Illustration courtesy of F. Chavez/K. Lance (Monterey Bay Research Institute/MBARI)

NASA · NOPP National Oceanographic Partnership Program · NOAA · BOEM Bureau of Ocean Energy Management

IOOS Integrated Ocean Observing System · Ocean Exploration and Research · National Marine Sanctuaries · NOAA Fisheries

MBON
Marine Biodiversity Observation Network

Emerging Trends in Biological Observations and Technologies

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Conversation topics:

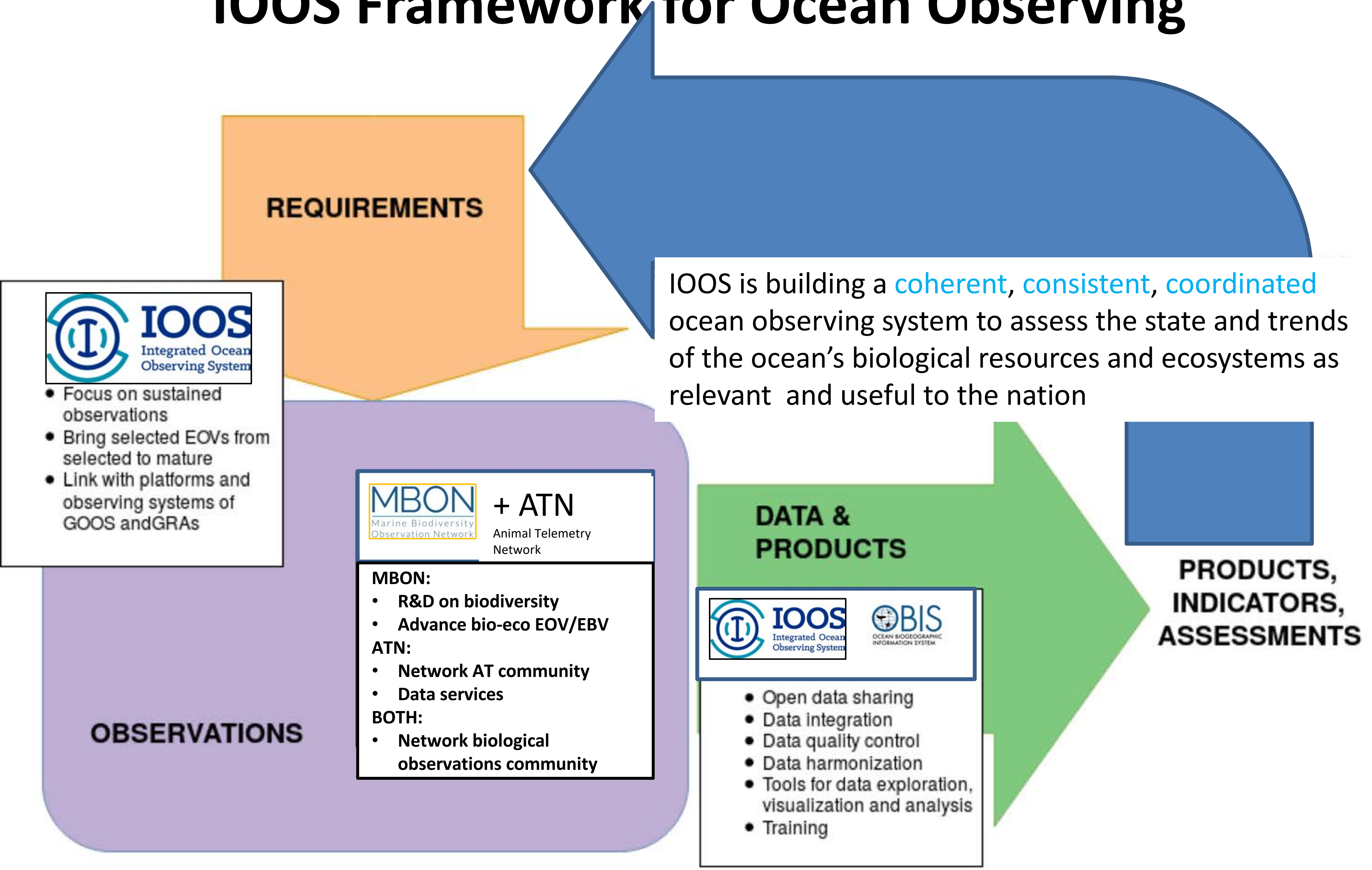
MBON
Marine Biodiversity
Observation Network

- Who requires which biological data?
- What approaches and technologies satisfy this need?
- Driver: The need to measure change

Conversation topics:

- Issues:
  - Addressing requirements with Framework for Ocean Observing: EOV
  - Cost
  - Coverage: Limited space, time resolution
  - Data latency
  - Data curation, archiving, services
  - Products
  - Data sharing

IOOS Framework for Ocean Observing

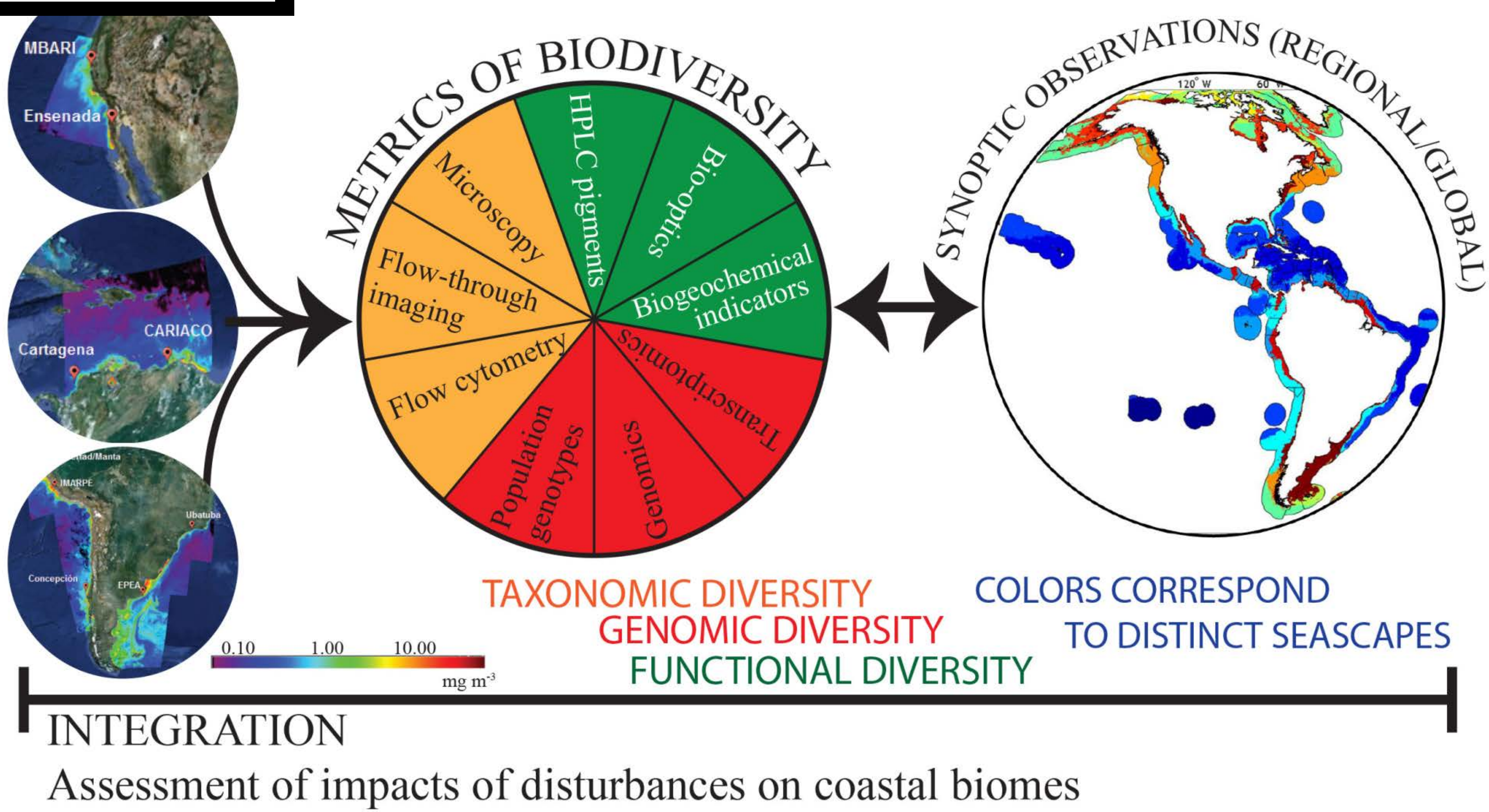


http://iobis.org/2016/12/15/goosgeobonobis/

STRATEGIES

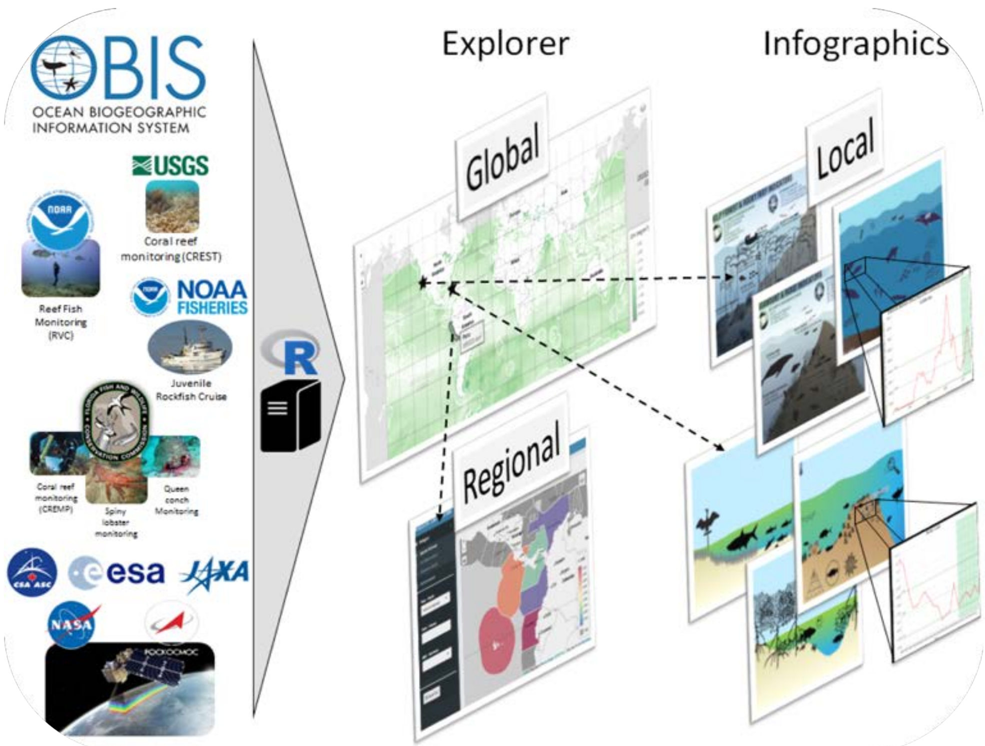
Time-Series

Seascapes



F.E. Muller-Karger, M. Kavanaugh, E. Montes, W.M. Balch, M. Breitbart, F.P. Chavez, S.C. Doney, E.M. Johns, R.M. Letelier, M.W. Lomas, H.M. Sosik, A.E. White. A framework for a Marine Biodiversity Observation Network within changing continental shelf seascapes. In press. Oceanography. September 2014.

What is needed is **Integration**:
Of programs, technologies, data types



Regional to global programs

Supports

NATIONAL MARINE SANCTUARIES

14 LIFE BELOW WATER

Explorer (global) **Infographic** (local)

https://mbon.ioos.us/

MBON Portal: Interactive Tools

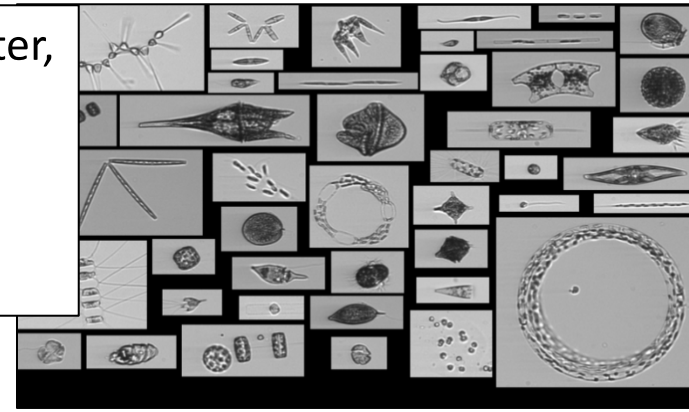
Evolving technology matrix

	Microbes/ Phyto	Zooplankton	Fish	Top Predators	Benthos, habitat forming
Optics/Imaging	X	X	X Benthic		X
Animal tracking (satellite, underwater)			X	X	
Acoustics		X active	X Active, passive	X Tags, passive	X Active, passive (noise)
Genomics	X	X	X	X	X
Platforms with samplers	AUVs, floats, moorings, satellites	AUVs, moorings	AUVs, moorings	AUVs, moorings, tags	AUVs, moorings, satellites
Data and visualization	X	X	X	X	X

Automated flow cytometer, *FlowCytobot* (FCB): Phytoplankton taxa, size, abundance (moored, flow-through)

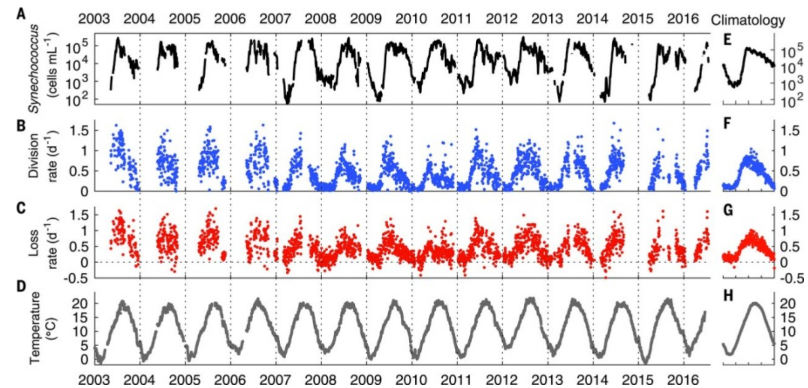
The Imaging Flow Cytobot (above) and basic specs (below). (Heidi Sosik – WHOI)

Weight	32 kg
Diameter	26 cm
Height	102 cm
Max Depth	40 m
Duration	Up to 6 mo.
Frequency	5 mL/20 min
Power	35W, 18-36VDC
Comms	10/100/1000-BaseT Ethernet

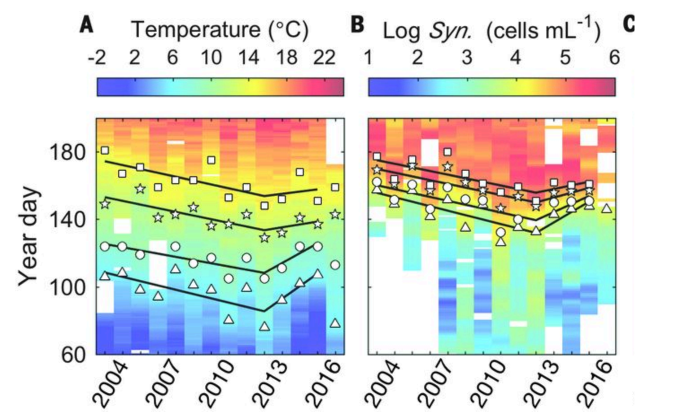


Phytoplankton cells automatically identified and categorized by the IFCB analysis software, from samples collected at Port Aransas, TX. (Lisa Campbell - TAMU)

Daily time series at MVCO from 2003 to 2016



Hunter-Cevera et al. 2016. Science. Vol. 354, Issue 6310, pp. 326-329 DOI: 10.1126/science.aaf8536



Changes in phenology with changes in temperature

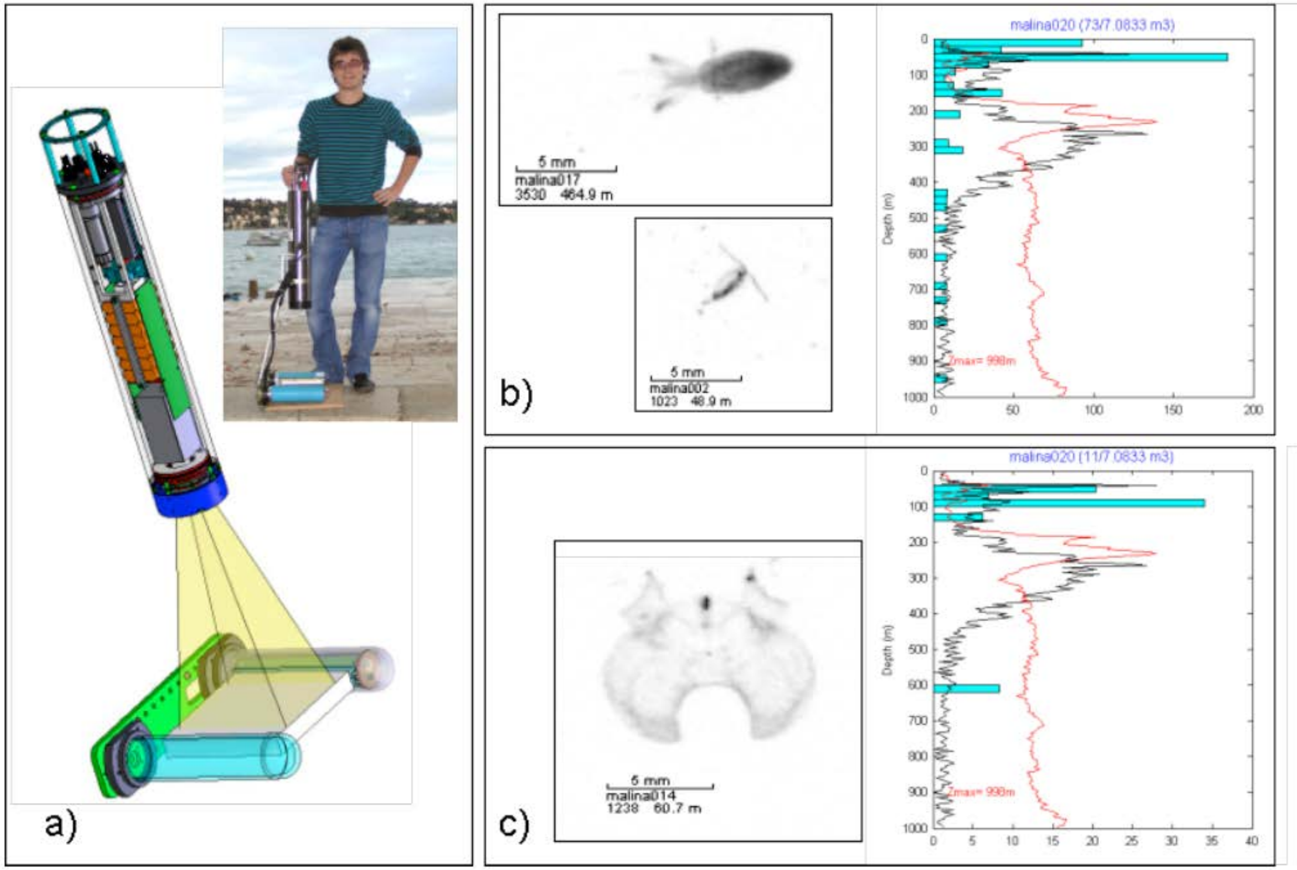
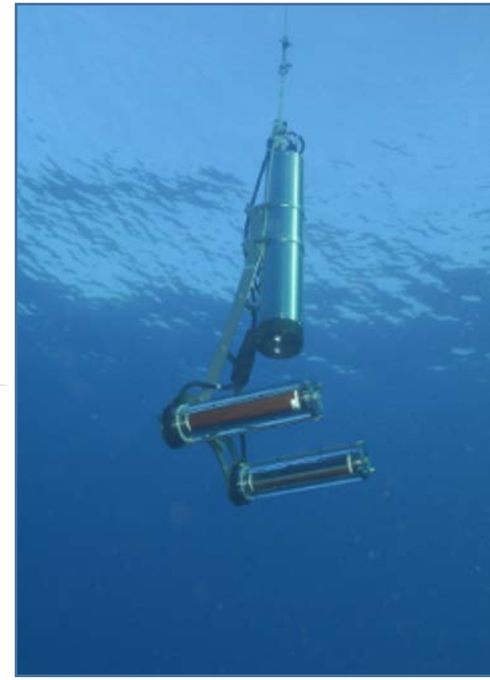
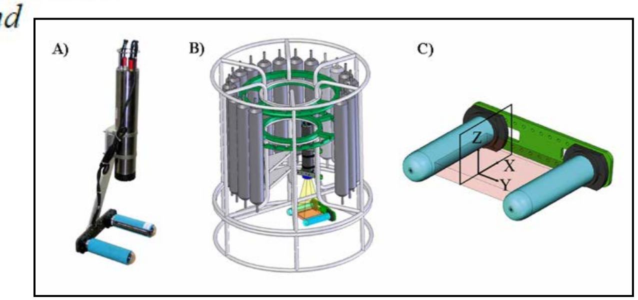


Figure 1: a) UVP5, b) specimens and vertical distribution of copepods (blue), particles below 200 µm (black) and particles above 500 µm (red) at station 20 of Malina cruise, c) specimen and vertical distribution of appendicularia (blue), particles below 200 µm (black) and particles above 500 µm (red) at station 20 of Malina cruise.



http://www.hydroptic.com/index.php/public/Page/product_item/UVP5-DEEP

Underwater Vision Profiler (UVP): Zooplankton taxonomy, size, and counts

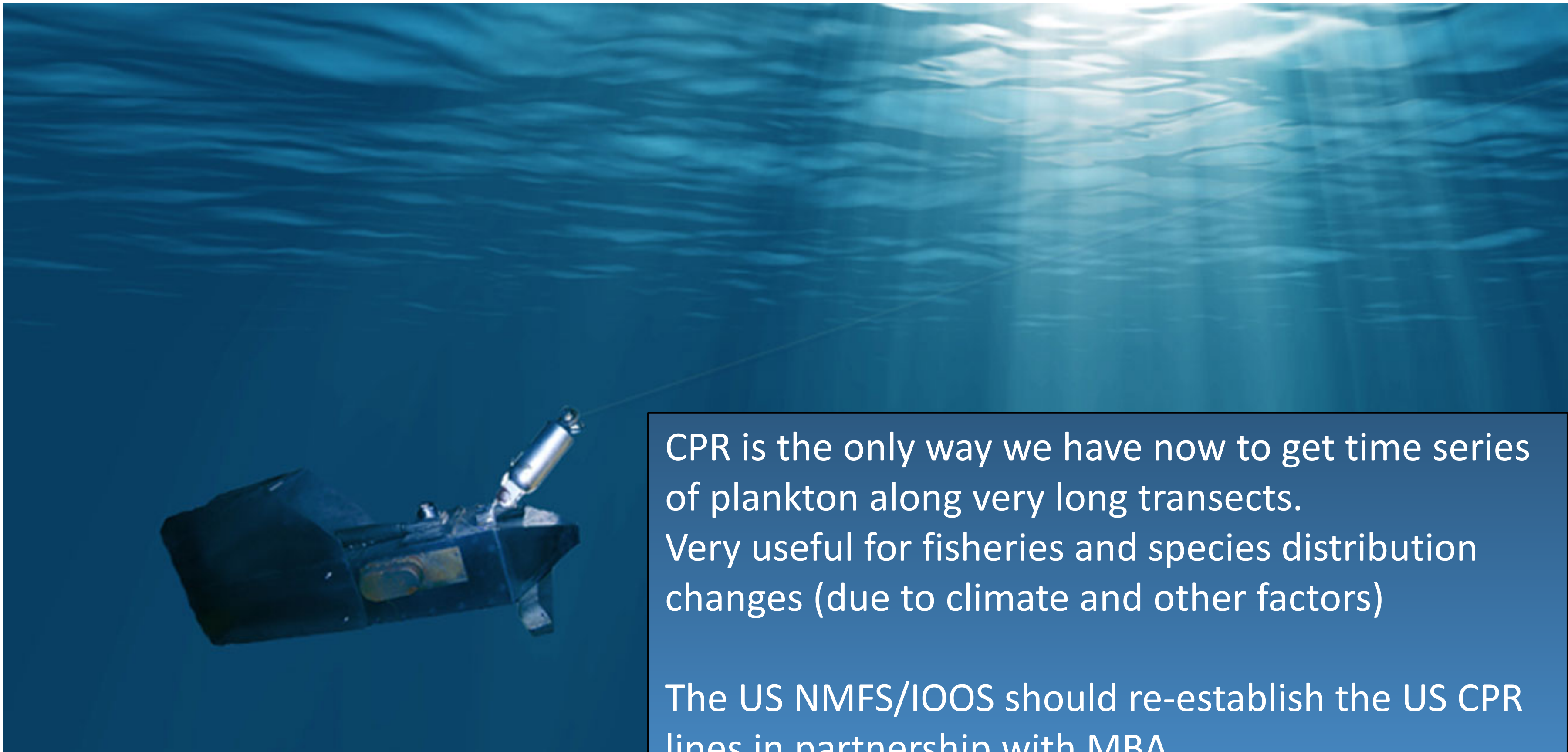


Picheral et al., 2010. Limnol. Oceanogr.: Methods 8, 2010, 462–473

THE CONTINUOUS PLANKTON RECORDER (CPR)

The Marine Biological Association of the UK

https://www.mba.ac.uk/fellows/cpr-survey



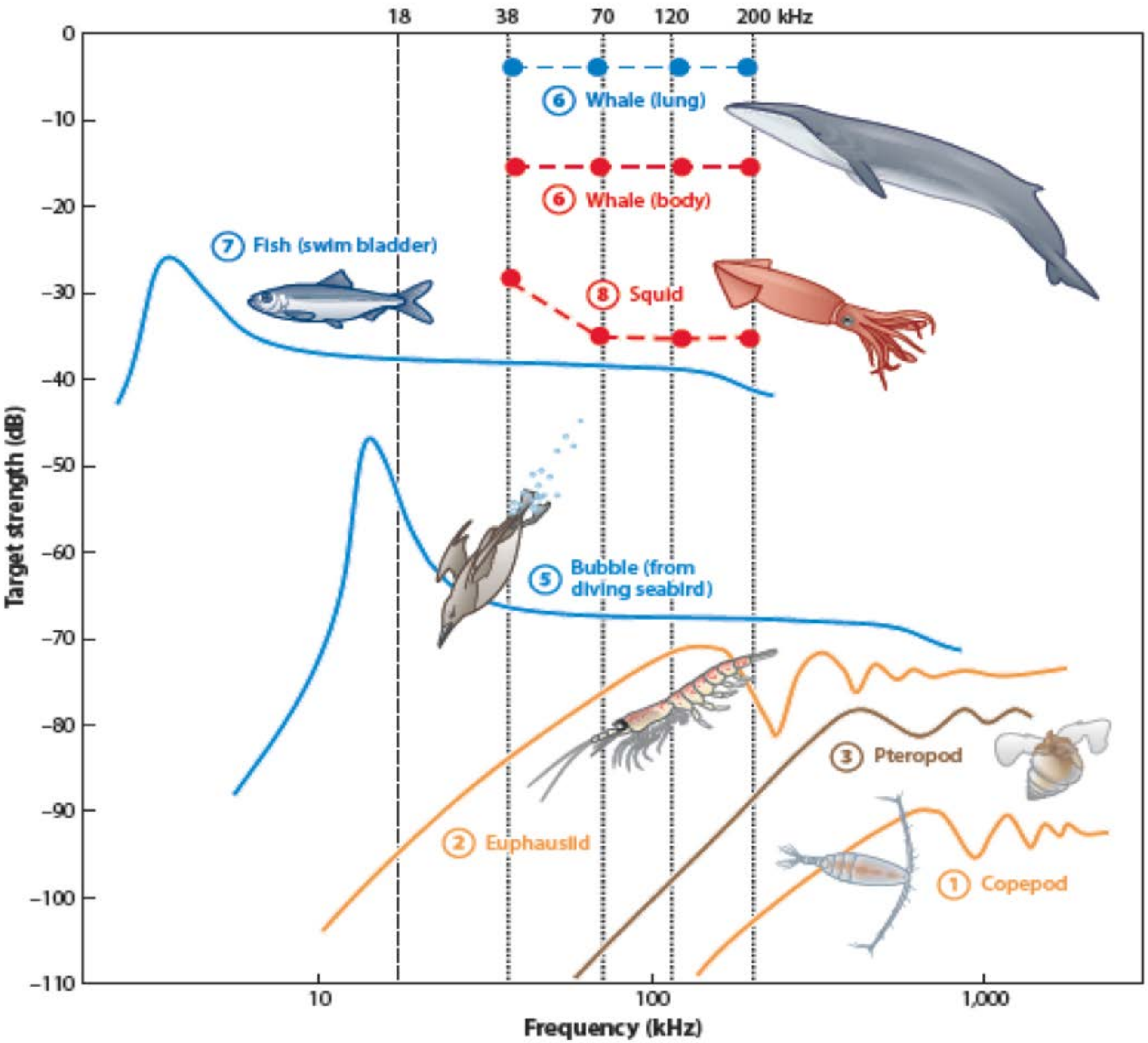
CPR is the only way we have now to get time series of plankton along very long transects.

Very useful for fisheries and species distribution changes (due to climate and other factors)

The US NMFS/IOOS should re-establish the US CPR lines in partnership with MBA

…with a commitment to process the data (zooplankton and phytoplankton), release it to Darwin Core

Active Acoustics

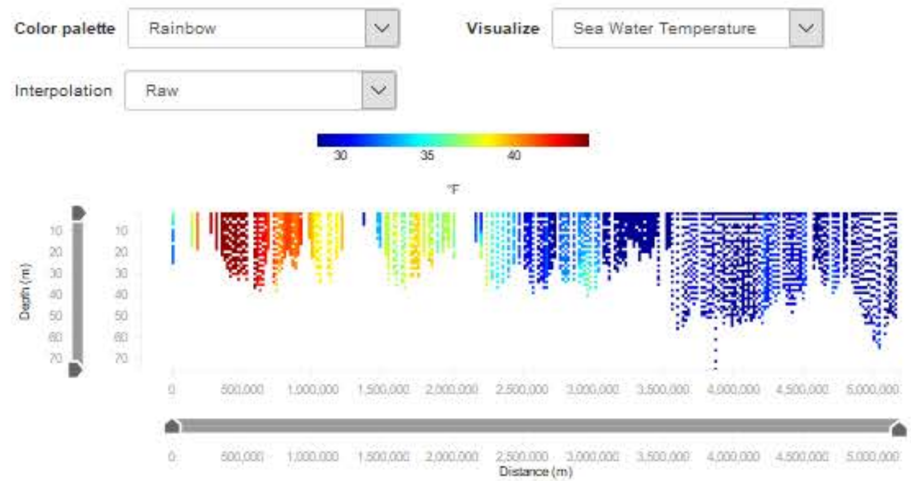


Animal borne sensors and telemetry

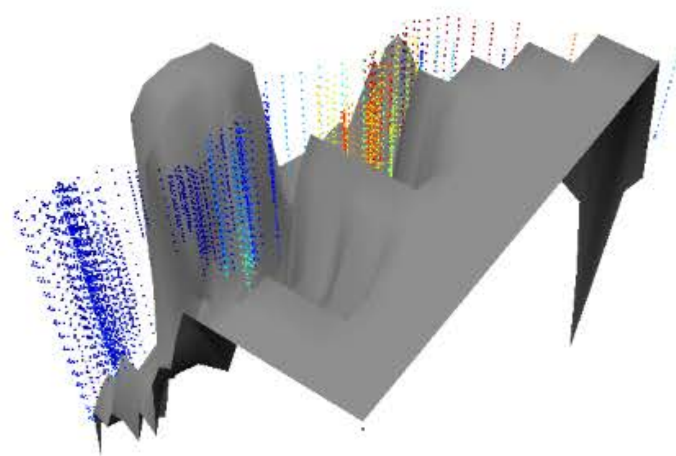
Animal Telemetry Network: ***ATN***
https://atn.ioos.us

eb03-061-15

Date range	Sep 11, 2015 07:26 (EST) - Feb 22, 2016 04:02 (EDT)
Depth range	2 (m) - 75 (m)
Points	4,149
Institution	MARES
Authority	uk.ac.st-andrews.smru

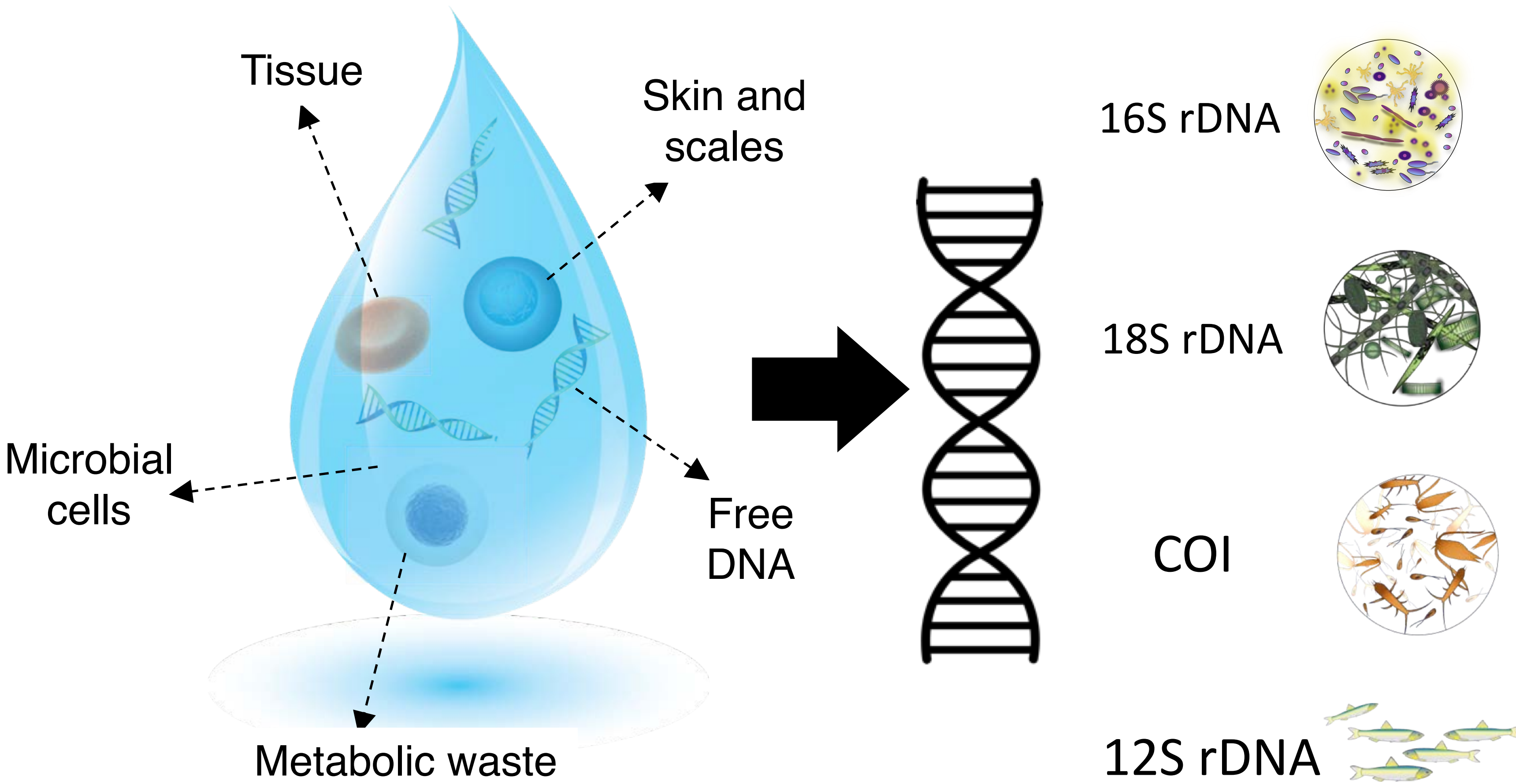


Many other things can be learned about marine animal movement and behavior using telemetry capabilities:
-migration corridors
-breeding behavior
-feeding behavior
-biodiversity hotspots

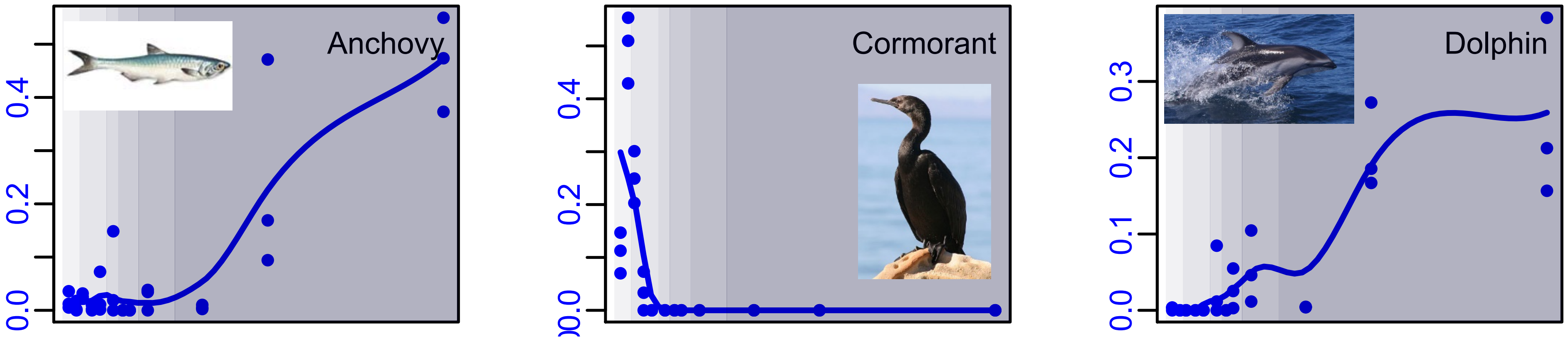


Environmental DNA (eDNA)

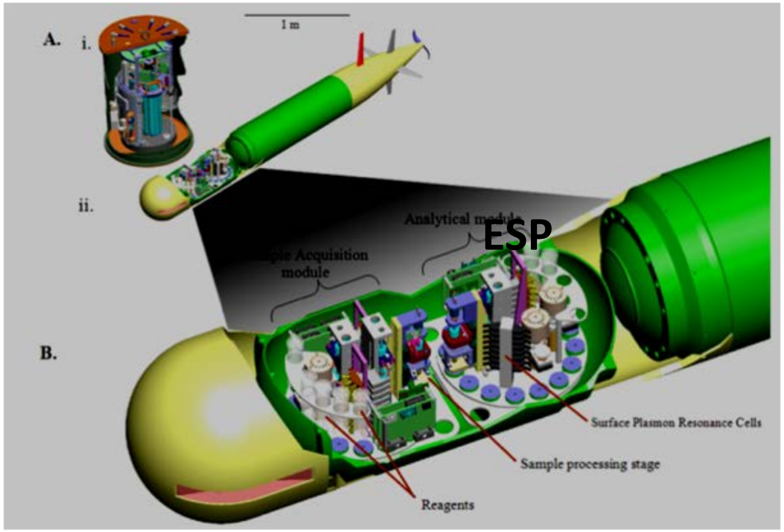
A cheaper, less invasive and larger scale approach to monitor species diversity - Each marker is most sensitive towards detecting different groups of organisms



eDNA can detect organisms that divers don’t



A revolution of autonomous platforms and sensors (biogeochemical, optical, genomic) is underway.

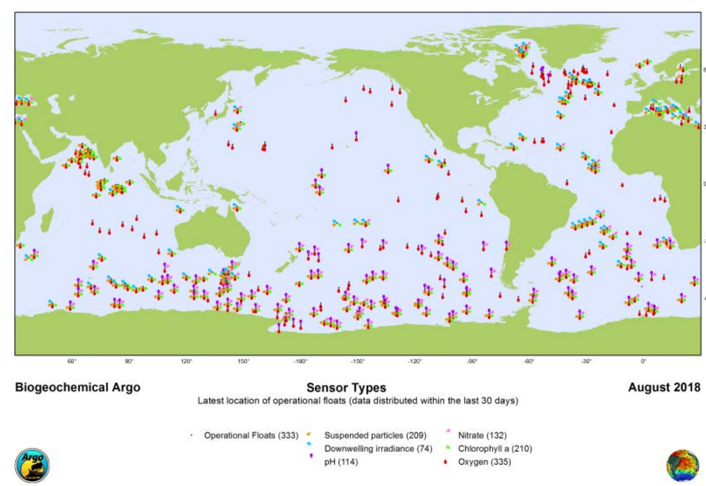


Long range AUV

(Courtesy of MBARI ESP and LRAUV teams)

Biogeochemical Argo

Oxygen
Nitrate
pH
Chlorophyll fluorescence
Suspended particles
Downwelling irrandiance
Zooplankton images



http://biogeochemical-argo.org/#

Satellite-derived Seascapes

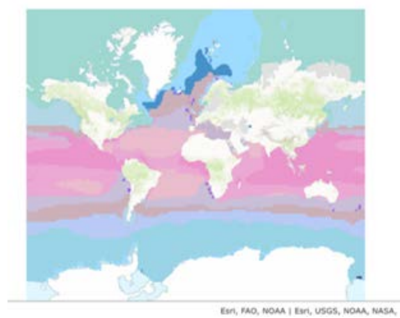
Kavanaugh (OSU), Doney (UVa), Grebmeier (UMCES),
Wright (ESRI), Otis/Montes/Djurhuus/Muller-Karger (USF),
Trinanes/DiGiacomo (NESDIS CoastWatch)

Collaboration:

- MBON sites
- NOAA NESDIS
- US IOOS
- NASA

Global classification

Static+3D



Ecological Marine Units

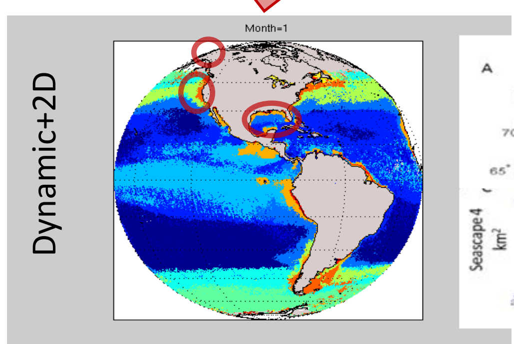
Regional downscaling

Arctic MBON; Distributed Biological Observatory

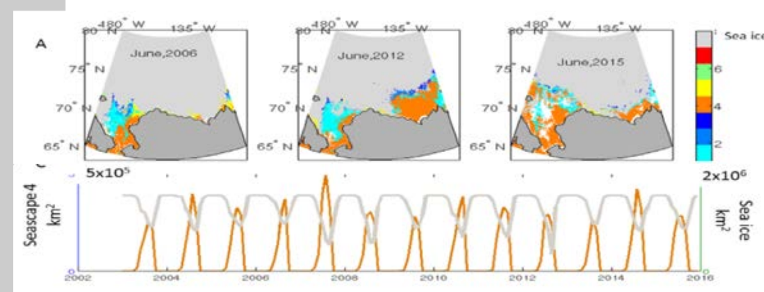
Ongoing efforts

- Global classification of dynamic seascapes
- EMU intercalibration
- Case Study: Arctic (polar, temperate, subtropic)
- Habitat –species relationships
- Operational multiscale products

Dynamic+2D

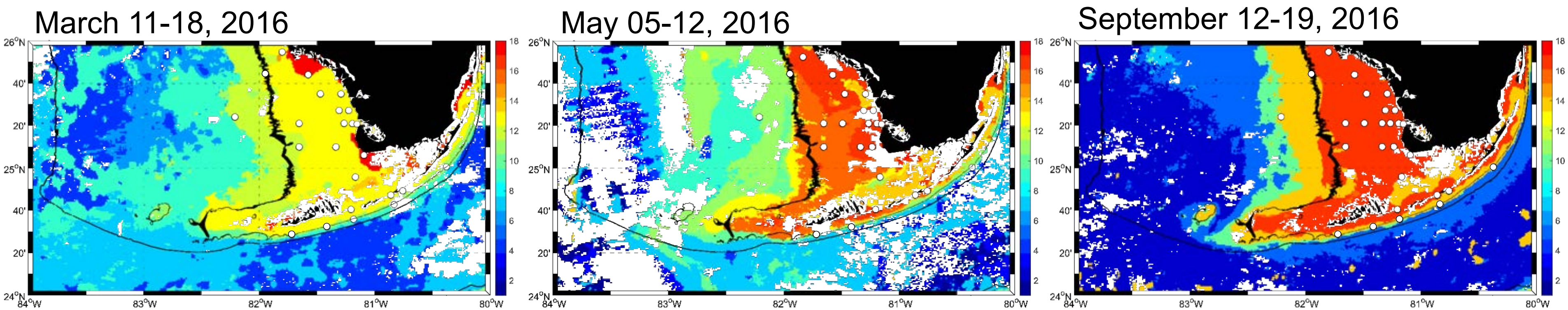


Dynamic Seascapes



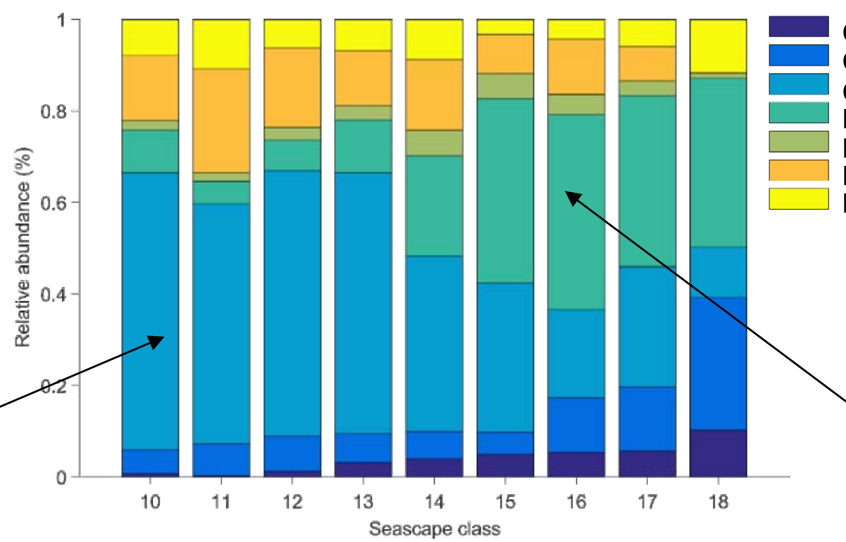
Dynamic habitat maps

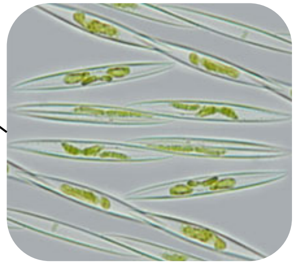
Seascape validation in south Florida



Spatial distribution and seasonal shifts of phytoplankton assemblages

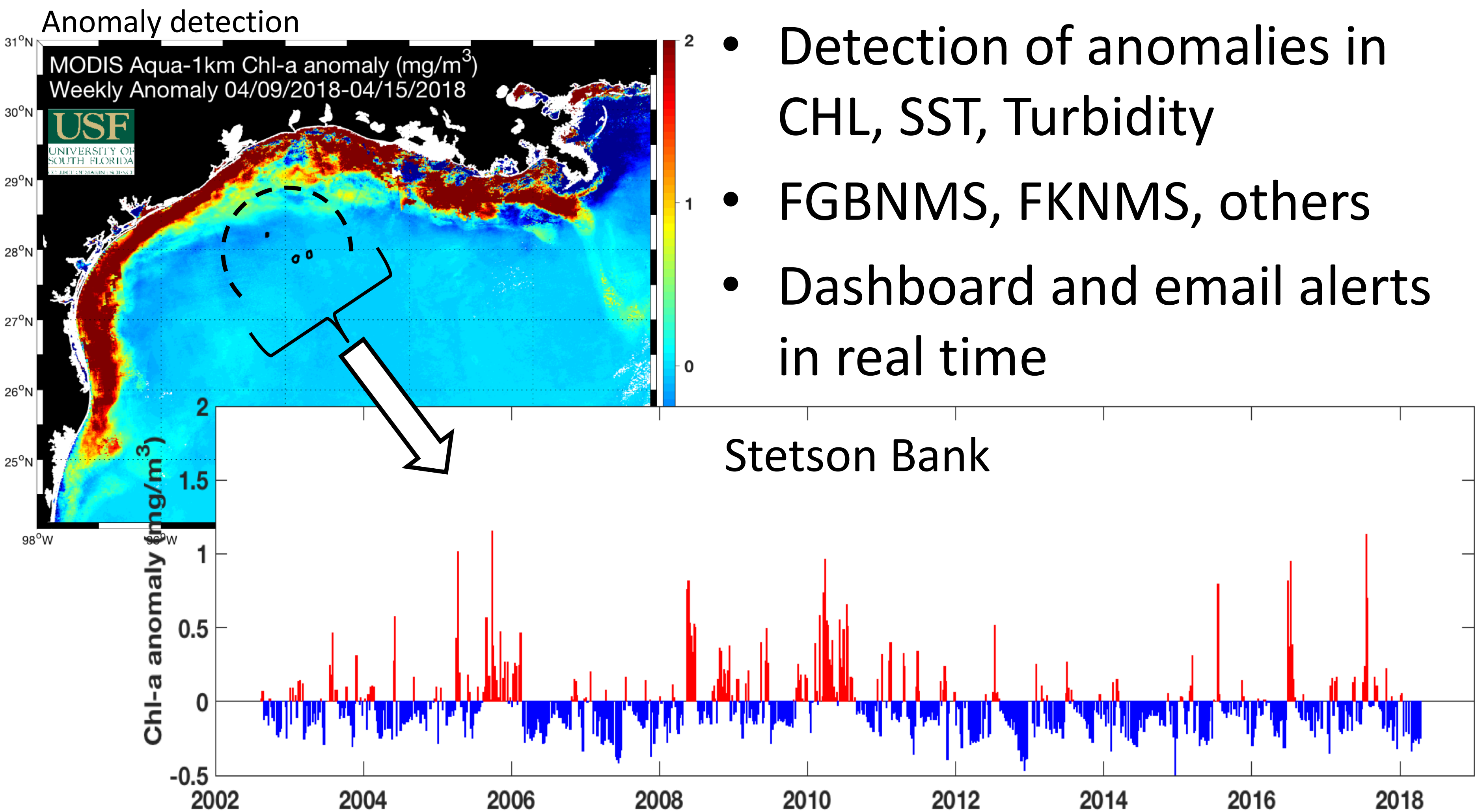
Also validating: eDNA, zooplankton





In prep: Dynamic satellite seascapes as predictors of seasonal shifts of phytoplankton assemblages in south Florida waters. Enrique Montes, Anni Djurhuus, Christopher R. Kelble, Daniel Otis, Frank E. Muller-Karger, and Maria T. Kavanaugh

Early warning and alert system for Sanctuaries



- Detection of anomalies in CHL, SST, Turbidity
- FGBNMS, FKNMS, others
- Dashboard and email alerts in real time

Coastal / Great Lakes aquatic remote sensing priorities

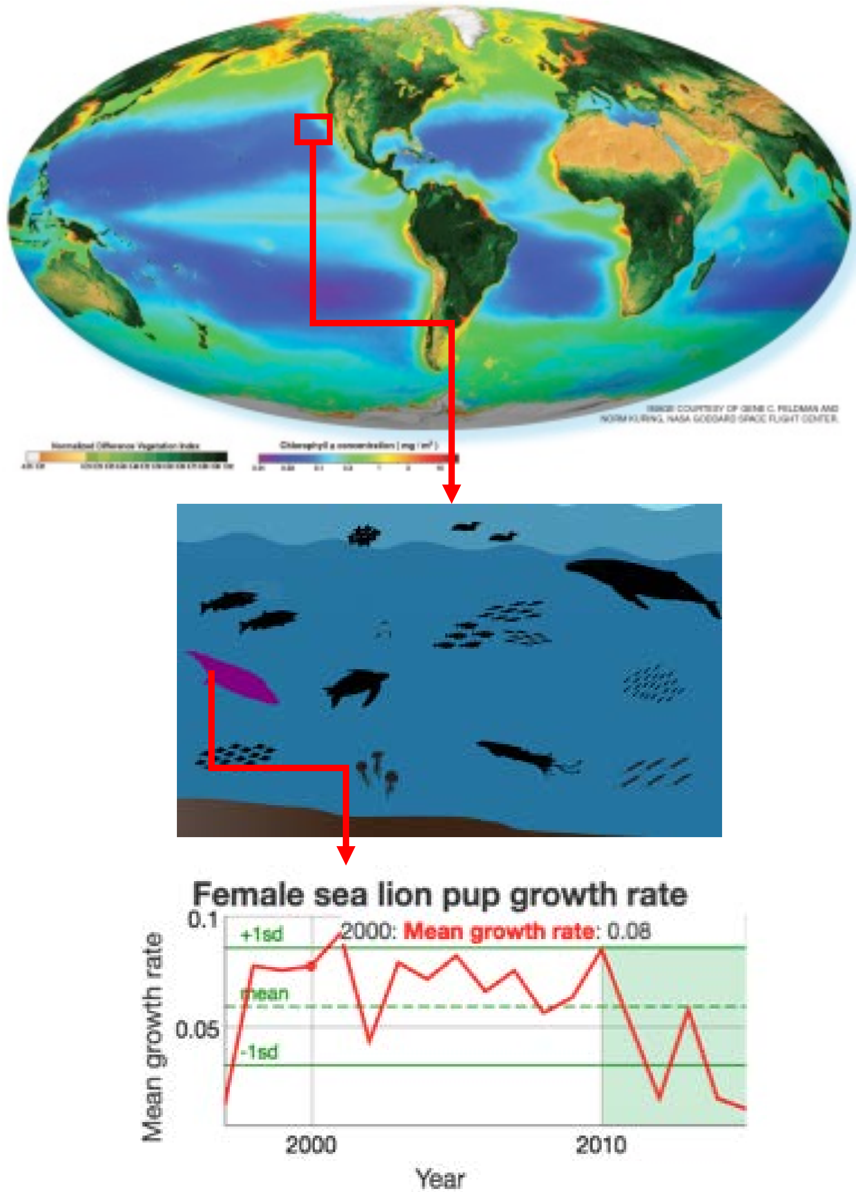
- High temporal
  - At some representative locations: twice weekly or more
- High spatial (~30-90 m)
  - Global + regional intensive
  - Consistency with Landsat history and global coverage
- High spectral (VIS and SWIR)
  - VIS can be ~5 nm except higher (~2 nm or better) in key areas such as around chlorophyll fluorescence (~685 nm) and O2 absorption bands
- Radiometric/geolocation: high quality
  - High SNR (ocean color class), high digitization/quantitization, minimal polarization sensitivity, minimal cross-talk or other out-of band, atmospheric correction scheme (including adjacency), sun-glint avoidance, cloud screening/masking, etc.
  - High geolocation accuracy
- Robust and data processing and distribution

Conceptual Model

<u>NCEAS Global Marine Ecosystems layers</u>:

Beach
Coral Reefs
Deep Hard Bottom
Deep Soft Benthic
Deep Waters
Hard Shelf
Hard Slope
Intertidal Mud
Kelp
Mangroves
Rocky Intertidal
Rocky Reef
Salt Marsh
Seagrass
Seamounts
Soft Shelf
Soft Slope
Sub-tidal Soft Bottom
Surface Waters
Suspension-Feeder Reef

Note: Abyssal-Hadal layers to be created



NASA, other regional/global data

Infographic of local habitats (EEZ, LME)

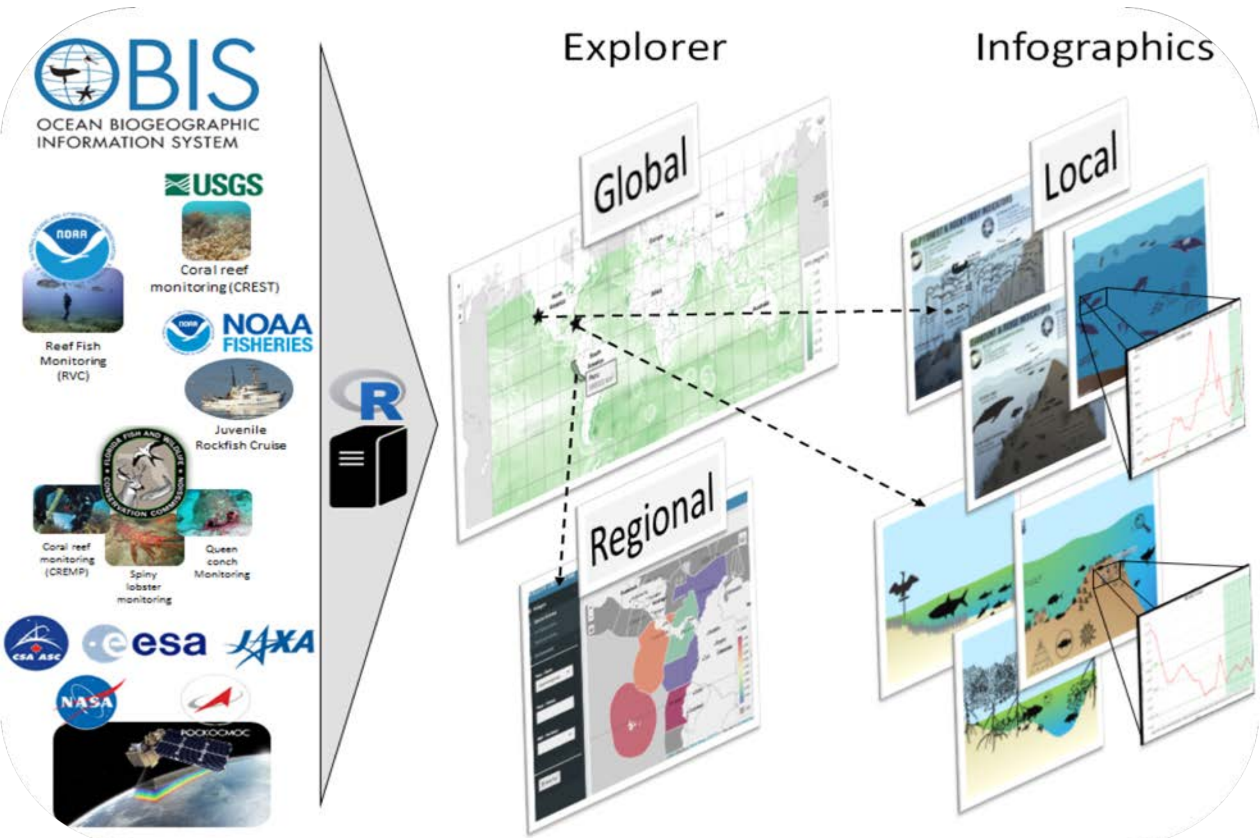
Local data/time series

Collaborators:
B. Best, J. Brown,
L. McEachron,
E. Montes

Data Integration

MBON Portal: Interactive Tools

for data storytelling



Supports

NATIONAL MARINE SANCTUARIES

INTEGRATED ECOSYSTEM ASSESSMENT

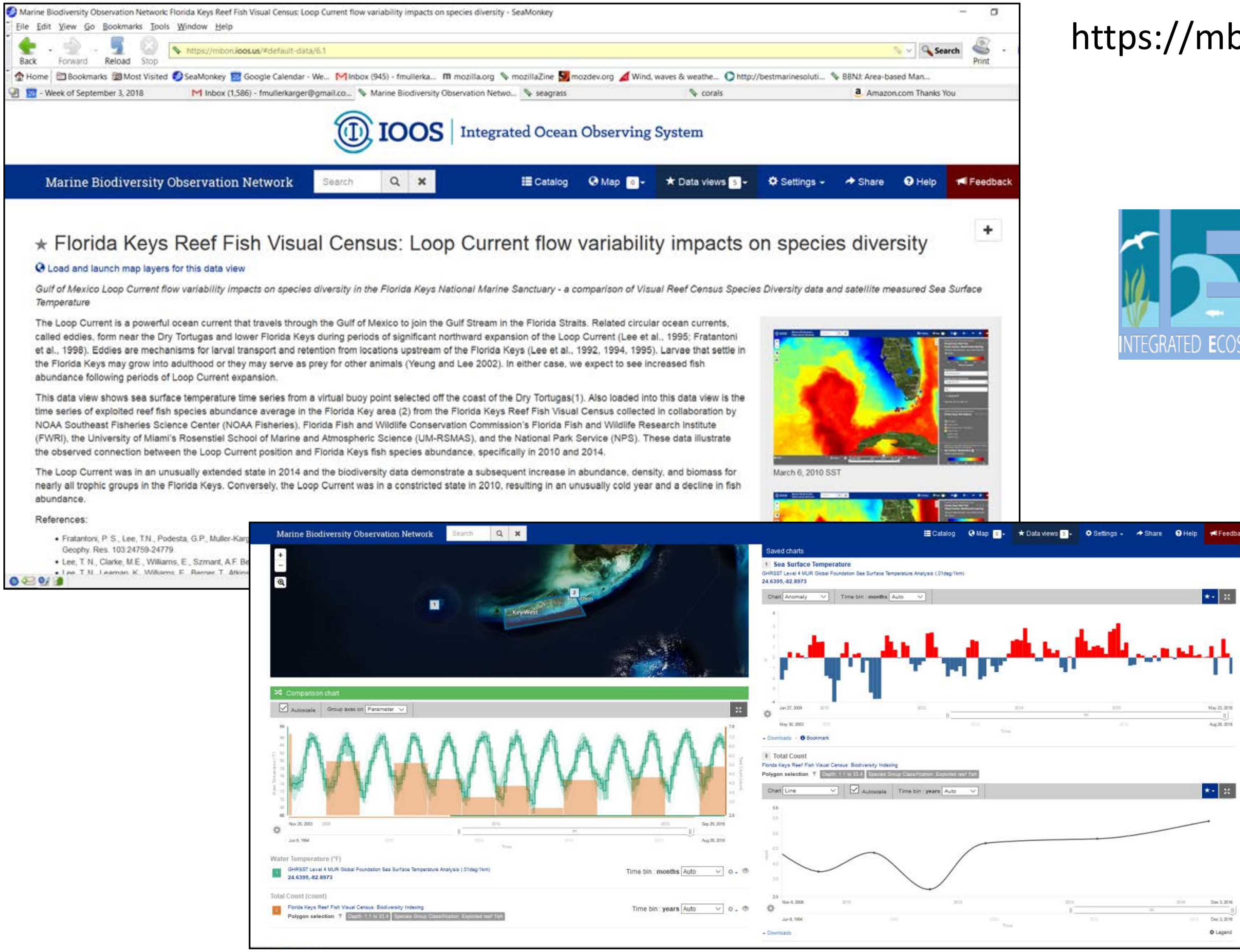
14 LIFE BELOW WATER

Explorer (global) **Infographic** (local)

https://mbon.ioos.us/

Dynamically updating status and trends:

https://mbon.ioos.us/

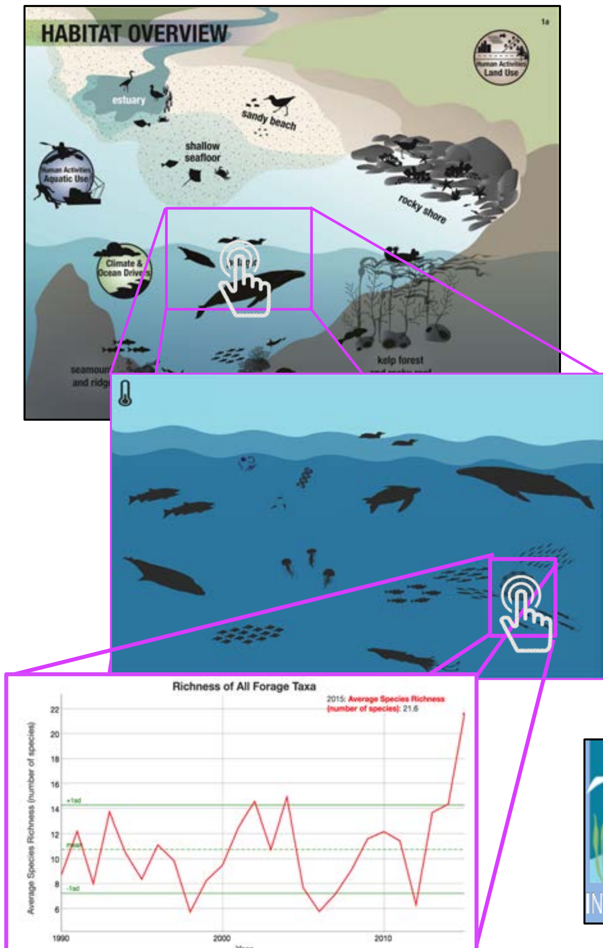


https://mbon.ioos.us/#default-data/6.1

Dynamically updating status and trends

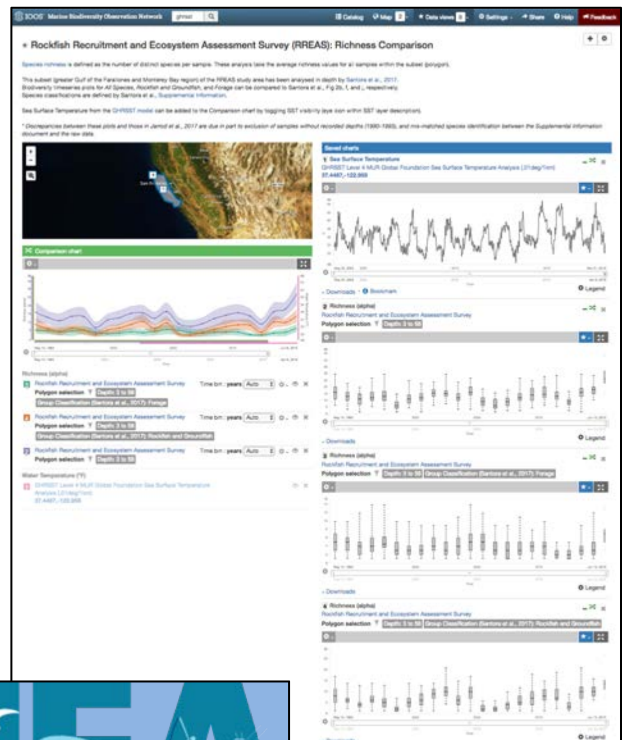
Infographics

Audience:
Public, managers, educators



Curated Data Views

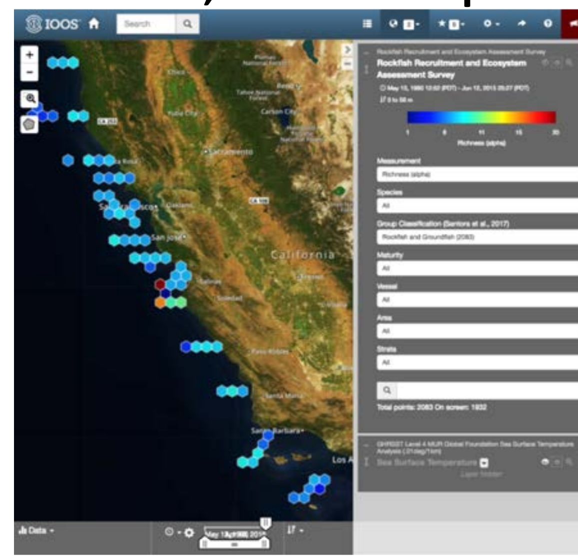
Audience:
Advisory groups, researchers, teams

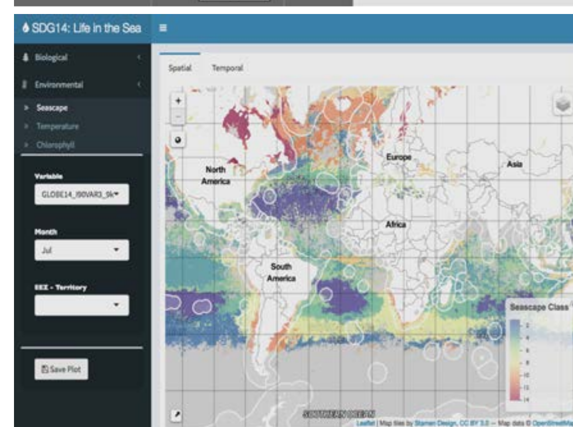


INTEGRATED ECOSYSTEM ASSESSMENT

Data portals

Audience:
Scientists, technical experts





Recommendations for IOOS (1)

- Carefully define specific user needs
  - Minimize shotgun approach
- Integrate biological observations into IOOS
  - *Ships, moorings, buoys, gliders, animals*
  - FlowCytobots
  - Underwater Vision Profilers (UVP)
  - Marine animal telemetry observations
  - Acoustics
  - eDNA
  - Satellite (SST, color, altimetry, wind, *Seascapes*)
- Expand IOOS collaboration across NOAA (OER, OAR, NMFS, NESDIS, NWS) to access/collect bio data
- IOOS gets engaged in defining recommendations for satellite remote sensing (regional H4 sensing and global biology)
- Develop integrated biological-physical coupled models designed for purpose

Recommendations for IOOS (2)

- Data management strategy:
  - RAs serve as regional coordinator/support/enroller of biological data (academic, state, Federal, e.g. NMFS FMC)
  - Fully accept and integrate Darwin Core/ERDDAP for biological data
  - Consider cross-linkages for complementary ATN-MBON-RA Portals:
    - Design linkages between the complementary ATN and MBON portals, in where there is a critical role for ATN to aggregate/curate and distribute/visualize animal tracking data, and that the IOOS MBON environmental and biological and biodiversity data layers are critical to understand the environmental and biotic drivers and interactions
  - Link OBIS and joint ATN-MBON Portal
  - Initiate Data Archaeology (a la Syd Levitus / NODC 1980's):
    - National (and provide leadership for international effort)
  - Regional to national to global IOOS product integration, seamless
  - Use infographics and user-defined data views and regional scenarios

Image courtesy of Francisco Chavez / MBARI

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