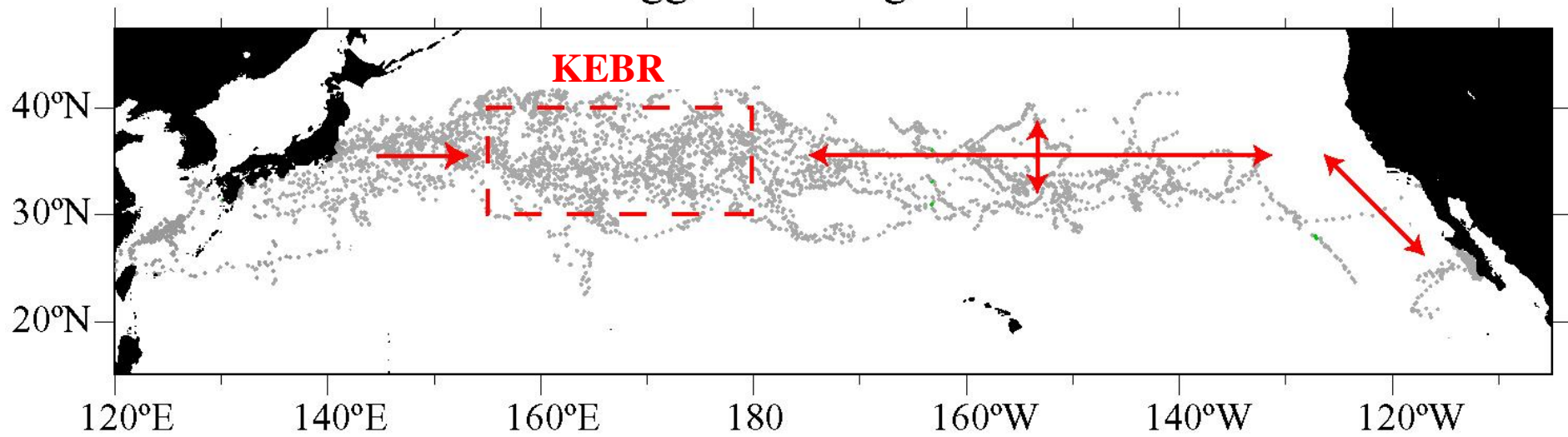


# 1997-2012 Satellite Tracking of Pelagic North Pacific Loggerheads



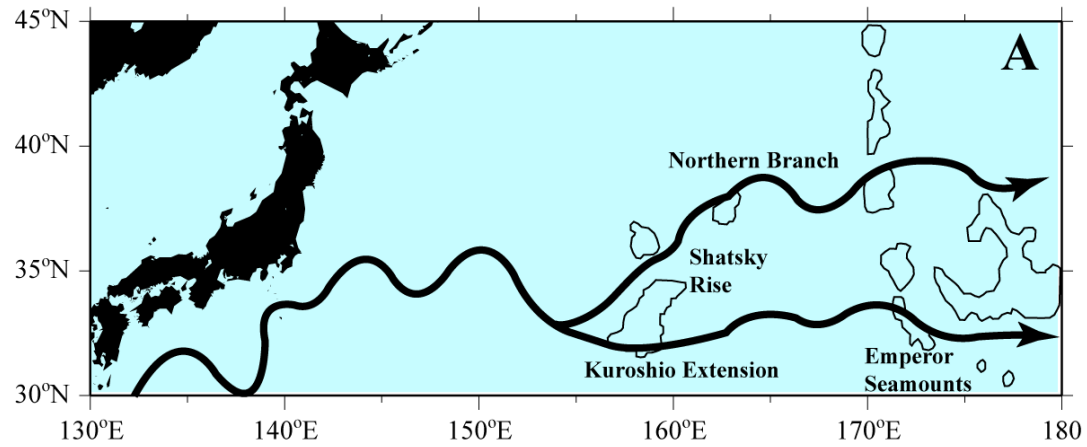


## Juvenile Loggerhead Migration Schematic

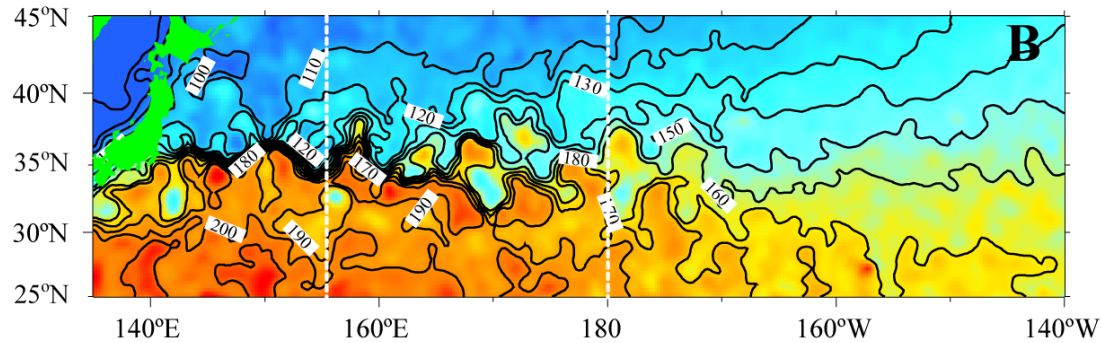




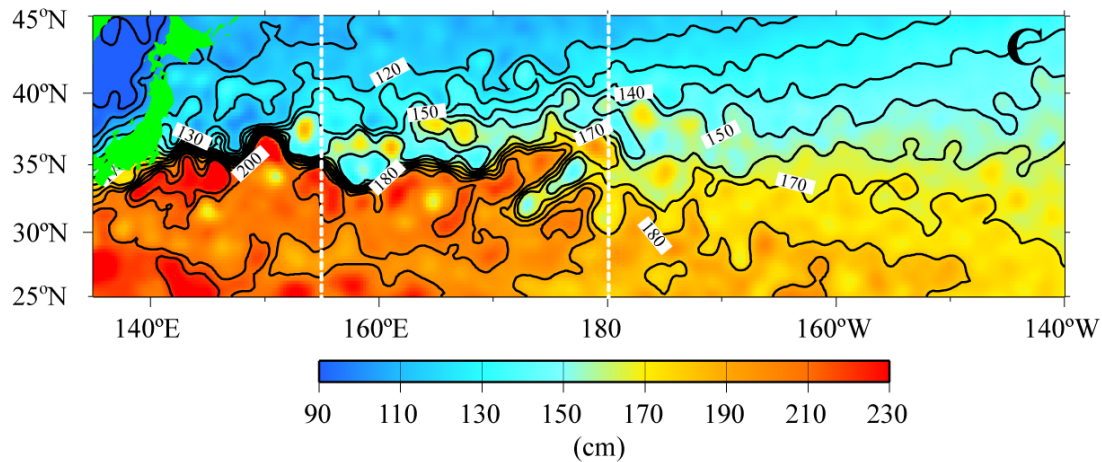
# Schematic of the Kuroshio Extension Bifurcation region (A)



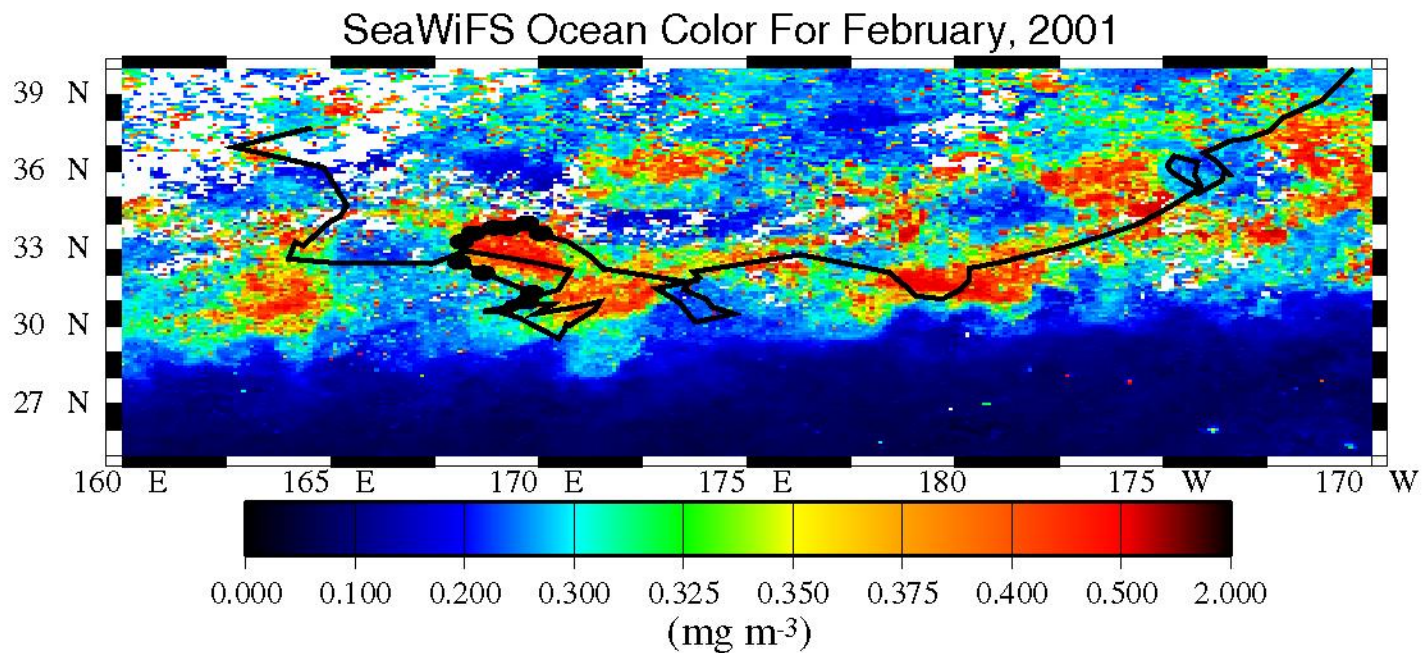
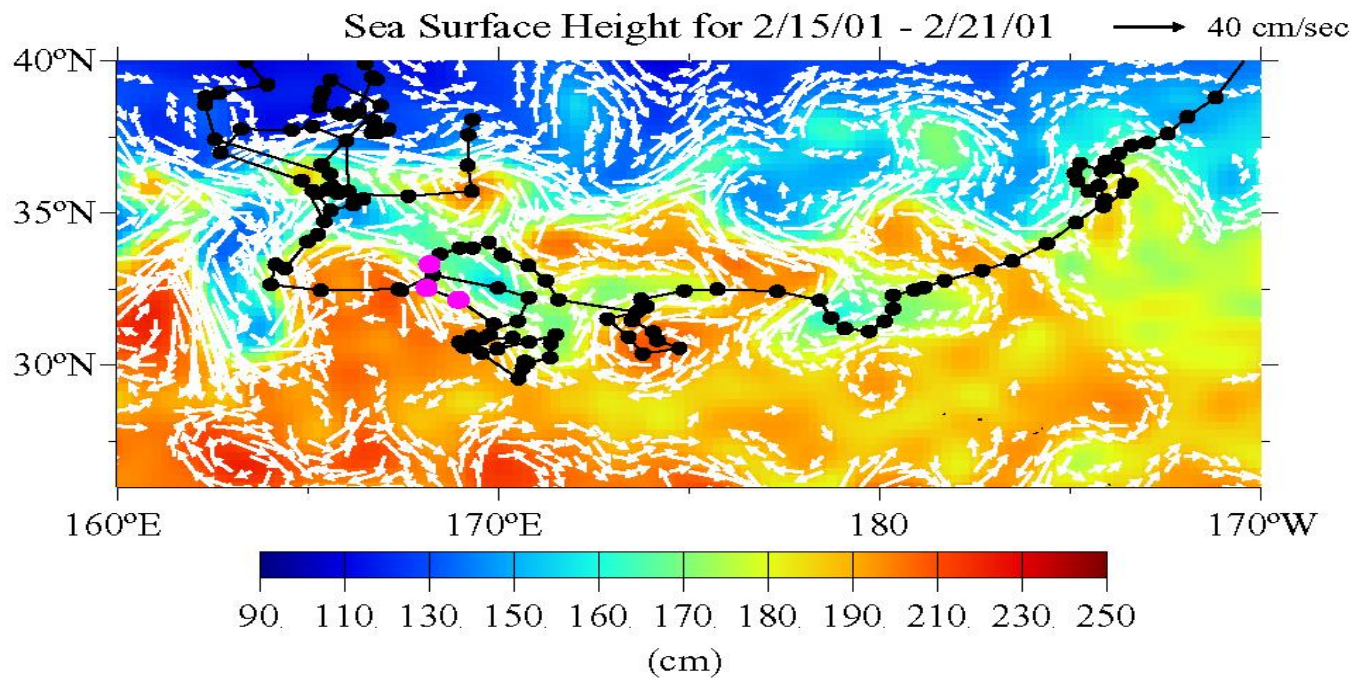
# AVISO altimetry for March 2003



# AVISO altimetry for September 2003

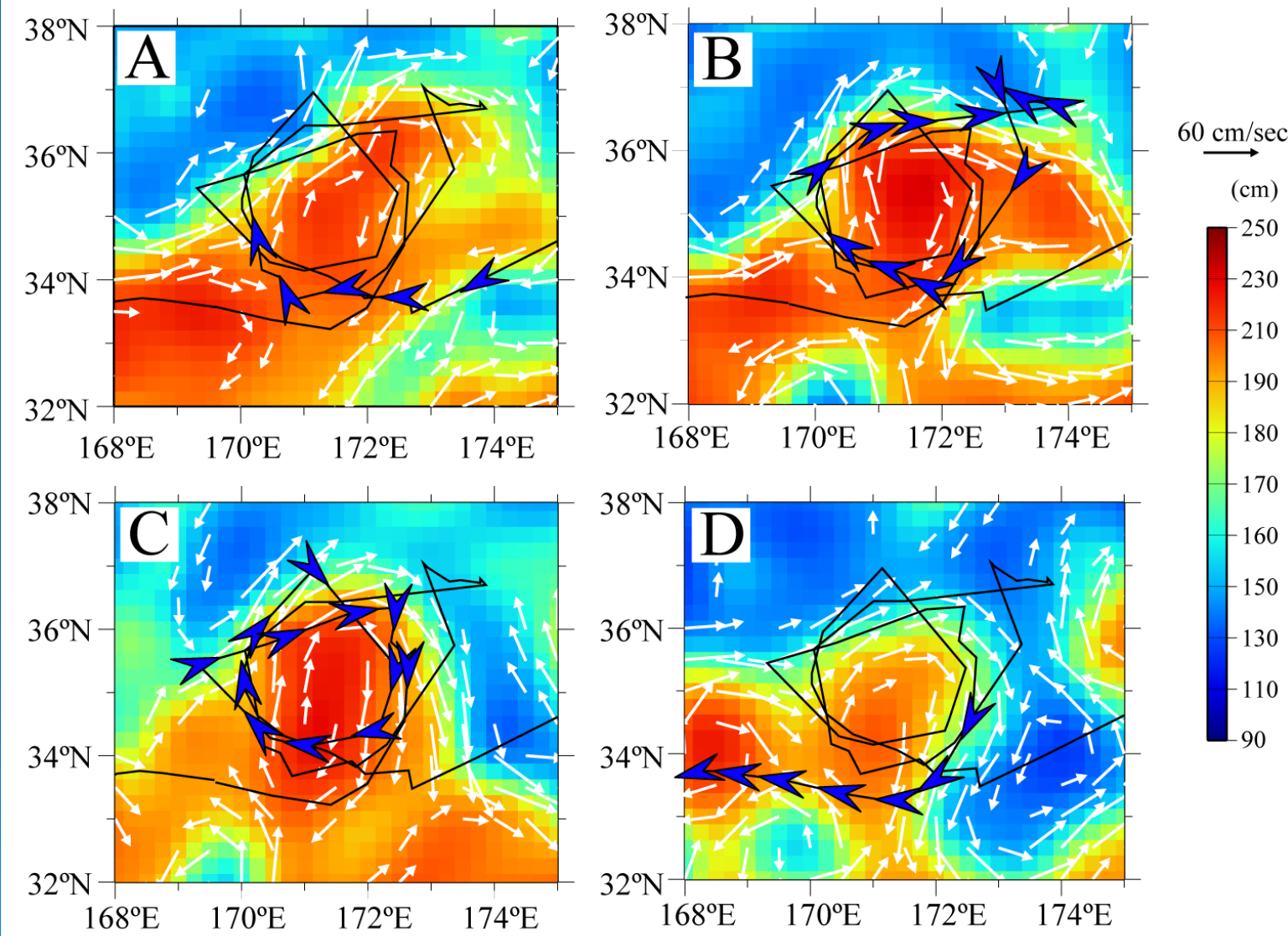








# Loggerhead track over SSH and geostrophic currents for October 2003 (A), November 2003 (B), December 203 (C), and January 2004 (D)





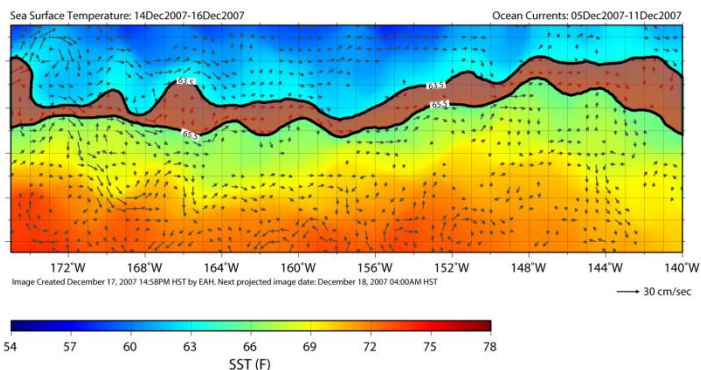
# EOD TurtleWatch

Evan.Howell@noaa.gov



## EXPERIMENTAL PRODUCT

avoid fishing between solid black 63.5°F and 65.5°F lines  
to reduce turtle interactions



PACIFIC ISLANDS FISHERIES SCIENCE CENTER  
ECOSYSTEMS AND OCEANOGRAPHY DIVISION  
2570 Dole Street, Honolulu, HI 96822  
<http://www.pifsc.noaa.gov/eod/turtlewatch.php>  
contact: [turtlewatch@noaa.gov](mailto:turtlewatch@noaa.gov)

Data provided by Central Pacific CoastWatch node

TURTLEWATCH



Vol. 5: 267-278, 2008  
doi: 10.3354/esr00096

ENDANGERED SPECIES RESEARCH  
Endang Species Res

Printed December 2008  
Published online July 1, 2008

Contribution to the Theme Section 'Fisheries bycatch: problems and solutions'

OPEN  
ACCESS

## TurtleWatch: a tool to aid in the bycatch reduction of loggerhead turtles *Caretta caretta* in the Hawaii-based pelagic longline fishery

Evan A. Howell<sup>1,\*</sup>, Donald R. Kobayashi<sup>1,2</sup>, Denise M. Parker<sup>1,3</sup>, George H. Balazs<sup>1</sup>, Jeffrey J. Polovina<sup>1</sup>

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<sup>2</sup>Department of Environmental Sciences, University of Technology, Sydney, Broadway, New South Wales 2007, Australia

<sup>3</sup>Joint Institute for Marine and Atmospheric Research, 1000 Pope Road, University of Hawaii, Honolulu, Hawaii 96822-2396, USA

**ABSTRACT:** Operational longline fishery characteristics, bycatch information, and loggerhead turtle satellite tracks were all used in conjunction with remotely sensed sea surface temperature data to identify the environmental area where the majority of loggerhead turtle bycatch occurred in the Hawaii-based longline fishery during 1994 to 2006. In the first quarter of each calendar year from 1994 to 2006, the majority of shallow longline sets and associated loggerhead turtle bycatch were above 28° N, which corresponds to the area near the North Pacific Subtropical Frontal Zone. Based on the thermal ranges of bycatch, sets and the satellite-tagged turtles, it was recommended that shallow sets should only be deployed in waters south of the 18.5°C (~65.5°F) isotherm to decrease loggerhead turtle bycatch. This recommendation formed the basis for the TurtleWatch tool, a map providing up-to-date information about the thermal habitat of loggerhead sea turtles in the Pacific Ocean north of the Hawaiian Islands. TurtleWatch was released to fishers and managers in electronic and paper formats on December 26, 2006, to assist in decision making during the first quarter of 2007. Fishery information from 2007 was later compared with data for the years 2005 to 2006 to assess the response of the fishery to TurtleWatch. The observed fleet movement during the first quarter of 2007 was to the north of the 18.5°C (~65.5°F) isotherm (i.e. in the area recommended for avoidance by the TurtleWatch product) with increased effort and lower bycatch rates. We discuss possible reasons for this decrease in turtle bycatch north of the frontal zone together with future research directions which may lead to refinement of the TurtleWatch product.

**KEY WORDS:** Loggerhead turtles · Bycatch · Remote-sensing · Sea surface temperature · Longline fishery · Transition zone · Swordfish

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## INTRODUCTION

The interactions of sea turtles with high seas fisheries are a global concern, with fisheries bycatch implicated as one of several factors in the population decline of many sea turtle species, including the loggerhead turtle *Caretta caretta* (Hatase et al. 2002, Hays et al. 2003, Peckham et al. 2007). The loggerhead is a circumglobal sea turtle species (Dodd 1988) that undergoes a series of ontogenetic shifts during its life cycle, with stages occupying a series of habitats that

include nesting beach, oceanic, and neritic areas (Bjorndal 2003). In the North Pacific, loggerhead nesting beaches are only found in Japan, where, during the last half of the 20th century a substantial decline (50 to 90%) in the size of the annual loggerhead nesting population at nesting beaches was reported (Kamezaki et al. 2003). The importance of the oceanic stage to juvenile loggerheads was hypothesized first by Carr (1987) with recent work by Polovina et al. (2006) reporting that specific pelagic regions, such as the Kuroshio Extension Bifurcation Region of the North

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# TurtleWatch: Background

Bycatch:  
Fishery data



Fishery/Bycatch  
in specific area



Turtles/Sword  
assoc. fronts<sup>1</sup>

<sup>1</sup>Polovina (Seki) et al, 2001, (2002),2004, 2006

Response =  
MPA (closures)



Static closures,  
dynamic fronts

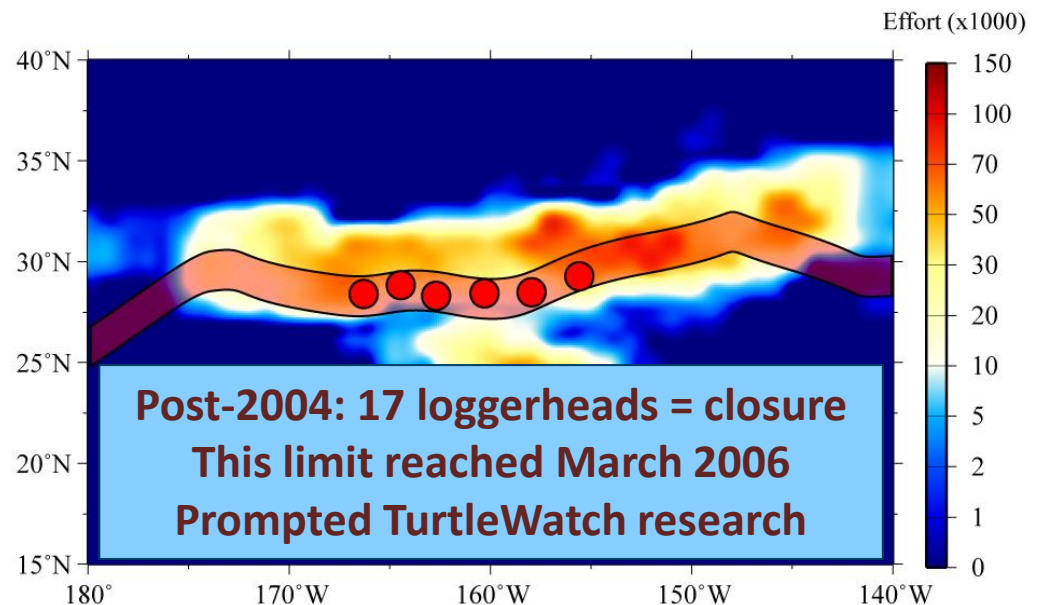


Frontal/effort  
shifts (turtles)

Desire: Method to create  
turtle avoidance areas from  
environment (SST/Chl a?)

“DYNAMIC HABITAT ZONE”

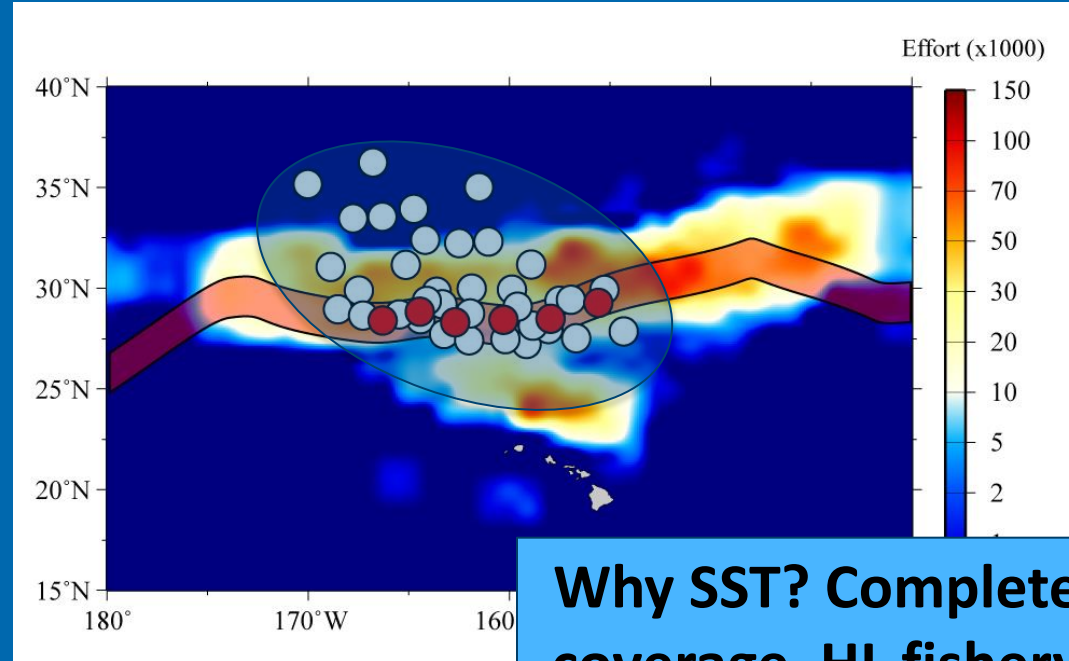
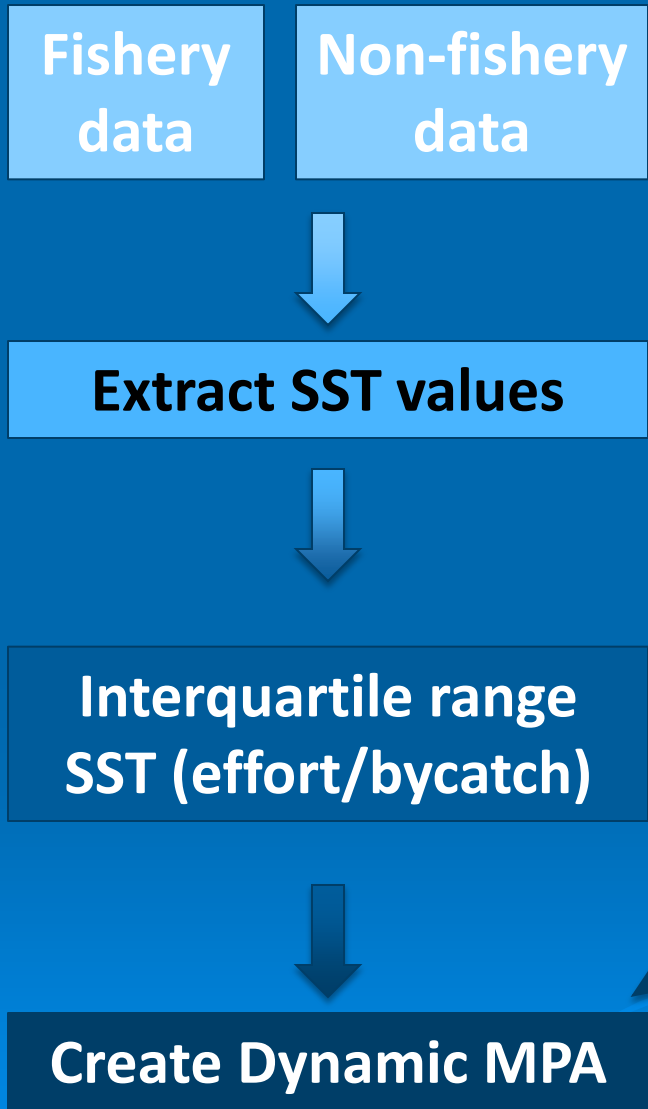
Distribute daily to fishery



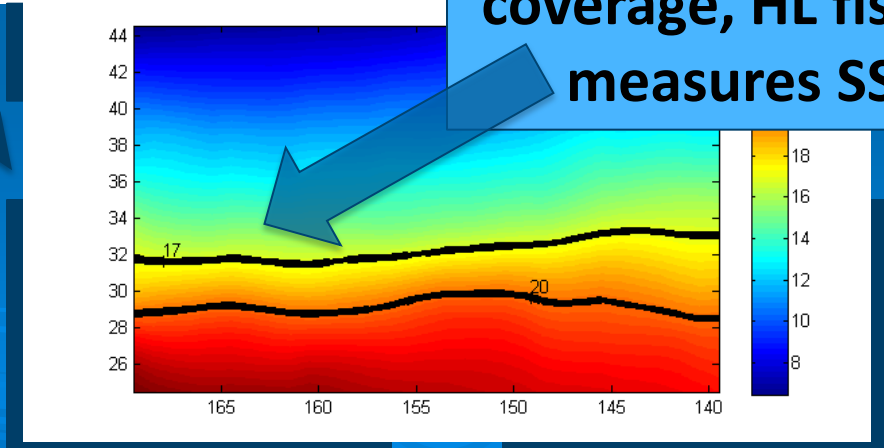
First need to understand bycatch pattern (time/space)



# TurtleWatch: Methods



**Why SST? Complete coverage, HL fishery measures SST**





# TurtleWatch: Loggerhead bycatch results

First quarter has > 60% of all bycatch

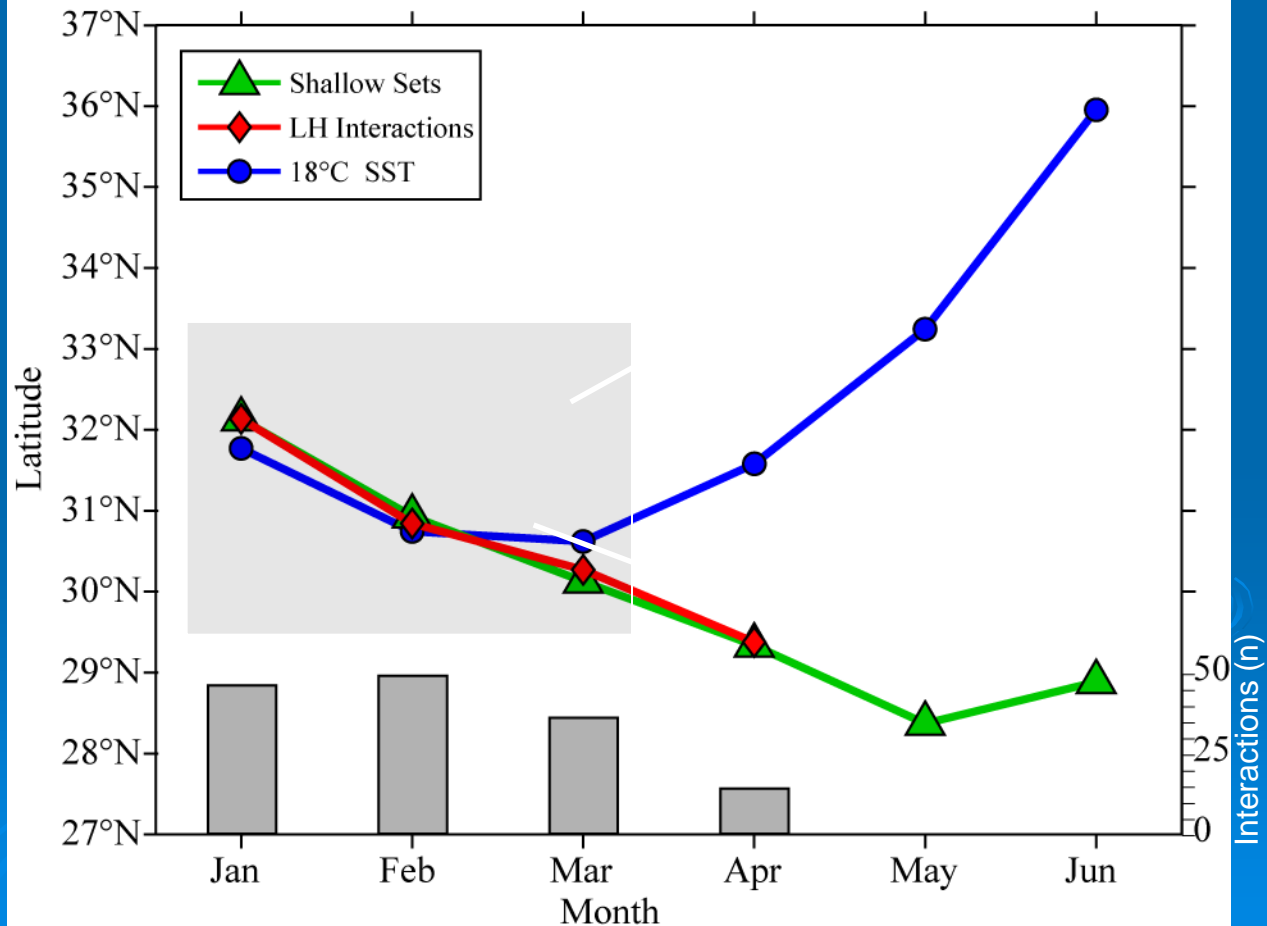
Bycatch/18C SST (TZCF) correlated

SST front/effort (bycatch) split Q2

Turtles track front, intra/interannual movements

Q1: Use SST habitat proxy (MATCH)

## Monthly mean Fishery and RS SST data (180° -160° W 1994-2006)





# TurtleWatch: Final product / ongoing work

12/2006: TurtleWatch released

12/2007: TurtleWatch refined

2006 recommended  
large area NO GEAR

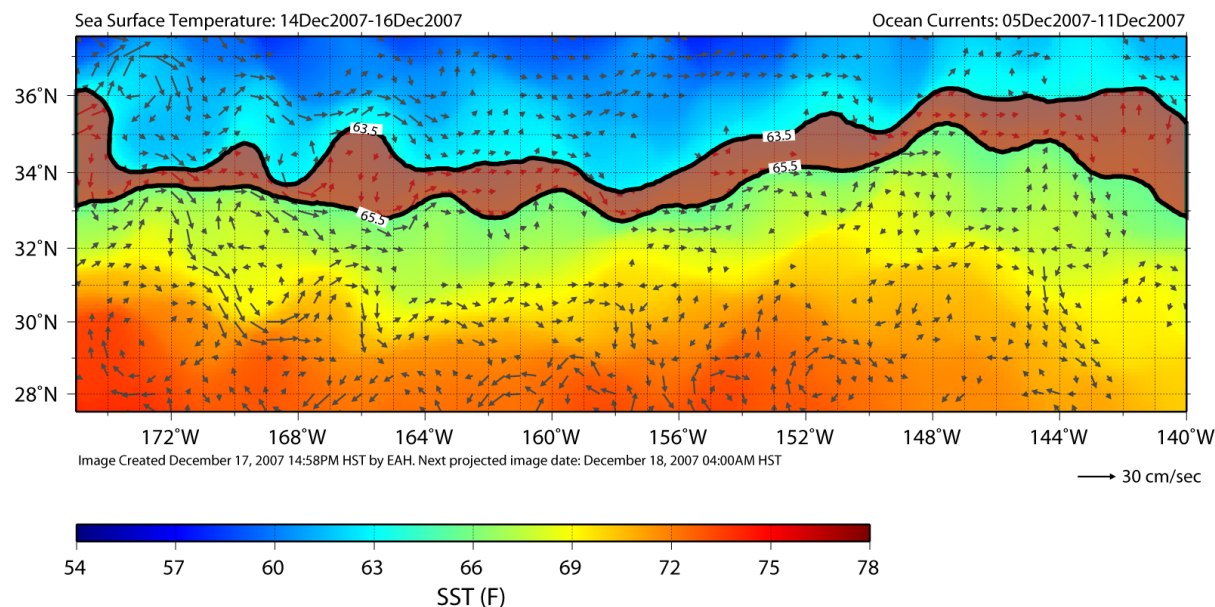
2007 results no  
bycatch in NE +  
SST < 17.5° C

Based on lack of  
interactions changed  
to band (17.5-18.5° C)

Additional refinement ongoing 2012

## EXPERIMENTAL PRODUCT

avoid fishing between solid black 63.5°F and 65.5°F lines  
to reduce turtle interactions



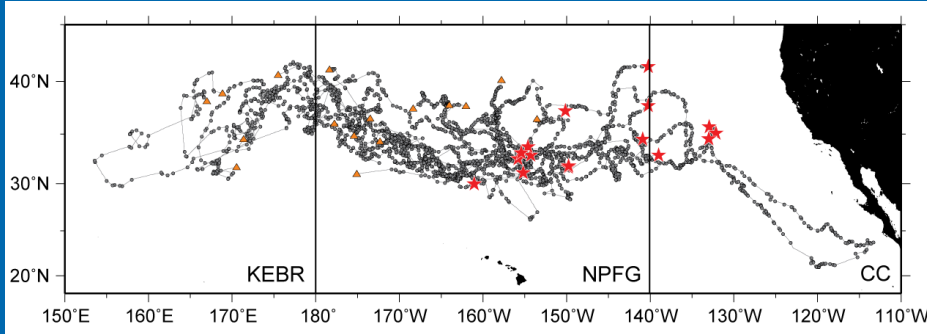
PACIFIC ISLANDS FISHERIES SCIENCE CENTER  
ECOSYSTEMS AND OCEANOGRAPHY DIVISION  
2570 Dole Street, Honolulu, HI 96822  
<http://www.pifsc.noaa.gov/eod/turtlewatch.php>  
contact: [turtlewatch@noaa.gov](mailto:turtlewatch@noaa.gov)  
Data provided by Central Pacific CoastWatch node





# Loggerhead dive behavior: Background

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Work to date studied 2-D (surface) behavior of loggerheads

Here we look at 3-D (+vertical) behavior of loggerheads

Goal: Identify dive behavior “types” and relationship to oceanography

Mar Biol (2010) 157:1011–1026  
DOI 10.1007/s00227-009-1381-0

ORIGINAL PAPER

## Oceanographic influences on the dive behavior of juvenile loggerhead turtles (*Caretta caretta*) in the North Pacific Ocean

Evan A. Howell · Peter H. Dutton ·  
Jeffrey J. Polovina · Helen Bailey ·  
Denise M. Parker · George H. Balazs

Received: 4 August 2009 / Accepted: 22 December 2009 / Published online: 21 January 2010  
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**Abstract** Satellite telemetry data from 17 juvenile loggerhead turtles (43.5–66.5 cm straight carapace length) were used in conjunction with oceanographic data to analyze the influence of regional and seasonal oceanography on dive behavior in the North Pacific Ocean. Combined dive behavior for all individuals showed that turtles spent more than 80% of their time at depths <5 m, and more than 90% of their time at depths <15 m. Multivariate classifications of dive data revealed four major dive types, three representing deeper, longer dives, and one representing shallower dives shorter in duration. Turtles exhibited variability in these dive types across oceanographic regions, with deeper, longer dives in the Hawaii longline swordfish fishing grounds during the first quarter of the year, as well as in the Kuroshio Extension Bifurcation Region and the region near the Baja California Peninsula, Mexico. Turtles in the Kuroshio Extension Bifurcation Region also exhibited dive variability associated with mesoscale eddy

features, with turtles making deeper, longer dives while associated with the strongest total kinetic energy. Turtles in the central North Pacific exhibited seasonality in dive behavior that appeared to reflect synchronous latitudinal movements with the North Pacific Subtropical Front and the associated seasonal, large-scale oceanography. Turtles made deeper, longer dives during the first quarter of the year within this region, the reported time and area where the highest loggerhead bycatch occurs by the longline fishery. These results represent the first comprehensive study of dive data for this species in this region. The increased understanding of juvenile loggerhead dive behavior and the influences of oceanography on dive variability should provide further insight into why interactions with longline fisheries occur and suggest methods for reducing the bycatch of this threatened species.

### Introduction

Loggerhead turtles (*Caretta caretta*) are a threatened species widely distributed throughout temperate ocean basins. In the Pacific, loggerheads generally consist of two distinct genetic stocks; a North Pacific stock originating from breeding sites in Japan summarized in Kamezaki et al. (2003), and a South Pacific stock originating from breeding sites in Australia and New Caledonia (Bowen et al. 1995; Bowen and Karl 2007). The North Pacific stock inhabits foraging and developmental areas in coastal neritic and oceanic habitat all the way to the northeast Pacific off the coast of the Baja California Peninsula (BCP), Mexico (Bowen et al. 1995; Kamezaki and Matsui 1997; Peckham et al. 2007). Similarly, foraging and developmental habitat for the South Pacific breeding stock extends across the South Pacific, including offshore areas of the South

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# Seasonal movement

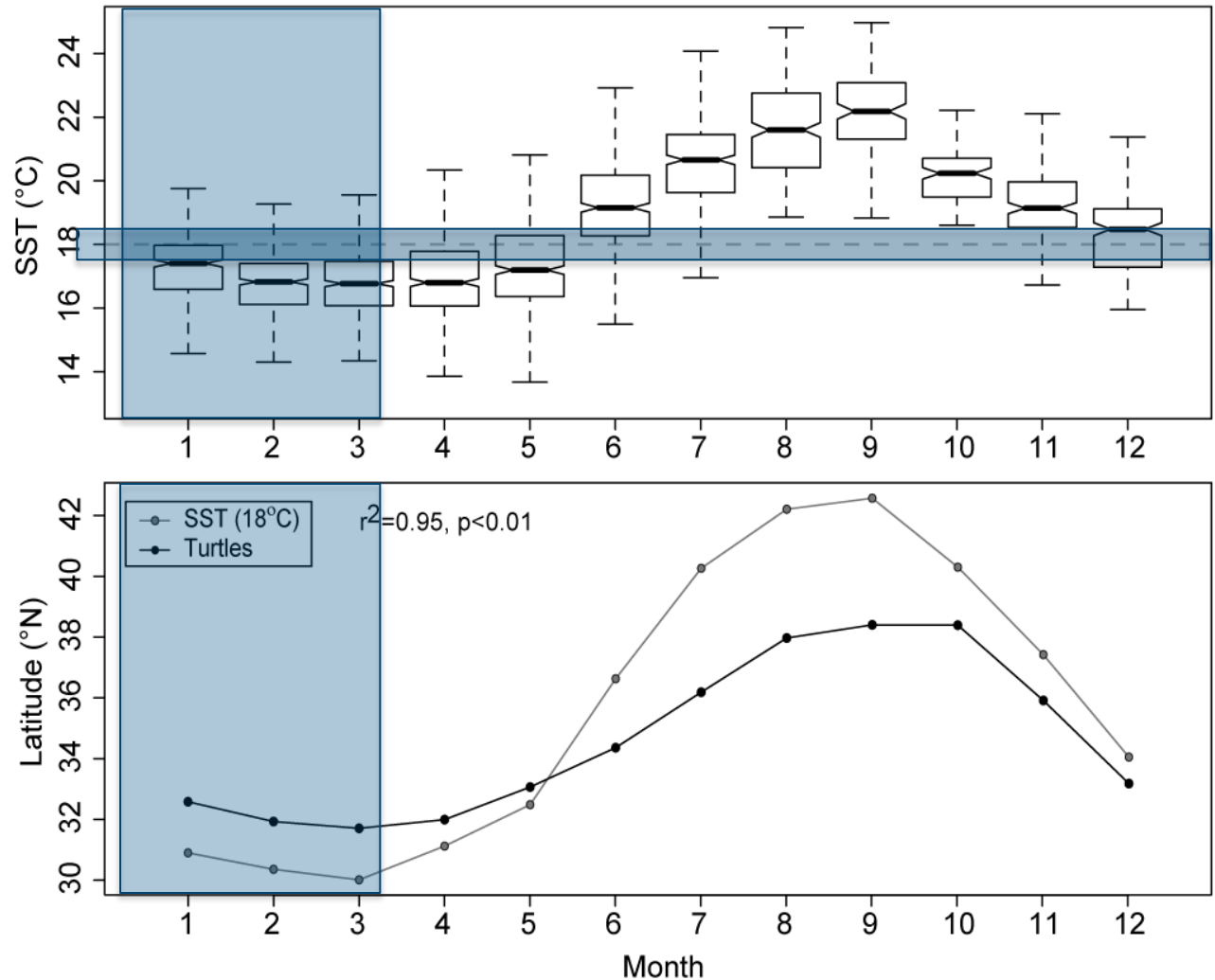
Satellite telemetry data (n=17) from 180-150° W north of Hawaii

Turtles follow  
fronts ~18-20° C

Follow front  
throughout year

Coldest SST Q1

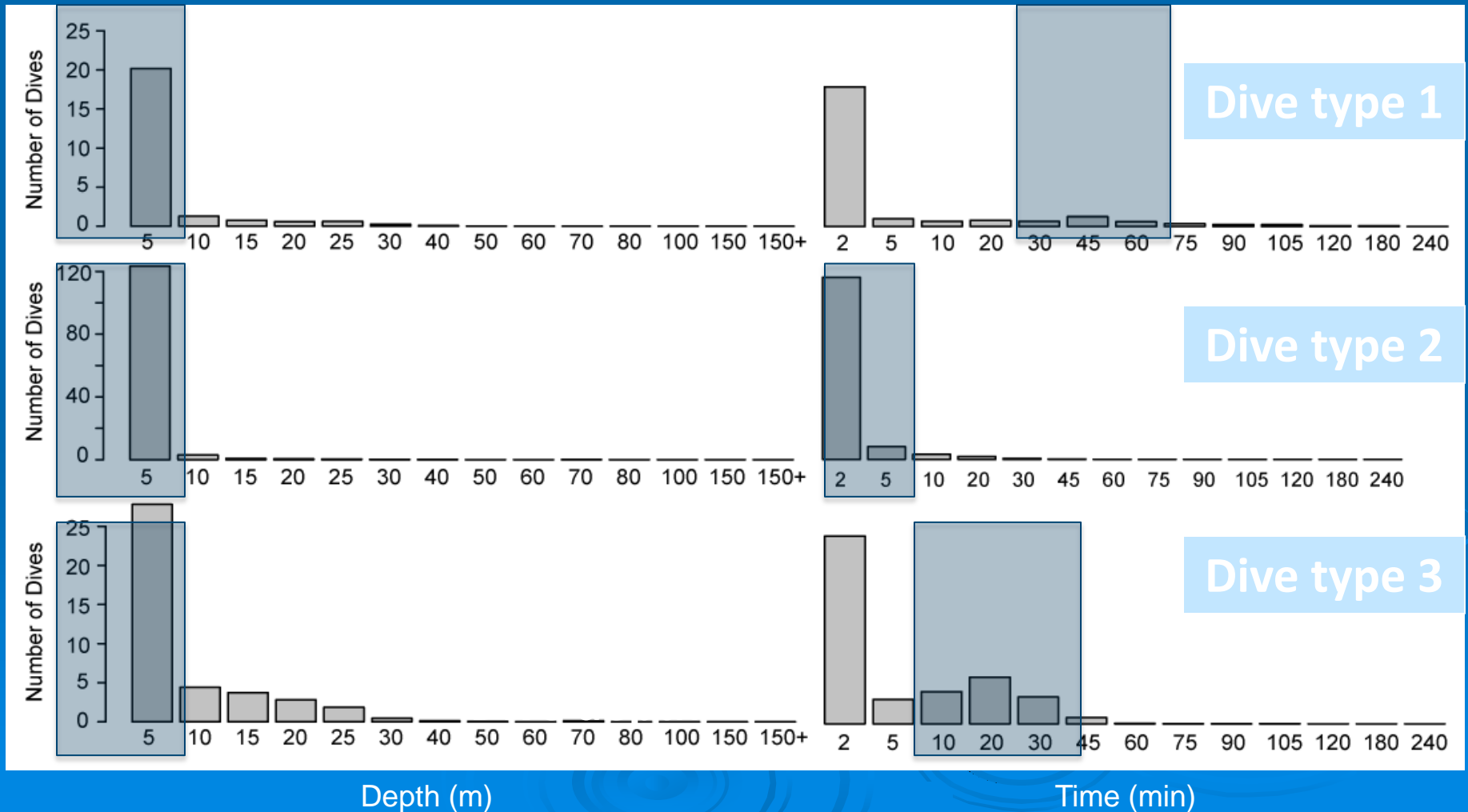
Surface pattern  
similar to tagged  
(TurtleWatch)



# Dive type results

K-means cluster analysis: 3 distinct dive types north of Hawaii

Types 1,3 deeper, longer | Type 2 shallower, shorter





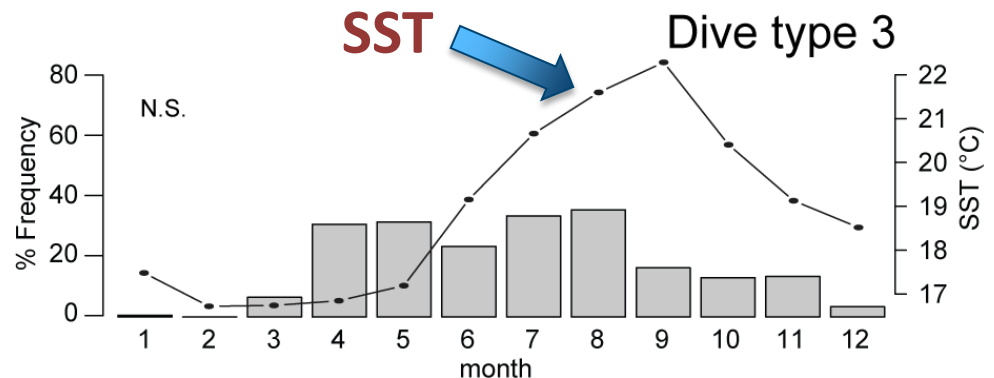
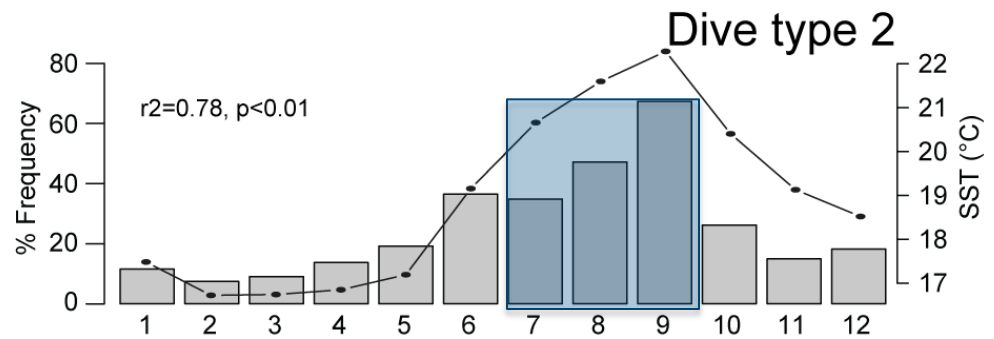
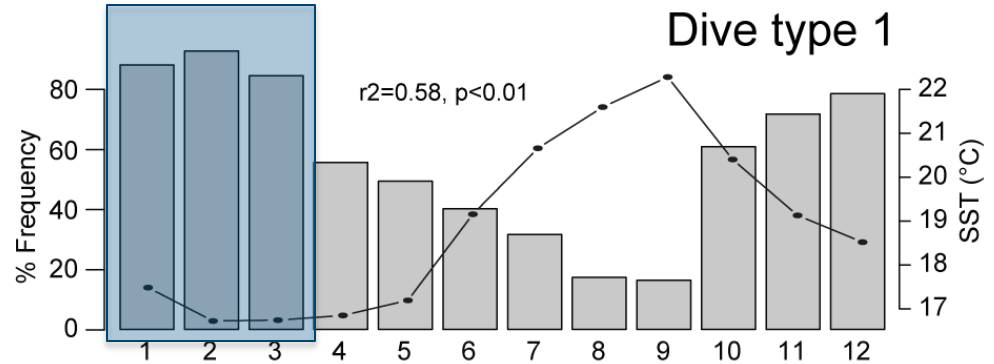
# Dive variability (North of Hawaii)

Seasonal variability  
synced to movement of  
front (fishing ground)

Observed monthly  
changes in dive  
behavior

Coldest SST Q1 =  
deepest/longest dives

Contrast to later  
months where  
shorter/shallower dives



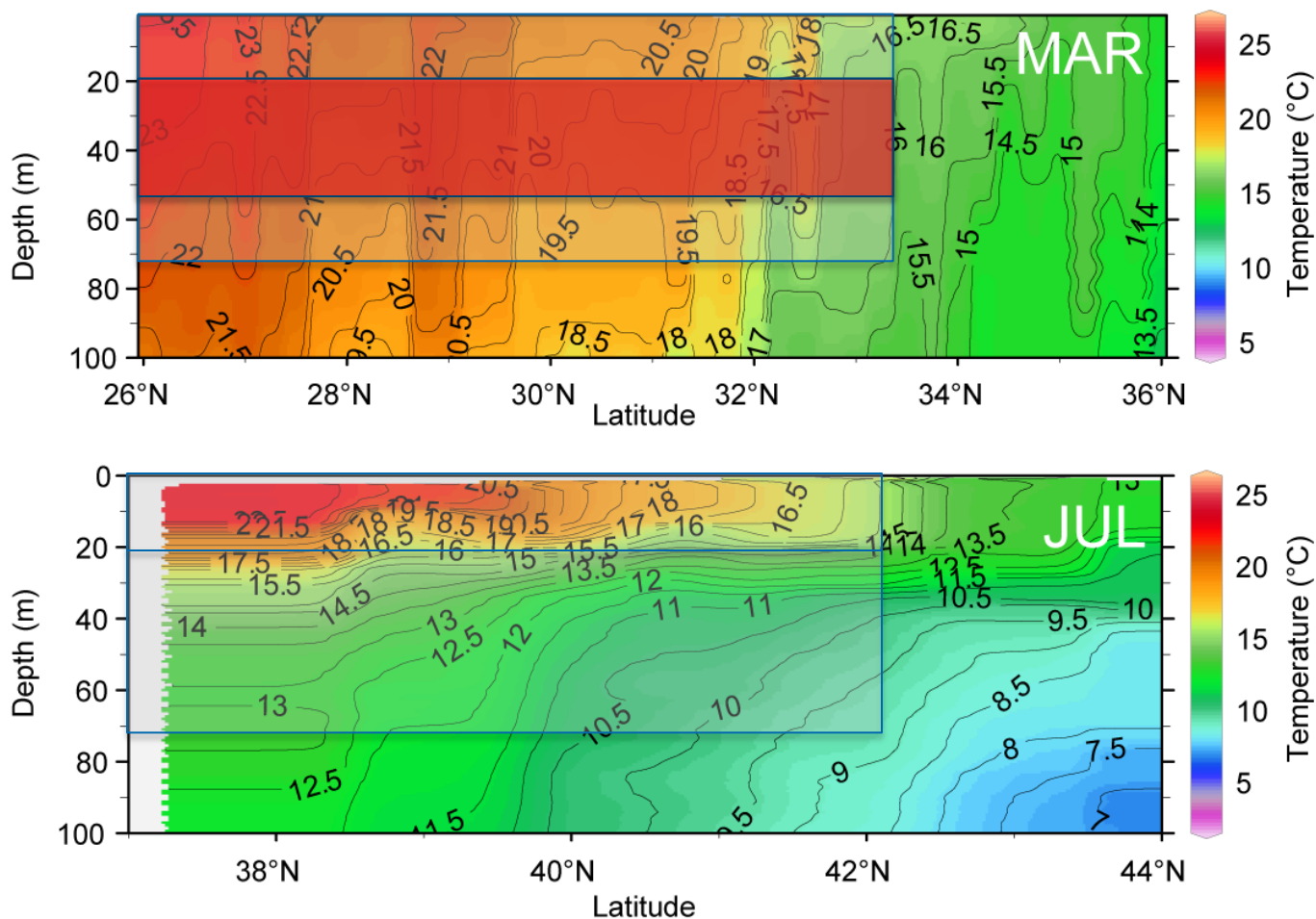
# Loggerhead Oceanographic Habitat

March 2008 – In-situ Temperature from NOAA Sette  
July 2005 – In-situ temperature from Oshoro Maru

**Q1: deep  
mixed layer  
Temp. front**

**Q3: shallow  
mixed layer  
Sal. front**

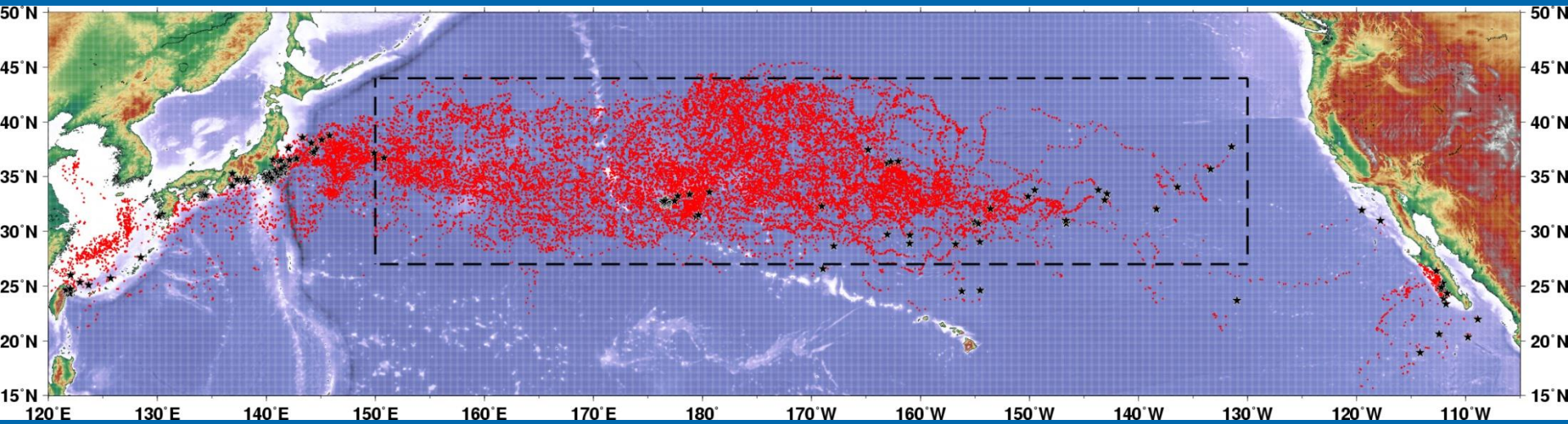
**Rule: Fishery  
MUST target  
below 20m**





# North Pacific loggerhead track data

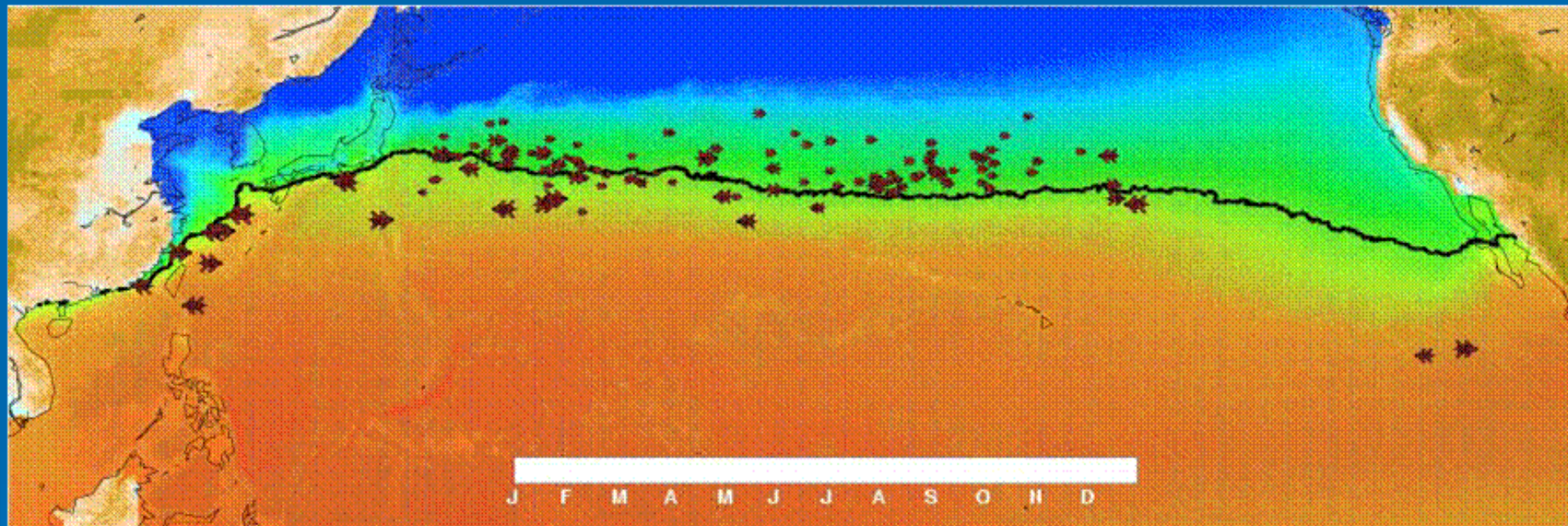
Donald.Kobayashi@noaa.gov



2008. Kobayashi\*, Polovina, Parker, Kamezaki, Cheng, Uchida, Dutton, Balazs. Pelagic habitat characterization of loggerhead sea turtles, *Caretta caretta*, in the North Pacific Ocean (1997-2006): Insights from satellite tag tracking and remotely-sensed data. *Journal of Experimental Marine Biology and Ecology* 356: 96-114.

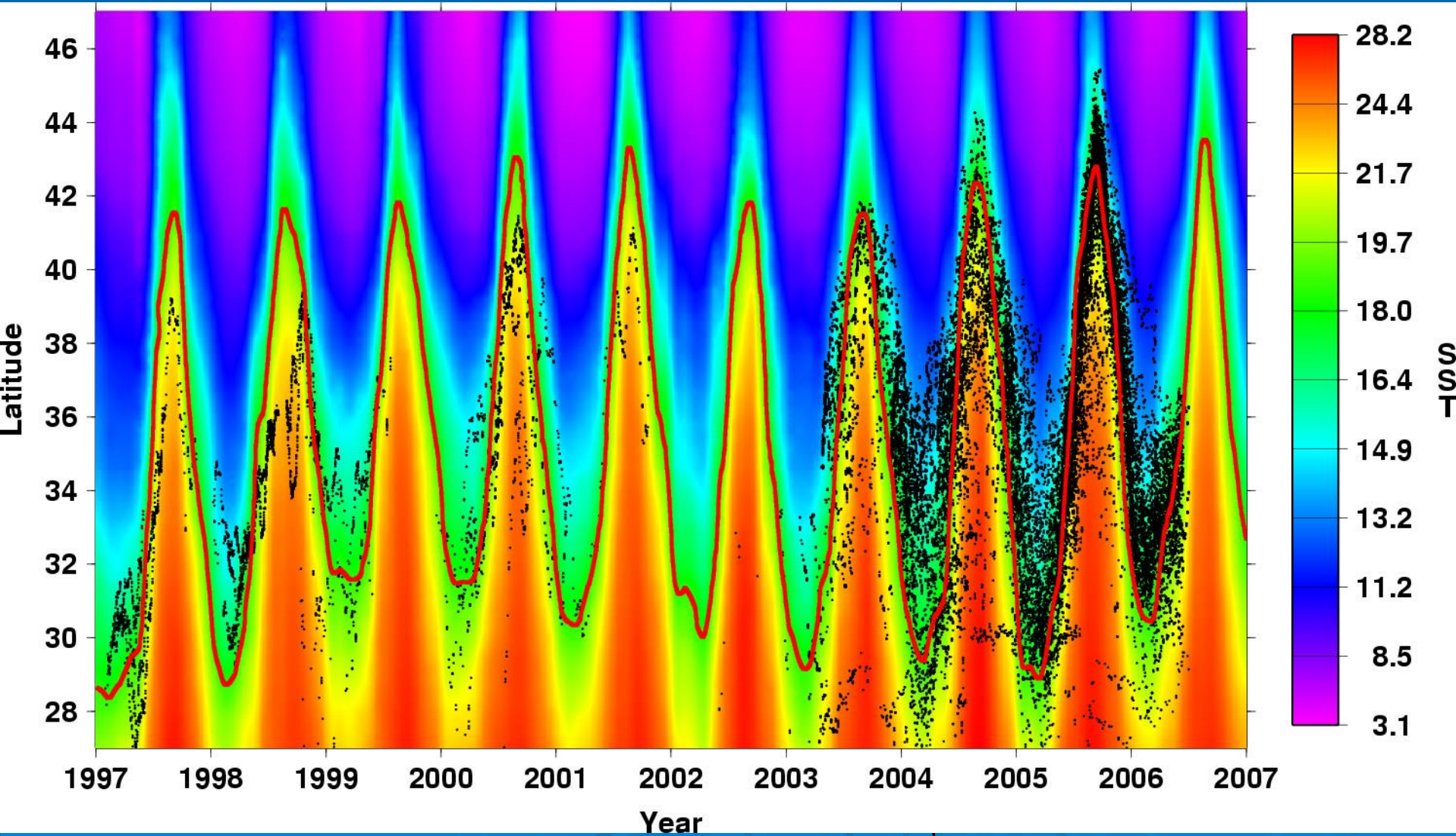
\* Dr. Donald R. Kobayashi, Research Fishery Biologist in the Ecosystems and Oceanography Division at the Pacific Islands Fisheries Science Center, NMFS/NOAA US Department of Commerce.

# Movement appears to relate to oceanography

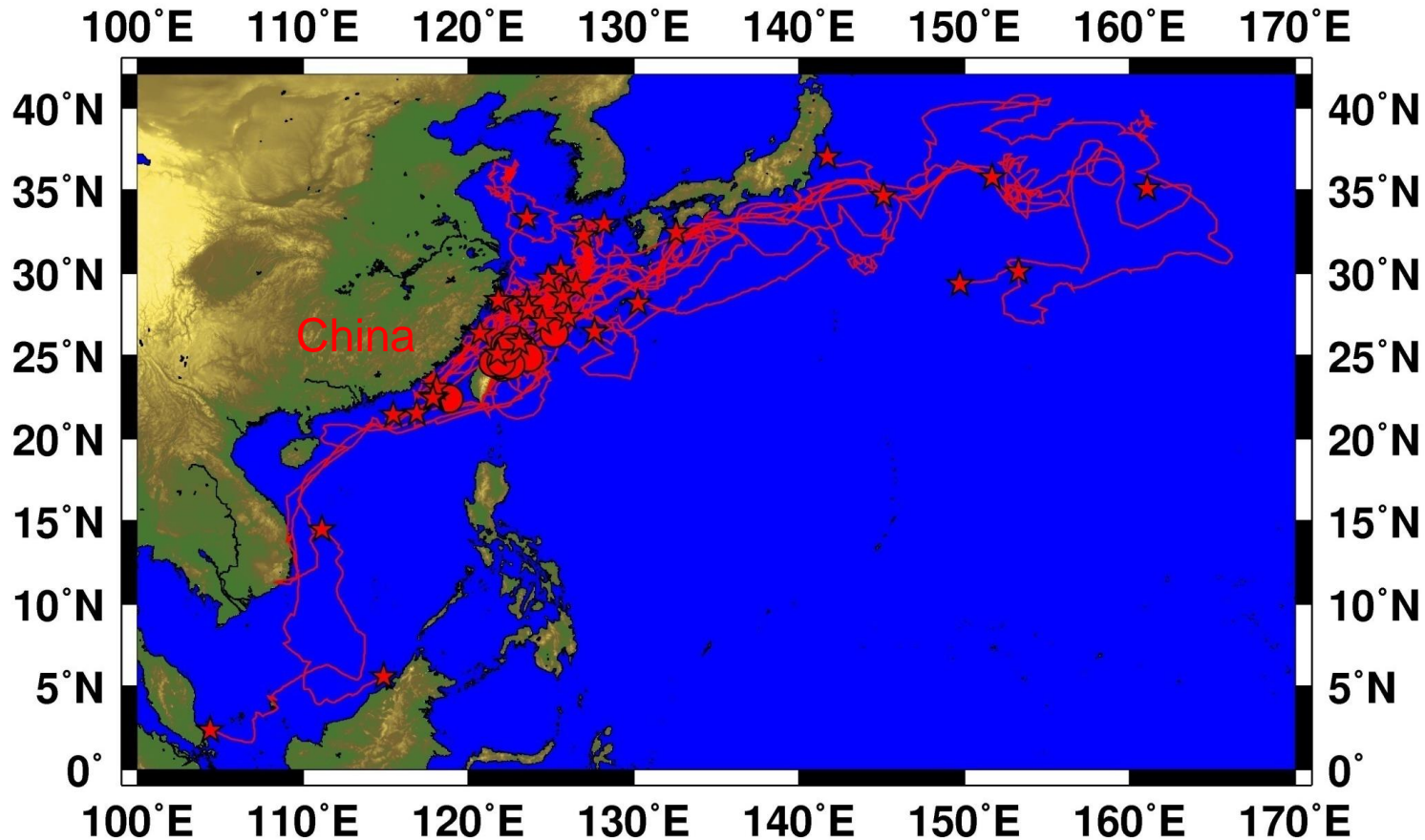




# North Pacific loggerhead movement and sea surface temperature (SST)



# Taiwan by-catch tagged loggerheads

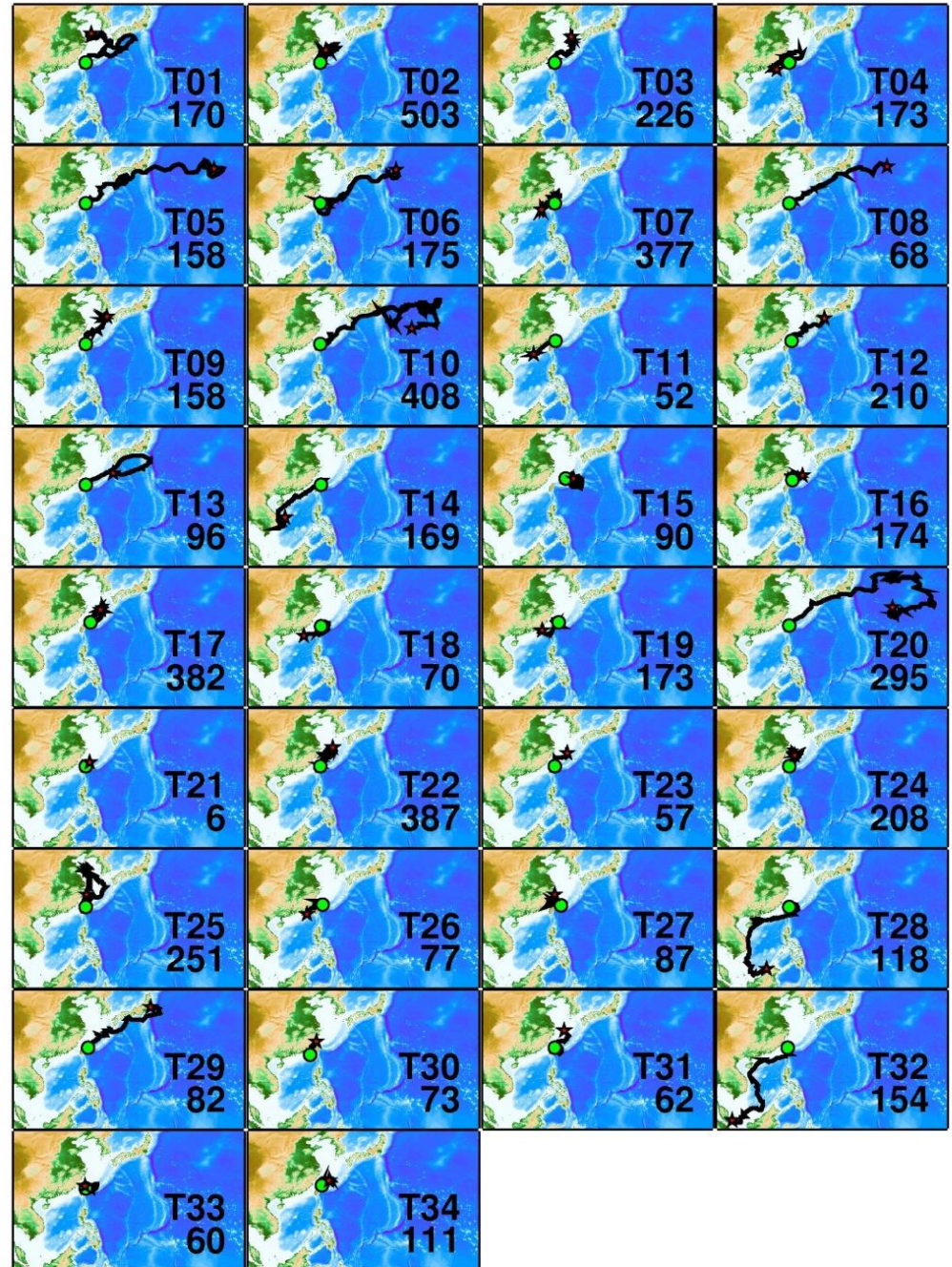


2011. Kobayashi\*, Cheng, Parker, Polovina, Kamezaki, Balazs. Loggerhead turtle (*Caretta caretta*) movement off the coast of Taiwan: characterization of a hotspot in the East China Sea and investigation of mesoscale eddies. ICES Journal of Marine Science. 68(4): 707-718.

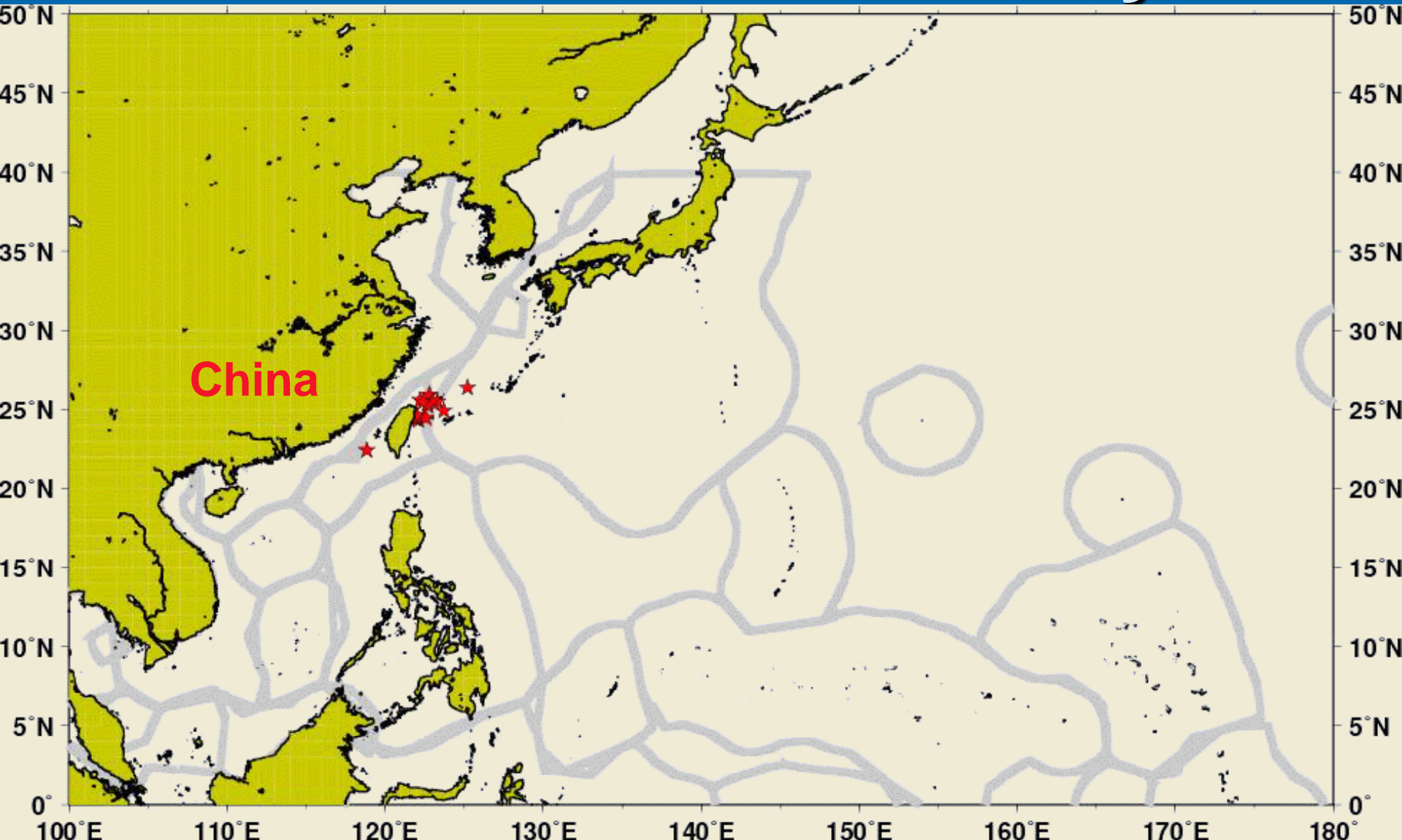


## Several movement strategies identified:

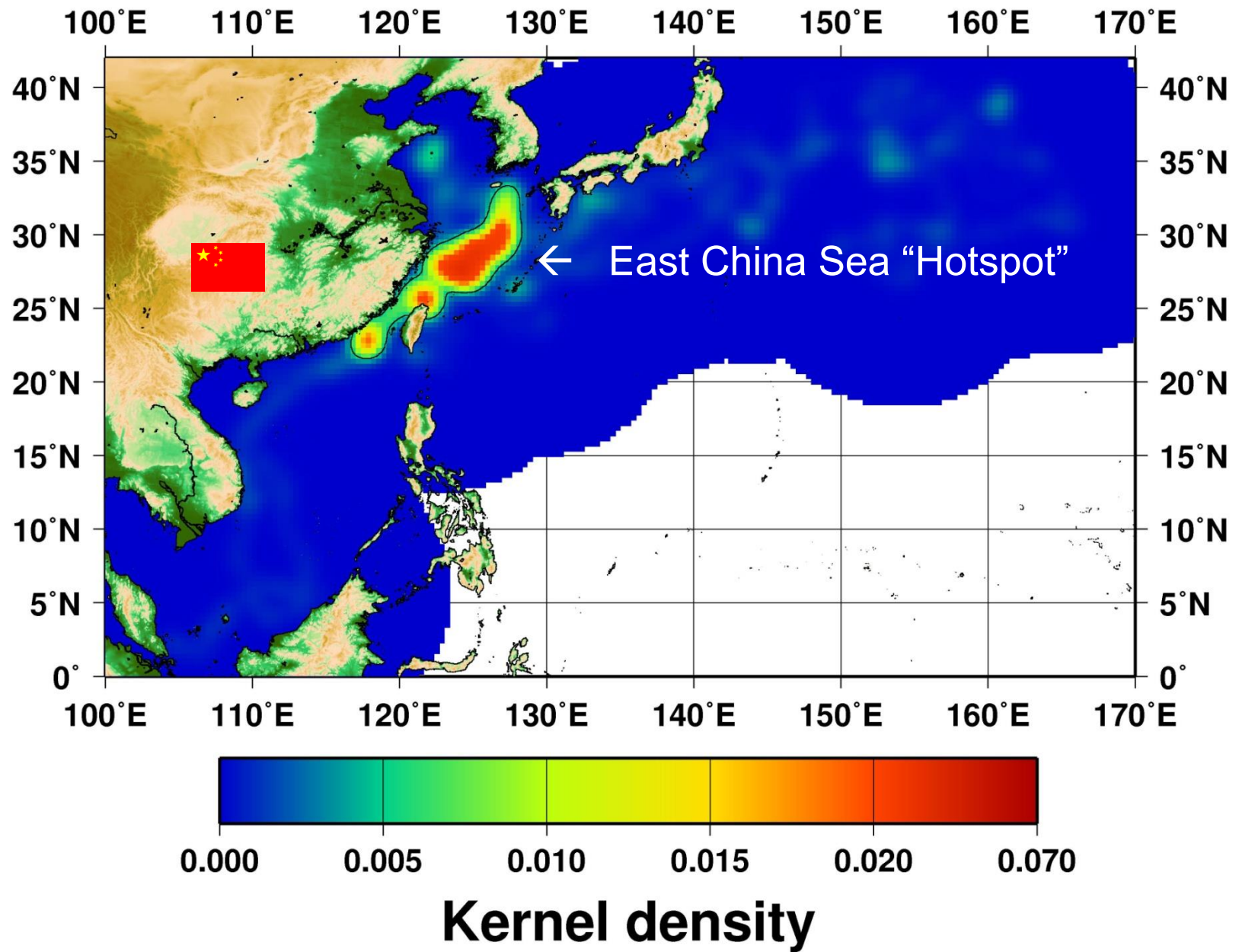
- Pelagic entry to the “Kuroshio Extension Bifurcation Region”.
- Coastal movement to southwest.
- Persistent occupancy over continental shelf in the East China Sea.



# Animation of first 70 days







East China Sea "Hotspot" covers ~400,000 square kilometers of ocean.

Shallow, productive, effects of rivers/currents, multinational, location of many fisheries.

FINAL MAP:  
2011 movement of Taiwan coastal net by-catch loggerhead ID 53767  
TAM-2639 6/48 SCL: 78.4 cm  
Date deployed: 3/7/11 Days transmitting: 246 days  
Distance traveled: 5,311 km Mean speed of travel: 0.9 km/hr



The End  
報告完畢



GMT map by Denise Parker 12/09/11



# Releasing Turtles for Research



海龟放流的研究机会



# Sea Life Park Hawaii

An aerial photograph of Sea Life Park Hawaii. The central focus is a large, irregularly shaped pool of bright blue water containing several sea turtles. To the left of this pool is a rocky waterfall structure. In the foreground, a large circular structure with a red roof and a glass-enclosed interior is visible. The park is surrounded by paved walkways, greenery, and palm trees. The text "Sea Life Park Hawaii" is overlaid in yellow at the top, and "Partnership Research" is overlaid in yellow at the bottom.

Partnership Research





NOAA Fisheries

NATIONAL MARINE  
FISHERIES SERVICE  
MARINE  
TURTLE  
PROGRAM

ISLANDSNOW

NAME TAG

Sea Life Park

Sea Life Park

Sea Life Park  
Animal Care