

Grand Challenges For Equatorial Oceans and Reefs

Barbara A. Block & Fio Micheli

Stanford University

- **Earth Warming**
- **Ocean Deoxygenation**
- **Ocean Acidity**



We Were Just In the Line Islands Surveying Oceanography and Reefs



Robert Seamans at Fanning Island June 06, 2015

We Study Stress on Our Ocean Ecosystems

FISHING

- Overexploitation
- By-Catch
- Habitat Degradation



CLIMATE CHANGE

- Thermal, pH, CO₂
- Hypoxia, Acidity
- Stress, Disease
- Sea Level Rise
- Habitat Loss

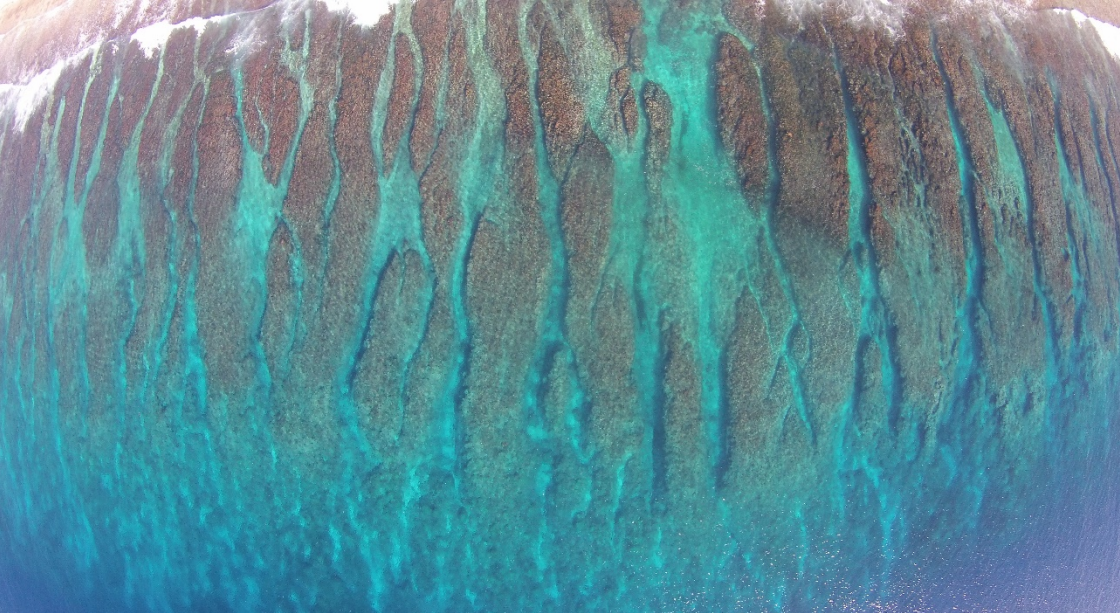


Challenges for Marine Protected Areas Everywhere

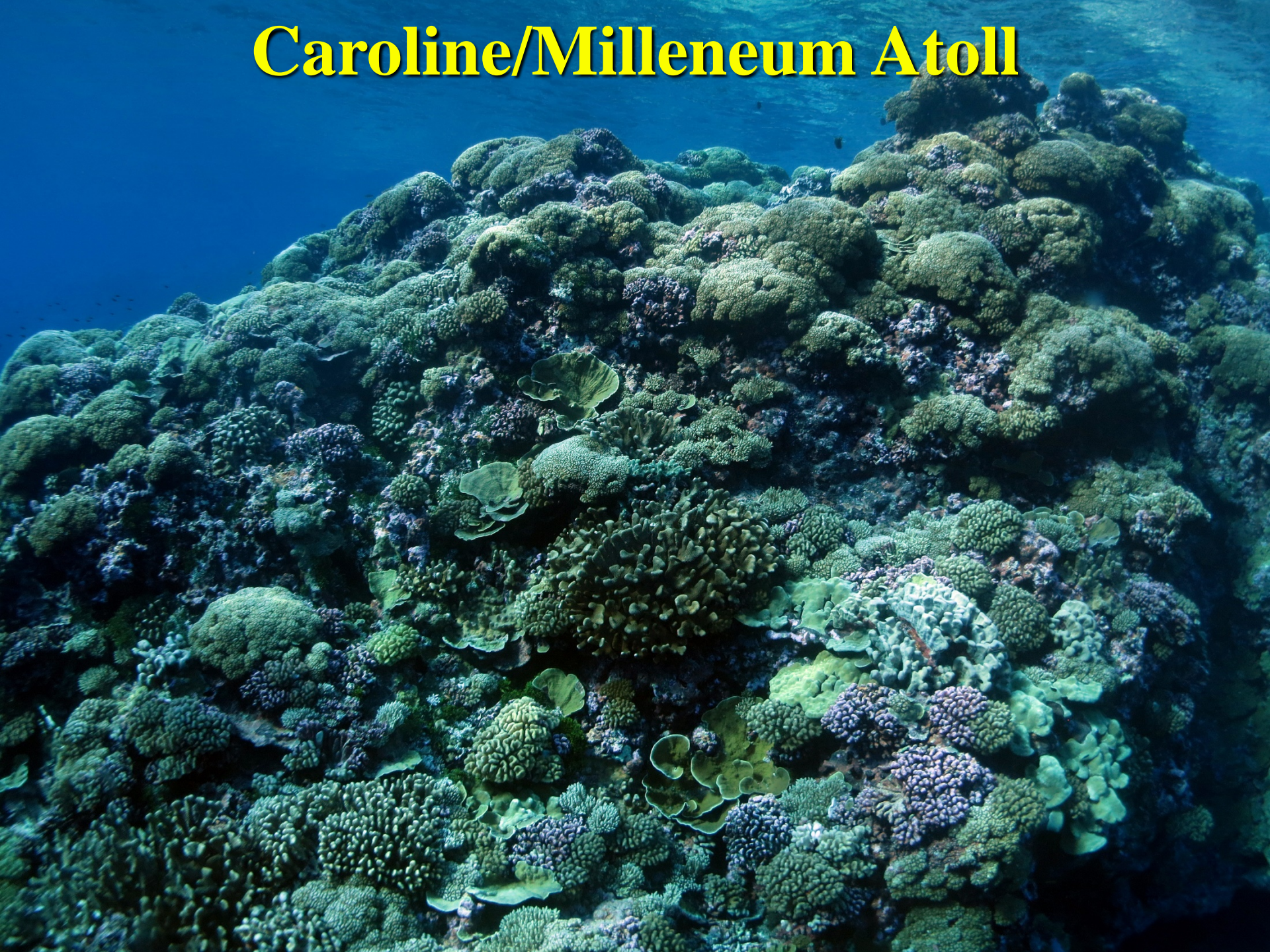
How Will We Know When Our Seascapes are Changing?



Can We Measure Resilience? Line Islands Are Diverse Islands/Atolls with Numerous Conditions



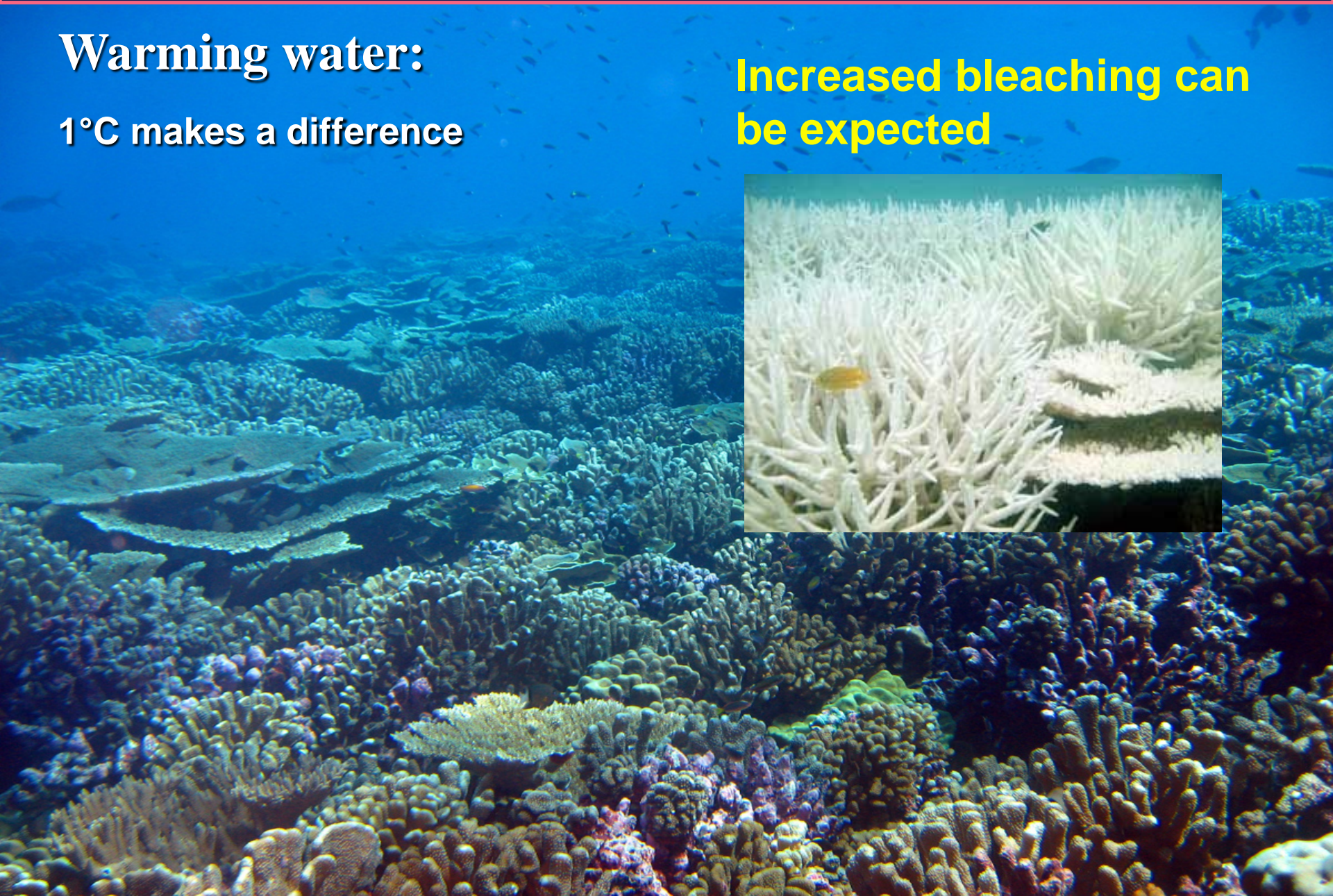
Caroline/Milleneum Atoll




Warming and Coral Reefs

Warming water:
1°C makes a difference

Increased bleaching can
be expected





*How will we know
When our oceans
Become more
acidic?*

*Long Term
Monitoring*

**We Just Collected Intensive
Genomic Background Samples for Measuring
Resilience and Monitoring**



Will Protections for Tunas Increase Local Production?

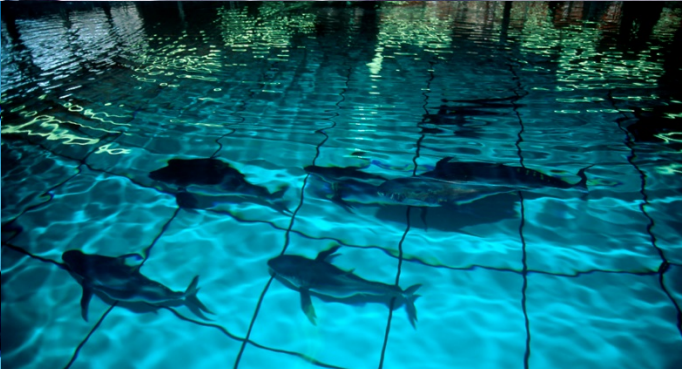
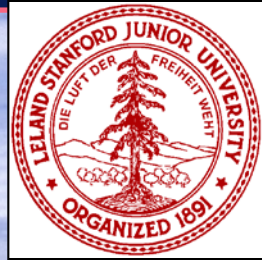


Healthy Ocean Ecosystems Require Predators



Tuna Research & Conservation Center

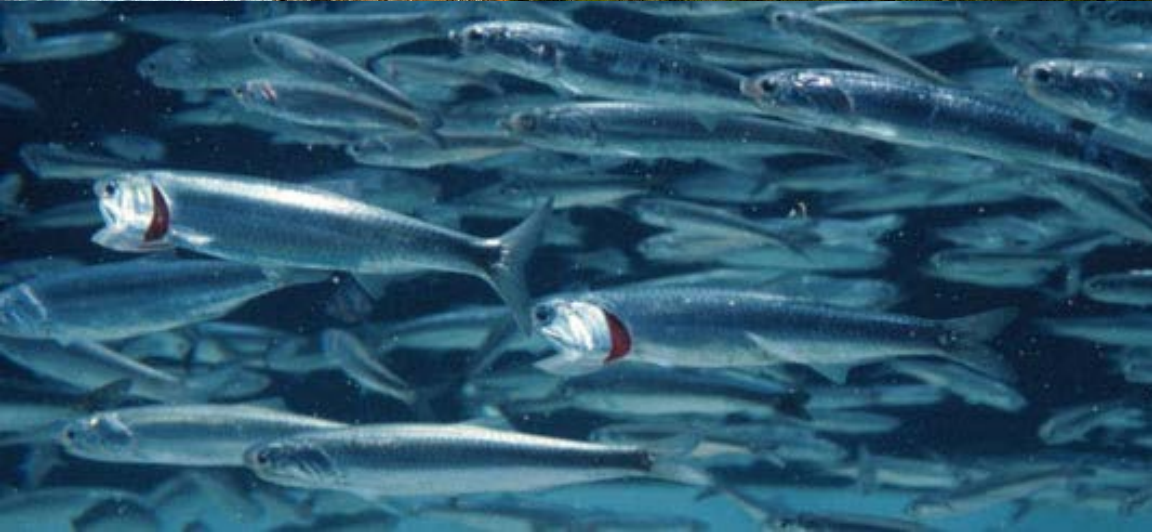
Large on Land Tuna Facility: 1994-2014



Tuna in Captivity at Stanford & Monterey Bay Aquarium 1994-2014



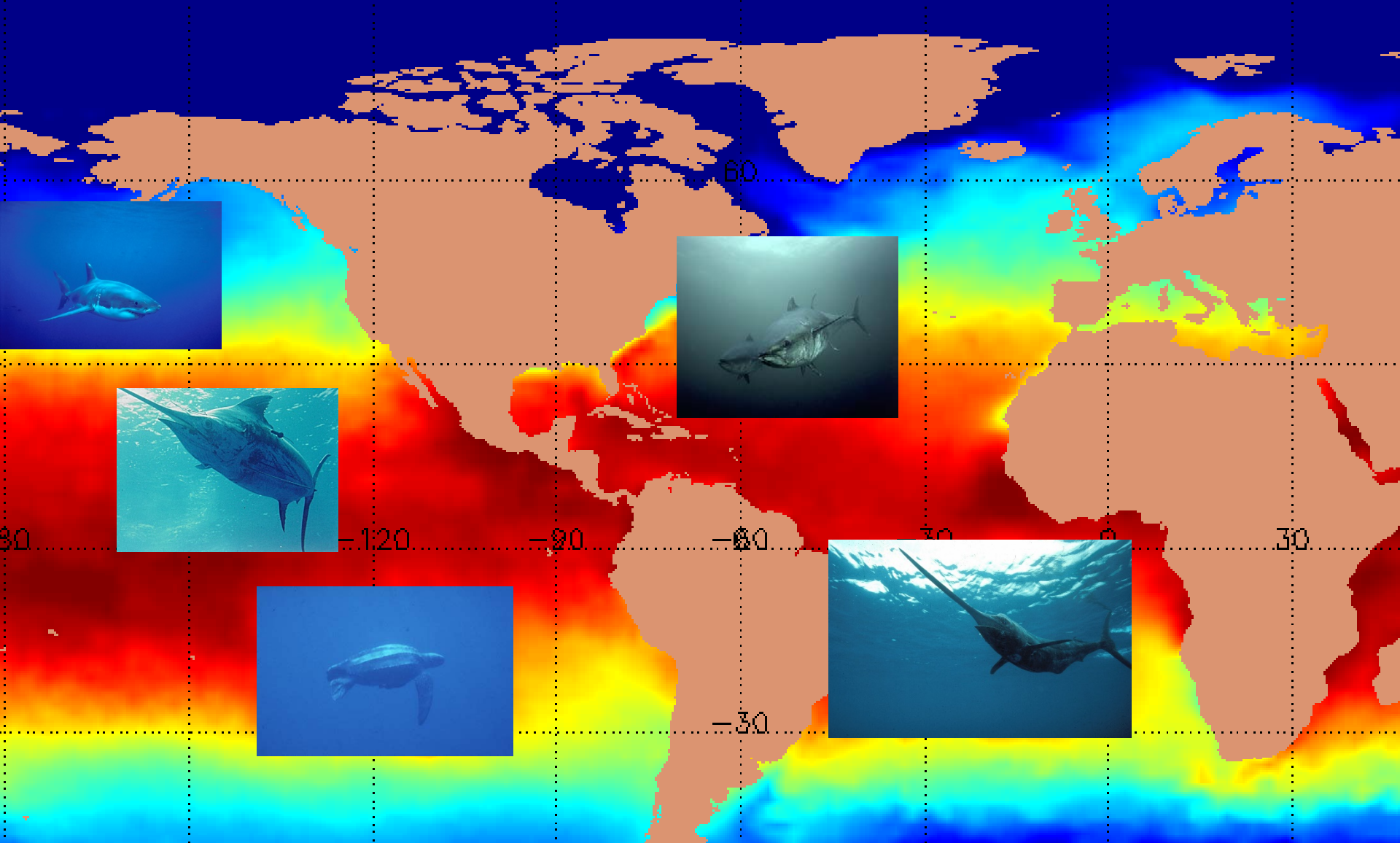
Who We are? We ask Big Questions: Can We Monitor The California Current?



WHAT SCIENCE DO WE NEED?

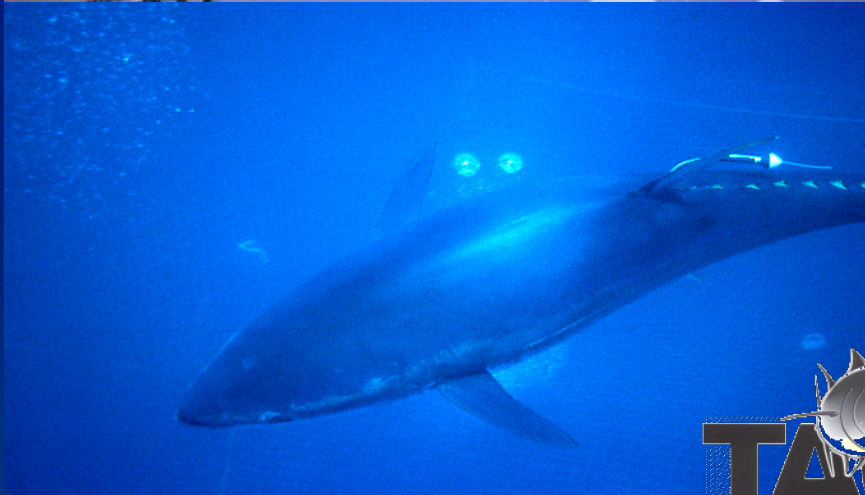
Requires a Multi-Disciplinary Approach

Biology, Oceanography, Engineering, Informatics (IT), Models



TAG A GIANT CAMPAIGN 1996-2015

~2000 Atlantic & Pacific Bluefin Tuna Tagged



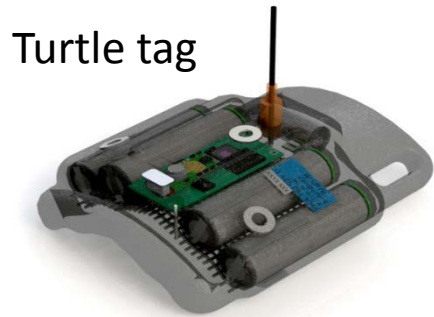
Conservation Technology: Ecosystem Monitoring With Animal Tags

“Environmental Intelligence”



MiniPAT
Pop-up

Daily Diary



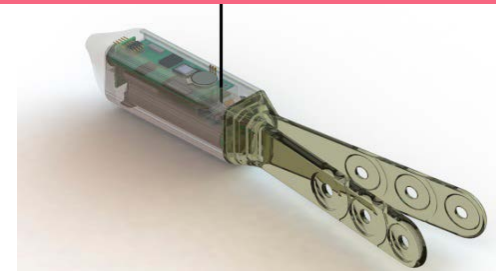
Turtle tag



Acoustic
Tags



Accelerometer



Satellite Relay Data Logger (SRDL)



DESERT STAR SYSTEMS

SMRU Instrumentation

Microwave Telemetry, Inc.

Cefas

VEMCO

LOZEK WIRELESS FISH & WILDLIFE MONITORING

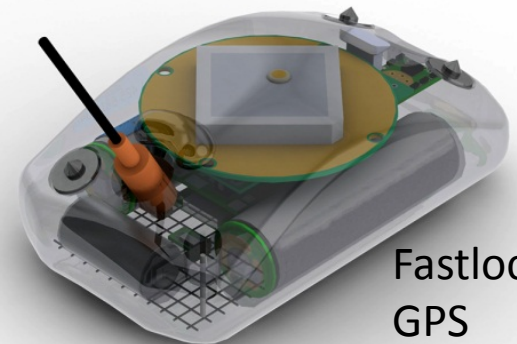
Wildlife Computers

STAR:ODDI

Archival
Tag



Fin
Mount

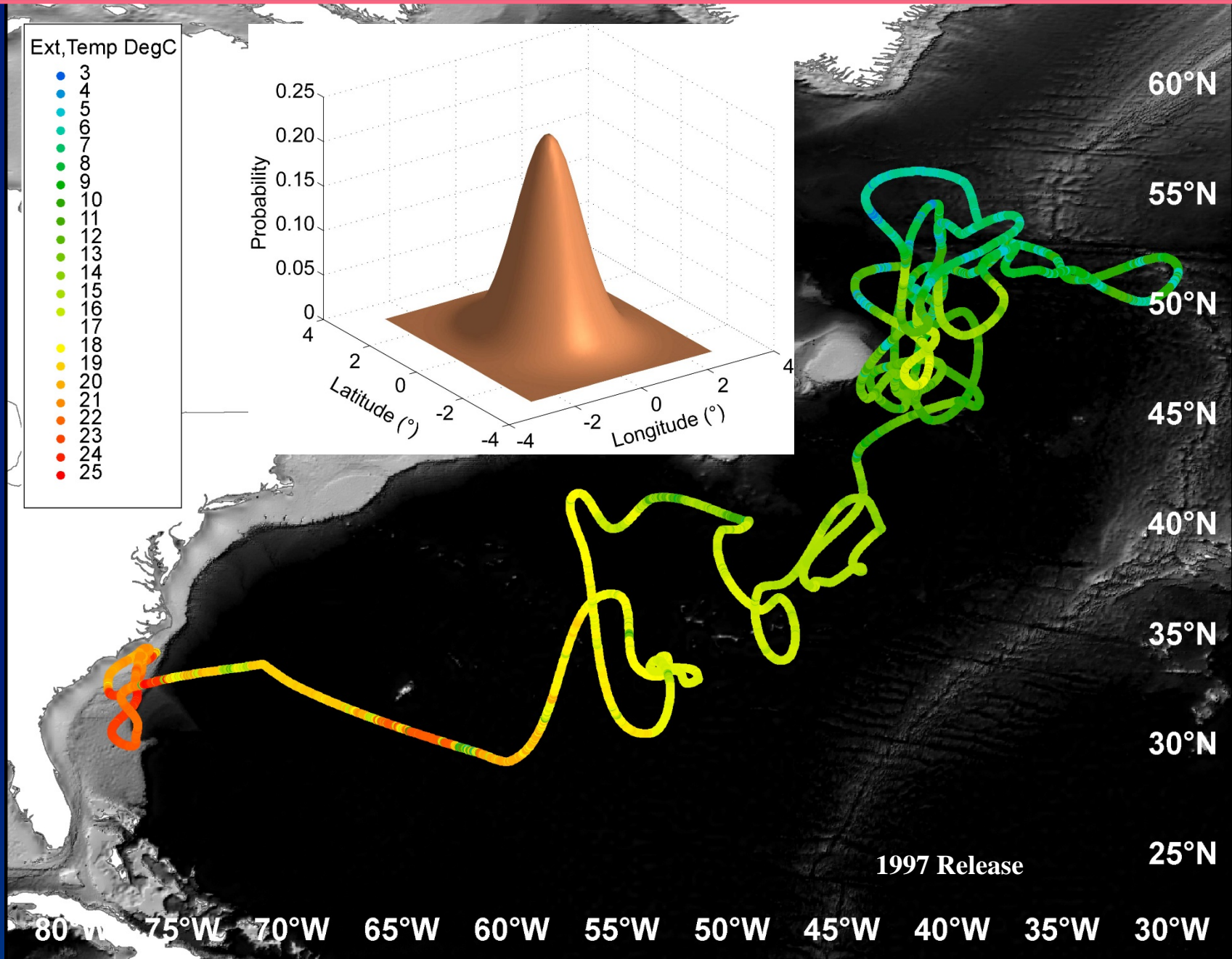


Fastloc™
GPS

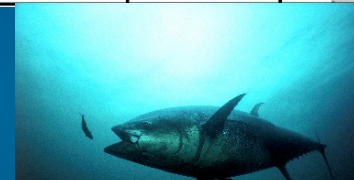
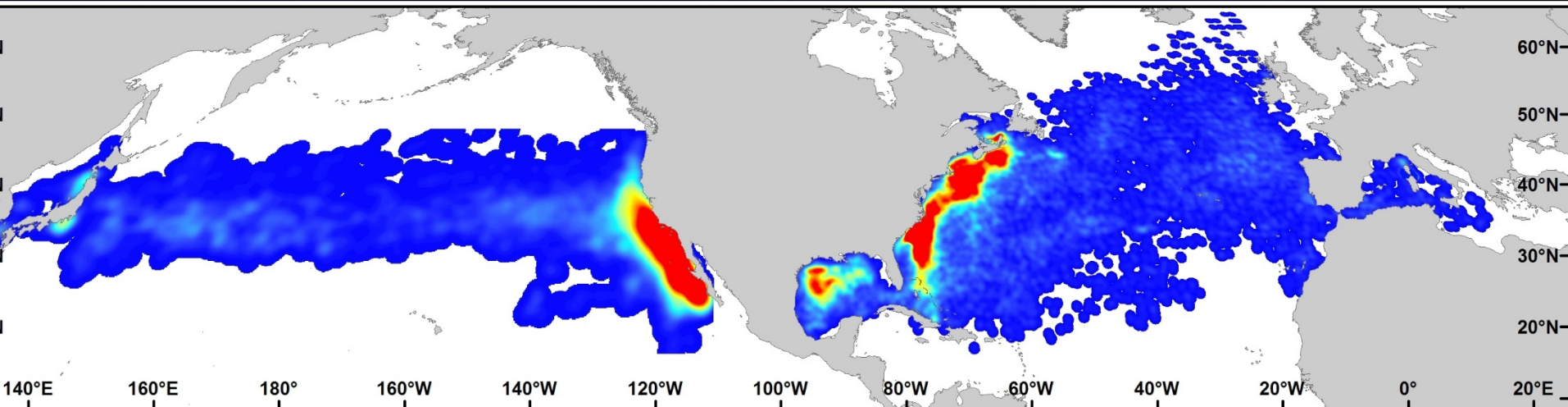
Giant Bluefin: Tracking Animals that Remain Submerged



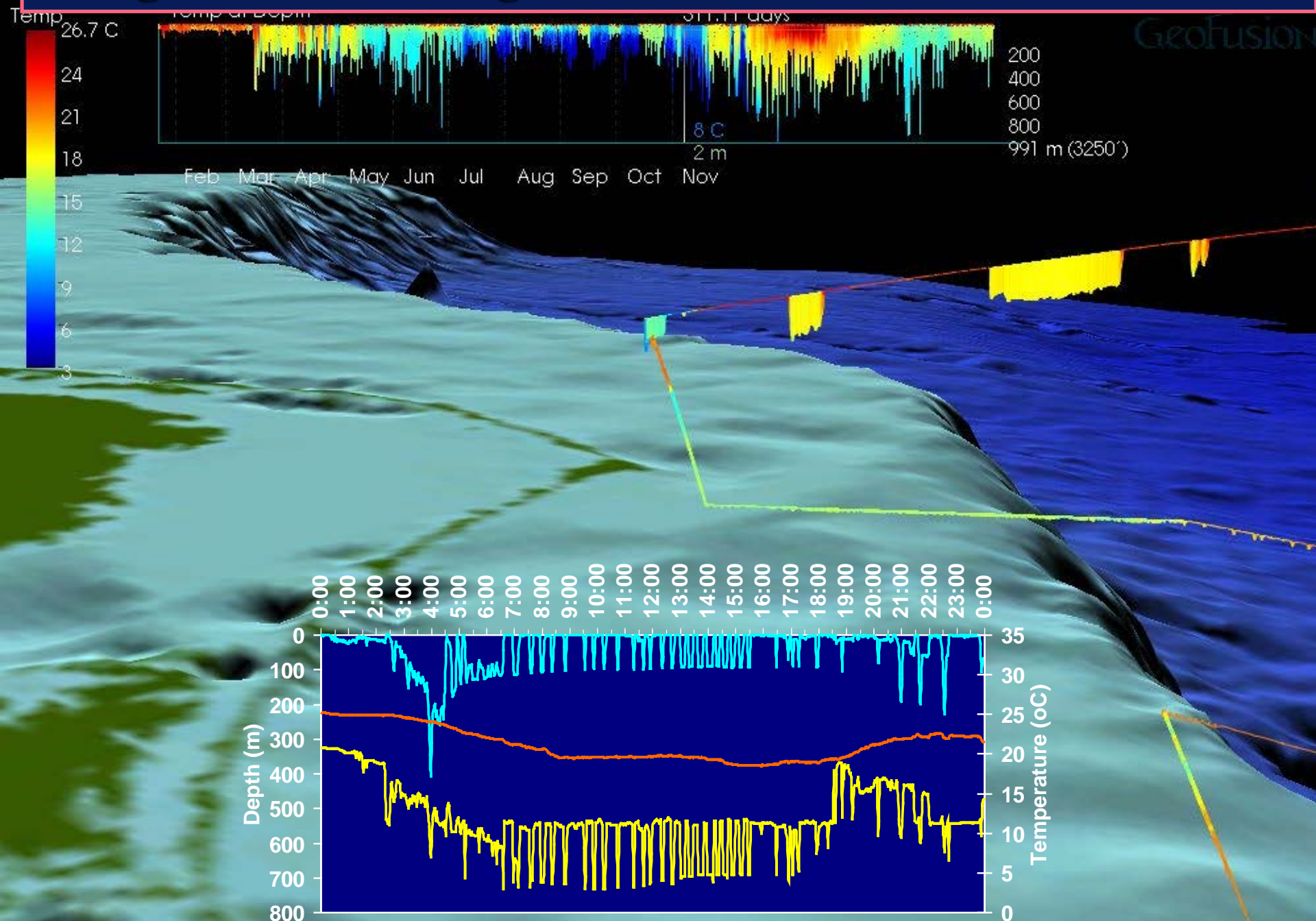
Bluefin: Tracking Animals that Remain Submerged



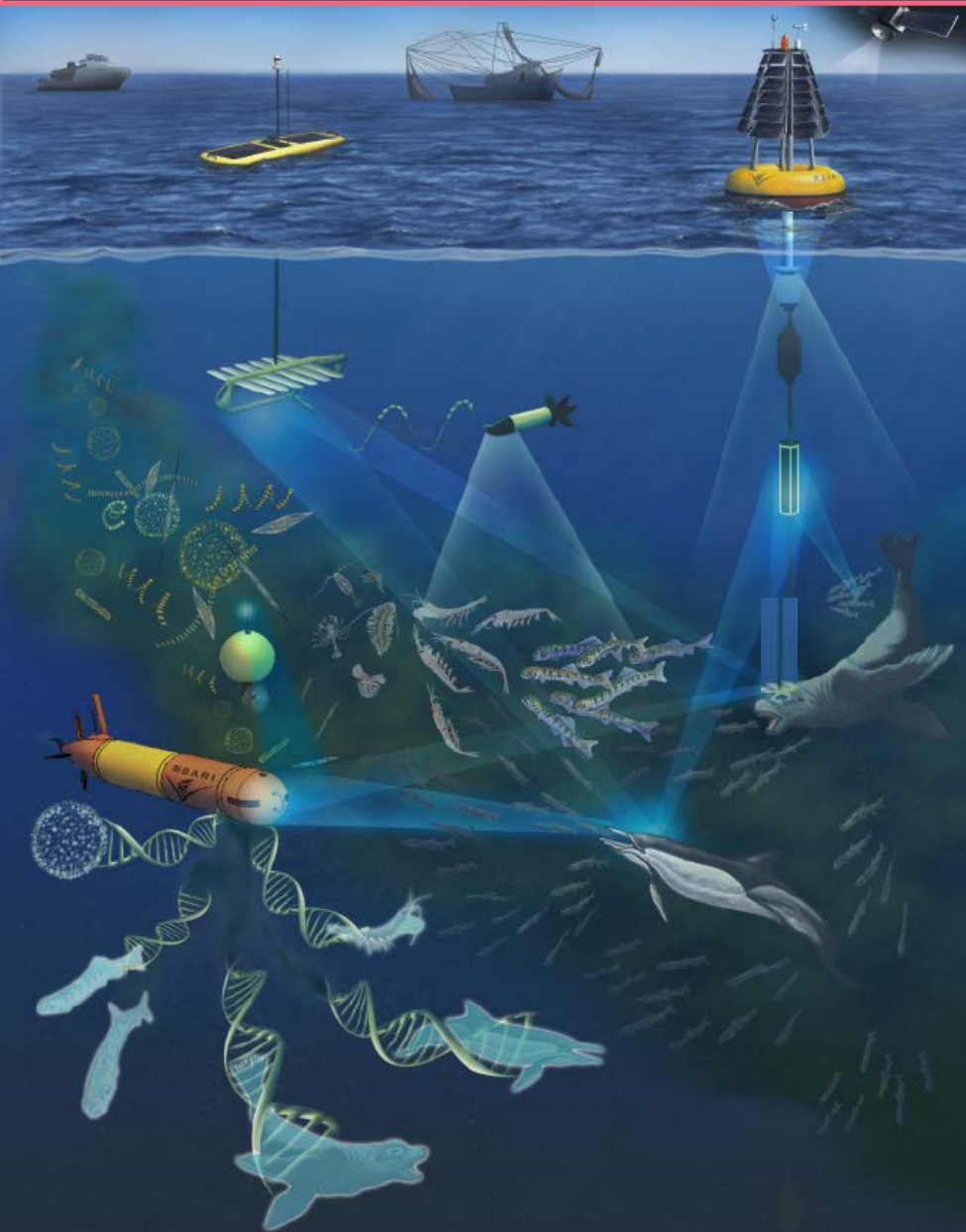
Can Electronic Tagging Data Improve Bluefin Tuna Population Assessments? Mortality, Maturity, Population Structure, Life History



Tags Provide Diving Behavior & Info on Environment



Can We Monitor Ecosystems?



- **Biologging (ARGOS)**
- **Gliders/ Drones**
- **Buoys**
- **eDNA**
- **Environmental Monitoring for Oil?**
- **Look for Eggs**
- **Identify Genes that Indicate exposure**

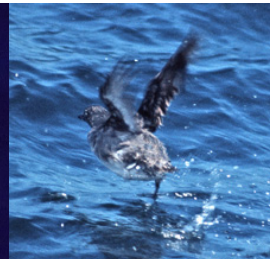
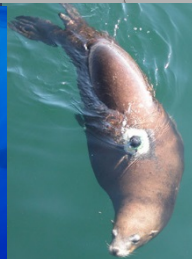
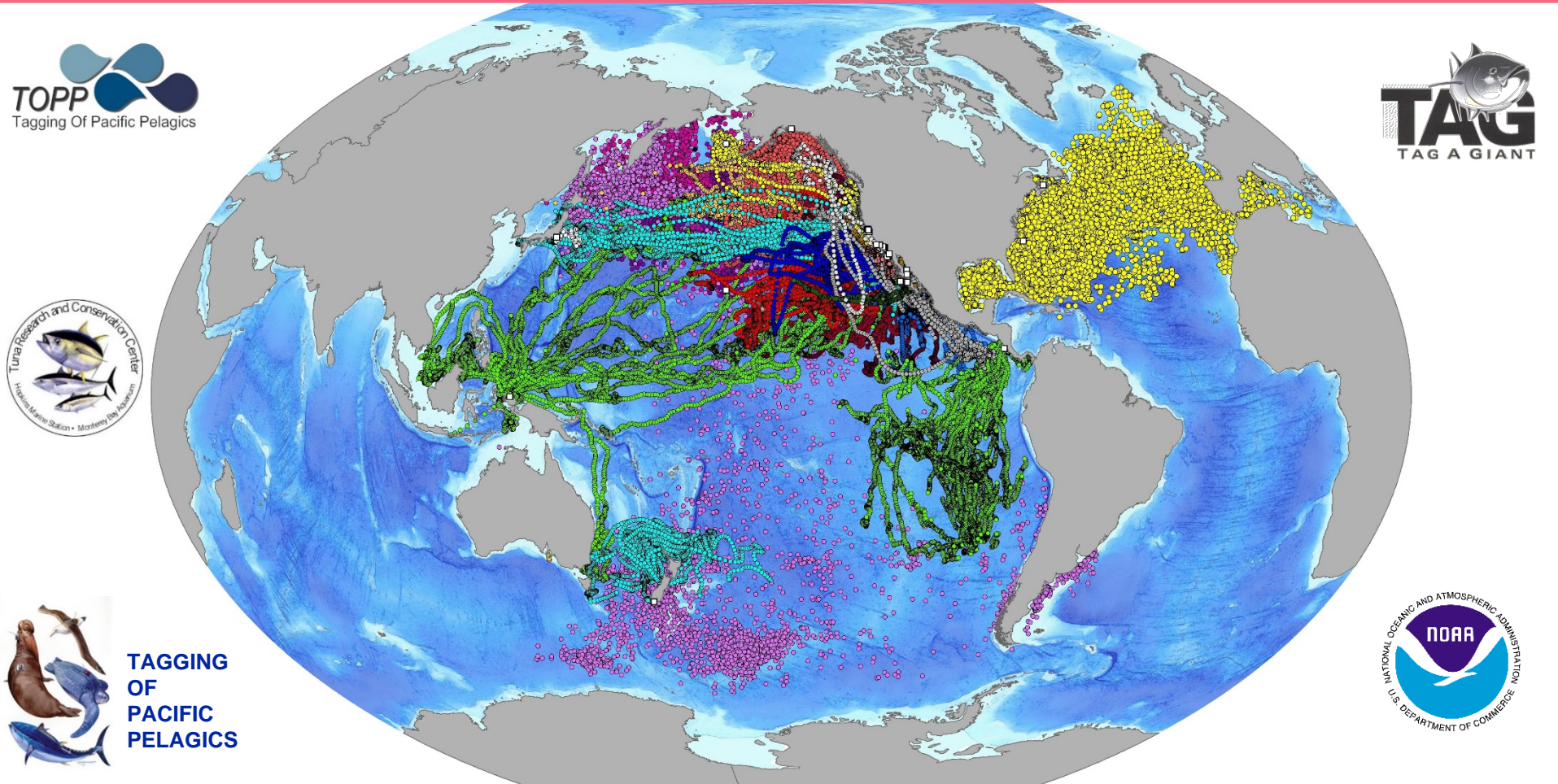
Observing, Monitoring and Protecting the Blue Serengeti off Our California Shores

Tagging of Pacific Pelagics



Pacific Bluefin Tuna Electronic Tagging Program

*TOPP (ONR, Moore, Packard, & Sloan)
Monterey Bay Aquarium & Stanford University*



Argos Satellite Telemetry



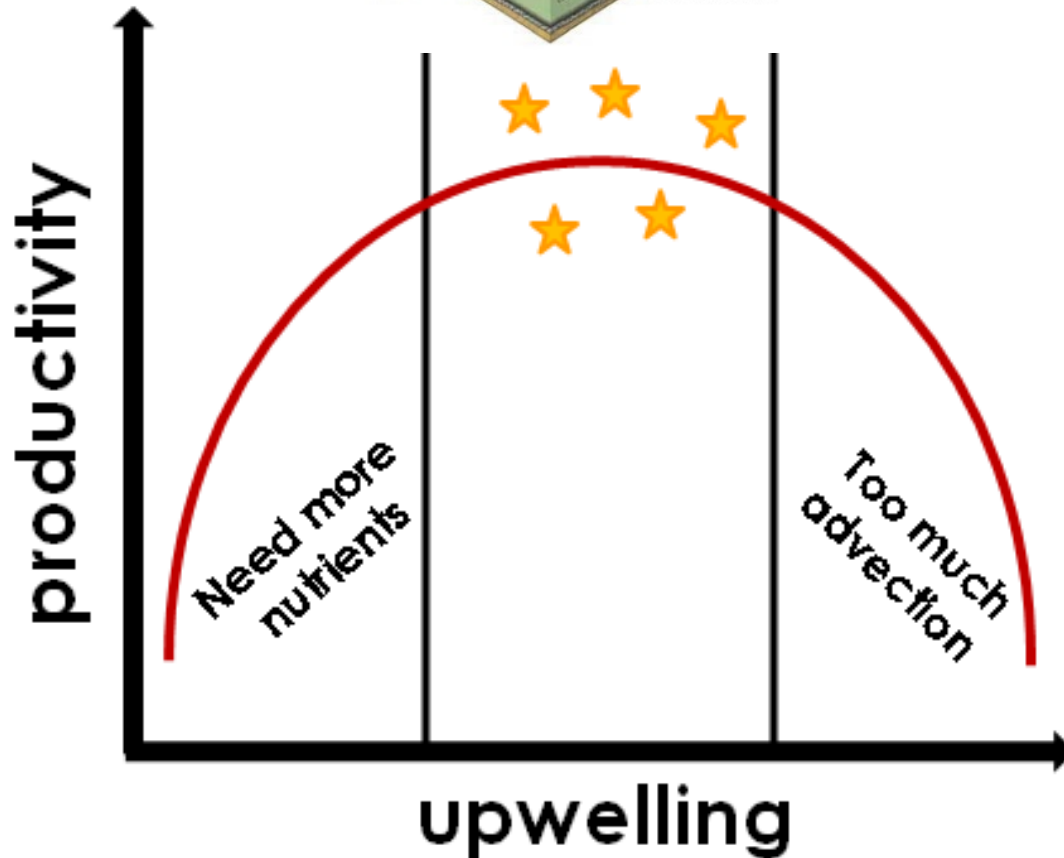
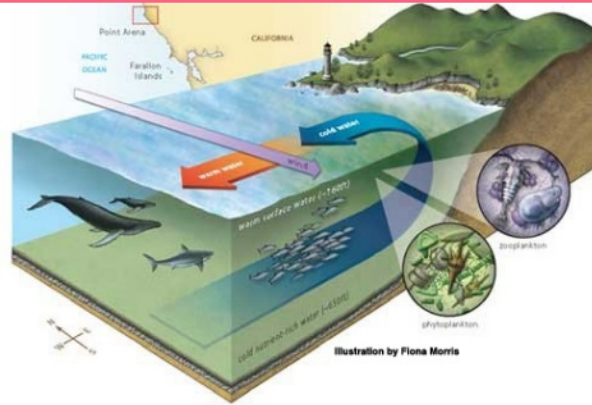
- Radio Telemetry
- Position
- Oceanography
- Behavior & Physiology
- Life History (mortality, survivorship data)
- Population Abundance



Biologging: Tag, Track, & Monitor Marine Animals

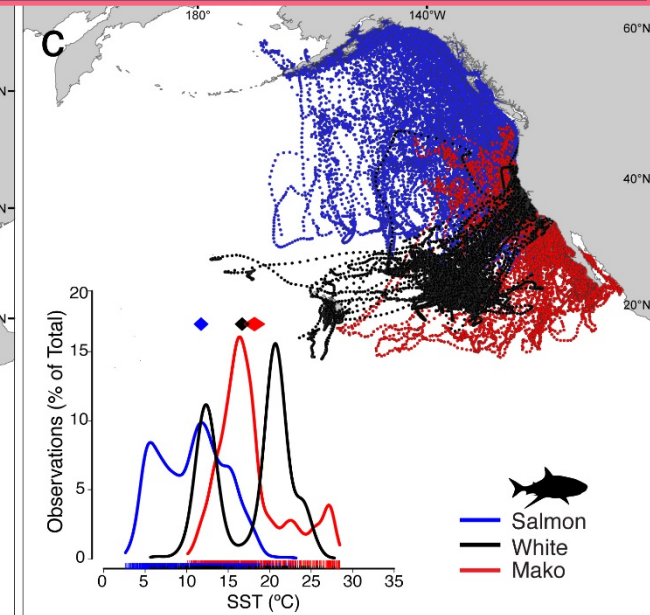
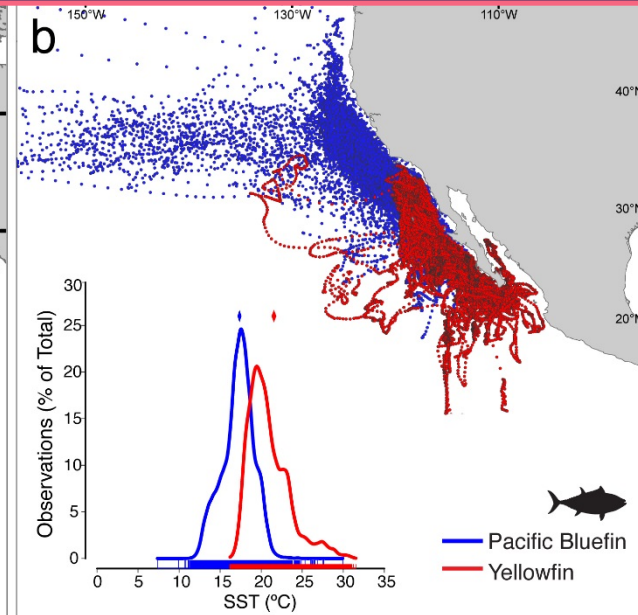
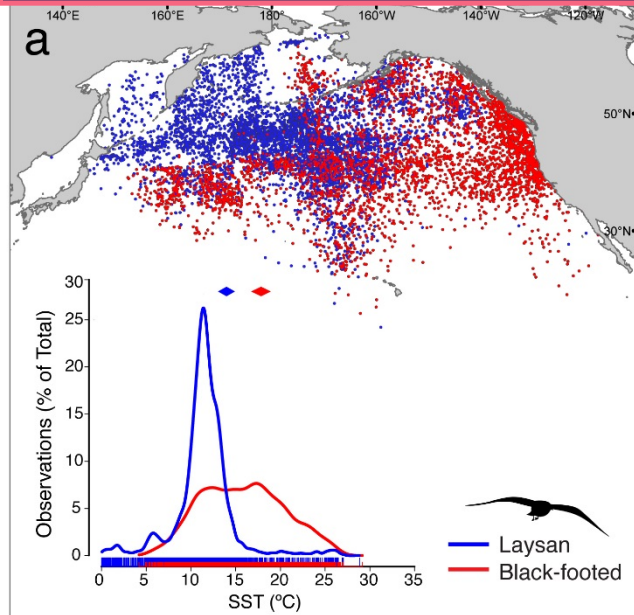


Where are Windows of Optimal Habitat?

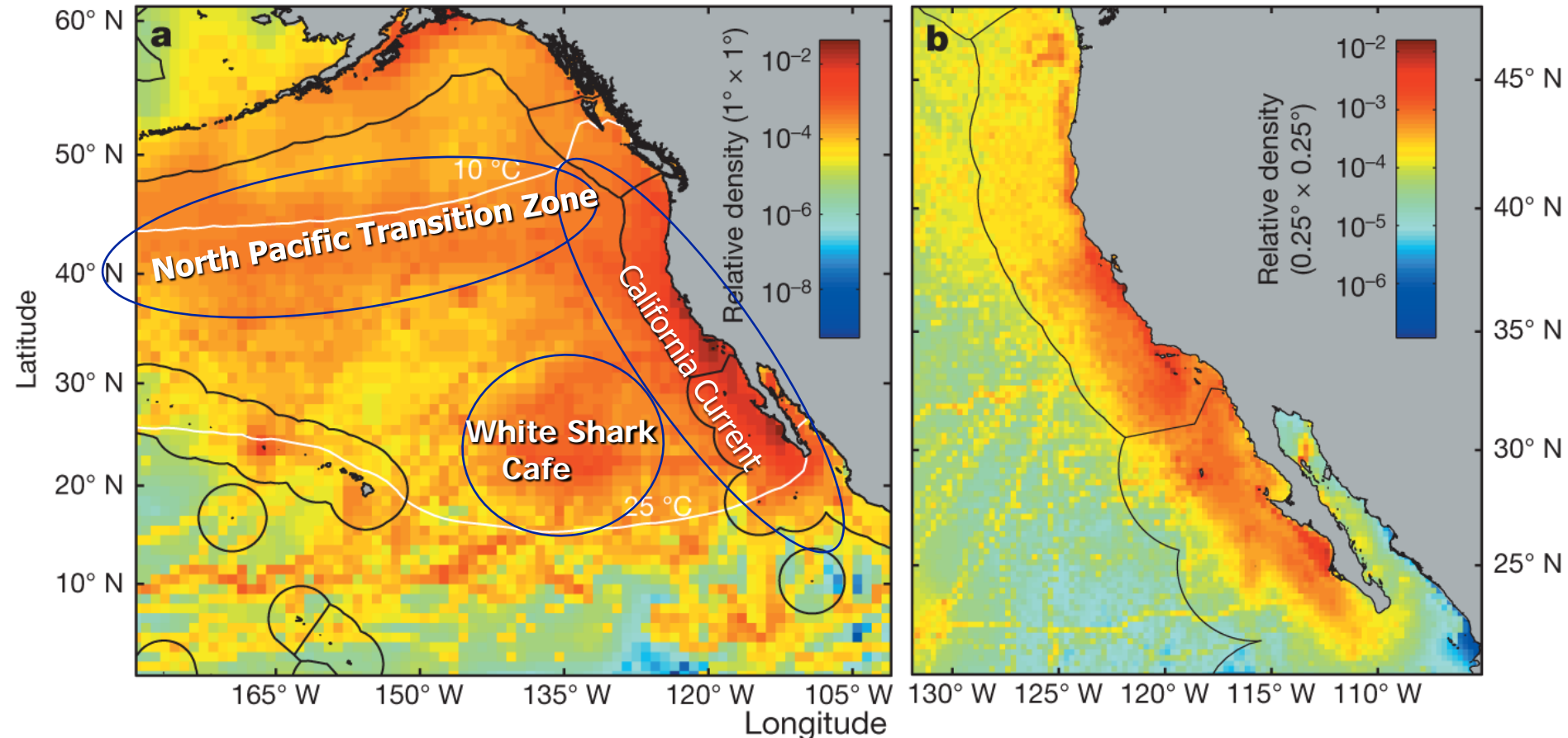


Tagging Reveals Niche Utilization

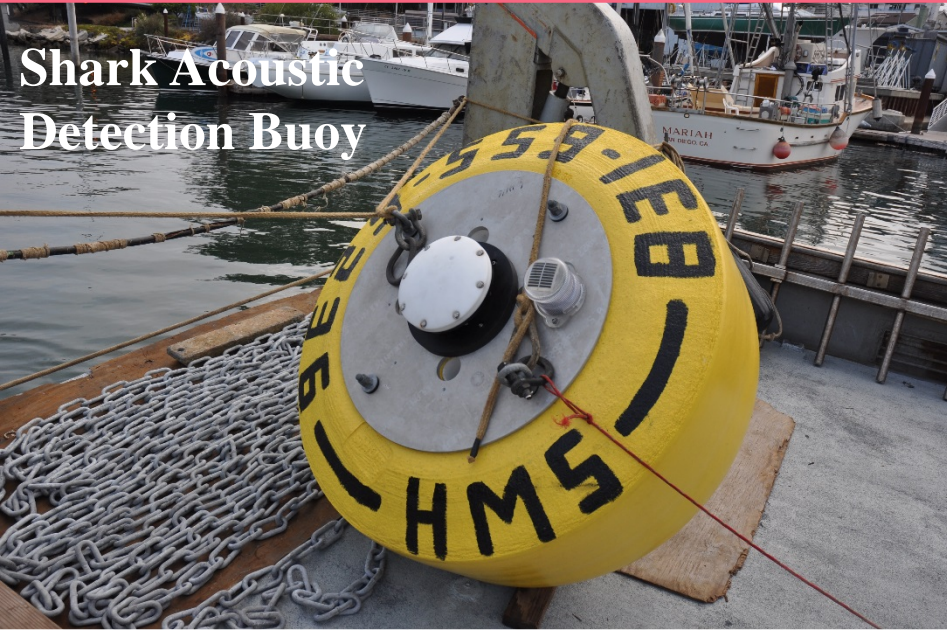
Thermal Niche Separation: Albatross, Tunas, Sharks



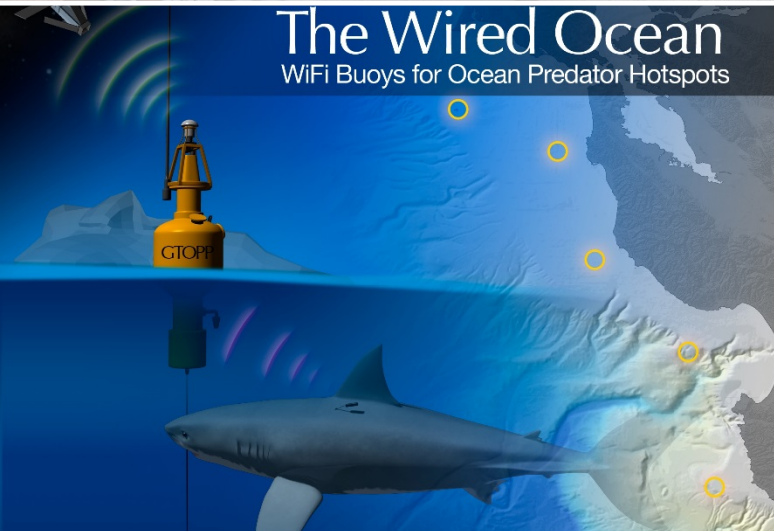
TOPP Biological Hot Spots (Density) in the CCLME: Where the Predators (23 Species) Roam



Can We Monitor Apex Predators in Real Time? Yes

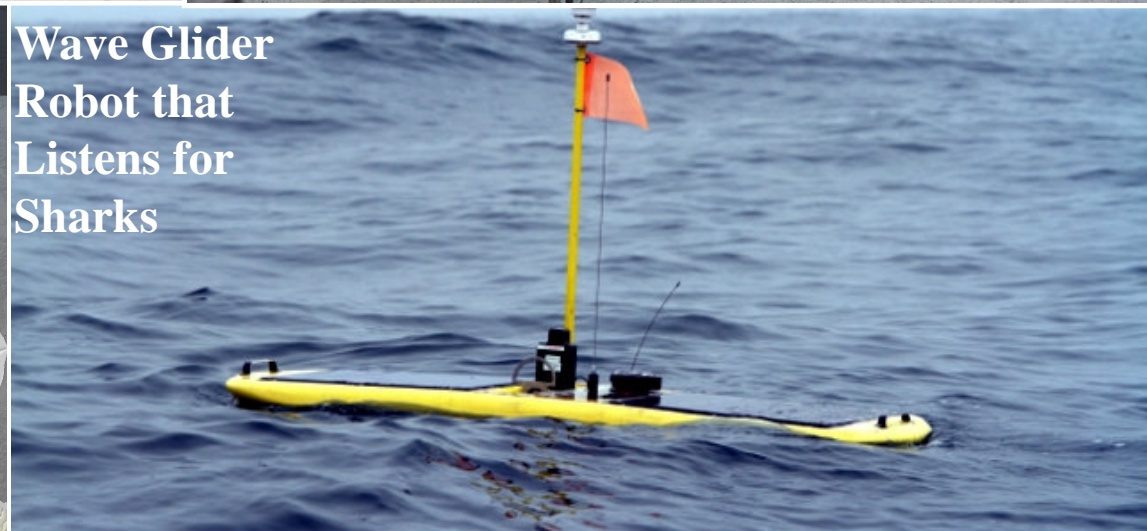


**Shark Acoustic
Detection Buoy**

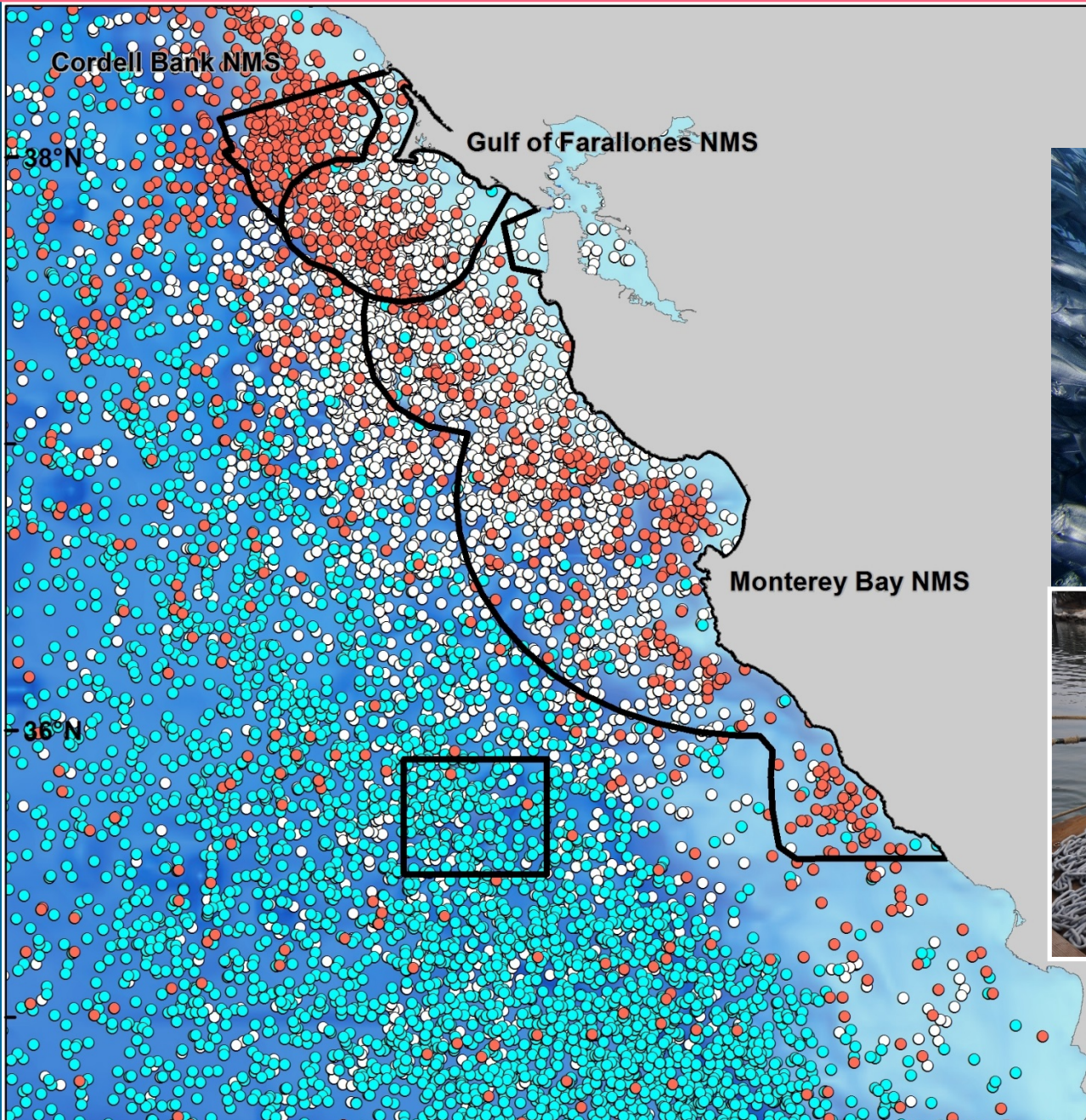


The Wired Ocean
WiFi Buoys for Ocean Predator Hotspots

**Wave Glider
Robot that
Listens for
Sharks**



Can We Monitor Sharks in our National Sanctuaries?



- Pacific Bluefin tuna
- Salmon shark
- White shark



SharkNet: Live Shark Detection Buoys



Map Buoy Sightings

Año Nuevo North

Info Photos

3D Model

Description

6 Sharks Sighted (last 255 days ago)

Land Map Ocean Chart

Showtime

14 4

Año Nuevo

R "24 14

FI R 6s

WHIS

5³ 7

mp Engine Wave Glider "Carey" Tomales Point Point Reyes Año Nuevo North Farallons West End

bob.doiron@amirix.com, bdoiron74@gmail.com, gien.robinson@bblock@stanford.edu, tkchapple@ucdavis.edu, alans@mola.star.salvo@stanford.edu, paulkanive@gmail.com, mrcastle@stanford.monique@mbari.org, Kochevar@stanford.edu, sharkman1137@

Date: Tue, 23 Sep 2014 13:35:03 -0300

Subject: VR4G-200075: A69-1303-32528, Interval Count = 49



Tag ID: A69-1303-32528

Last Detect Time: 2014-09-23 16:34 +0000

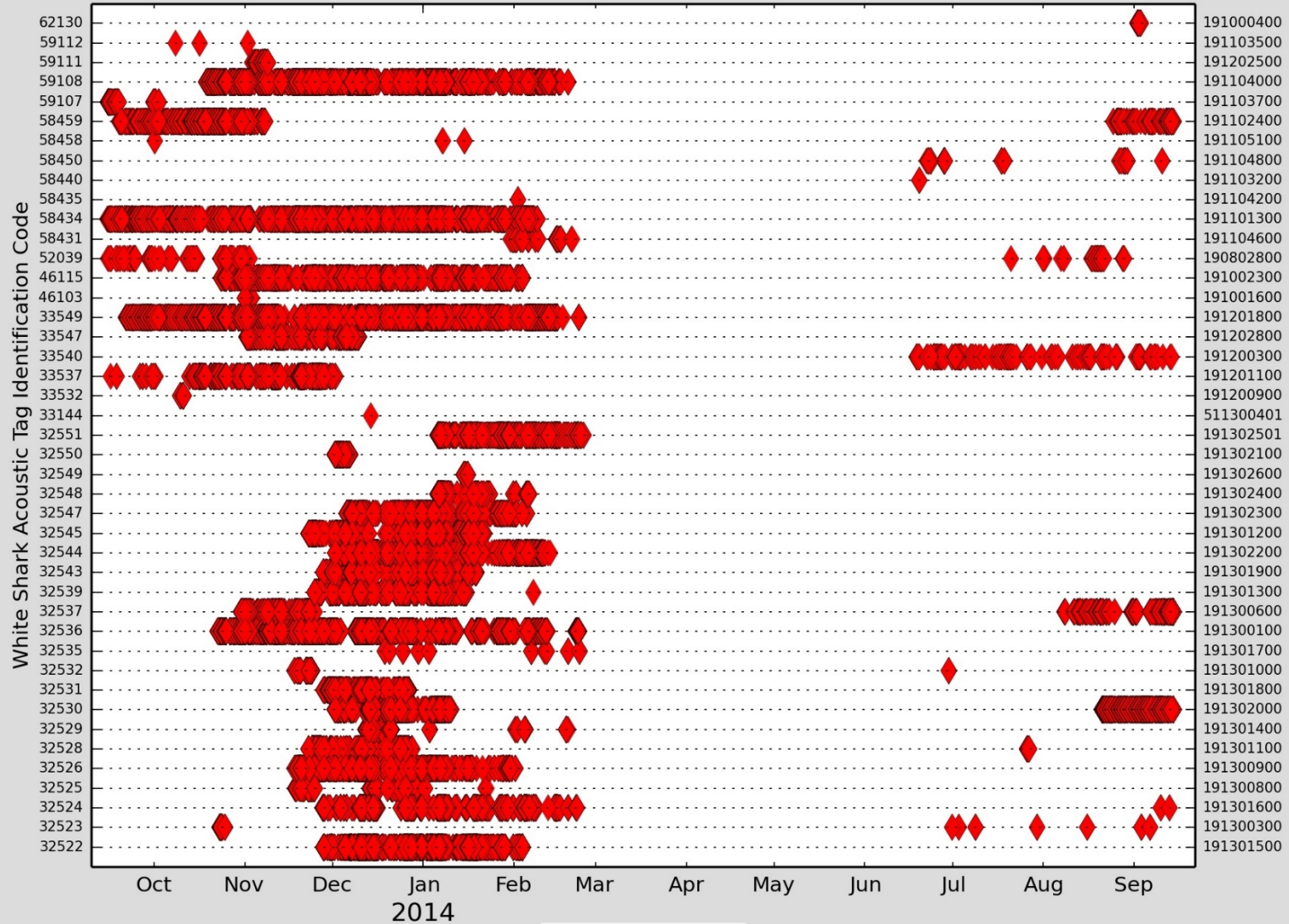
Interval Count: 49

Notification ID: 6811

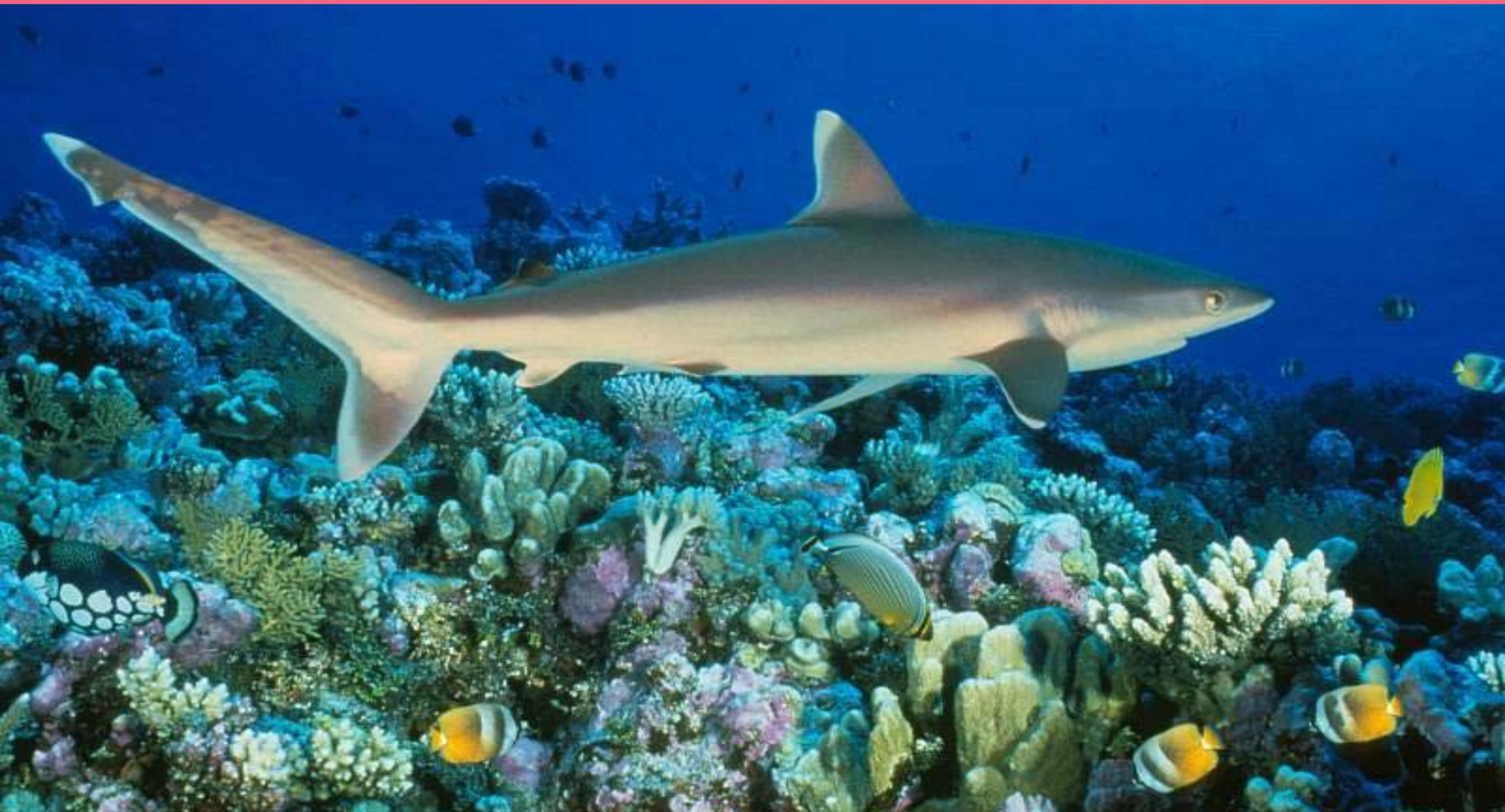
IMEI: 30-002501-092478-0

White Shark at Detection Buoy- Ano Nuevo Reserve, California

Acoustic Detections - 12 Months



How Can We Now Leverage the Technology To rapidly use it in the Line Islands?



Monitoring Marine Protected Areas

We Need to Census Health and Residents



MPA Environmental Monitoring



Active Wildlife Tracking & Anti-Poaching



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Fish and Shark Tracking



Ocean Observation for
Detecting Climate Change

Major Need for Surveillance Technology in Ocean

Will We know When Seascape Changes Occur?



Monitoring MPAs With Biologging Technology

Environmental Intelligence

- Know What you're Protecting
- Long-term Census
- Map Dynamic Nature of MPA Animal Movements (Tuna Versus sharks)

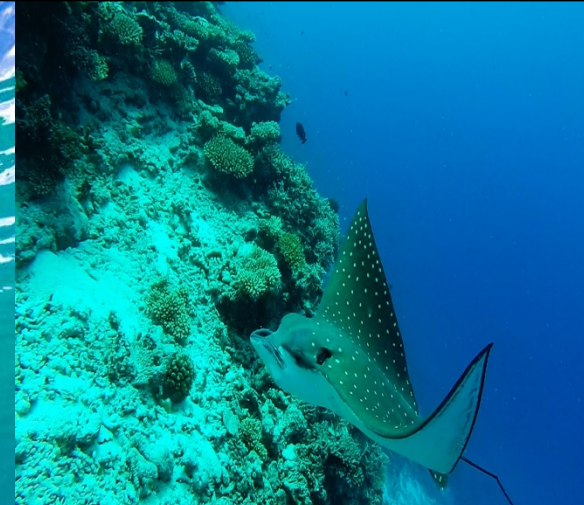
Active Management

- Iridium/Cell Enabled Buoys
- Predictive models from tag Movements
- Mobile Gliders Patrols
- Ocean Observing
- Vessel Intrusion Monitoring

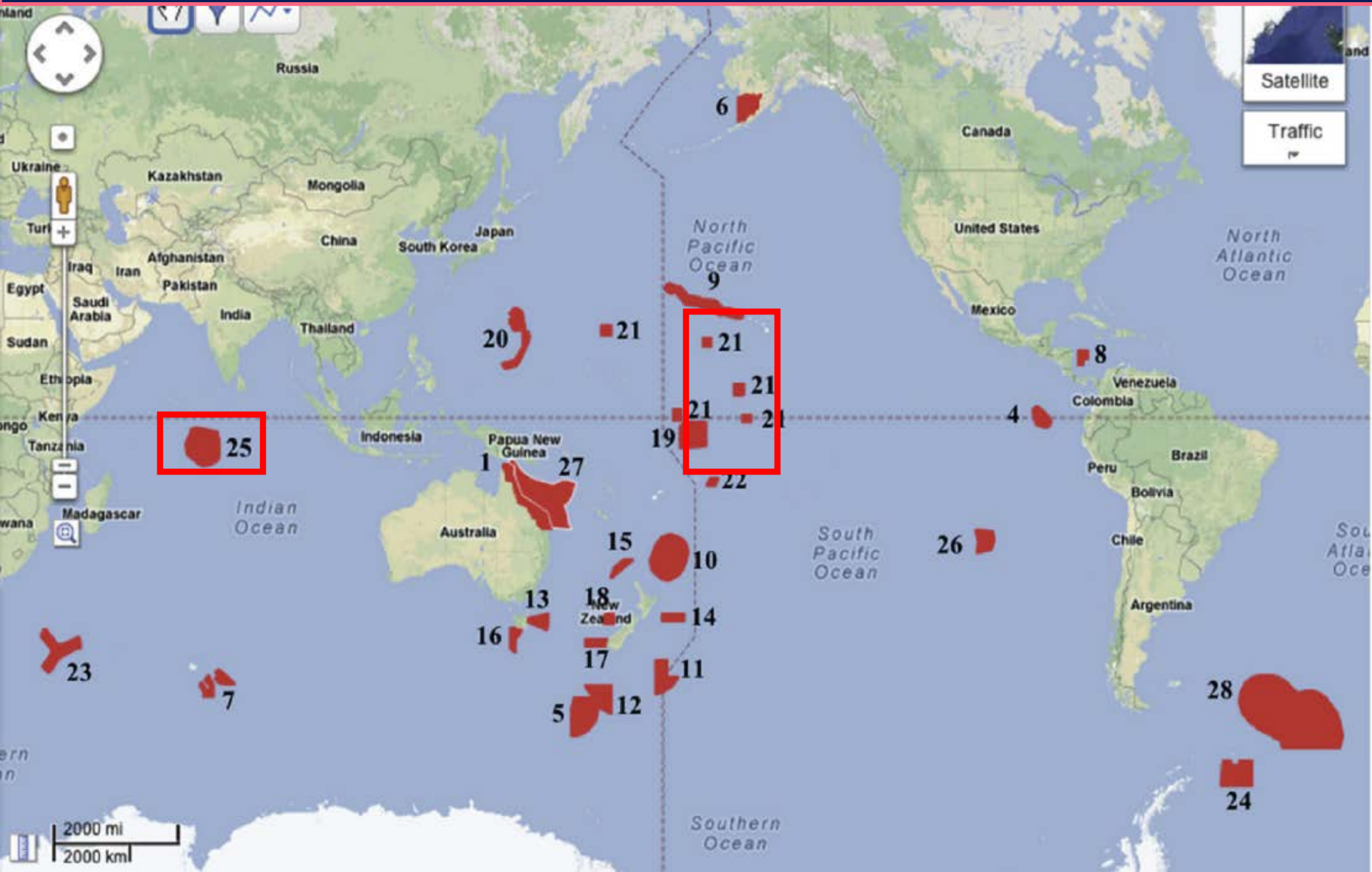


What If?

- You could Census MPA Residents Remotely?
- Know how Tunas and Sharks Utilize the Atolls/Islands
- Know the Residents Schedules by Tides, Daily, Seasonal, Annual Timescales
- Continuously Collect Data on Animal Activity
- Have Remote Photo Surveys of MPA
- Have Surveillance for illegal Fishers Presence



Large MPAs Require Technological Solutions for Monitoring



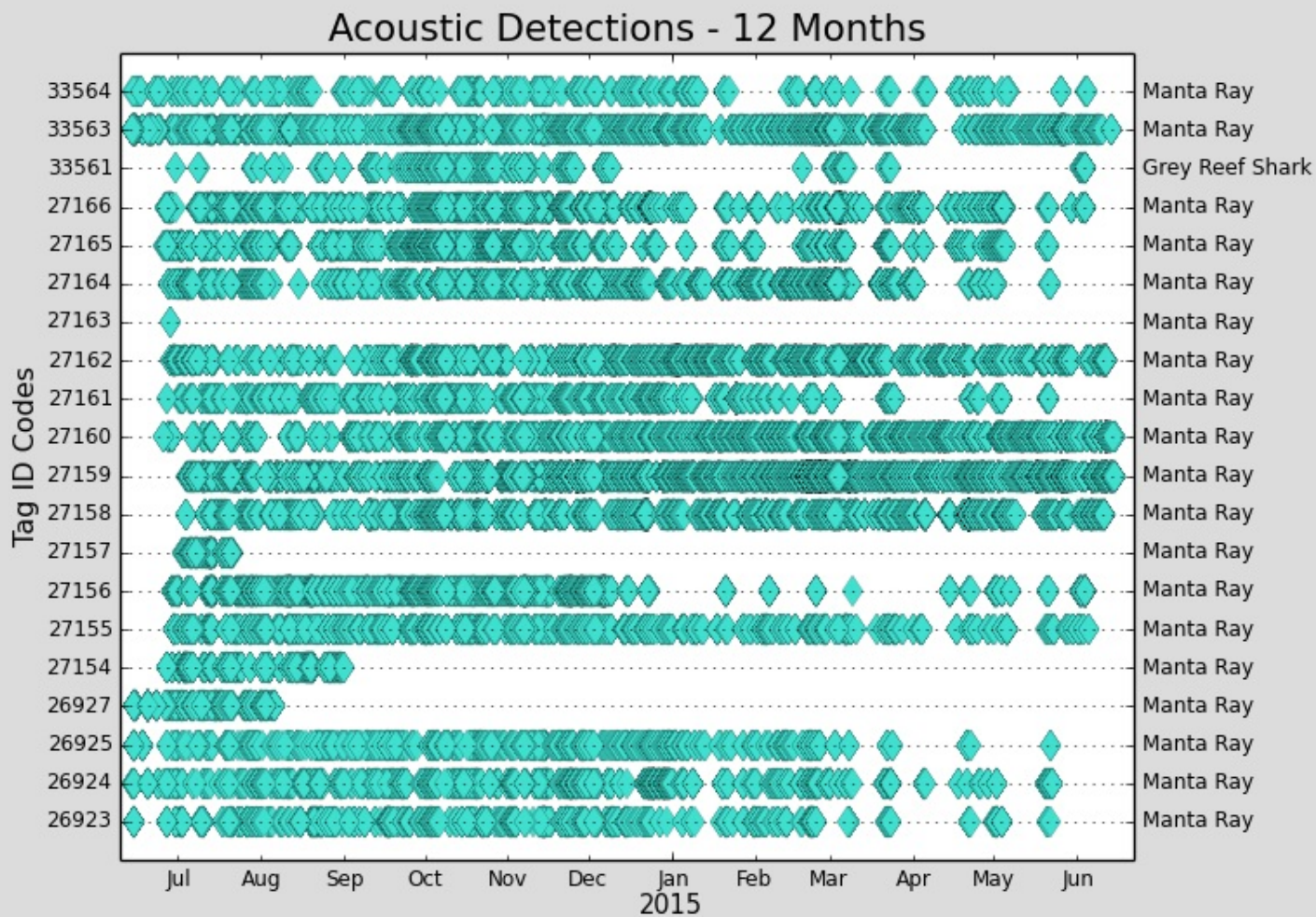
Stanford Researchers Are in the Line Islands

- **Palmyra Consortium**
- **PIPA Oceanography (SEA)**
- **Surveys of Caroline, Malden,
Christmas and Fanning**
- **Oceanographic Data**

Examples: Palmyra-Kingman Reef in Line Islands MPA Remote “Live” Pelagic Monitoring Experiment

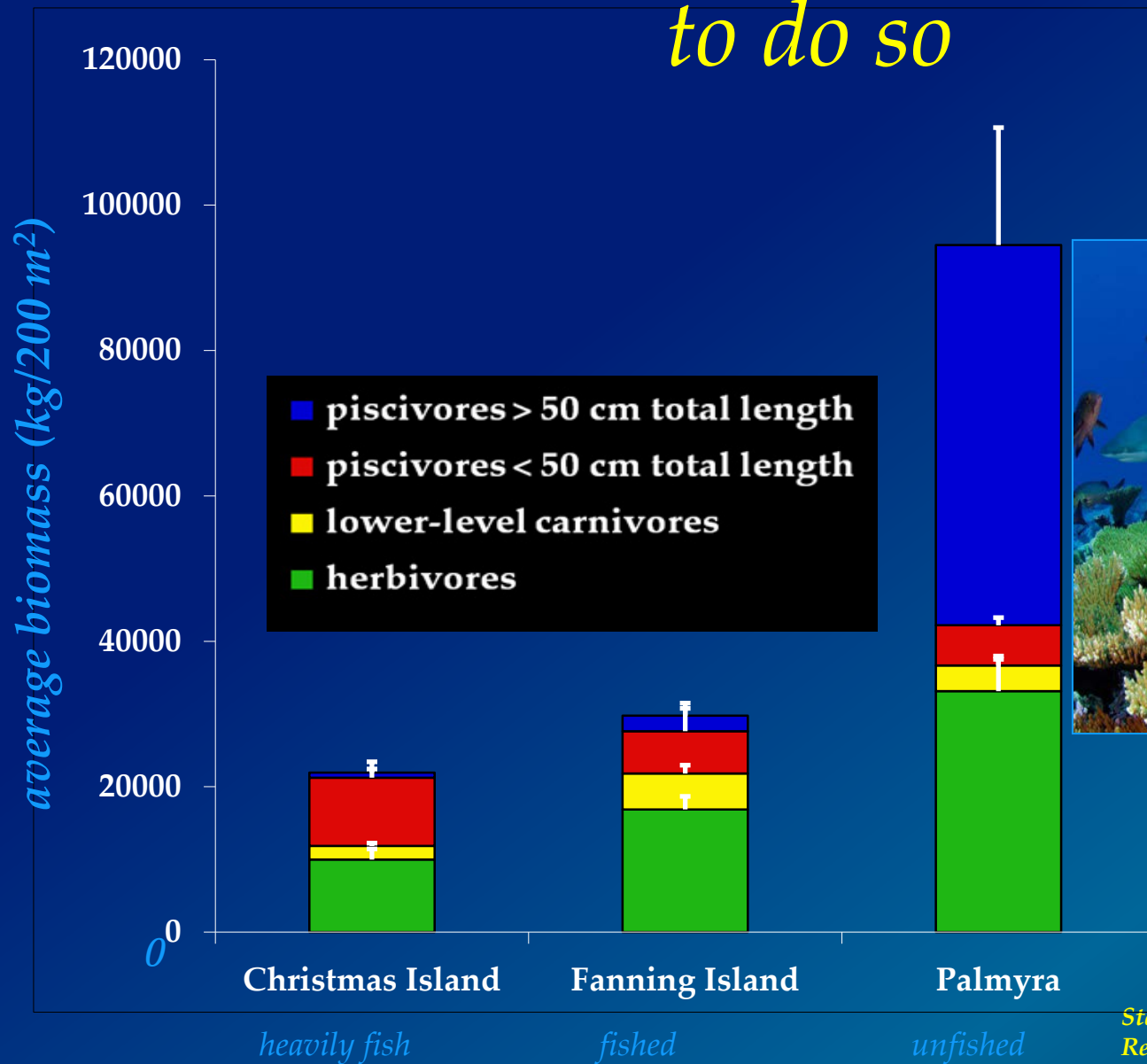


Live Buoys Tracking Mantas at Palmyra Channel

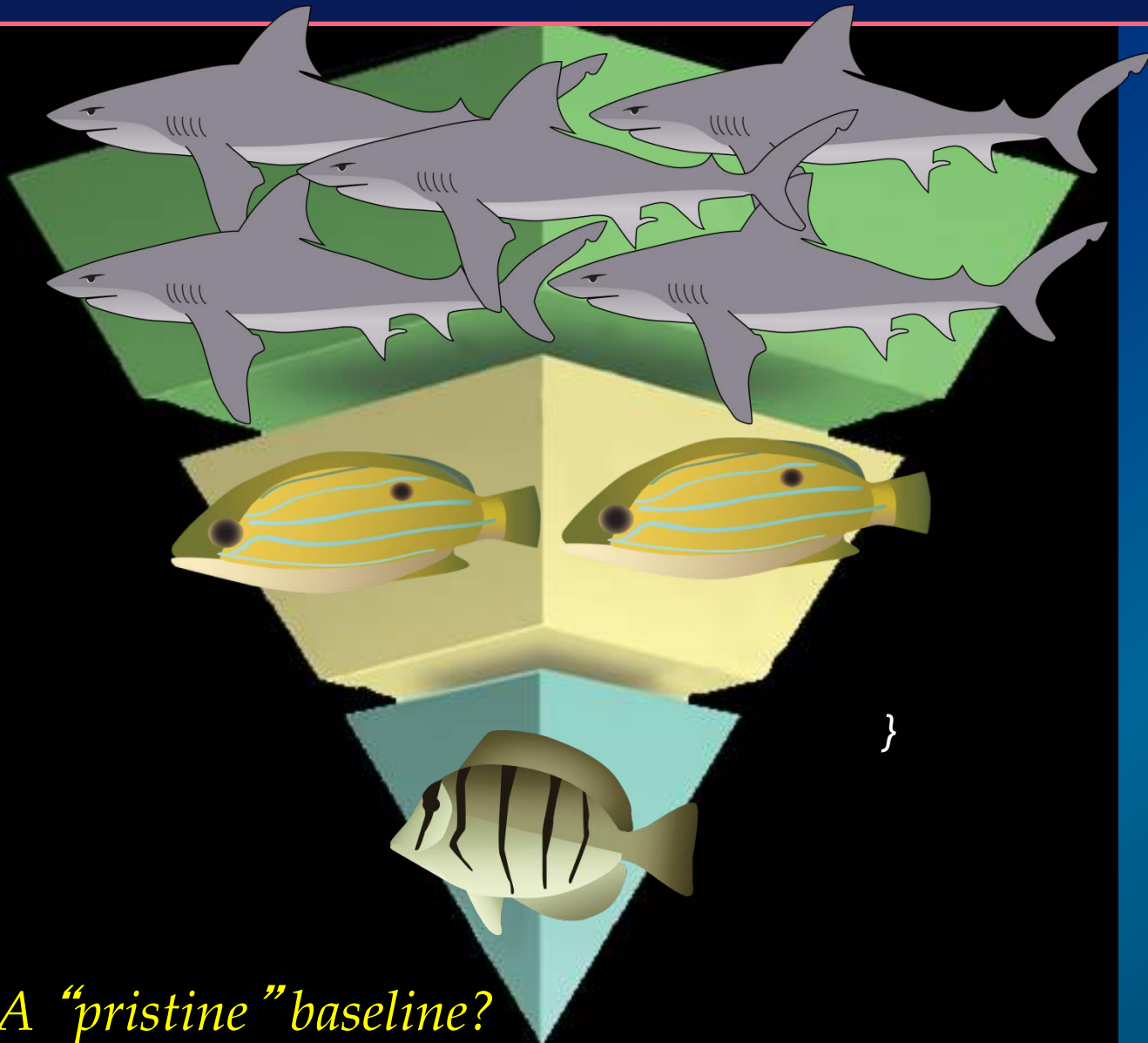


◆ Palmyra

We have measured the structure on coral reefs in Line Islands and continue to do so



Inverted trophic pyramid At Uninhabited Line Islands



A "pristine" baseline?

Large predator sampling: stable isotope analyses



Carcharhinus amblyrhynchos

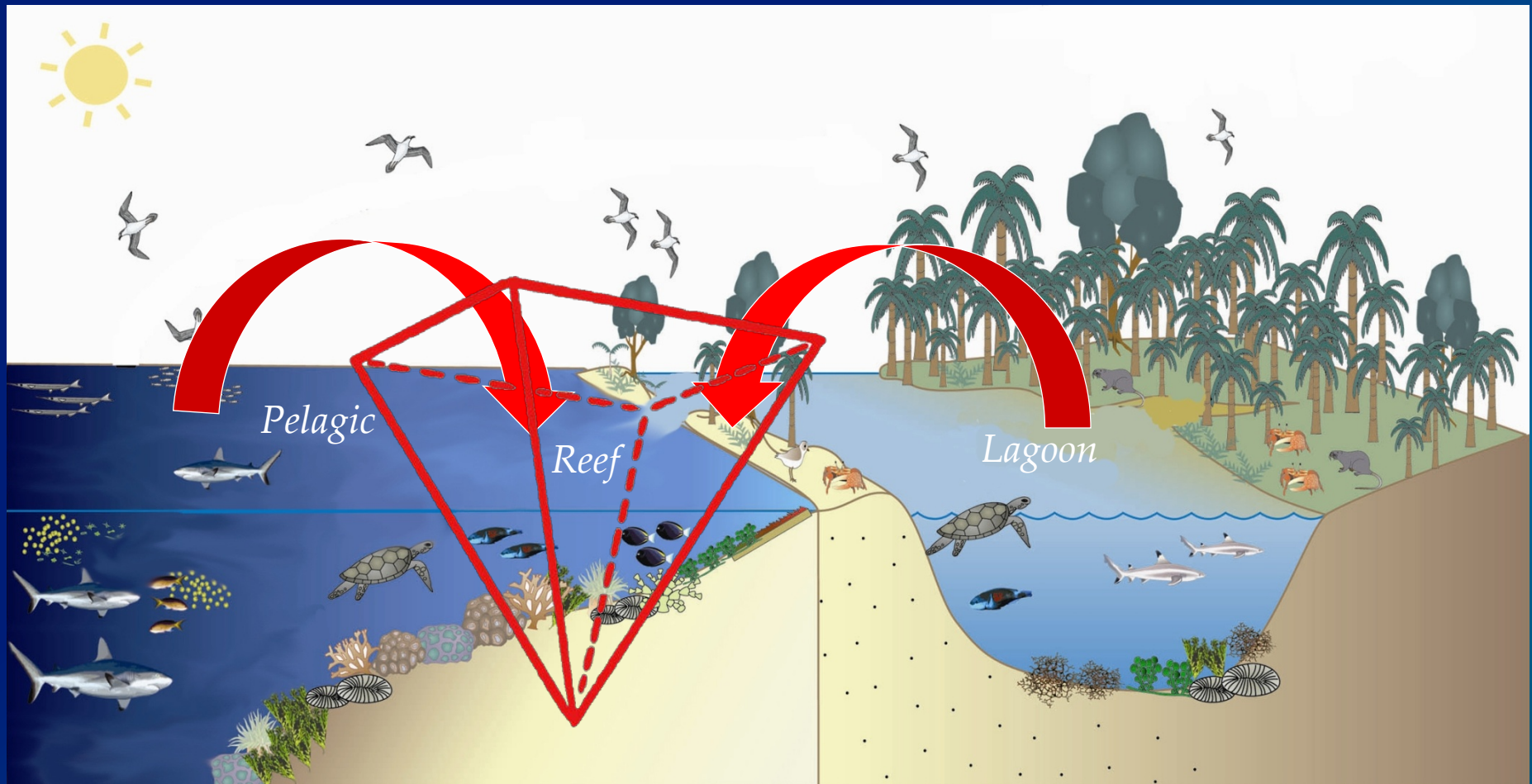


Lutjanus bohar

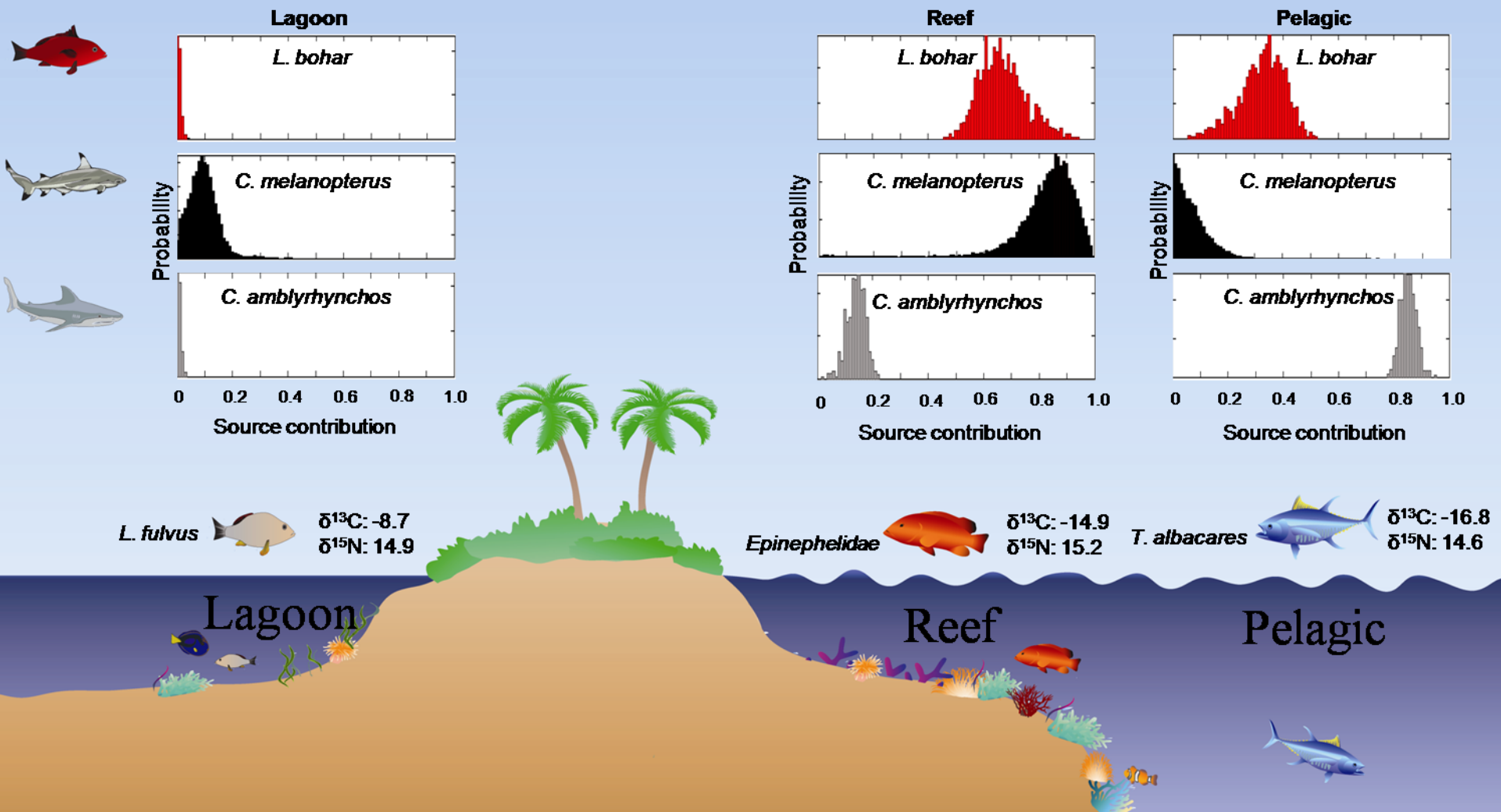


Carcharhinus melanopterus

Isotopes Reveal Mobile mega-fauna energetically link distinct communities



Mobile top predators draw energy from neighboring communities



**Twenty Years of Ocean
Data Stanford and SEA
This Year (2015) was Warmest Ever measured**



Chagos Tagging of Pelagics (Can we Partner?)

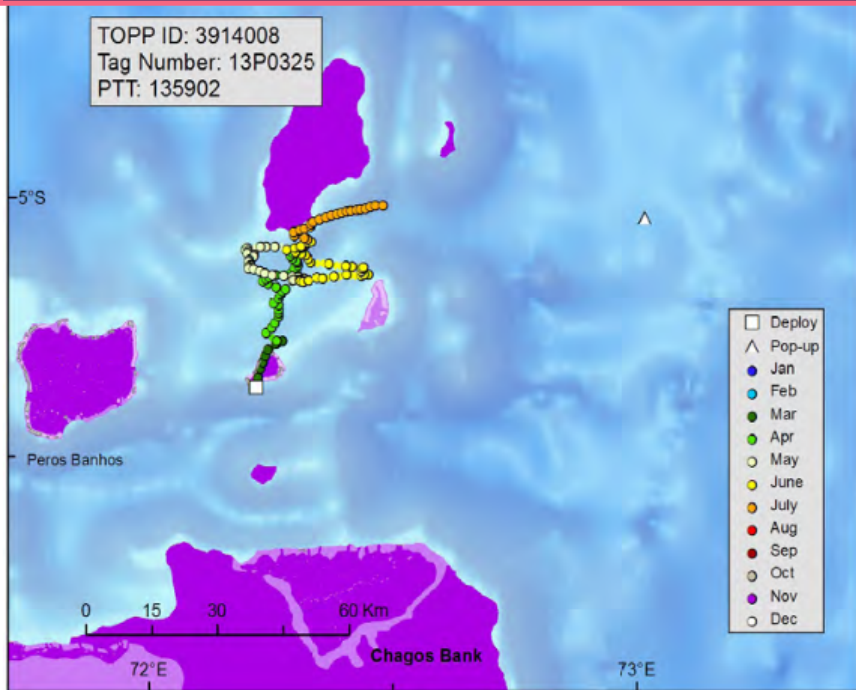
Observing, Monitoring and Protecting MPA Ecosystems





Tagging Reports

TOPP ID: 3914008
Tag Number: 13P0325
PTT: 135902



Eventid: 391400800

Tag Number: 13P0325

Length (PCL): 129 cm

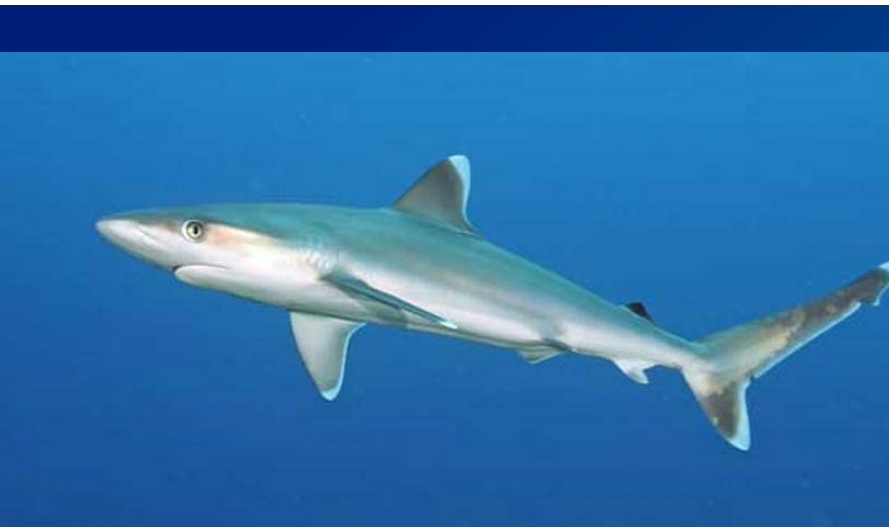
Tagging date: 03/24/2014

Popup date: 07/22/2014

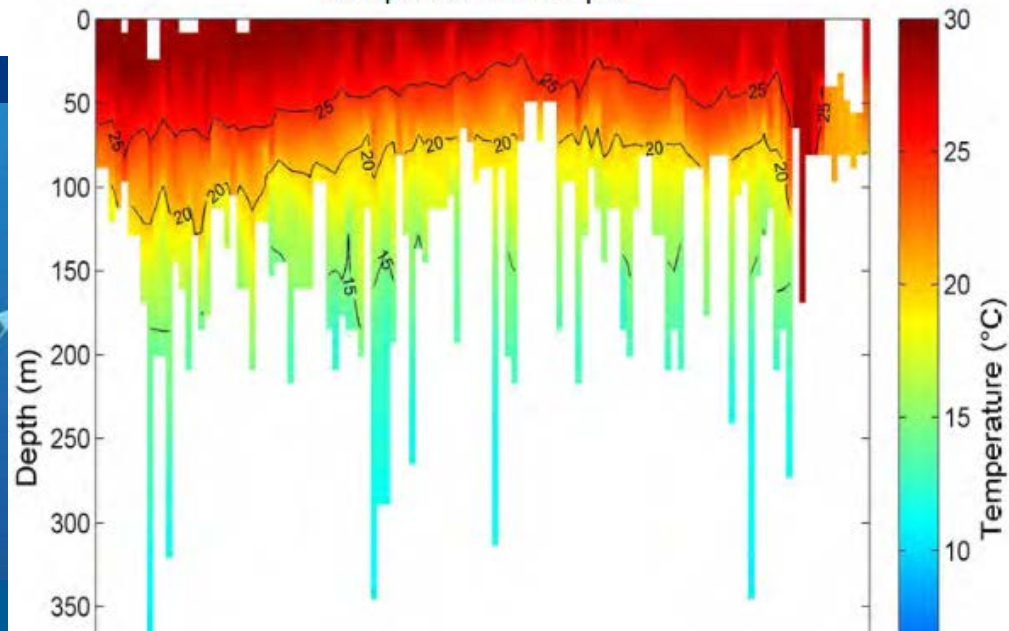
Recovery date: None

Comment:

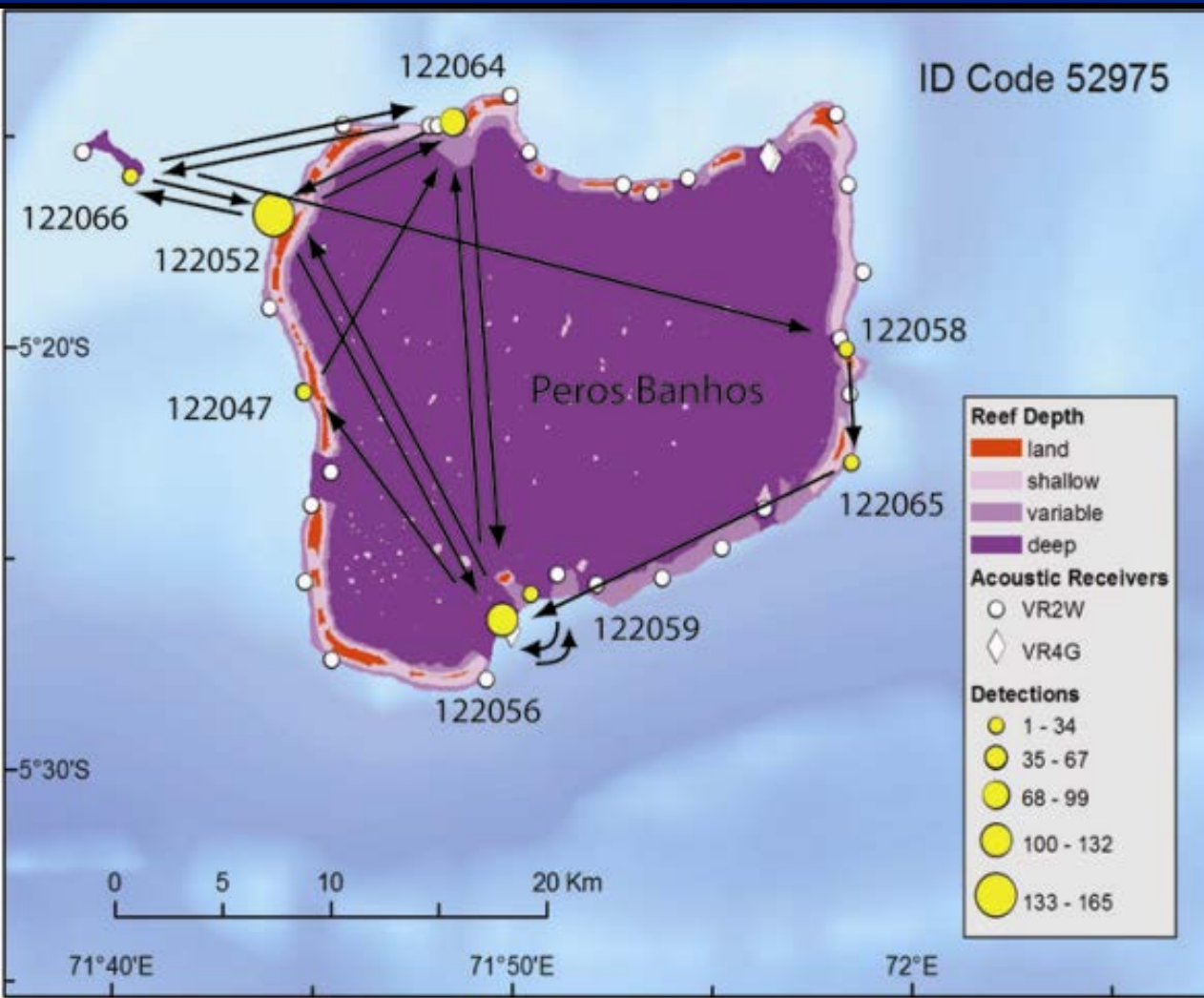
Possible predation event.



Temperature at Depth



Local Movements: Silver Tip with an Acoustic Arrays



The Frontier: New Technology for Improving Ocean Monitoring



Satellites



Ships



Ocean Buoys



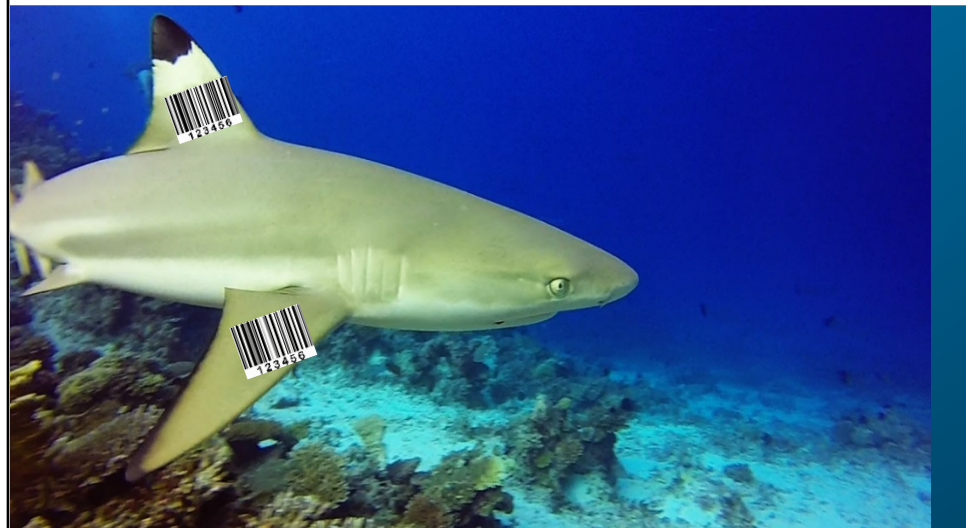
Gliders



Camera Tags

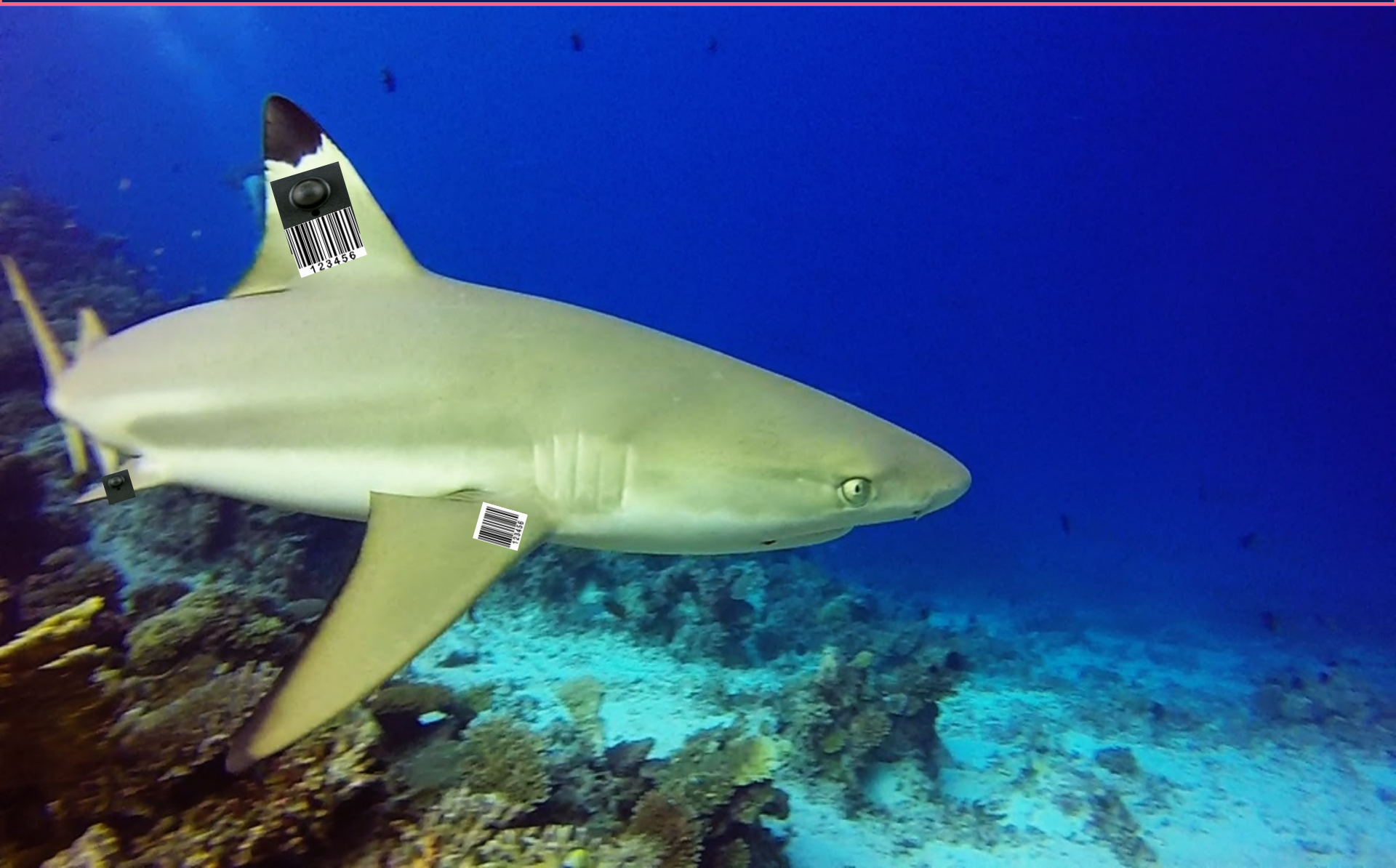


Developing Real Time Monitoring Tools

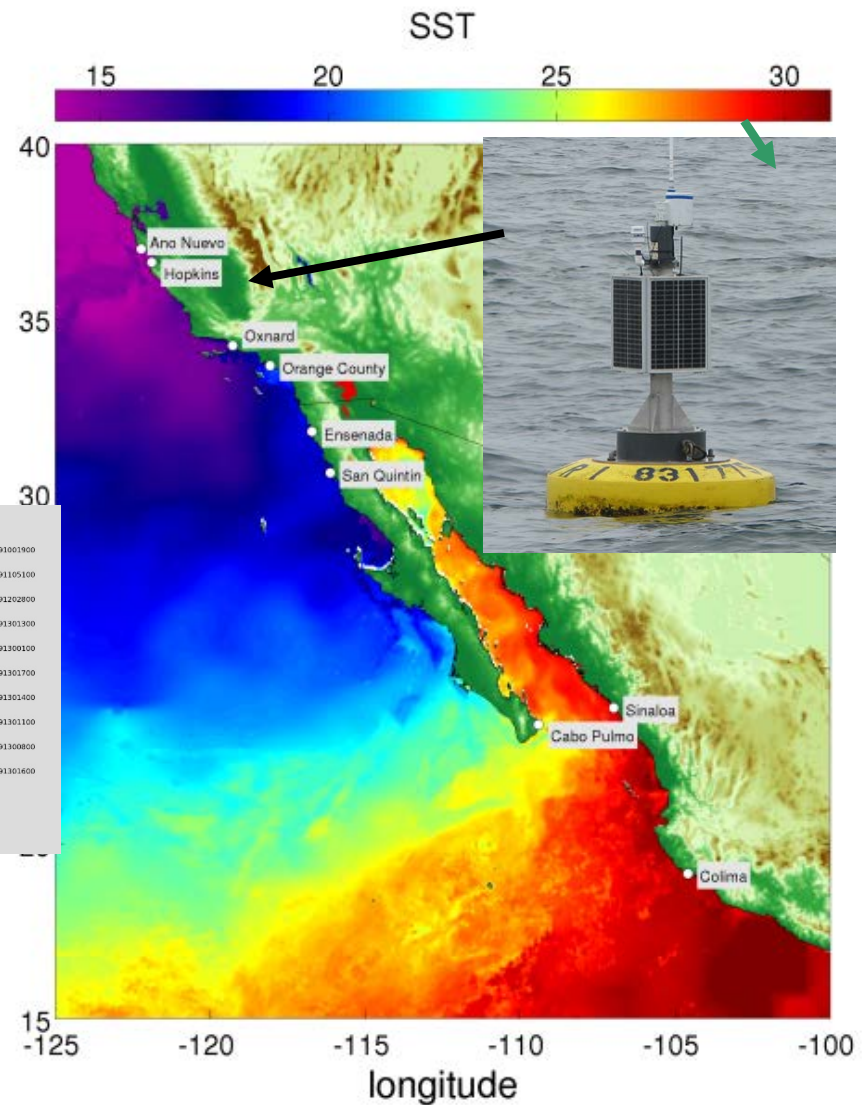
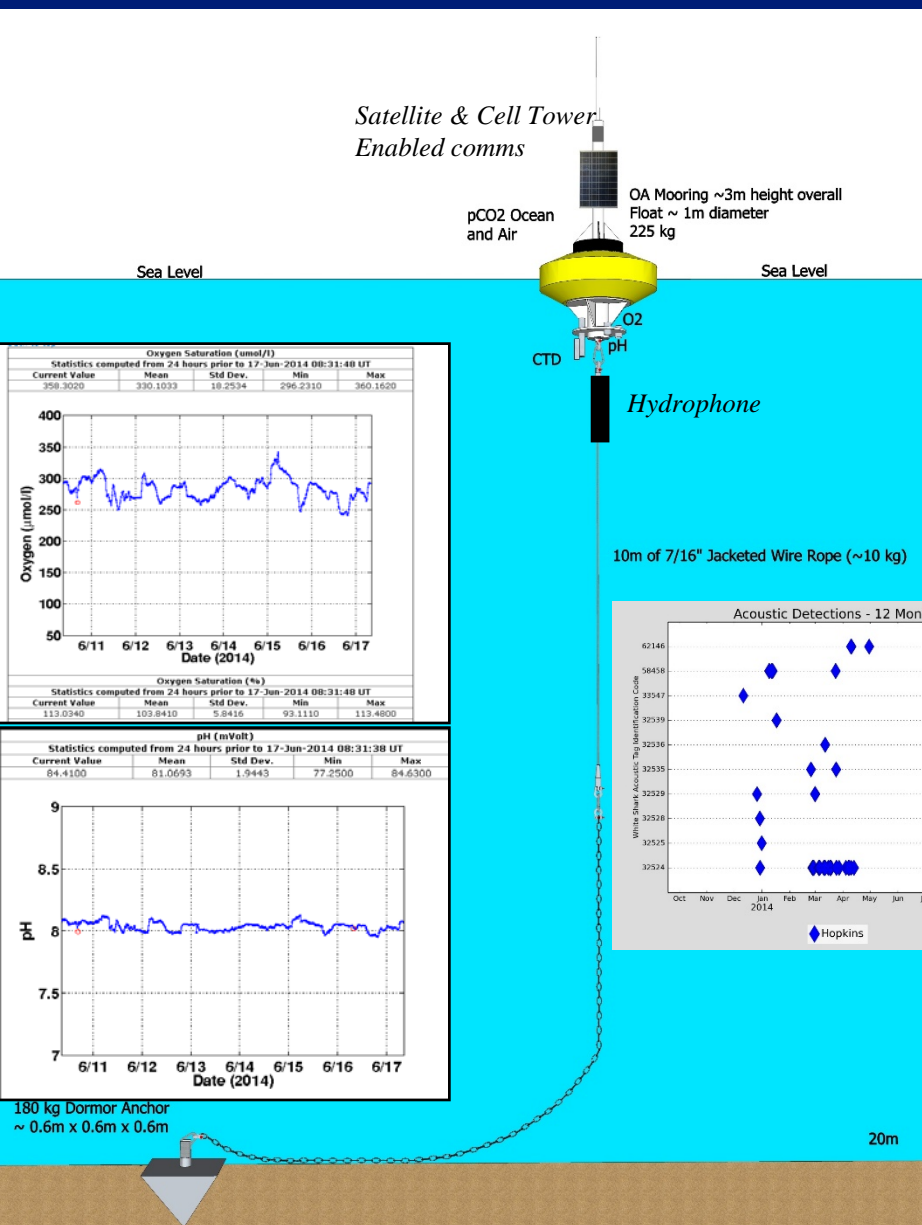


Shark “Fin Alarm” Tag

Will Provide protection for Sharks within an MPA



Ocean observation Buoys

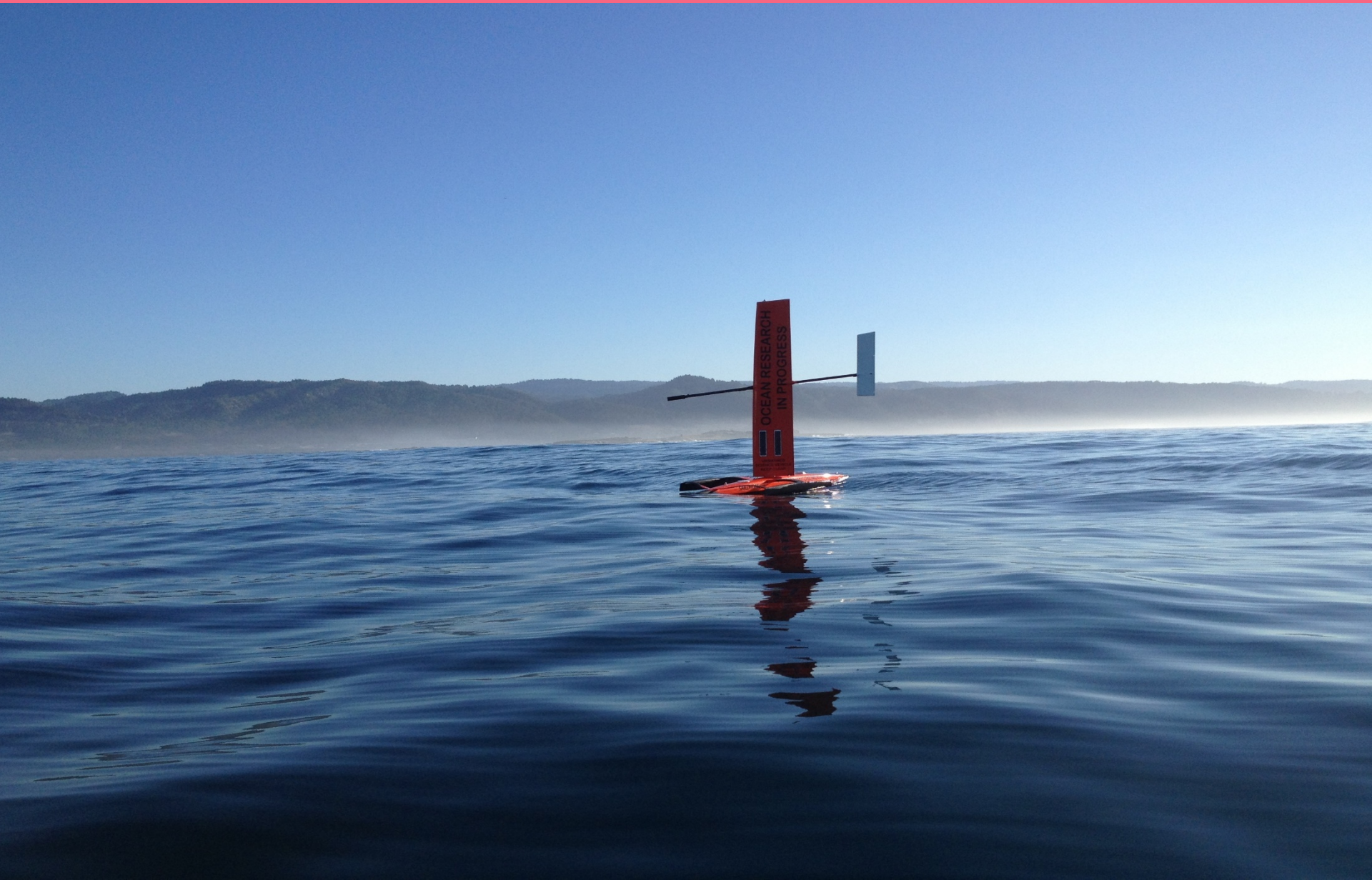


Suggestions for the PIPA MPA Employ Gliders for Monitoring

Anti Poaching Strategy



Experimenting With Continuous Monitoring Techniques



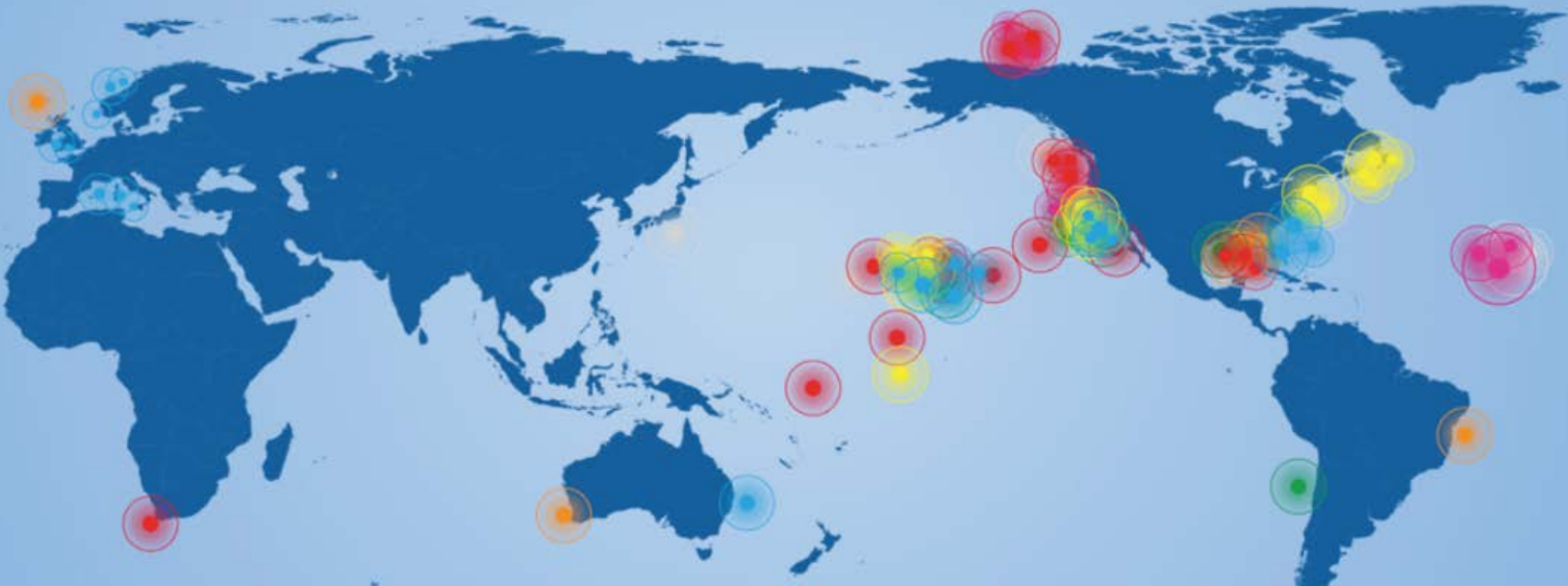
Integrated Acoustic Receivers on Mobile Gliders



Maritime Domain Awareness Persistent, Wide Area Surveillance

wave glider data services

liquid
robotics



Map

Buoy Sightings



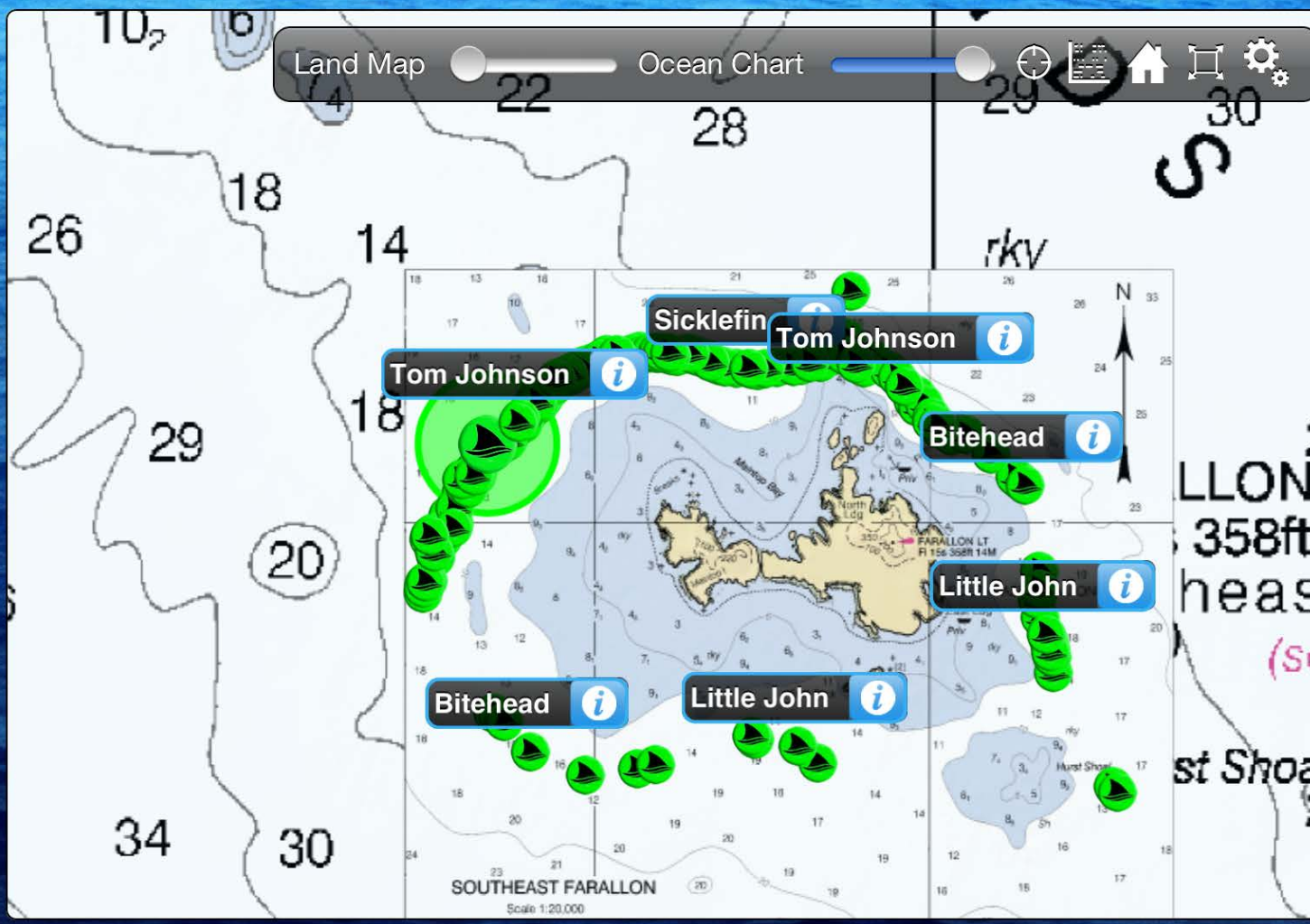
Wave Glider "Carey"

Info Photos Movies

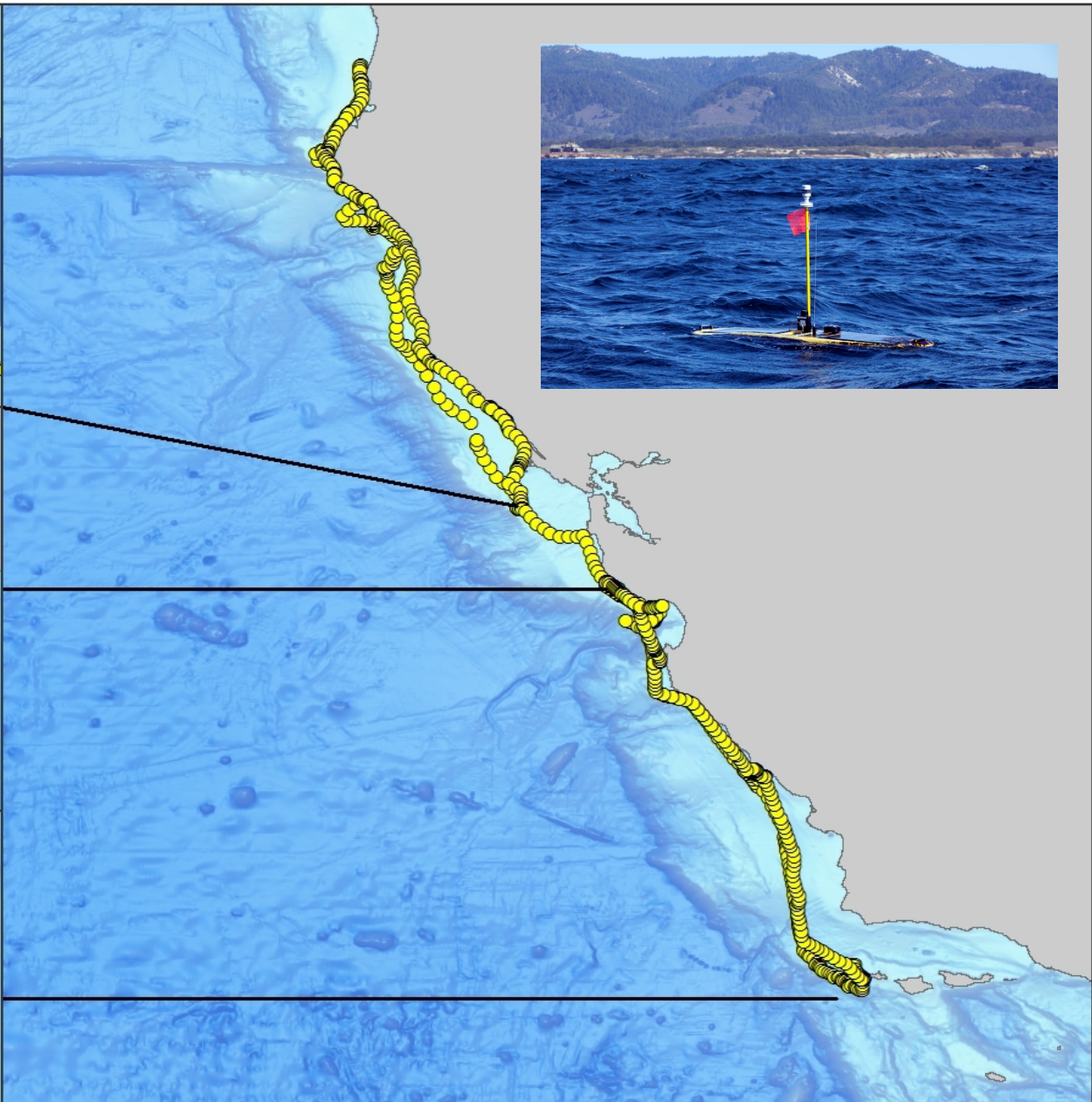
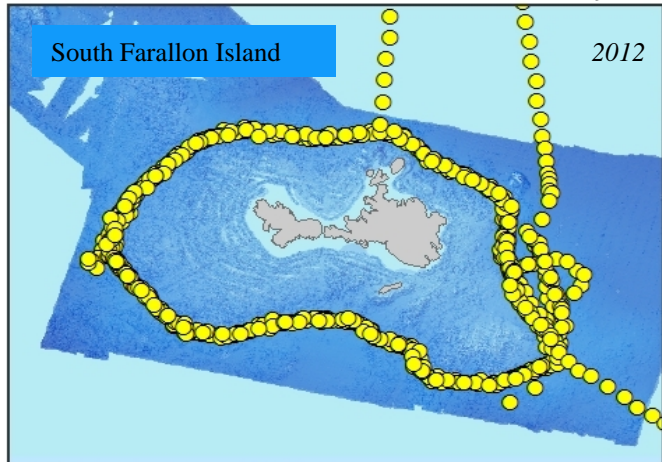
3D Model >

Description >

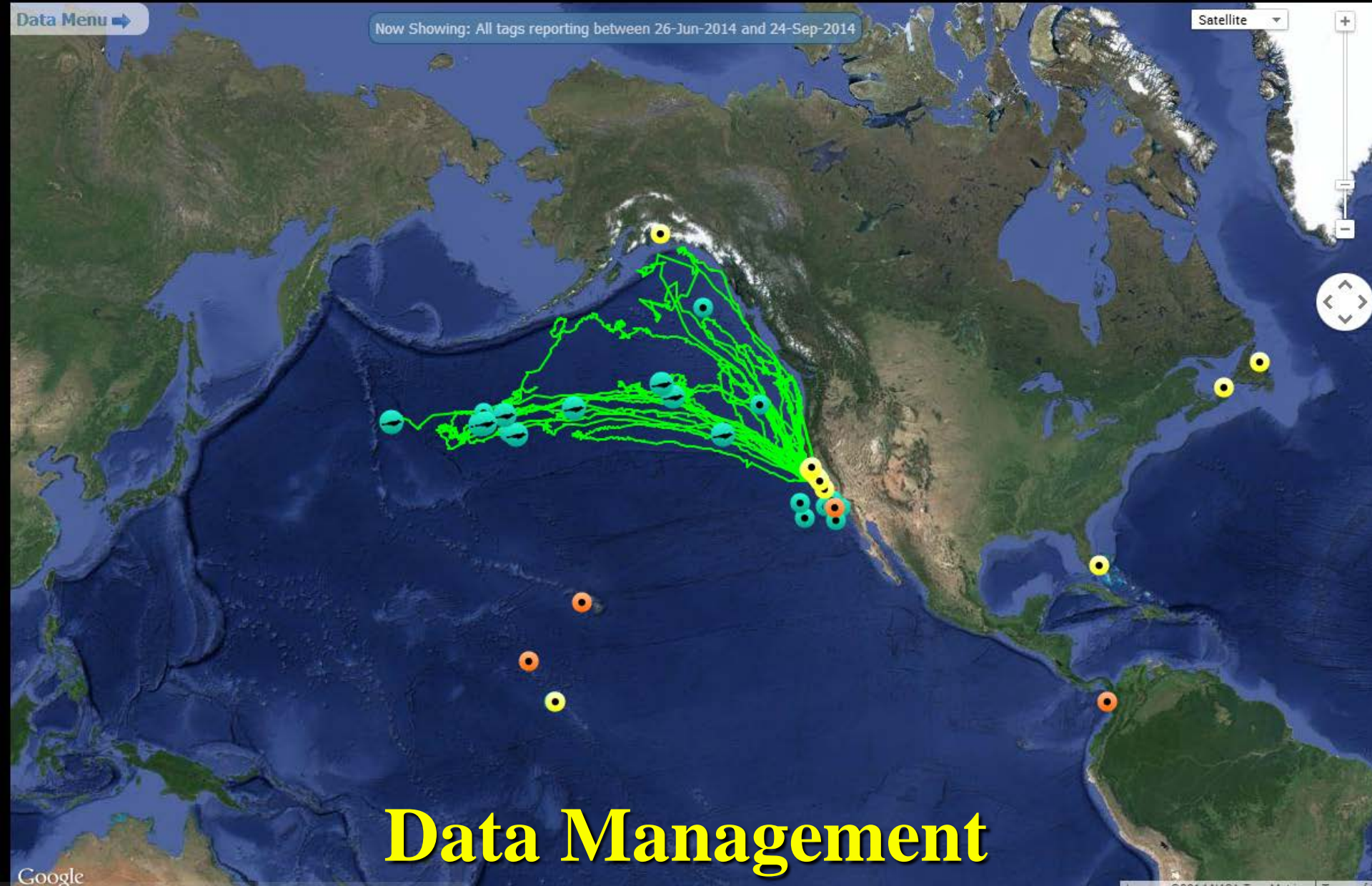
7 Sharks Sighted (under 6 hours ago) >



We've developed Capacity in Monterey Sanctuary that can easily be Moved to Line Islands- tested in remote locations already



Now Showing: All tags reporting between 26-Jun-2014 and 24-Sep-2014



Data Management

Live Line Island App



PIPA As A Global Leader

- **Develop a Comprehensive Chagos Electronic Monitoring Plan**
- **Discern Size of MPAS for Tunas/Sharks**
- **Develop Major Initiative to Demonstrate MPA Remote Monitoring Technology**
- **Showcase Technology for Globe**
- **Strategic Investments**

