Satellite-derived Dynamic Seascapes:

A Biogeographic Framework for the US and Global Marine Biodiversity Observing Network

MBON Update

26 April, 2018

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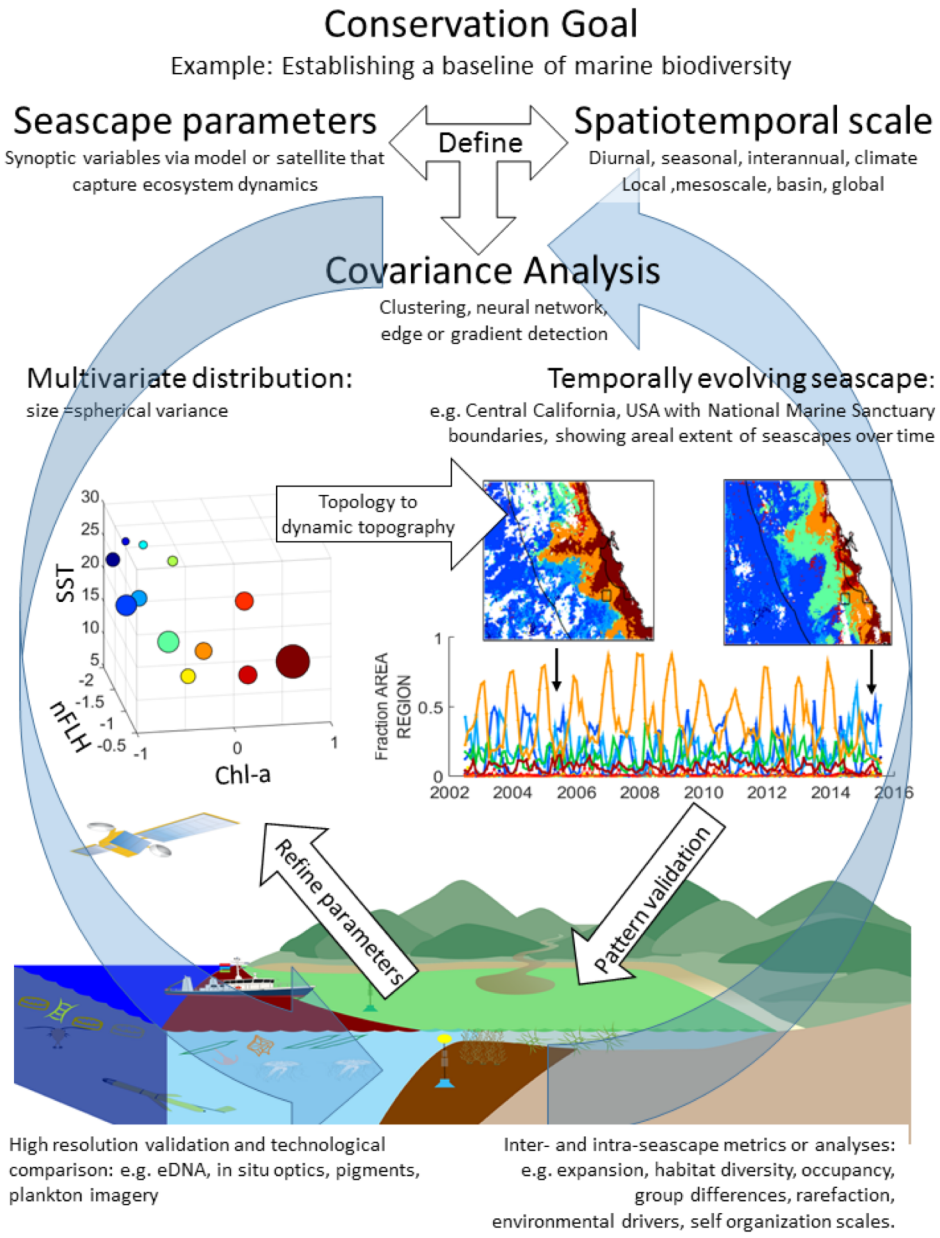
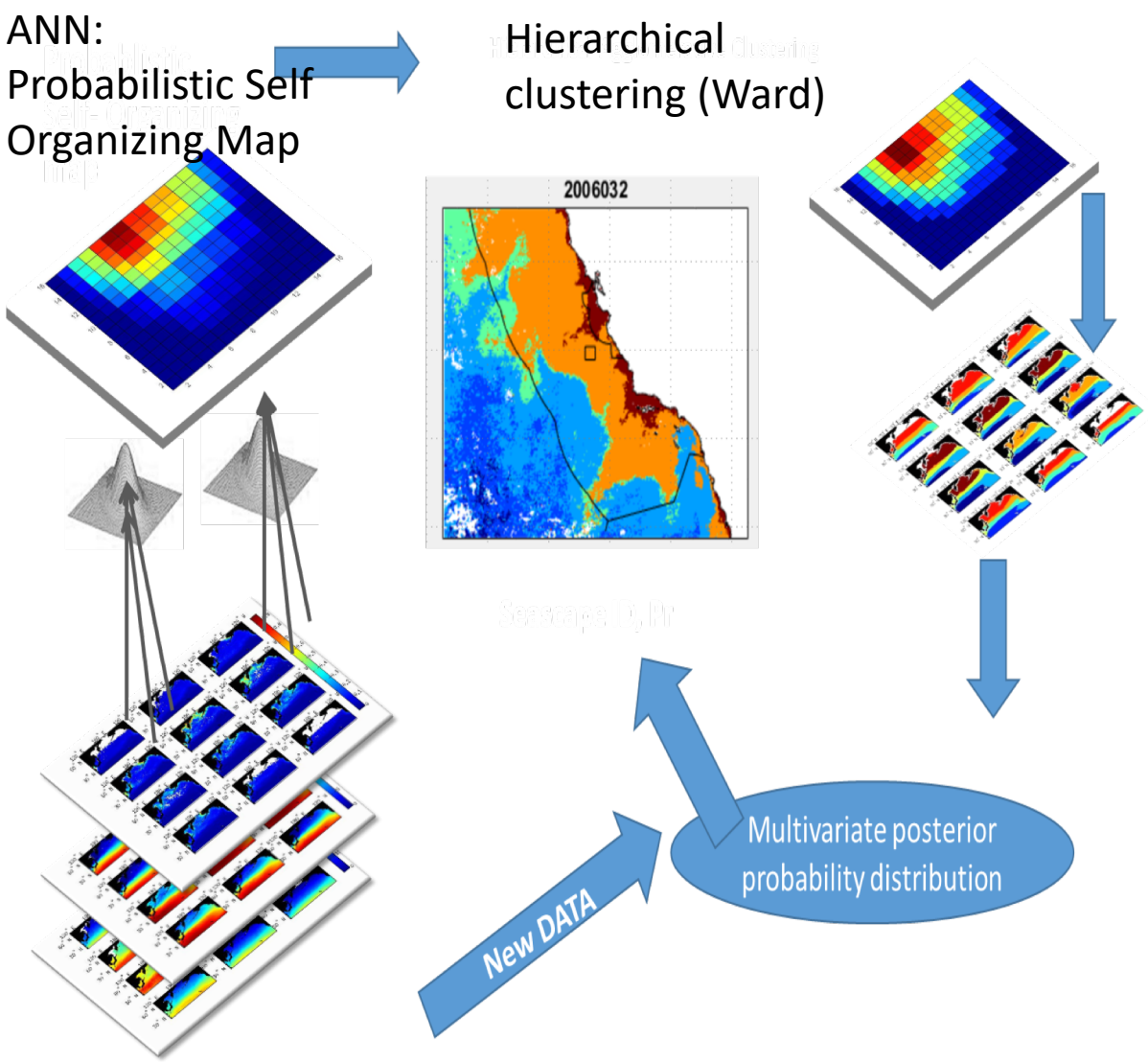
Why dynamic seascapes for the US-MBON?

- Biogeographic framework
- Rarefaction and patchscale
- Ecosystem comparison
- Methods comparison (functional, taxonomic genetic)
- *Seasonal and interannual dynamic habitat for species suites*
- Real time cruise planning, feature tracking



Kavanaugh et. al. 2016 ICES

Methods: hierarchical, dynamic, relationship-preserving (near real time)



Multiple scales: global, regional (e.g. CCS) and local (e.g. sanctuary)

Space and time classified simultaneously from synoptic time series using **hierarchical and topology preserving** machine learning

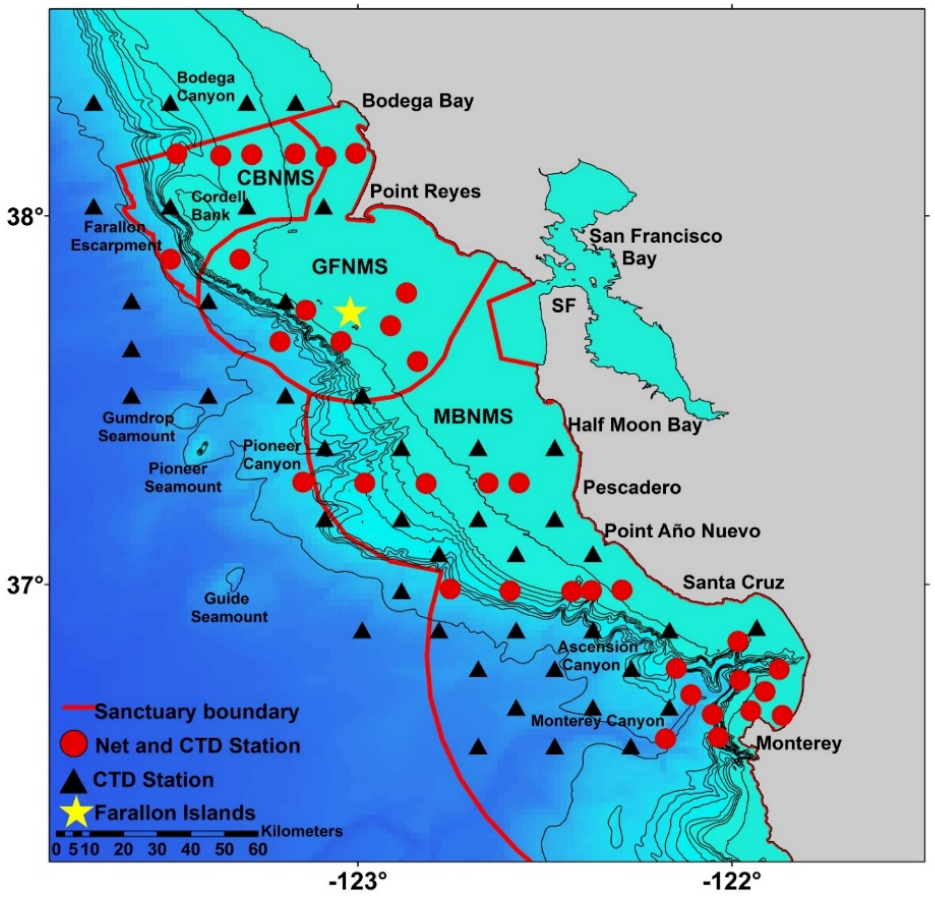
Phytoplankton response to physics

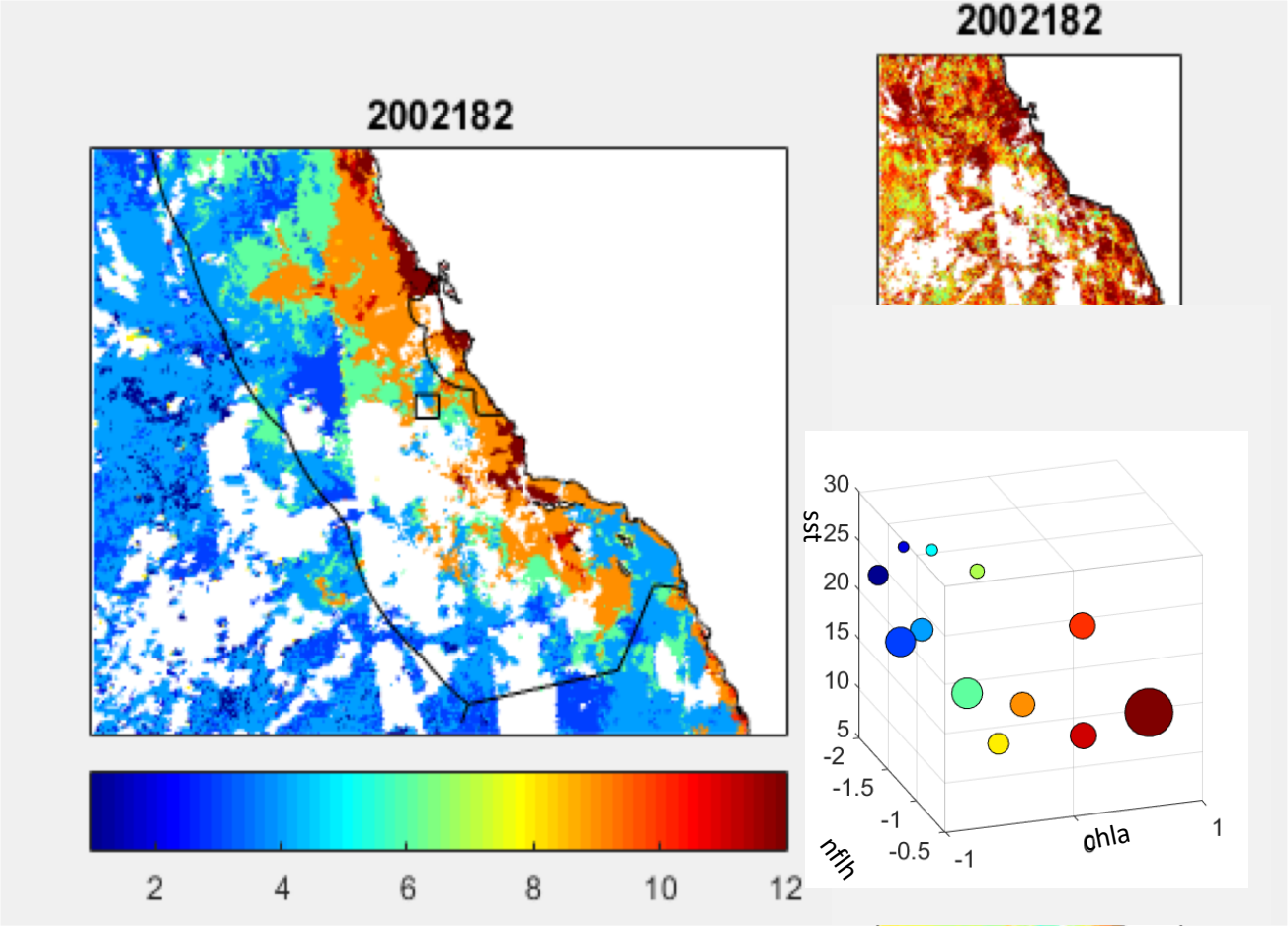
Probabilistic: allows new time points and near real time classification

Duration: 1997- present (sensor intercomparison)

Seascapes as habitat: forage fish indicators

NOAA (SWFSC) Rockfish Recruitment and Ecosystem Assessment Survey (RREAS); May-June 1983-present



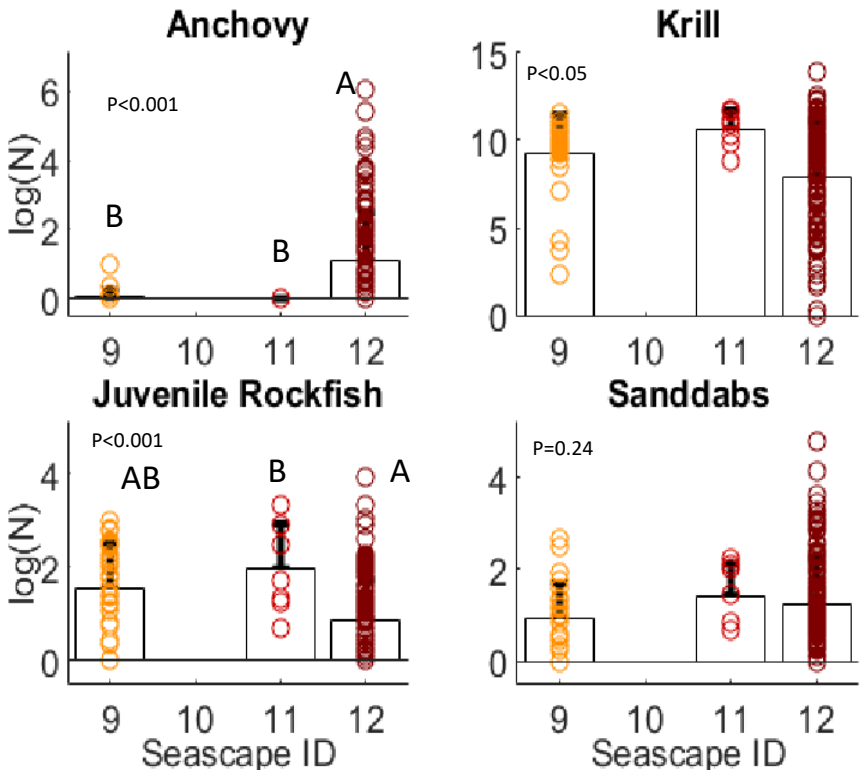


- Net and CTD stations; 2-3 times during May and June
- Night midwater trawl, 15 min, headrope 30 m

- Dynamic seascapes classified from sst, nflh, and chl-a.
- 1 km resolution; 8 day- monthly frequency

Seascapes as fish habitat indicator?

Forage fish abundance and occupancy across seascapes- extended time (to 2015), domain (to Oregon), and MS project (Klabjor).



Likelihood Ratio=

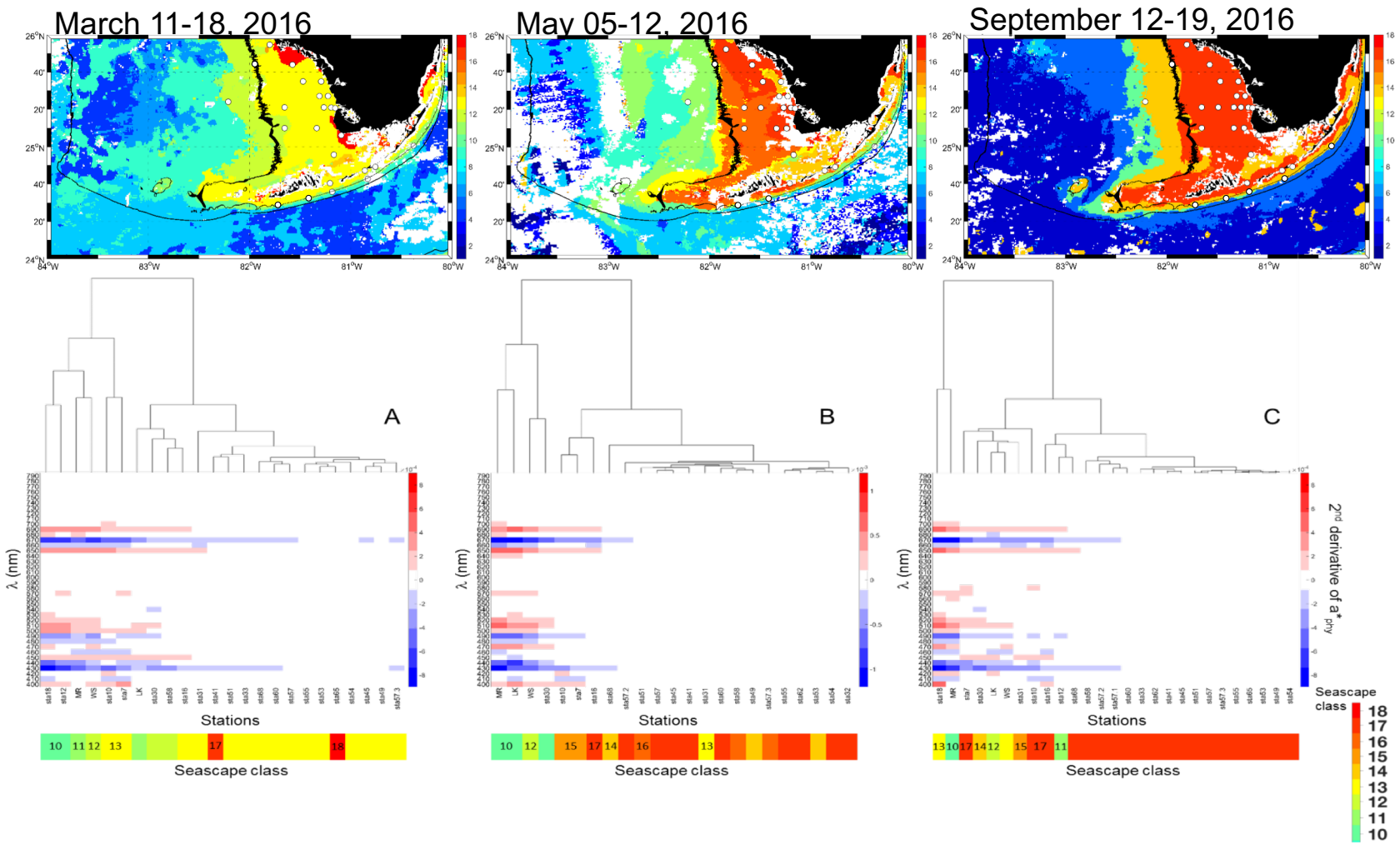
N in Seascape X/Total N

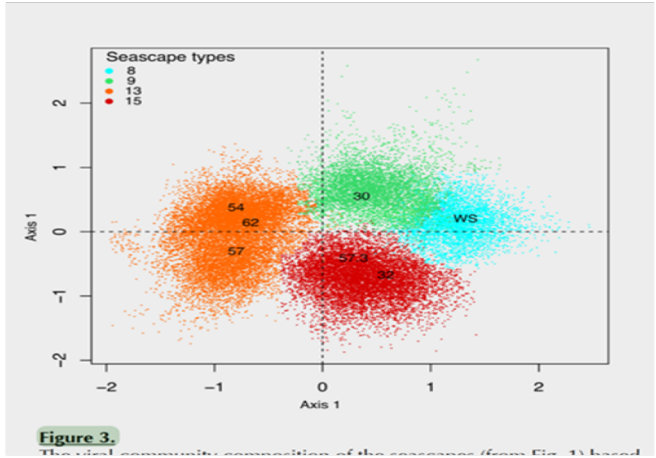
Likelihood of Seascape X (x,y,t)

Presence				
Seascape ID	Anchovy	Krill	Rockfish	Sanddab
9	0.2	1.0	1.0	0.8
11	0.0	1.0	1.3	1.1
12	1.3	1.0	1.0	1.0
Biomass				
Seascape ID	Anchovy	Krill	Rockfish	Sanddab
9	0.4	0.9	0.9	0.9
11	0.0	1.0	1.2	1.1
12	1.2	1.0	1.0	1.0

Analysis of variance of abundances across seascapes. Letters denote results of multiple comparisons tests, where unique letters have statistically significant different means.

Seascape delineate plankton communities in FKNMS





Anni Djurjuus: Metagenomics. Viral community composition of Florida seascapes based on the k-mer composition of 35 bp

In prep: phytoplankton 18S RNA

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

Seascapes as larval habitat
Gulf of Mexico

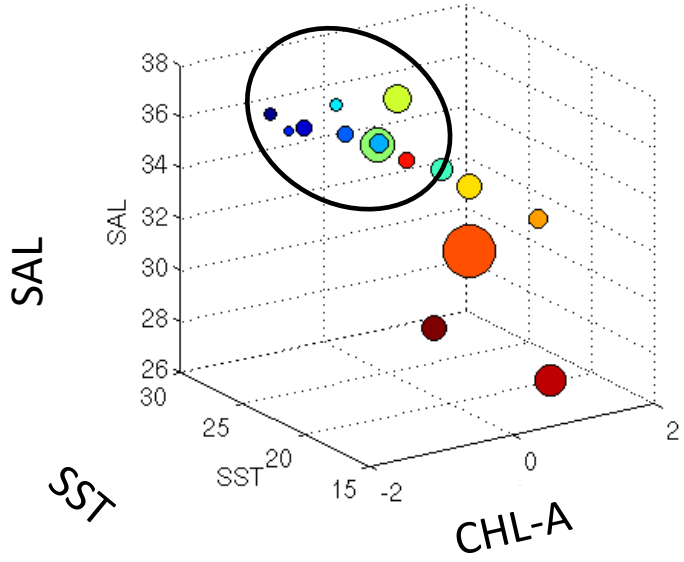
Southeast Area Monitoring and Assessment Program

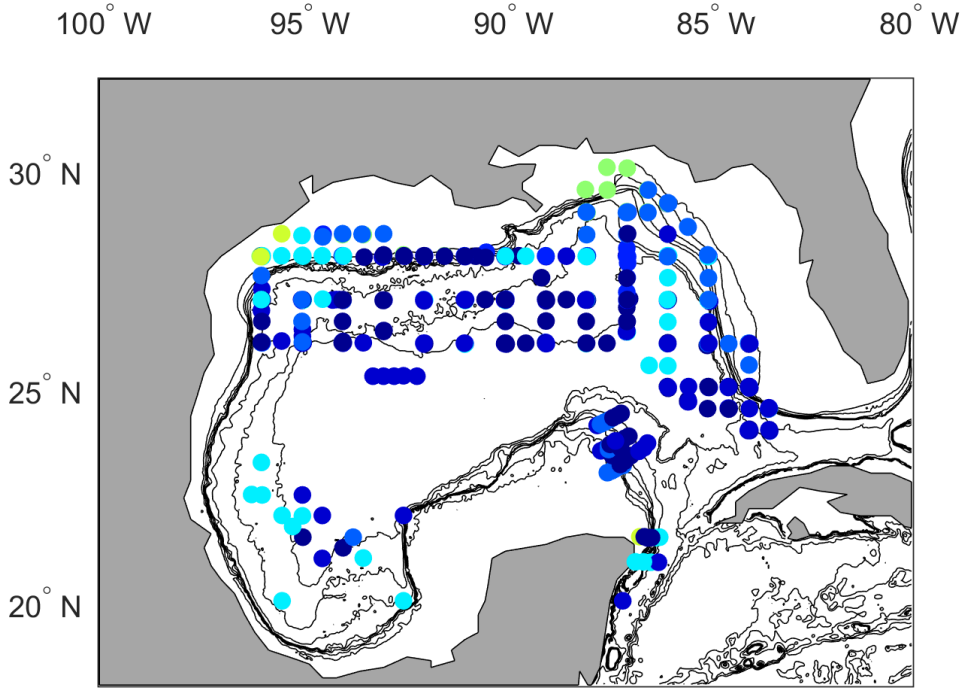
SEASCAPES

- Salinity, SST, chl-a, NFLH
- 4 km, 8d frequency
- 9/15 sampled: mostly oligotrophic, some eddies

SEAMAP

- Spring larval survey
- 61 cm bongos
- 200 m- surface oblique tow
- 333 um mesh
- Some taxa id-ed to species, most to family
- 1986- present, only 2003:2013 used





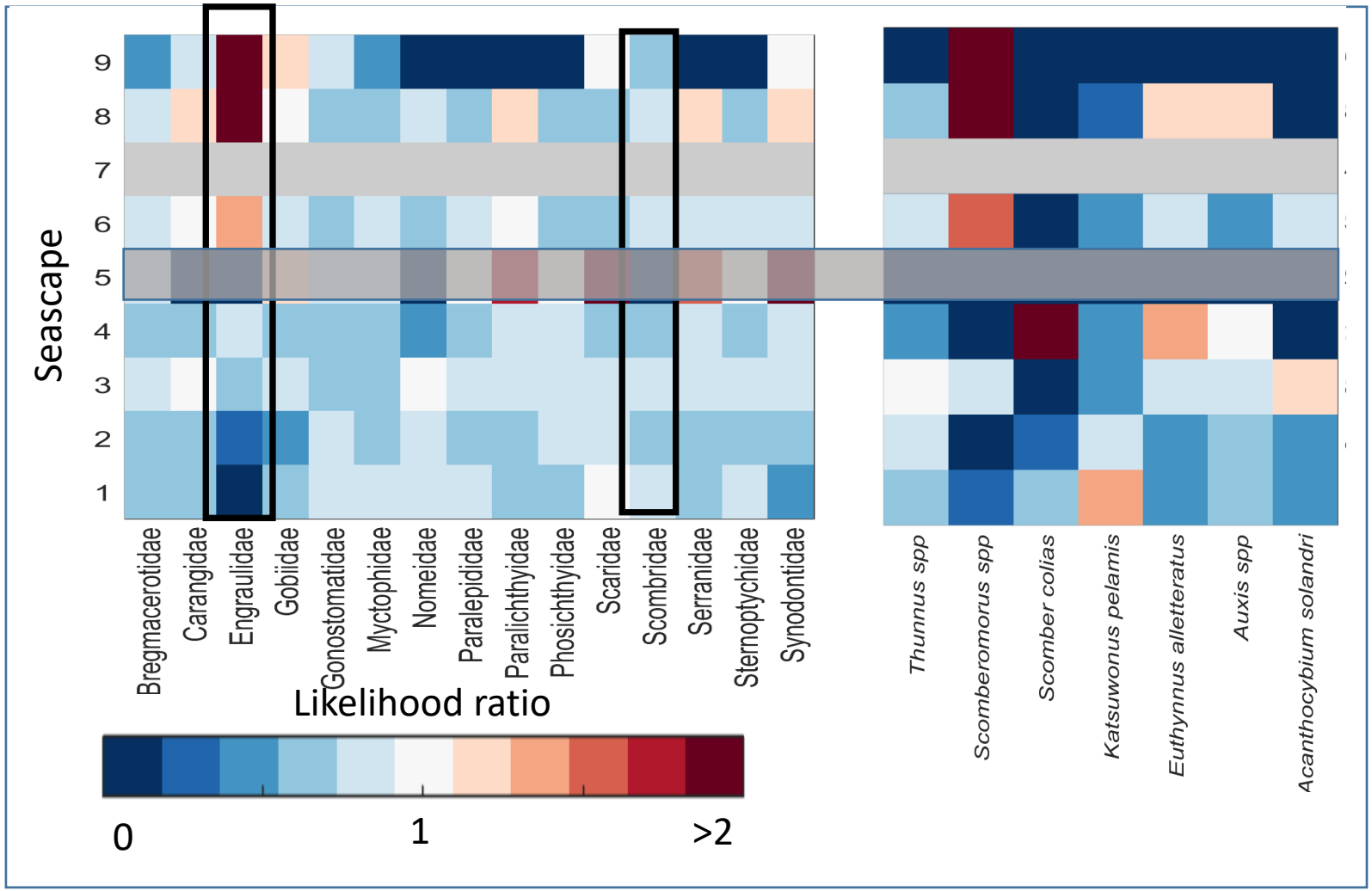
Shows *last* seascape sampled: variability masked

Seascapes as larval habitat in GOM

Occupancy Heat Maps: likelihood of occurrence with imperfect sampling

Meso-trophic, fresher cooler

Oligo trophic, oceanic warmer



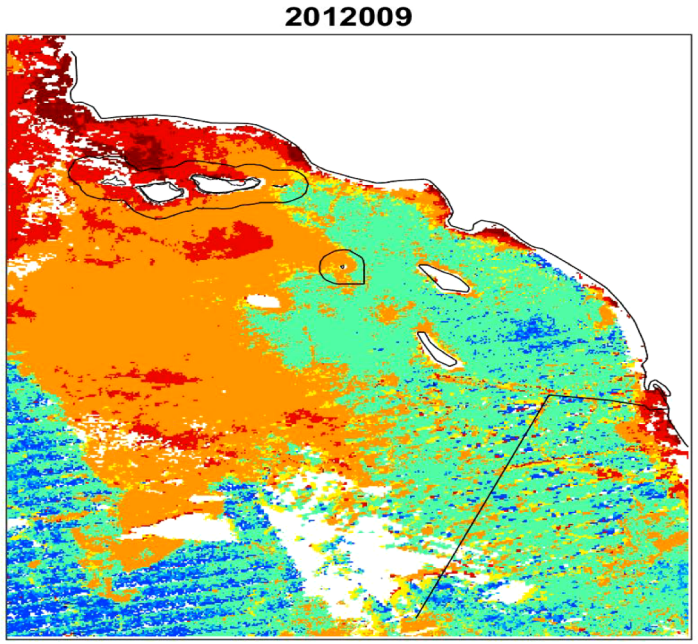
X-MBON Activities: extending seascape analysis to SC Bight

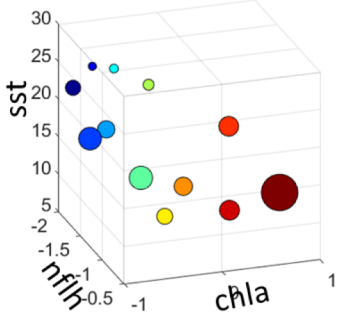
Uses same underlying classification scheme as MBNMS

Allows for intra and inter management unit (e.g. sanctuary) analyses of pelagic habitat representativeness and change.

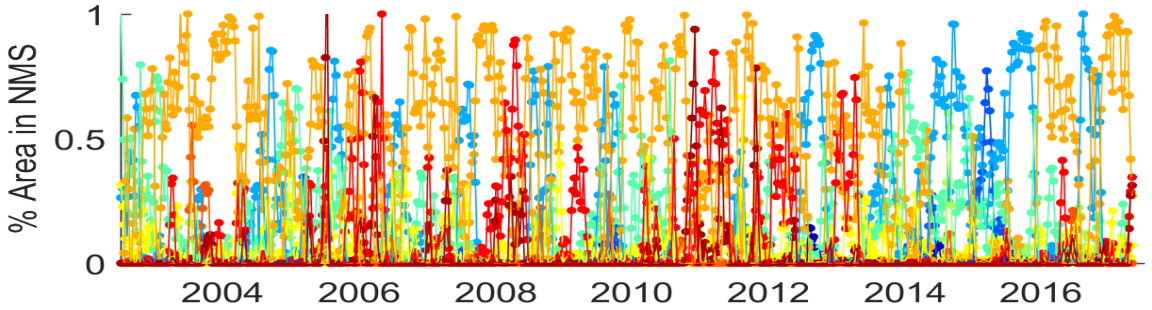
Specific SBLTER applications:

Time Series: % “coverage” or area
Channel Islands (North): 2002-present
SoCal Bight (domain): 2002-present

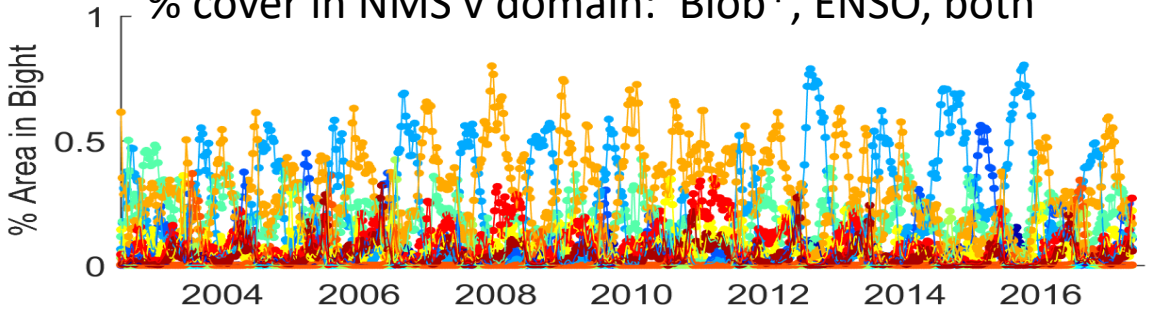




Legend: Mean seascape states
Video- highlighting dynamic seascapes from 2012 – present, 1 km, 8 day. Data gaps: point of discussion



% cover in NMS v domain: Blob*, ENSO, both

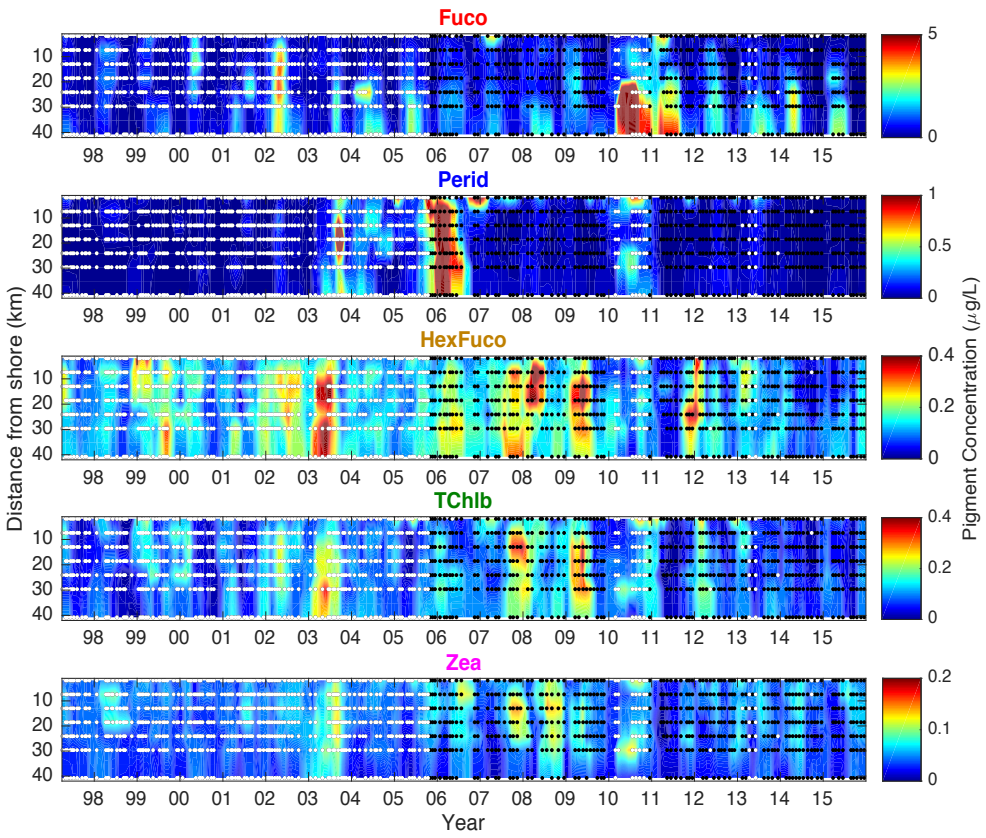


X-MBON Activities: extending seascape analysis to SBLTER

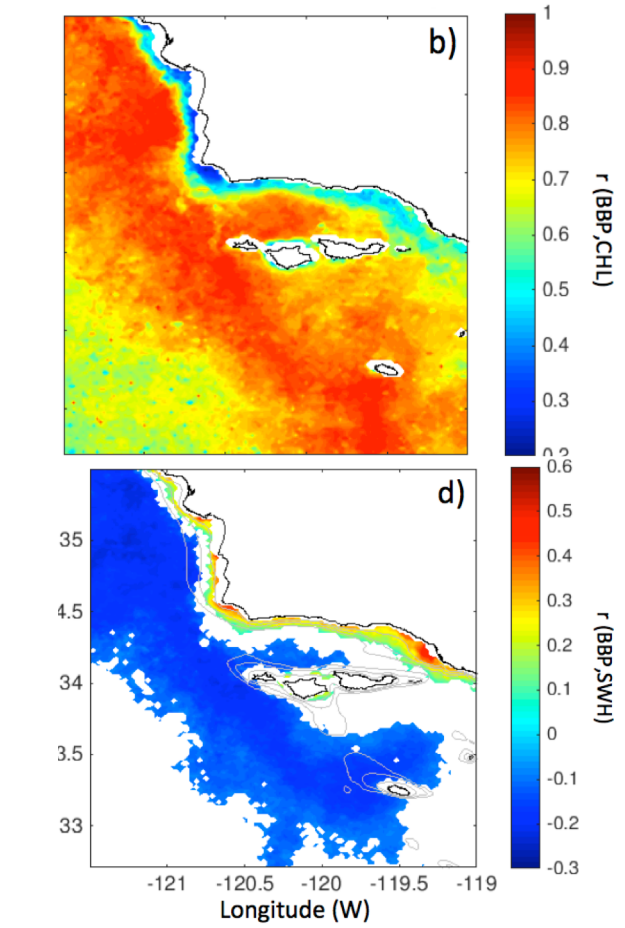
- Multiyear, multiple times a year transect for phytoplankton functional types (Dylan Catlett and David Siegel): regional test case for seascape boundaries.
- Gradients in the covariation of chl-a and particulate backscattering. Cross shelf gradient due to wave driven resuspension (Fernanda Freitas): need to better include regional products as well as

Phytoplankton PFT:

HPLC and absorption



Inclusion of scattering

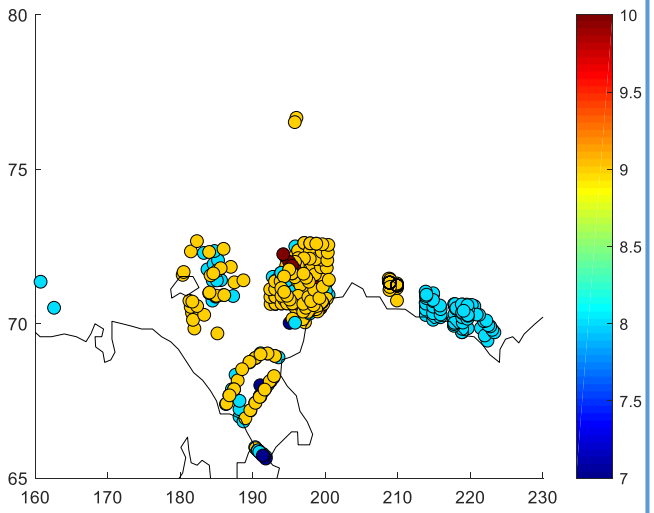


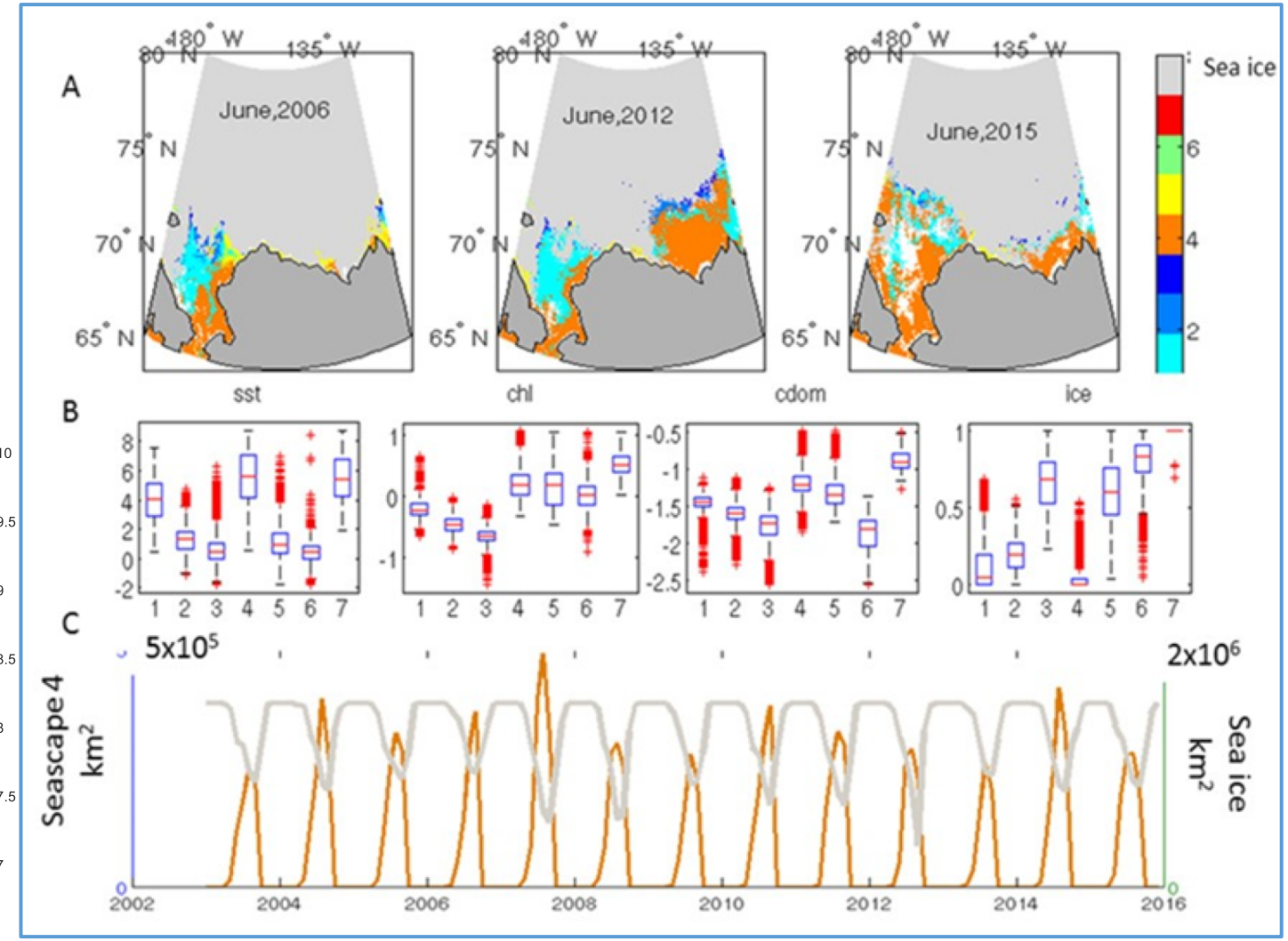
Regional downscaling: dynamic range and local products

Classifier is hierarchical

Karen Frey (Clark U): High resolution ice, local chl-a and CDOM

Multi-year zooplankton data set (Russ Hopcroft et al.)
>7000 samples,
~188 different taxa





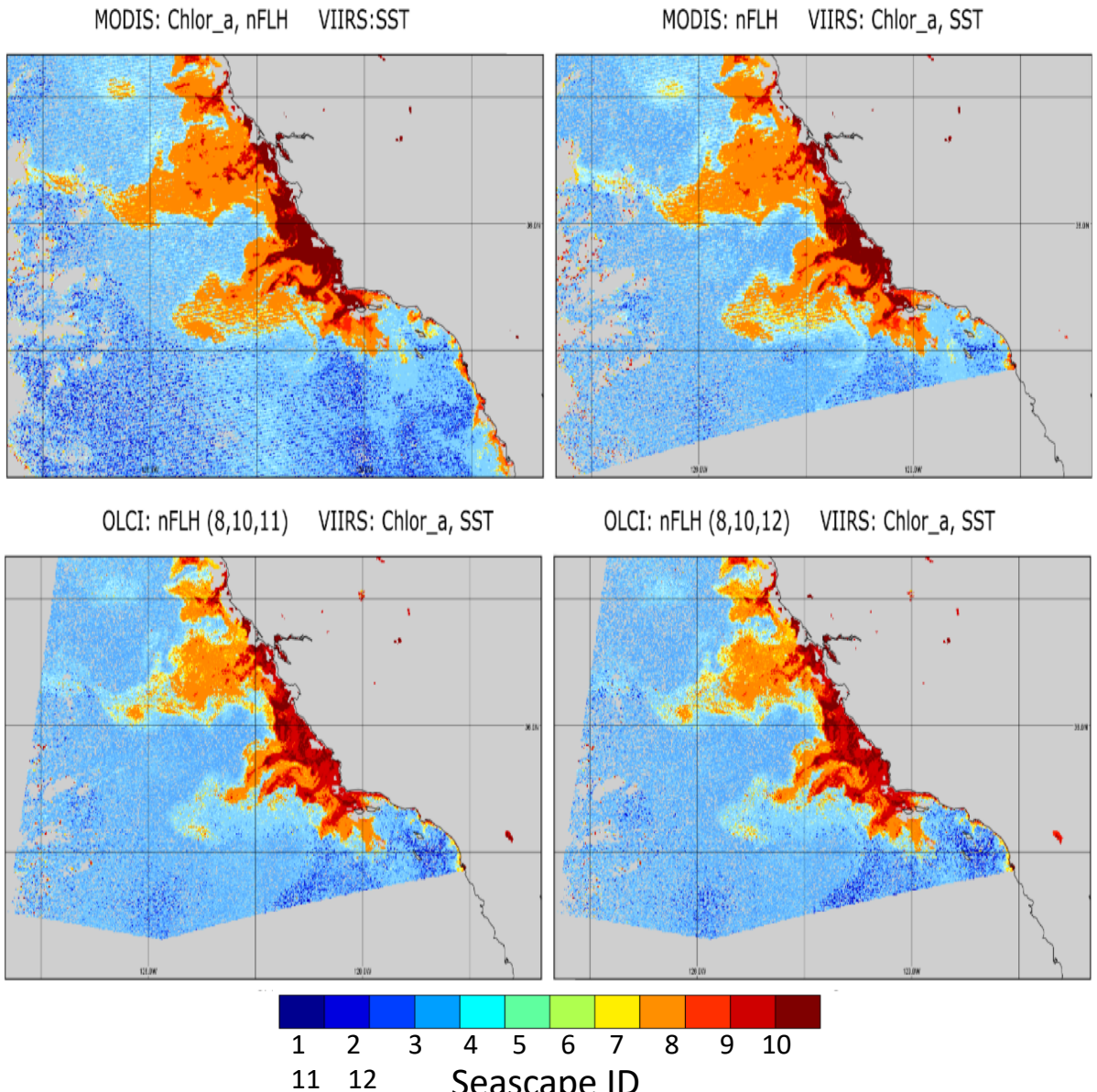
NOAA CoastWatch: toward operational

Pipeline for serving seascapes on CoastWatch nodes have been built based on early classifications

Uses classifier and near real time , high resolution input data and serves maps

Continuity:
Comparisons across MODIS and VIIRS have been excellent

Comparisons using Sentinal 3 (NFLH), are promising



Paul DiGiacomo, Michael Sarocco and Joaquin Trinanes

Dynamic seascapes: biogeographic framework for a global M(arine)-BON

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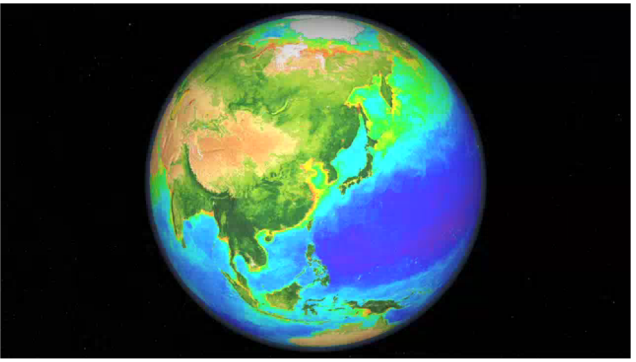
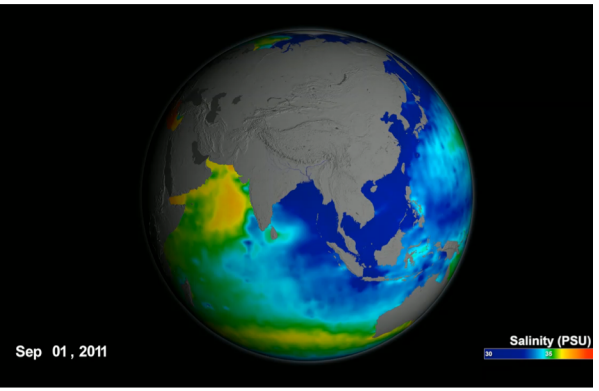
J. Grebmeier (U. MD), D. Otis, E. Montes, F. Muller Karger (USF),
D. Wright (ESRI), R. Sayre (USGS), G. Canonico (NOAA), V. Tsontos & J. Vasquez (NASA JPL)

Multiple NASA assets



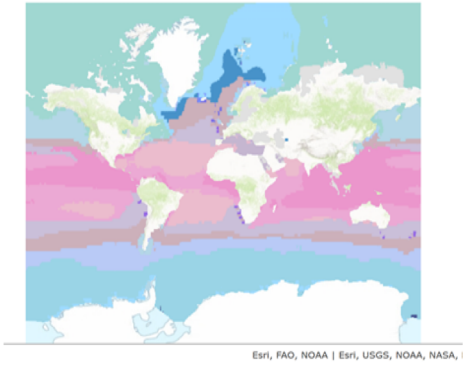
Biology: Ocean Color



Physics: e.g.
SSS, SST, winds, SSHa

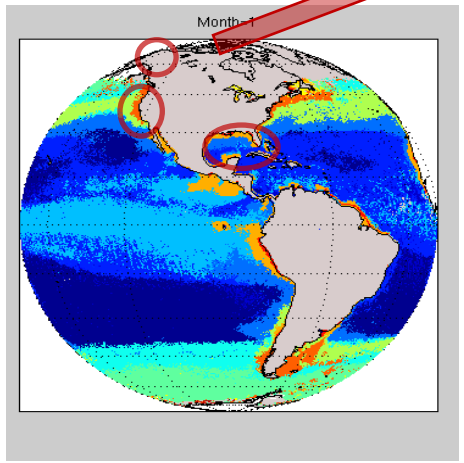
Global classification

Static+3D



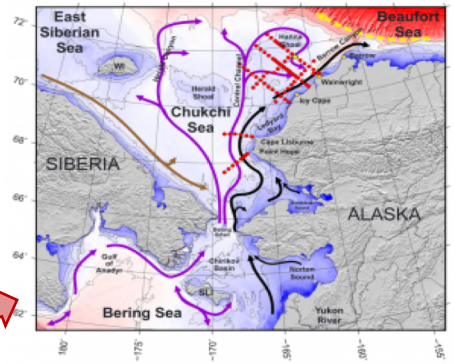
Ecological Marine Units

Dynamic+2D

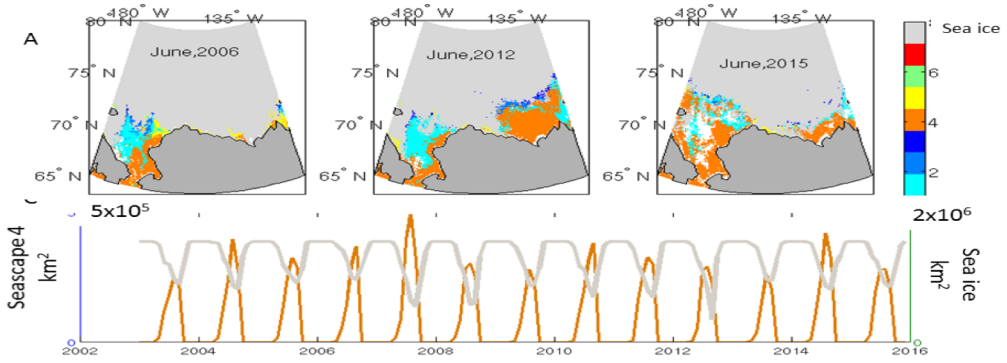


Dynamic Seascapes- see also E. Montes et al. Pole2Pole

Regional downscaling



Arctic MBON; Distributed Biological Observatory



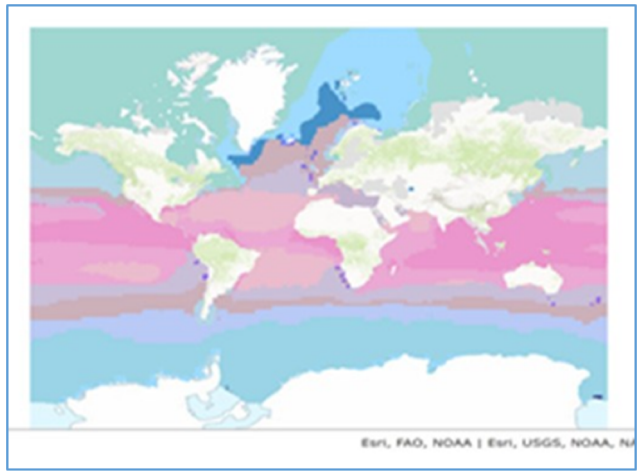
Dynamic habitat maps

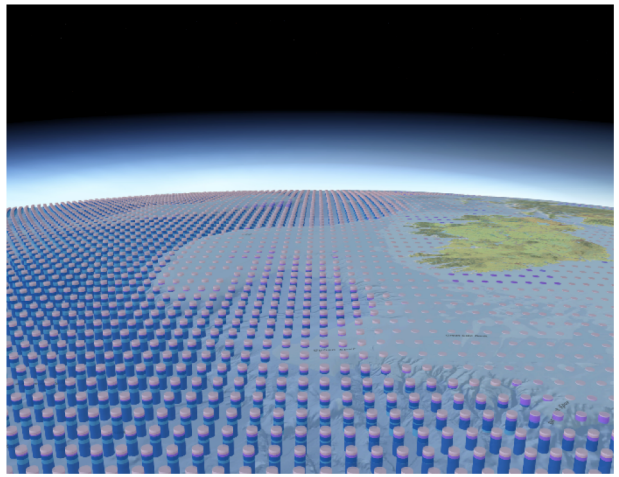
Objectives

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

EMU Seascape intercomparison

- Ecological Marine Units are a global 3-D static classification of ocean volumes using multi-year climatologies of physical and chemical data archived in the World Ocean Atlas (WOA). Intercomparisons with seascapes will highlight variability at depth not directly observed by satellites
- Conversely, dynamic seascapes will illuminate changes in habitat quality and extent not apparent from climatologies.





Satellite-derived Seascapes

Kavanaugh (OSU), Doney (UVa), Grebmeier (UMCES), Wright (ESRI), Otis, Montes, Djurhuus, Muller-Karger (USF)

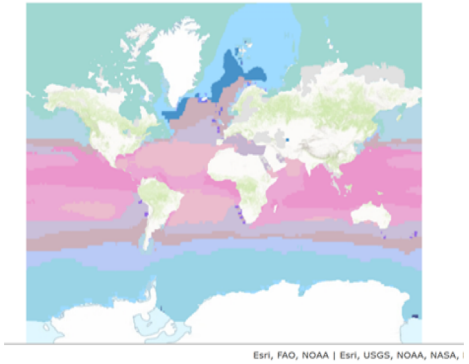
OSU Oregon State University
College of Earth, Ocean, and Atmospheric Sciences

Publications or Synergies (OSU portion only)

- **Kavanaugh, M.T.,** Church, M.E, Davis, C.O., Karl, D.M., Letelier, R.M. and S.C. Doney. ALOHA from the Edge: Reconciling three decades of in situ Eulerian observations and geographic variability in the North Pacific Subtropical Gyre. *Frontiers of Marine Science.*
- Bowman, J.S., **Kavanaugh, M.T.,** Doney, S.C. and H.W. Ducklow. Recurrent seascape units identify key ecological processes along the western Antarctic Peninsula. *Global Change Biology.*
- **Kavanaugh, M. T.**, Rheuban, J. E., Luis*, K. M. A., & Doney, S. C. 2017. Thirty-three years of ocean benthic warming along the U.S. Northeast Continental Shelf and Slope: Patterns, drivers, and ecological consequences. Journal of Geophysical Research: Oceans, 122. https://doi.org/10.1002/2017JC012953
- Rheuban, J. E., **Kavanaugh, M. T.**, & Doney, S. C. 2017.Implications of future northwest Atlantic bottom temperatures on the American Lobster (Homarus americanus) fishery. Journal of Geophysical Research: Oceans, 122. https://doi.org/10.1002/2017JC012949
- *NASA A.50 : Satellite seascapes to support a biogeographic framework for a Global Marine Biodiversity Observing Network. Pis Kavanaugh, Grebmeier, Muller-Karger, Wright*
- *Presentations at American Fisheries Society, Ocean Sciences Meeting, NASA GEOBON Kickoff, GEO-MBON, and several NOAA Webinars*

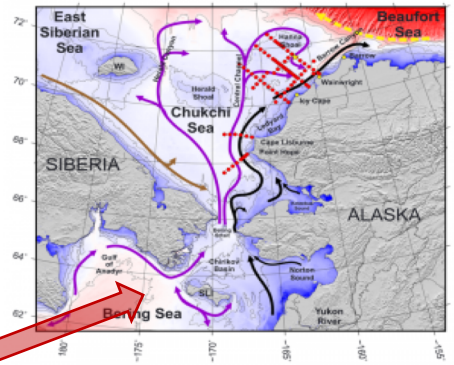
Static+3D

Global classification



Ecological Marine Units

Regional downscaling

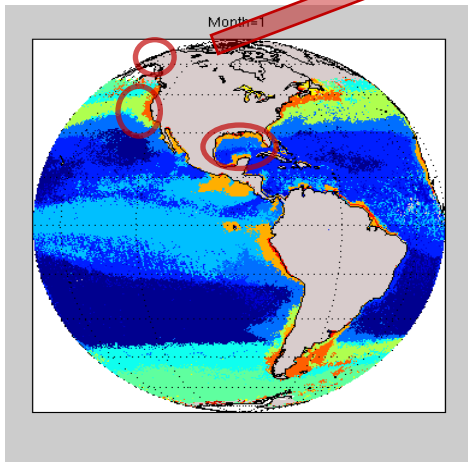


Arctic MBON; Distributed Biological Observatory

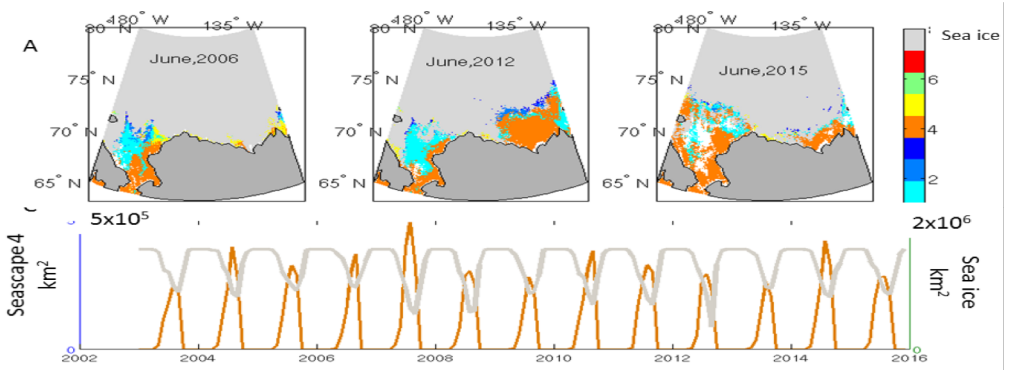
Ongoing efforts

- **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