Exploring the frontiers of knowledge of marine mammals:

What technology can tell us about these amazing creatures

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Naval Science & Technology Strategic Plan

Focus Areas

- Power and Energy
- Operational Environments
- Maritime Domain Awareness
- Asymmetric & Irregular Warfare
- Information Superiority and Communication
- Power Projection
- Assure Access and Hold at Risk
- Distributed Operations
- Naval Warfighter Performance
- Survivability and Self-Defense
- Platform Mobility
- Fleet/Force Sustainment
- Total Ownership Cost

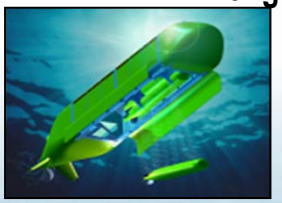
Near

Solid State Lights for Submarines

Mid

Advanced Materials

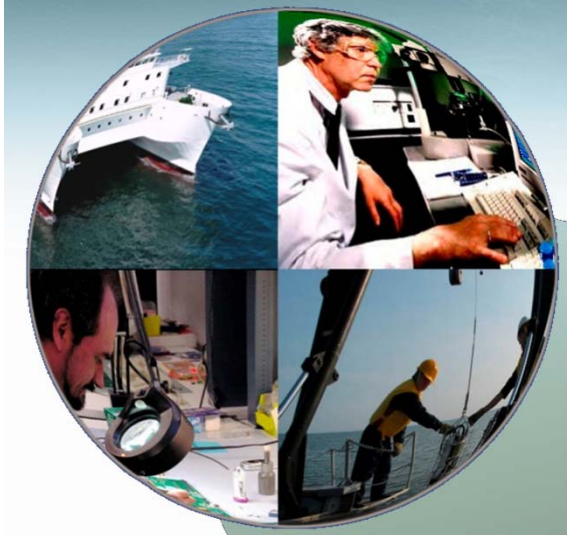
Long



LD UUV

D&I

How We Execute



ONR Global

FFRDCs

UARCs/Academia

Industry

NRL/Warfare Centers

- 70 Countries
- 50 States
- 1,078 Companies
- 1,035 Universities & Nonprofit Entities
  - 3,340 principal investigators
  - 3,000 grad students

Marine Mammals & Biology Program

Goal

Enable Navy to and meet operational training and testing objectives in an environmentally responsible and legal manner

Objective

Invest in basic (6.1) and applied (6.2) research and technology development to discover and understand the effects of sound exposure on marine mammals

Approaches

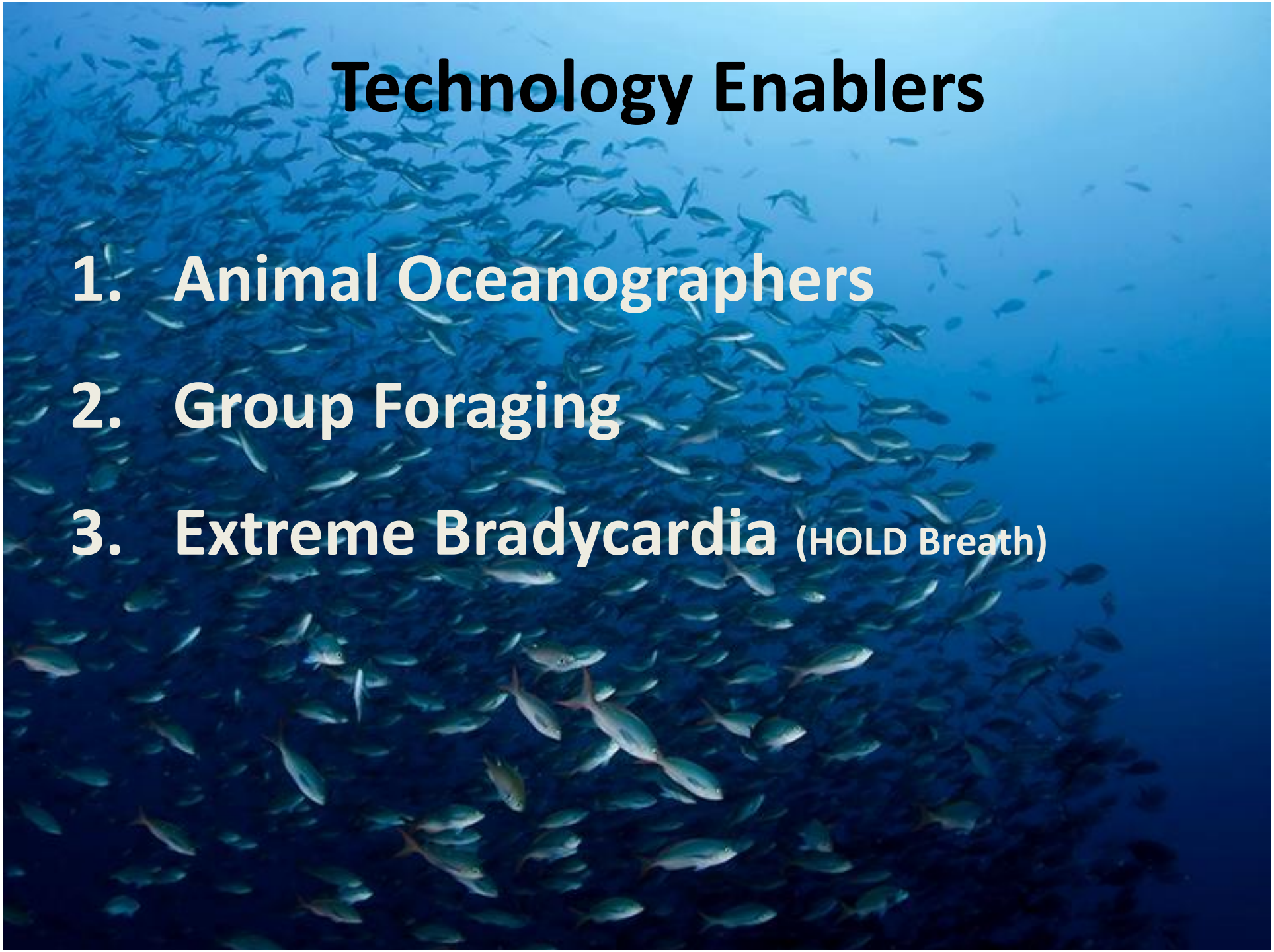
- Monitoring & Detection – Develop the capability to detect and monitor marine mammals
- Baseline Behavior - Investigate the baseline behavior and how they interact with their environment
- Effects of Sound - Characterize the behavioral, physiological, and population-level effects of exposure

Challenges in the Ocean Environment

- Difficult to observe (99% time below surface)
- Challenging Environment
- Difficult to handle

Brandon Cole Photo

Technology Enablers



Technology Enablers

1. Animal Oceanographers
2. Group Foraging
3. Extreme Bradycardia (HOLD Breath)

Animal Oceanographers: What Animals Tell Us About Their Environment

Daniel P Costa

Professor of Ecology and Evolutionary Biology

University of California at Santa Cruz

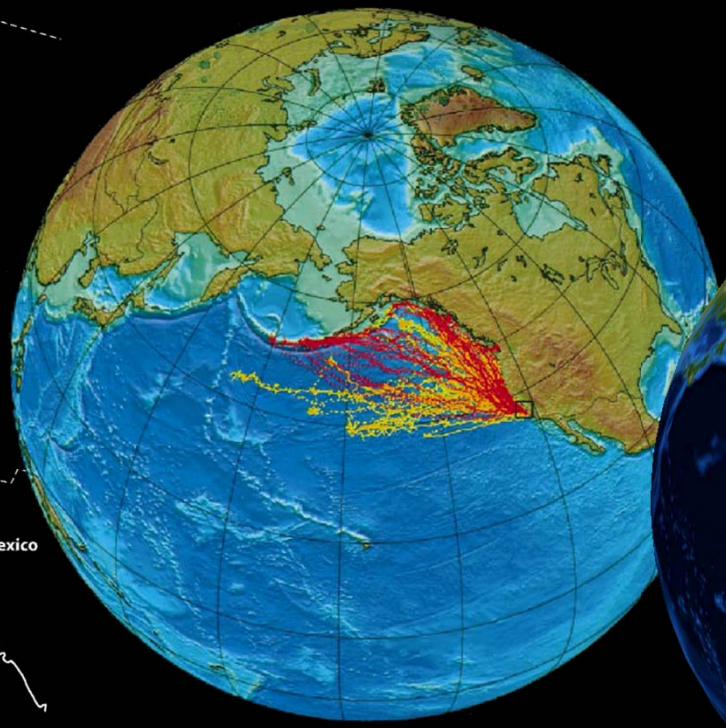
TOPP
Tagging Of Pacific Pelagics

Our Changing View

Visual Surveys

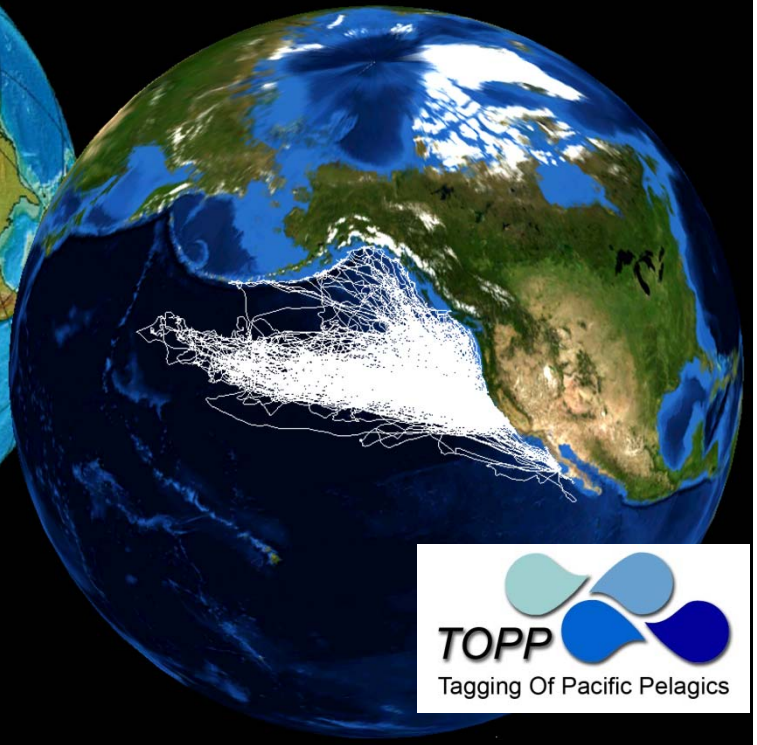
Riedman 1990

Satellite Tracking (N~50)



LeBoeuf et al 2000

Satellite + GPS Tracking (N~250)

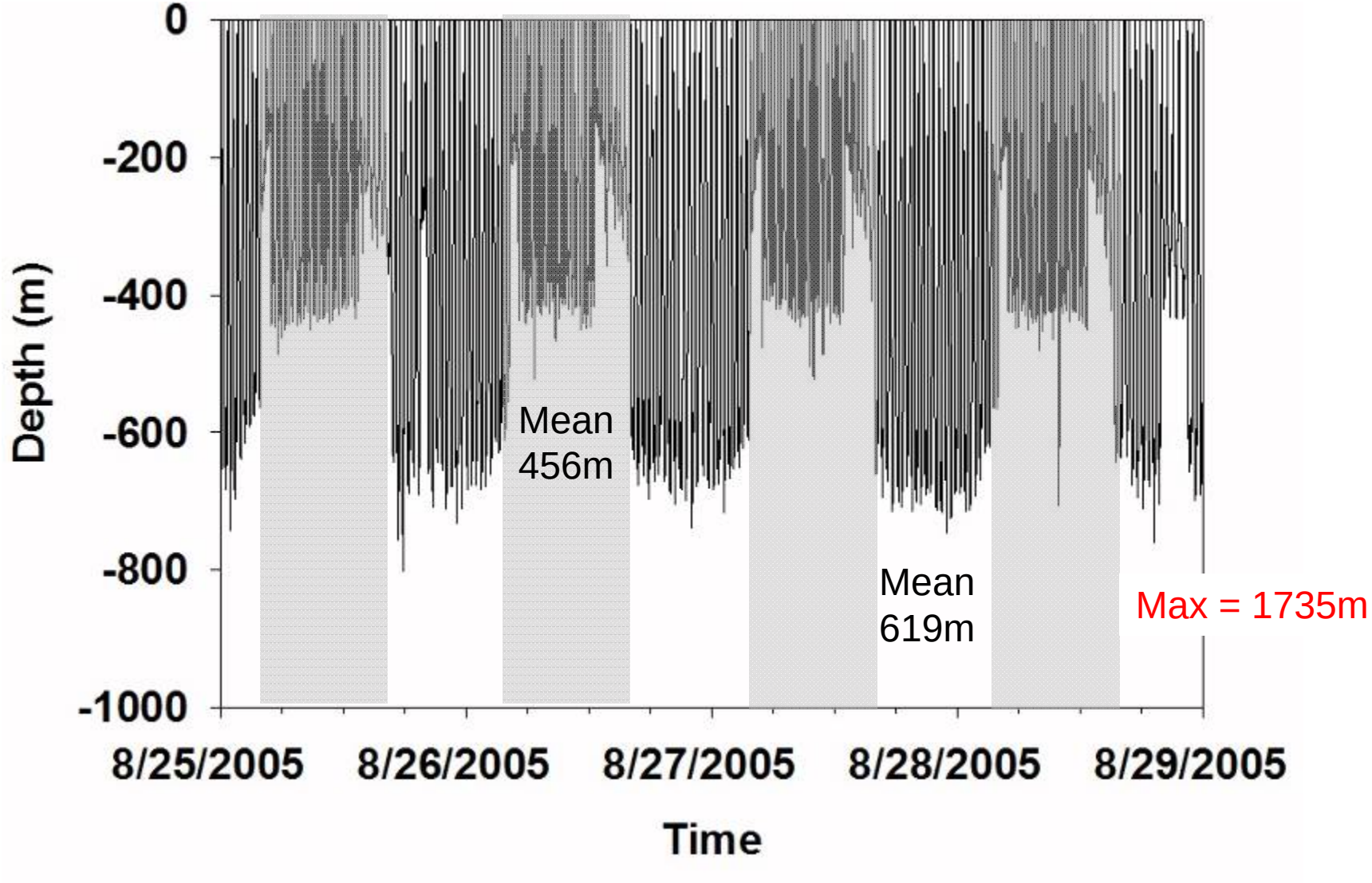


TOPP 2004-2010

TOPP
Tagging Of Pacific Pelagics


UCSC
RESEARCH

Diurnal Pattern



Importance of Ice as Habitat

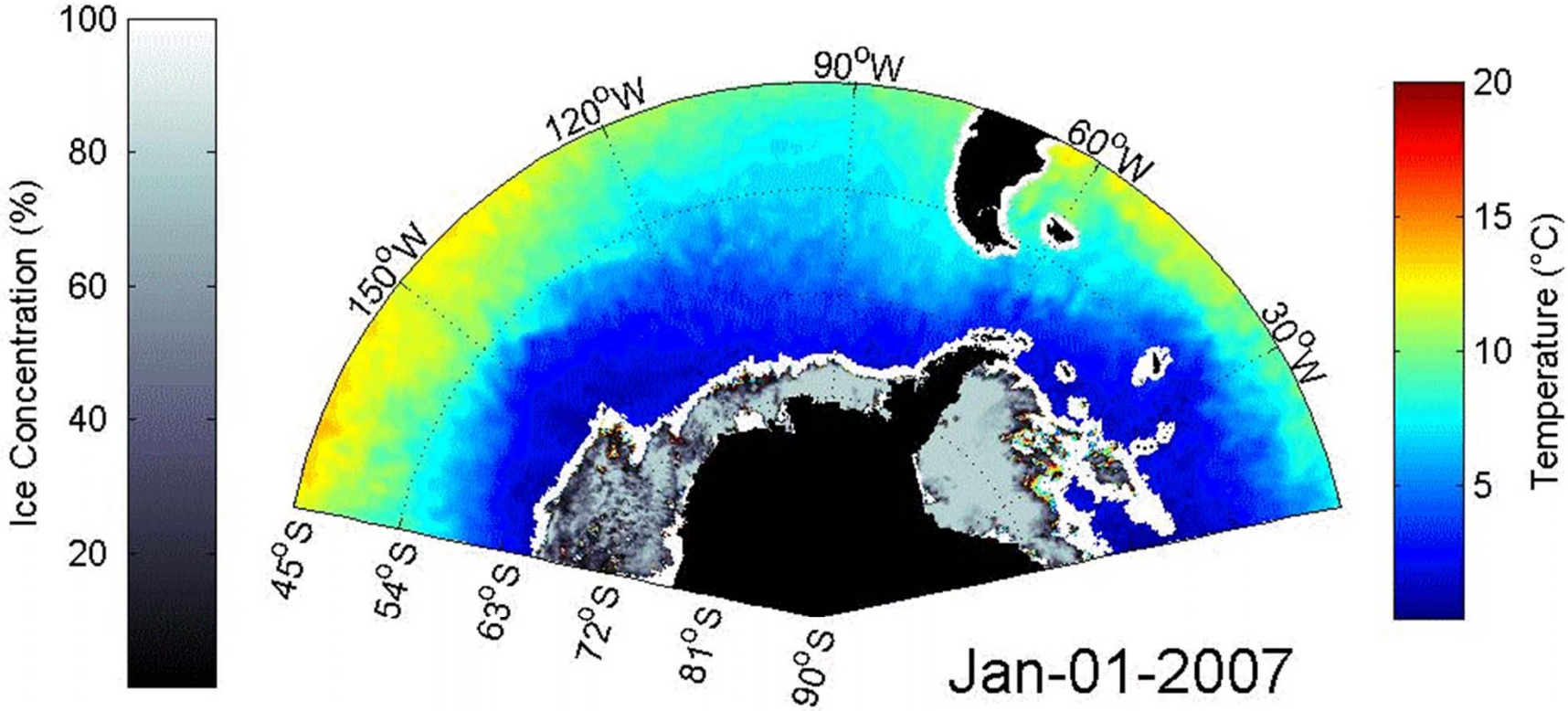
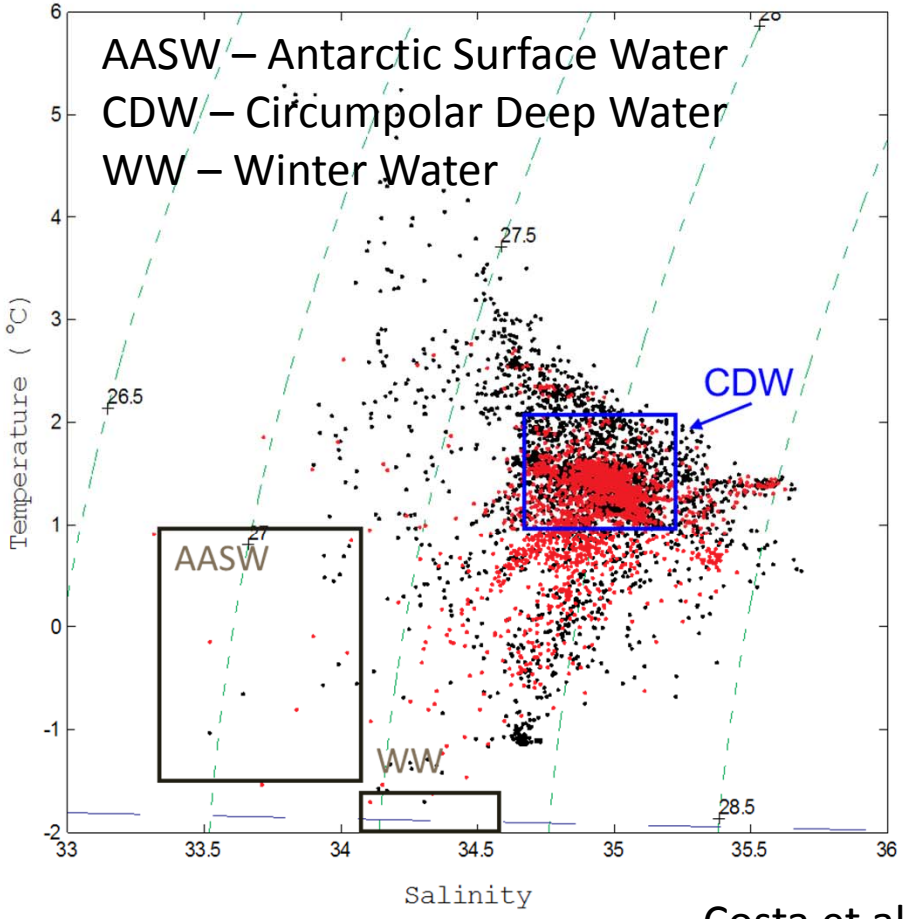
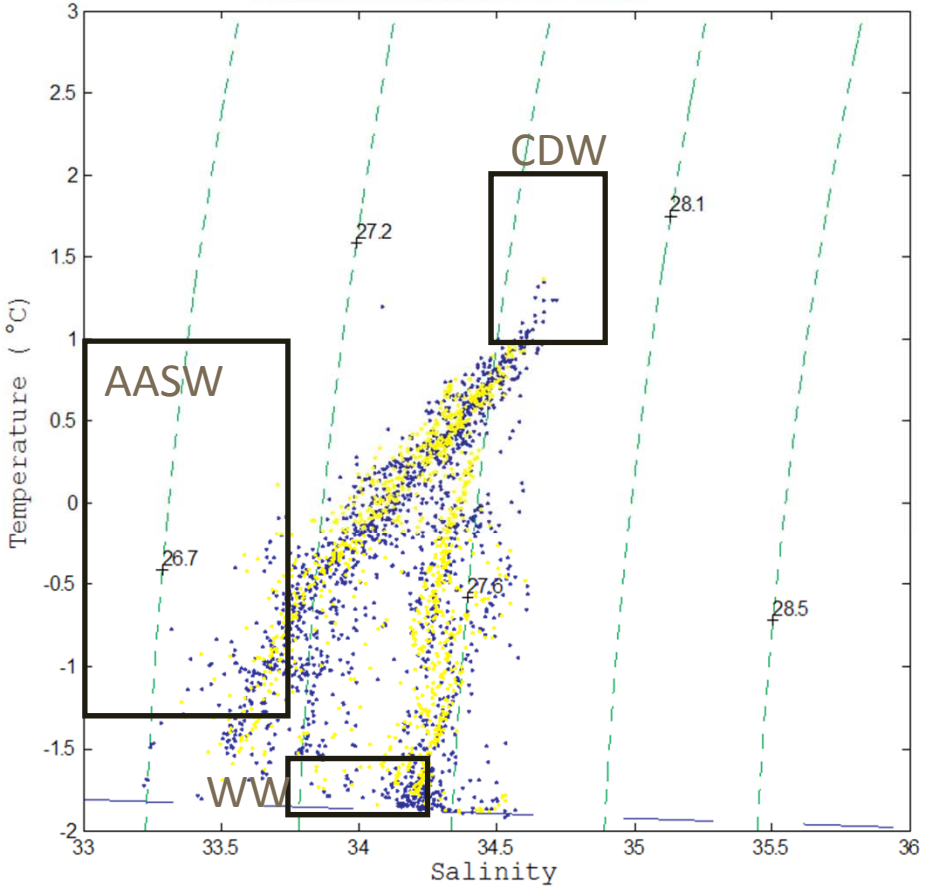


Figure by Huckstadt

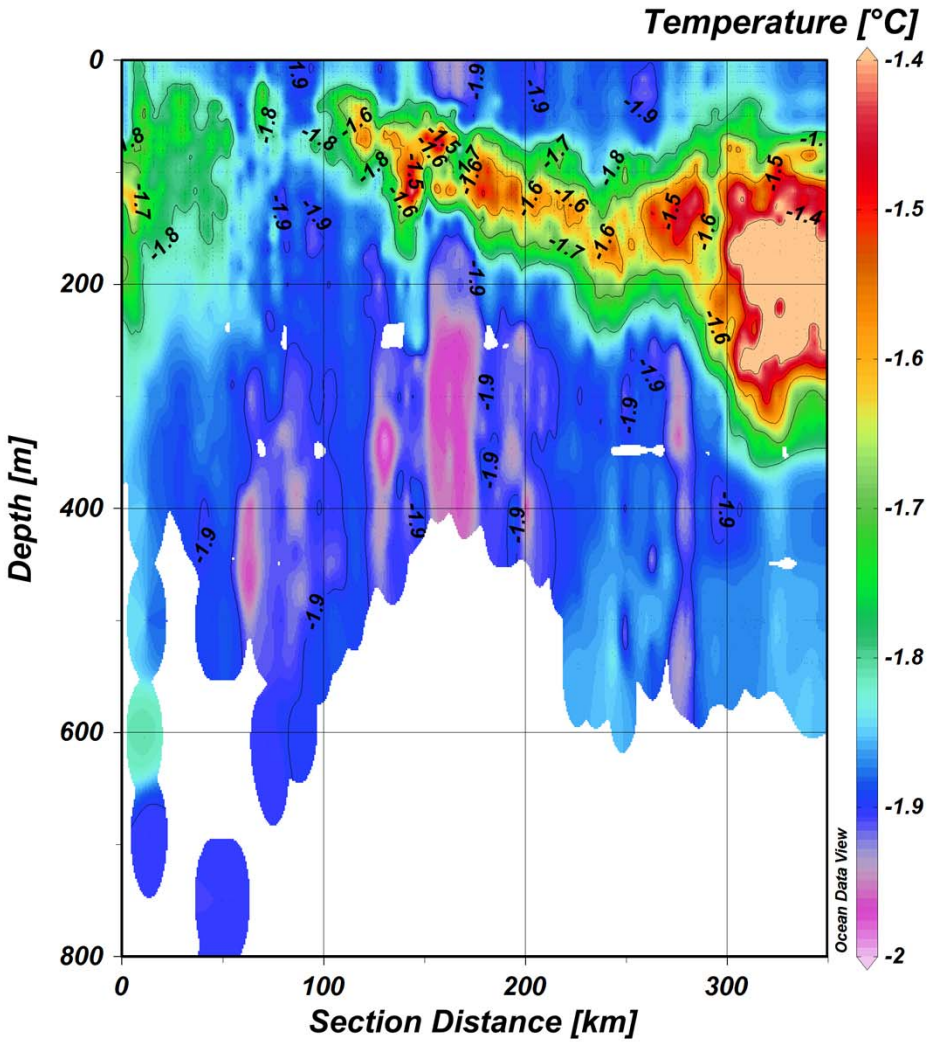
Habitat Partitioning by Water Mass

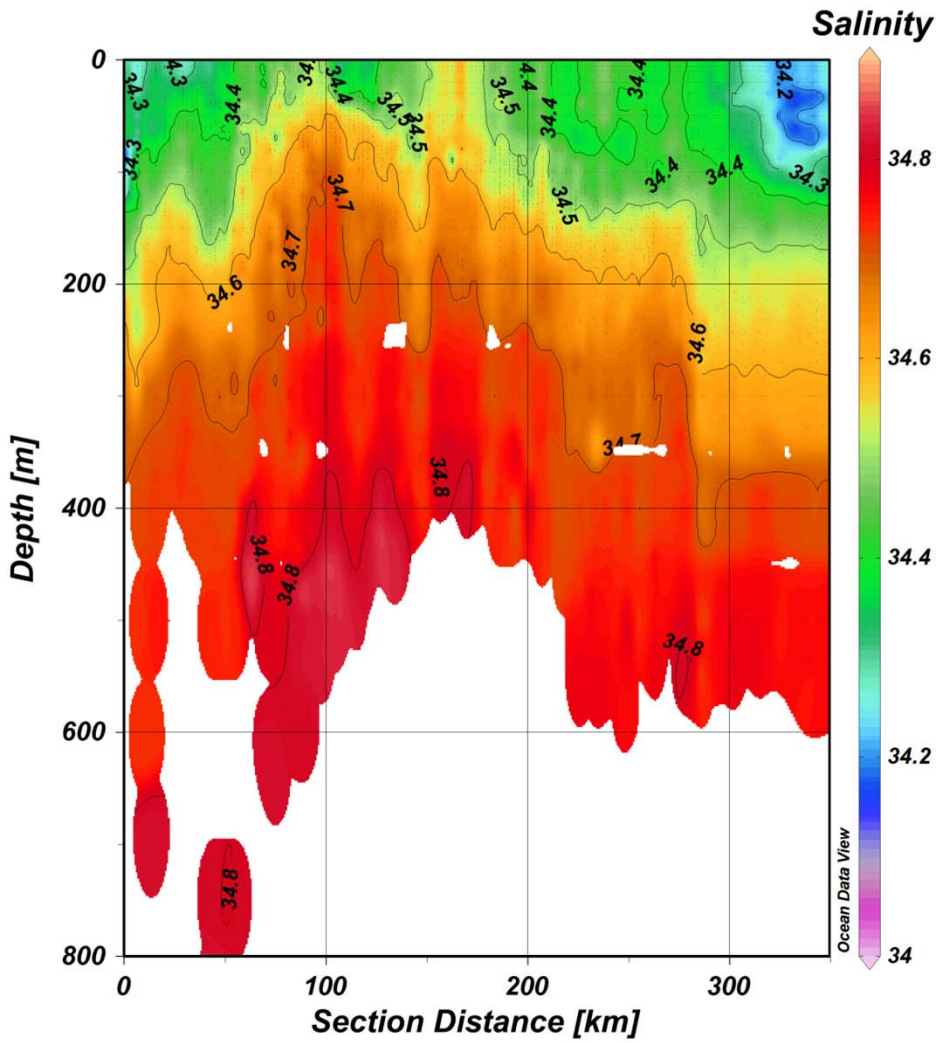




Costa et al ICB 2010

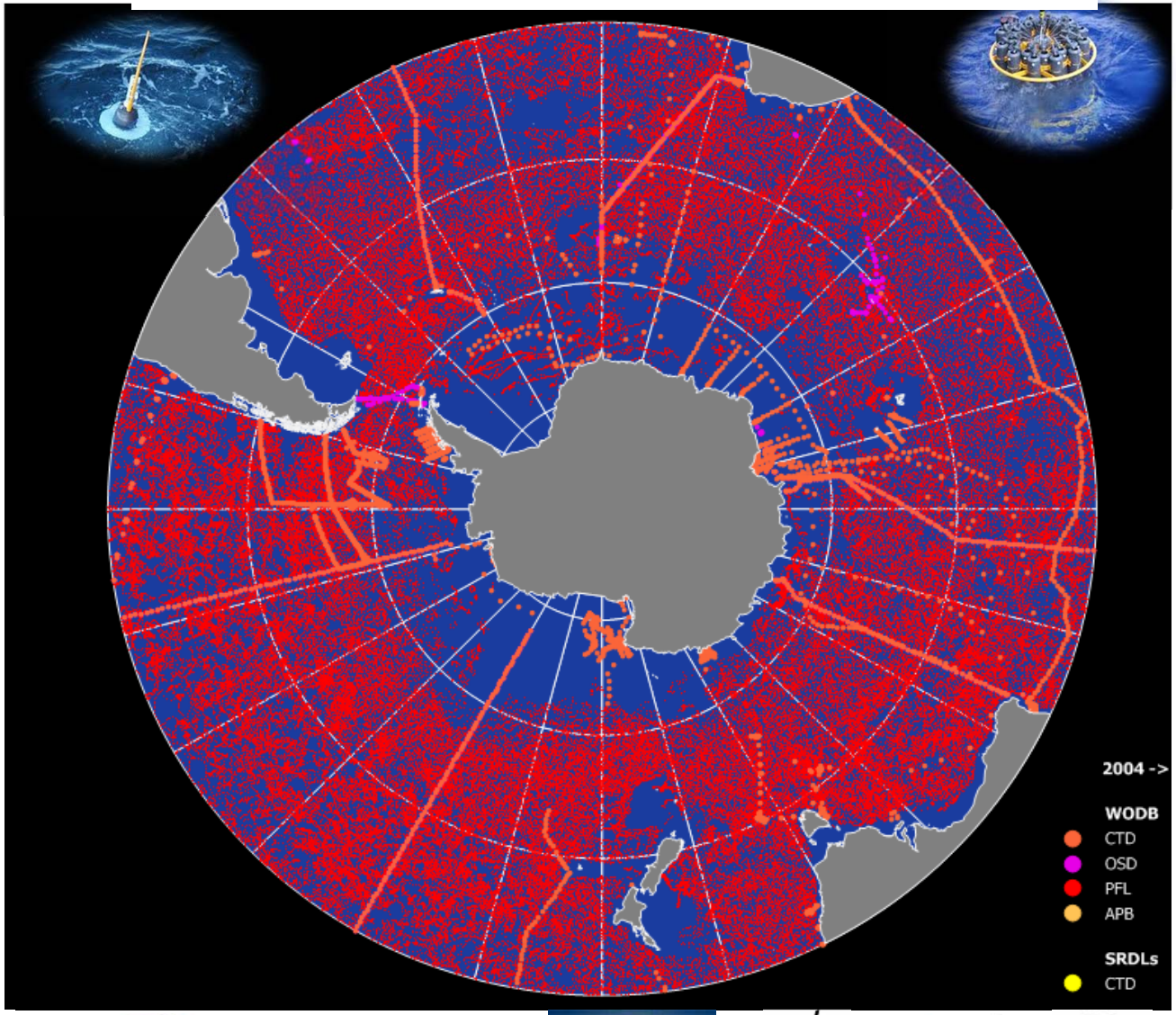
Weddell Seal Derived Hydrographic Profile





Improving Ocean Forecasts

Conventional Sources, Argo float , CTD



SEaOS project

USA

France

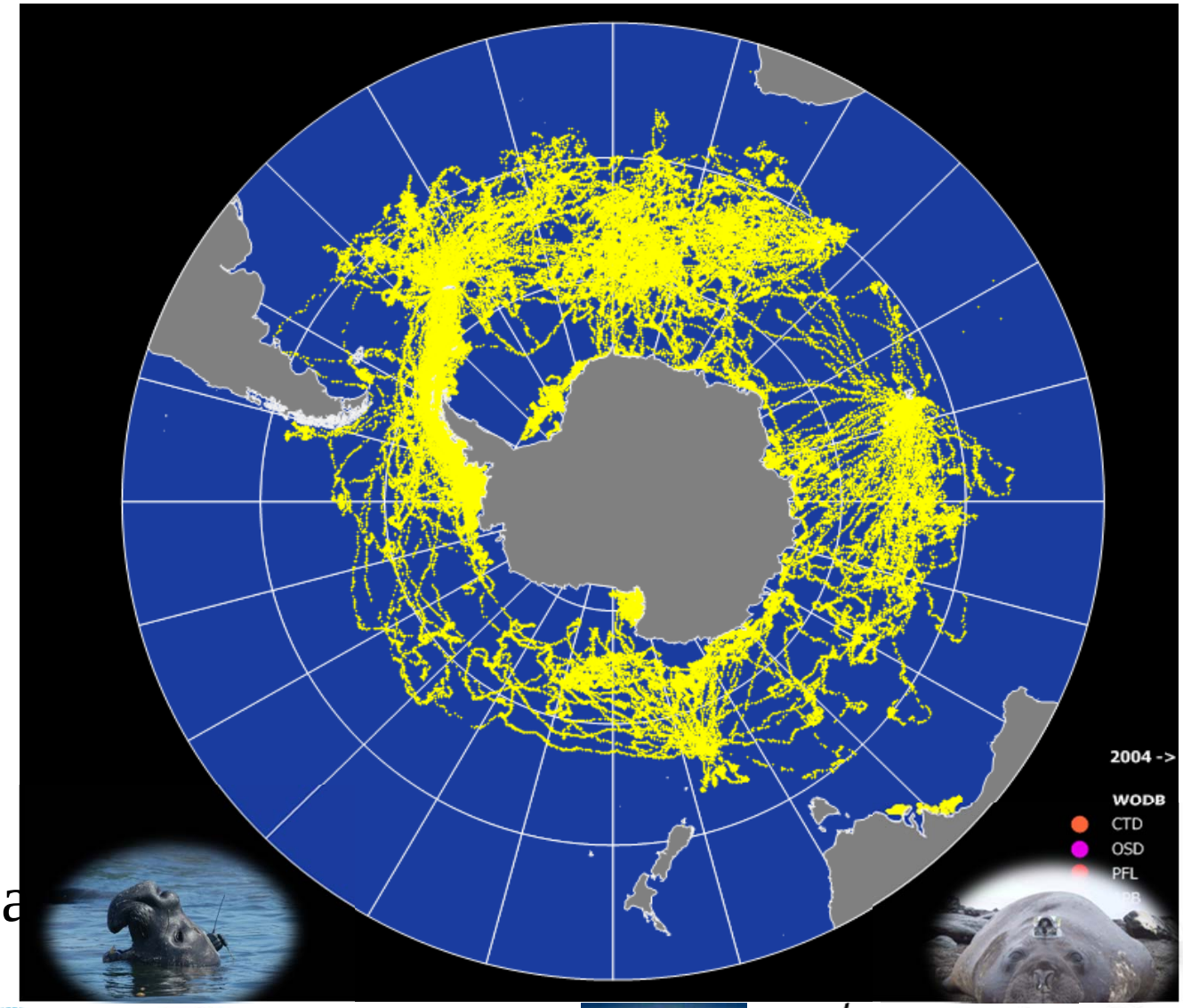
UK

Australia

UTAS CSIRO SMRU Office of Naval Research IFRTP CNRS CENSUS OF MARINE LIFE

Improving Ocean Forecasts

Animal Telemetry Source, Seals



SEaOS project

USA

France

UK

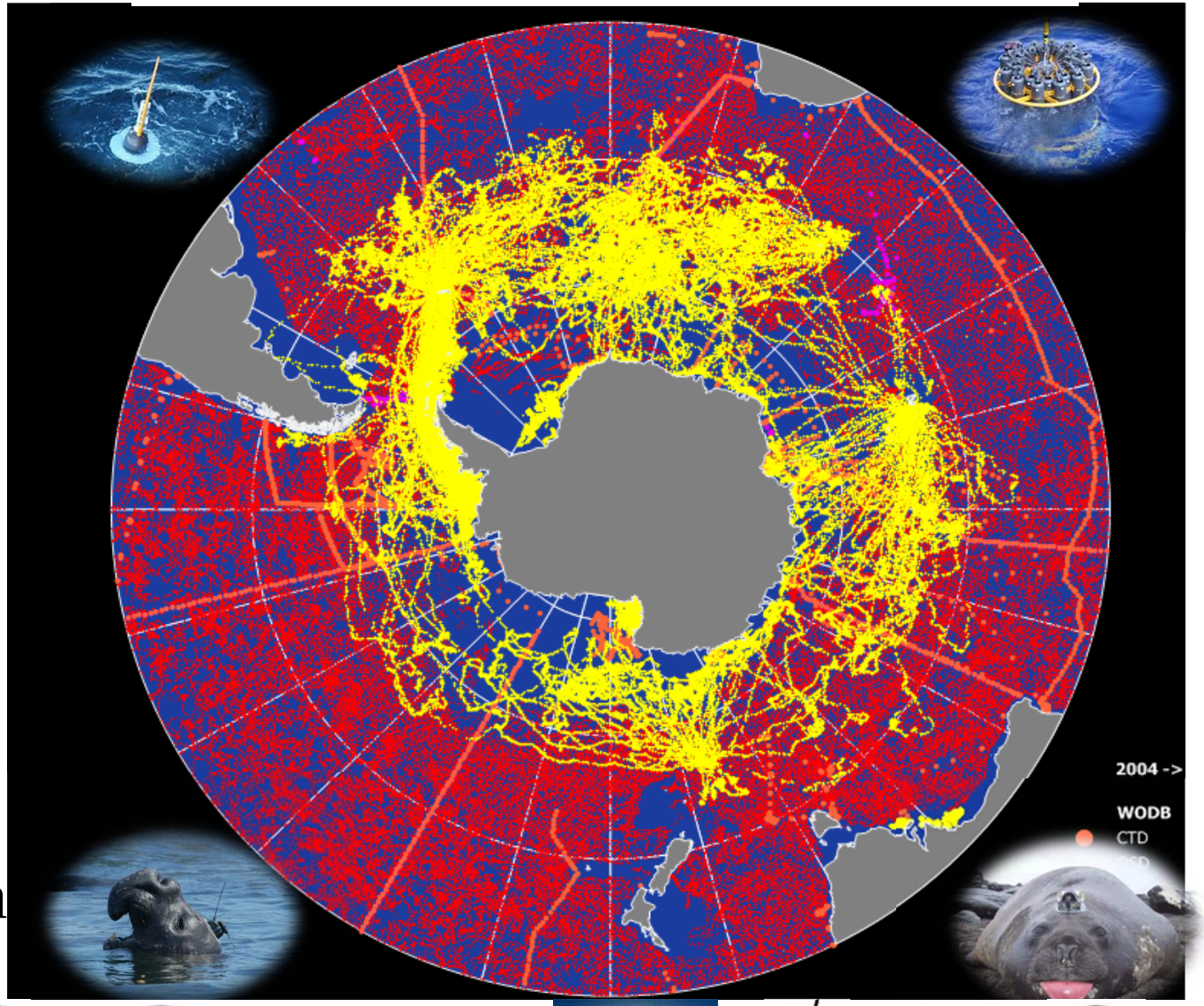
Australia

Office of Naval Research

CENSUS OF MARINE LIFE

Improving Ocean Forecasts

All Sources



SEaOS project

USA

France

UK

Australia

UTAS CSIRO SMRU Office of Naval Research IFRTP CNRS CENSUS OF MARINE LIFE

Animal Telemetry Network (ATN) thru Integrated Ocean Observing System (IOOS)

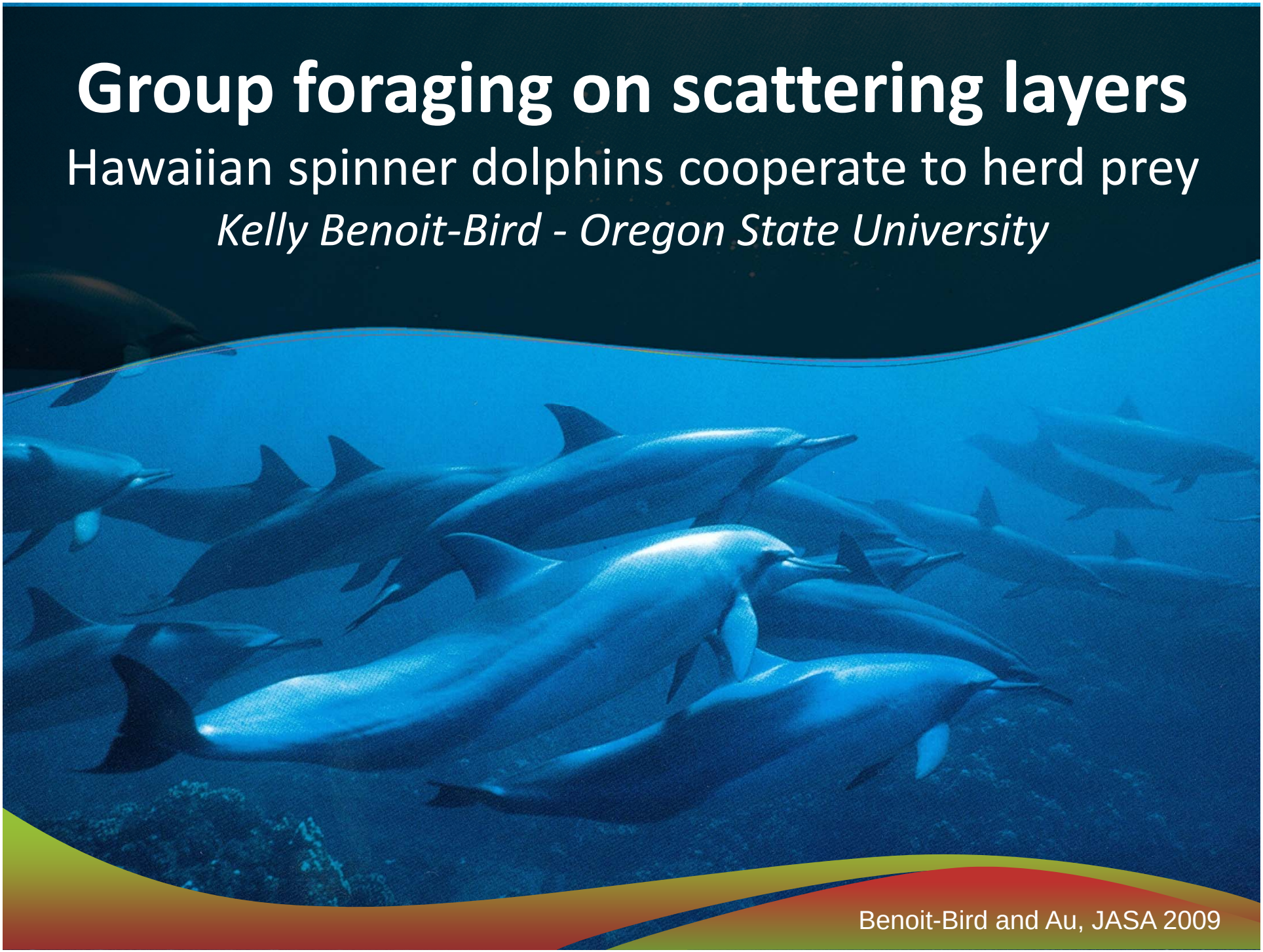
Goal - Meeting our Nation's Needs for Biological and Environmental Monitoring

- Coordinated Network of federal/state/regional agencies, IOOS RAs, and Academics
- ATN Strategic Plan & Recommendations
- Critical benefits will include:
  - ID essential & critical habitat for improved fisheries & listed species stock assessment across state, federal, and international boundaries
  - Sentinels of climate change
  - Improve ocean forecasting & ecosystem-based management

Group foraging on scattering layers

Hawaiian spinner dolphins cooperate to herd prey

Kelly Benoit-Bird - Oregon State University

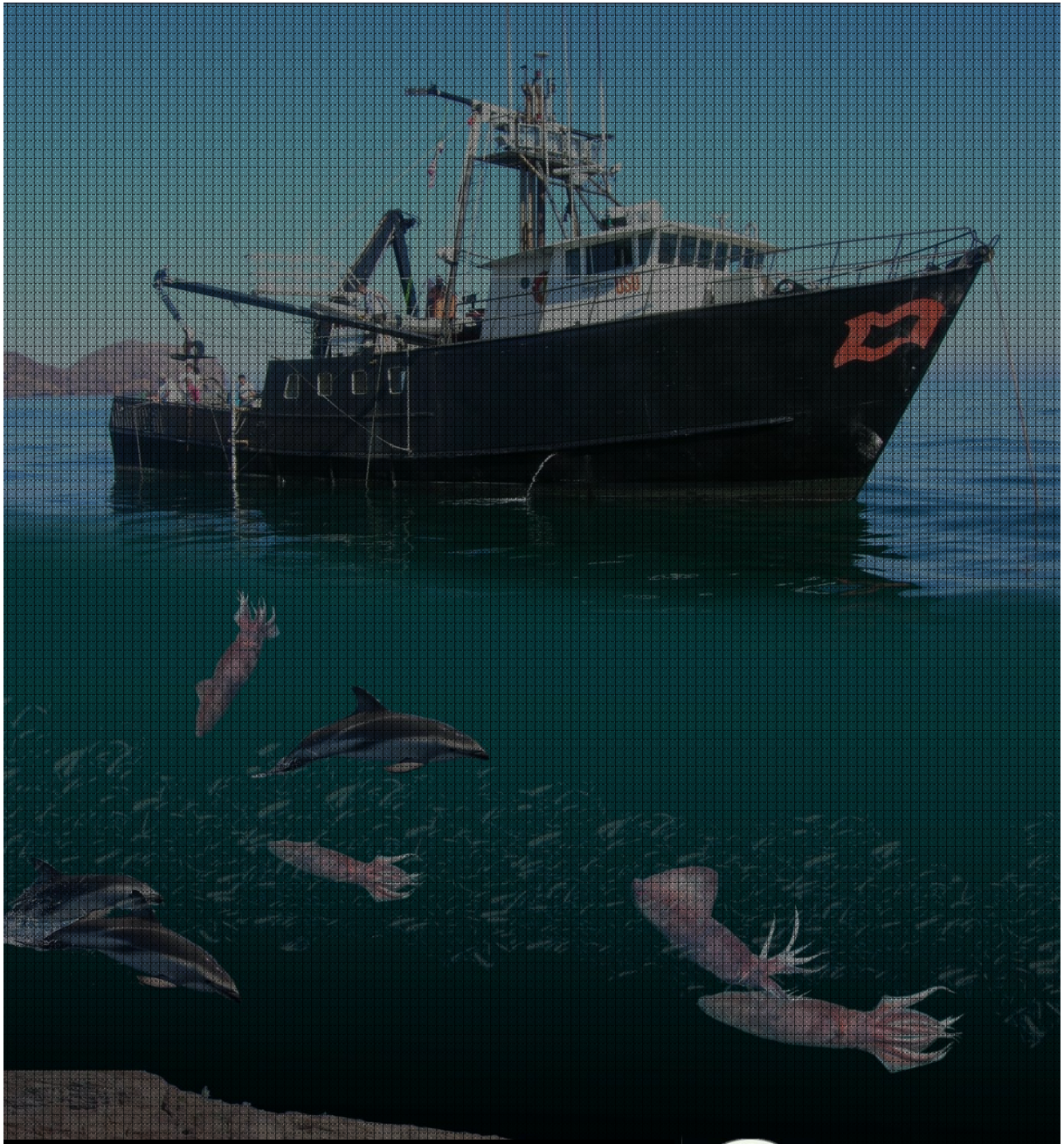


Benoit-Bird and Au, JASA 2009

Animals cannot survive on the *average* food in the ocean

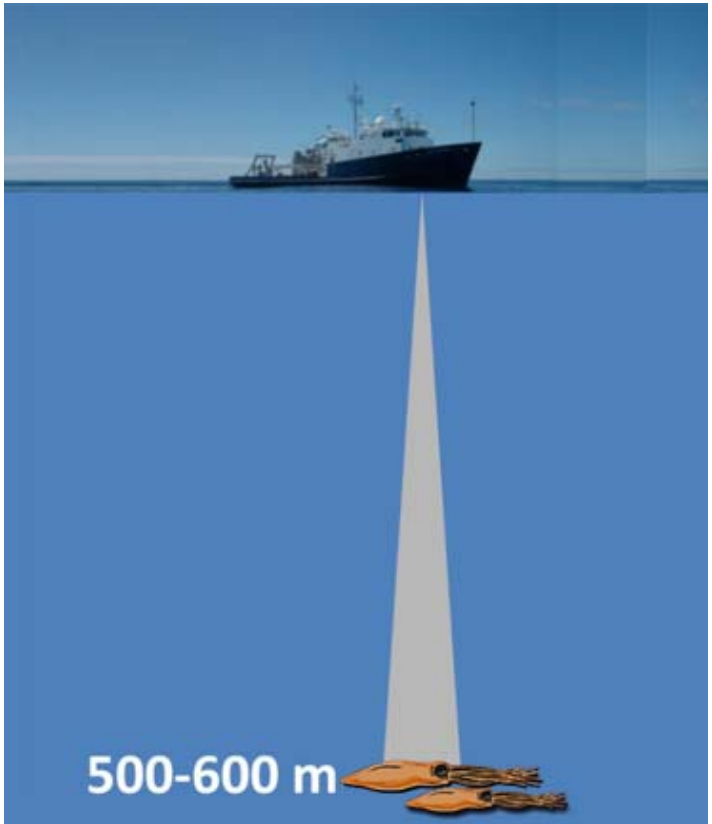
(Lasker 1975)

'patchy' resources are *critical* to animal survival in the ocean



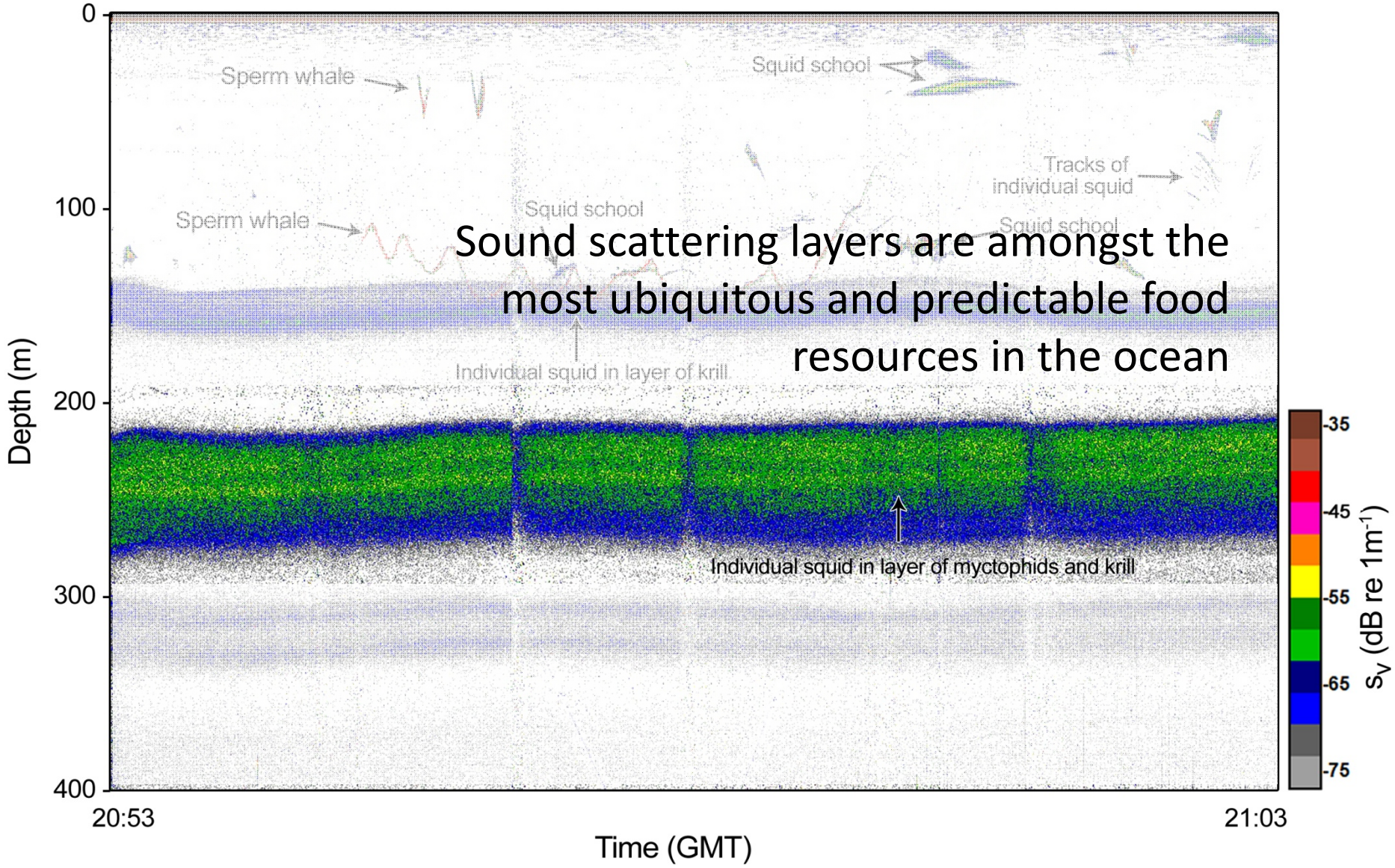
Oregon State UNIVERSITY | College of Earth, Ocean, and Atmospheric Sciences

Dr. Kelly Benoit-Bird

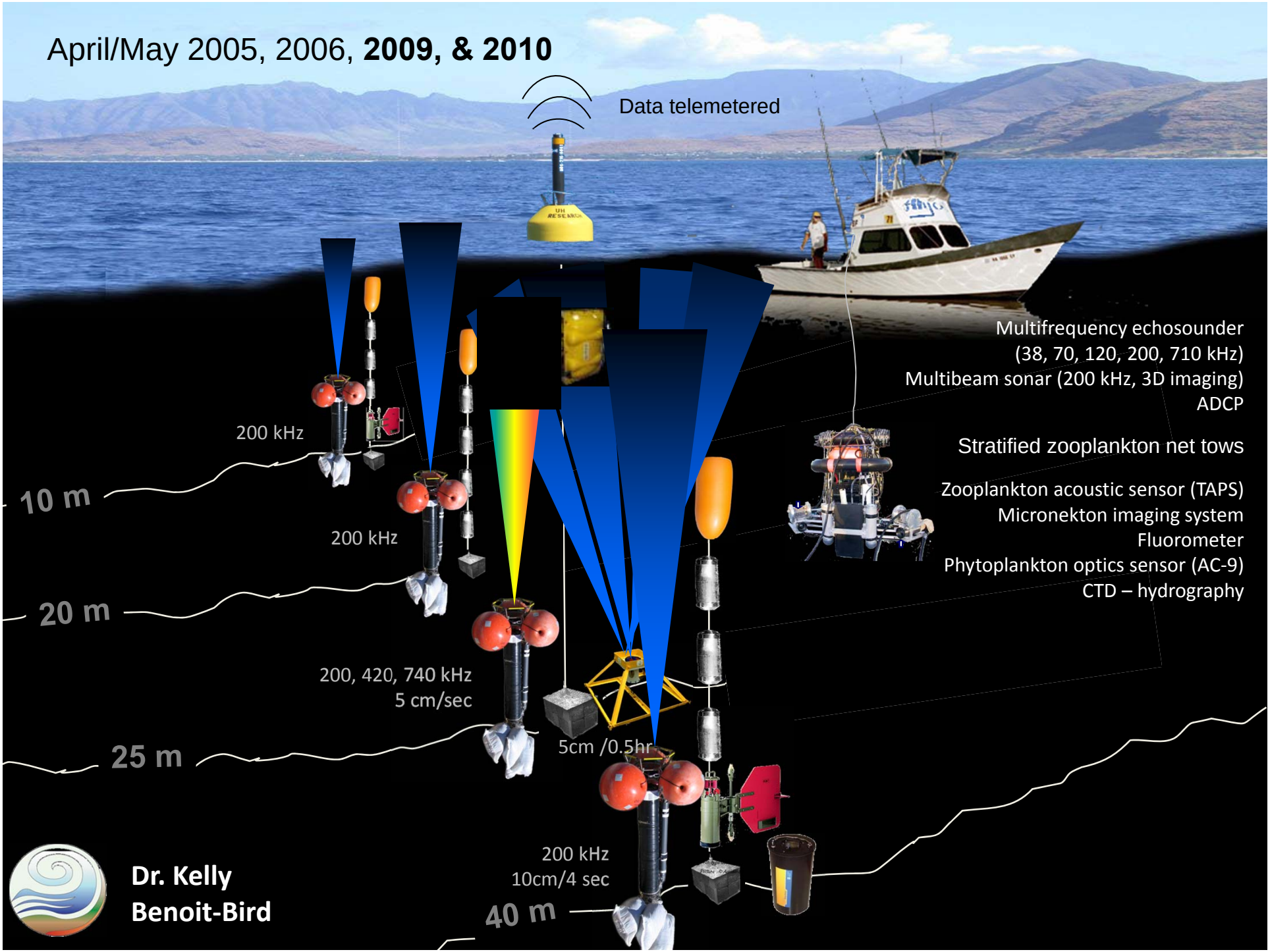


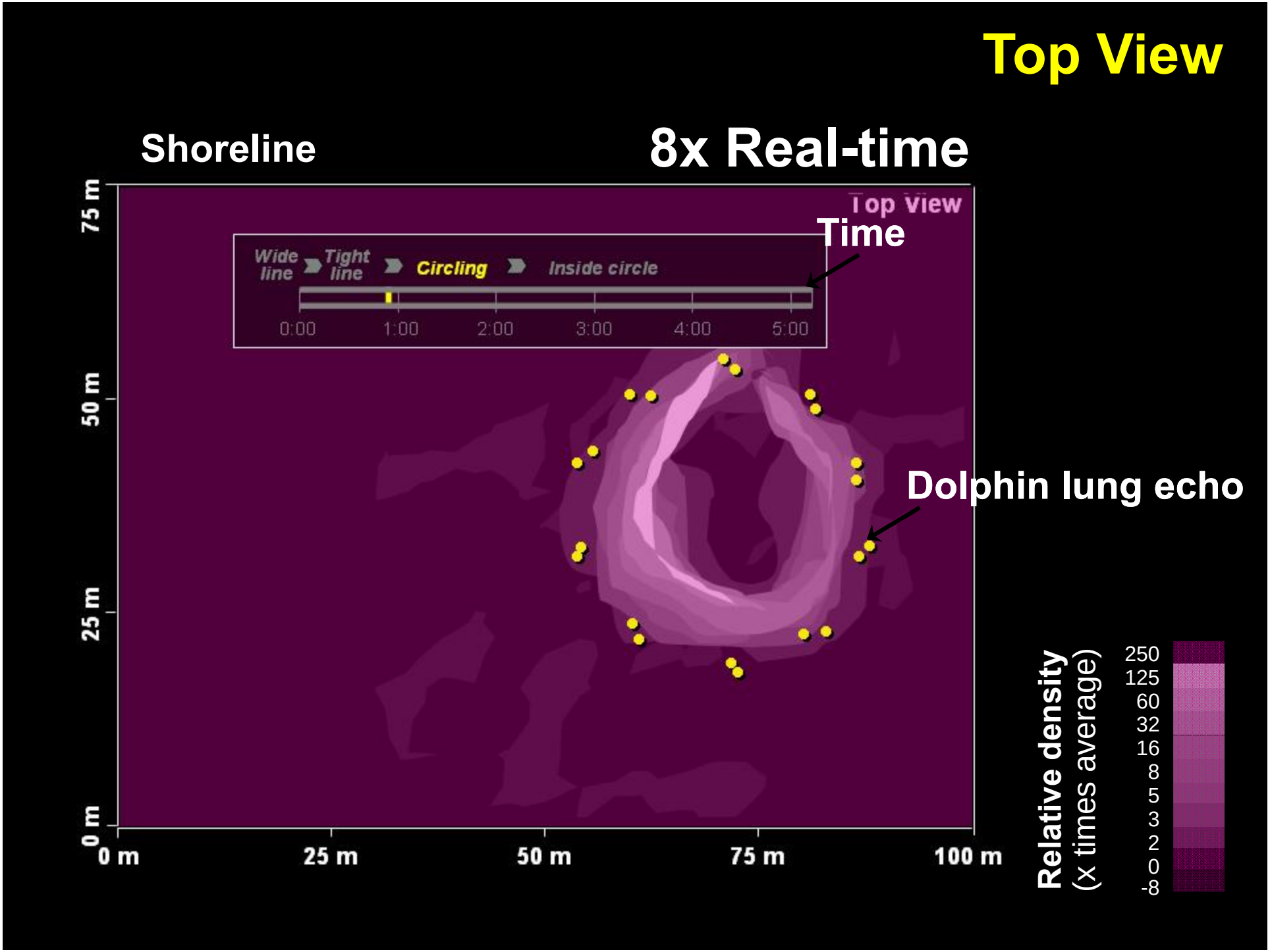
- Shipboard EchoSounders (fish finders) send sound out and receive echo's back of objects in the water column
- 38/120 kHz signals

Echo examples from three trophic levels

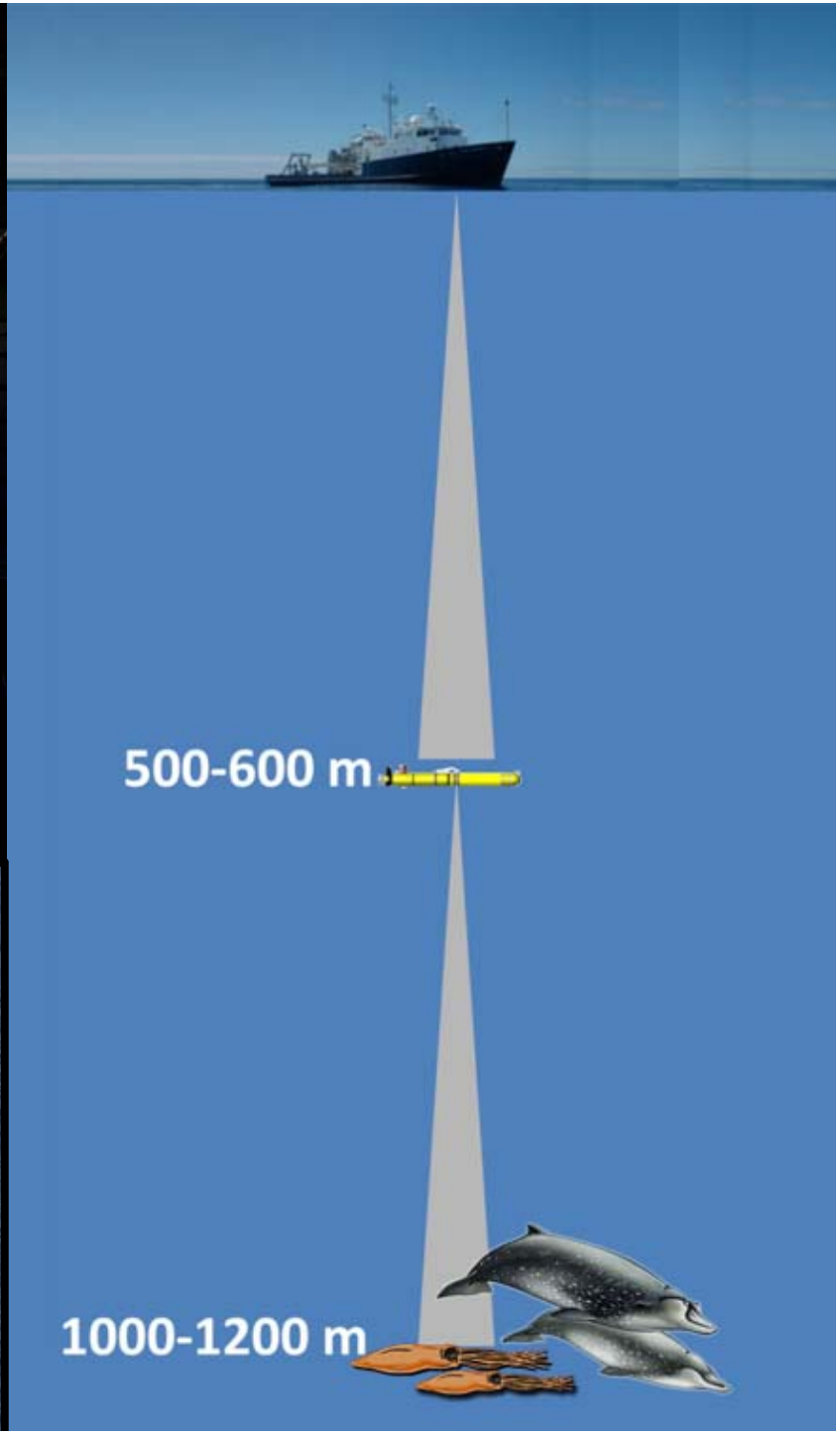


Sound scattering layers are amongst the most ubiquitous and predictable food resources in the ocean


April/May 2005, 2006, **2009, & 2010**
Data telemetered
Multifrequency echosounder
(38, 70, 120, 200, 710 kHz)
Multibeam sonar (200 kHz, 3D imaging)
ADCP
Stratified zooplankton net tows
Zooplankton acoustic sensor (TAPS)
Micronekton imaging system
Fluorometer
Phytoplankton optics sensor (AC-9)
CTD – hydrography
200 kHz
10 m
200 kHz
20 m
200, 420, 740 kHz
5 cm/sec
25 m
5cm /0.5hr
200 kHz
10cm/4 sec
40 m
Dr. Kelly
Benoit-Bird


Top View
Shoreline
8x Real-time
Top View
Time
Wide line
Tight line
Circling
Inside circle
0:00
1:00
2:00
3:00
4:00
5:00
Dolphin lung echo
75 m
50 m
25 m
0 m
0 m
25 m
50 m
75 m
100 m
Relative density
(x times average)
250
125
60
32
16
8
5
3
2
0
-8


SERDP
DOD • EPA • DOE


500-600 m
1000-1200 m

Deep-diving sea lions exhibit extreme bradycardia in long-duration dives

Hold Breath?

Birgitte McDonald & Paul Ponganis

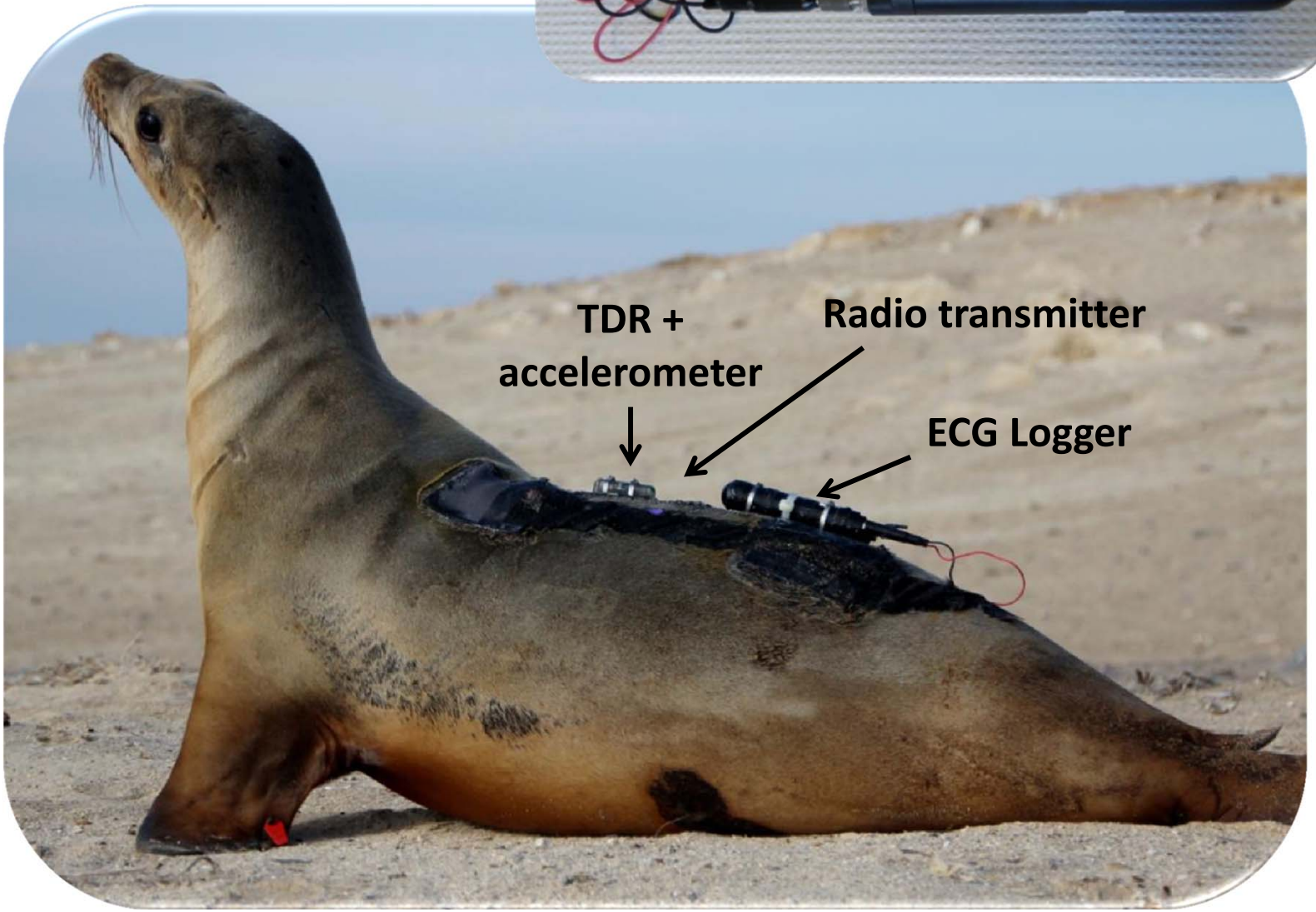
Aarhus University

Scripps Institution of Oceanography

Brandon Cole Photo

ECG logger

N = 5

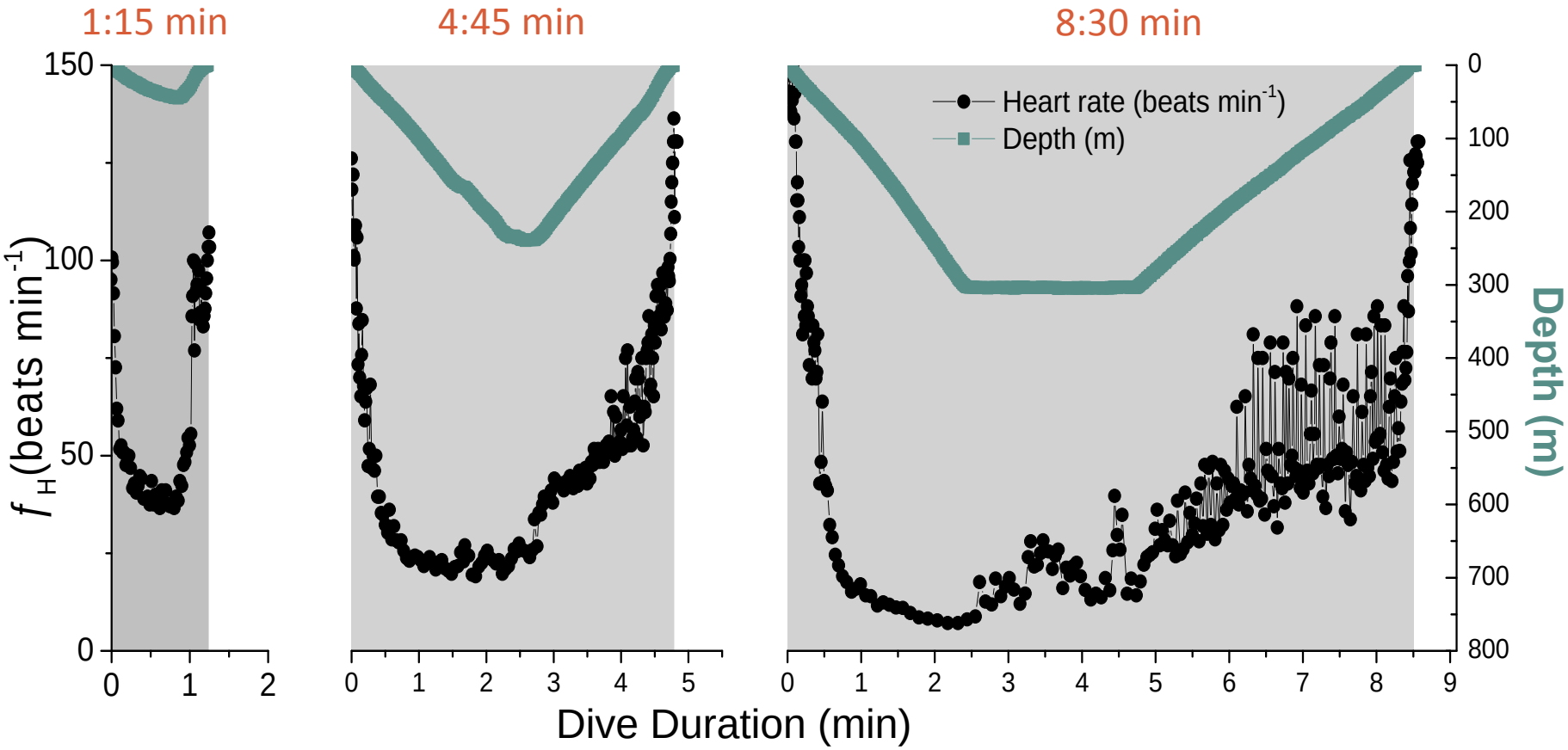


Sea lion heart rate

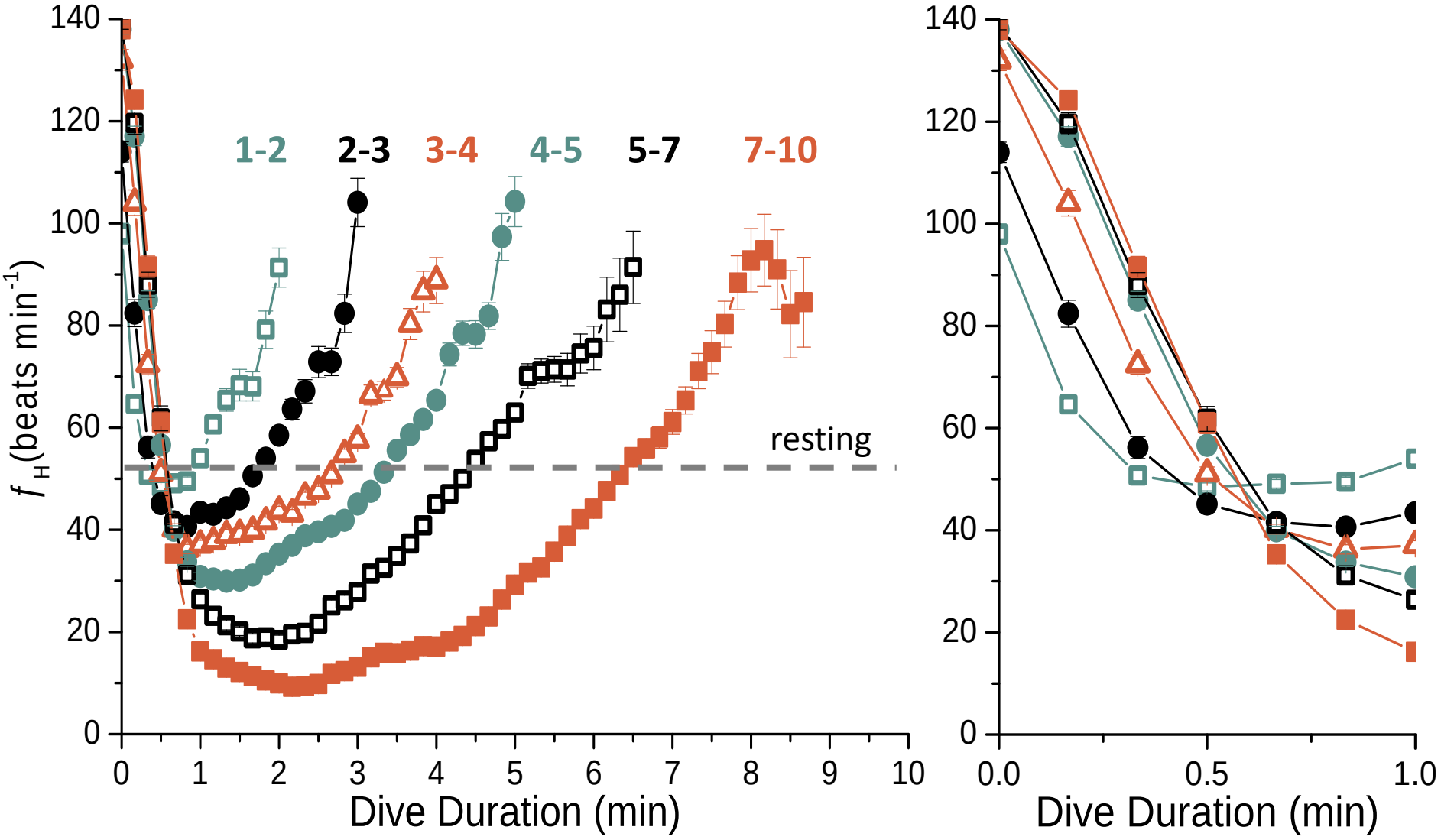
Resting f_H = 54 ± 6 bpm

Average surface f_H = 113 ± 5

Dive f_H = 50 ± 9 (range 28 – 81)



Dive Heart Rate Profiles




Thank
You!!