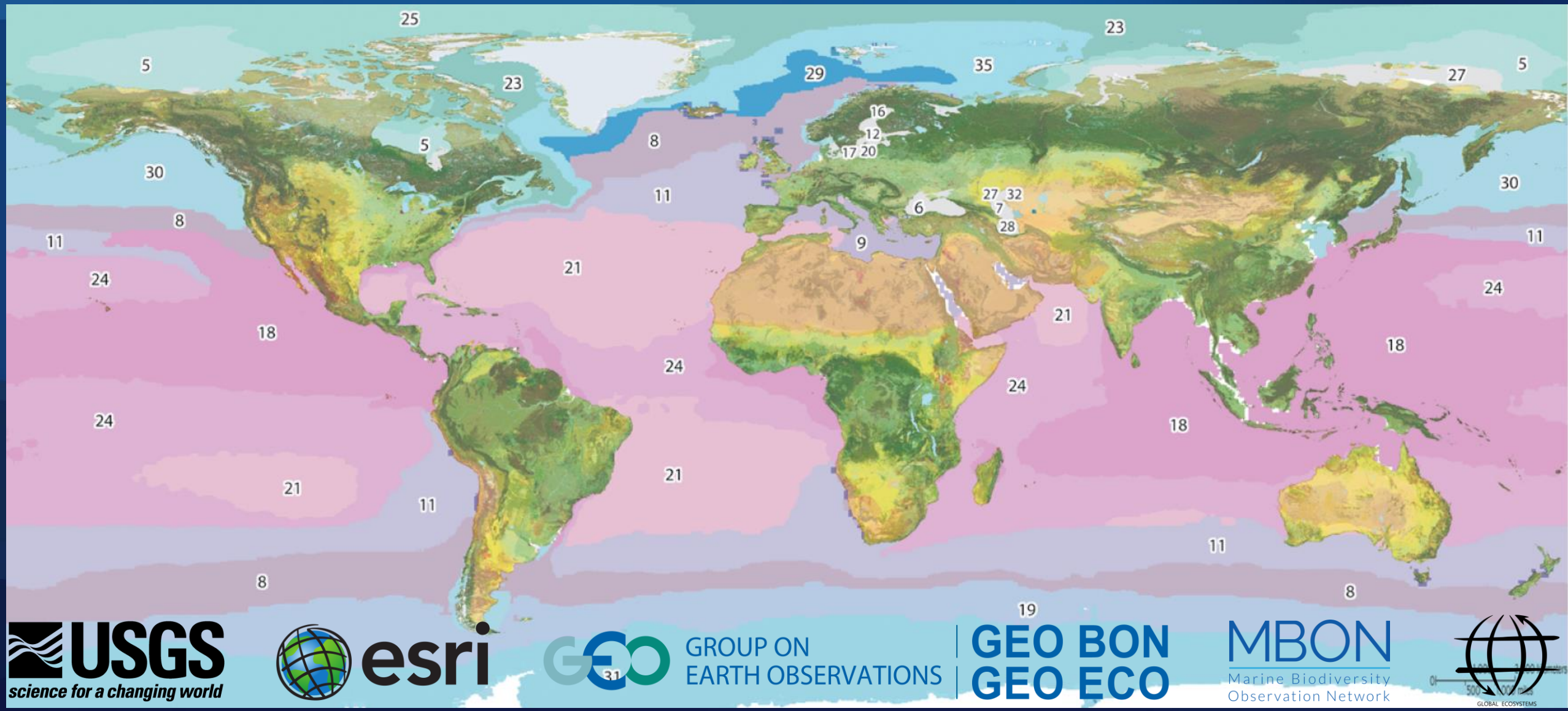
A NEW MAP OF GLOBAL ECOLOGICAL MARINE UNITS (EMUs)

ROGER SAYRE, U. S. GEOLOGICAL SURVEY

1 JUN 2017 BLUE PLANET SYMPOSIUM



USGS science for a changing world

esri

GEO 31 GROUP ON EARTH OBSERVATIONS

GEO BON | GEO ECO

MBON Marine Biodiversity Observation Network

GLOBAL ECOSYSTEMS

The GEO Global Ecosystem Mapping Initiative

GEOSS Task GI-14 GEO ECO: Global Ecosystem Mapping

- Develop a standardized, robust, and practical global ecosystems classification and map for the planet's *terrestrial, freshwater,* and *marine* ecosystems.
- USA – Responsible Member; USGS – Responsible Federal Agency; Dr. Roger Sayre - Task Lead.
- Esri is a partner, engaged in producing and hosting the content. Esri leads are Dawn Wright and Sean Breyer.

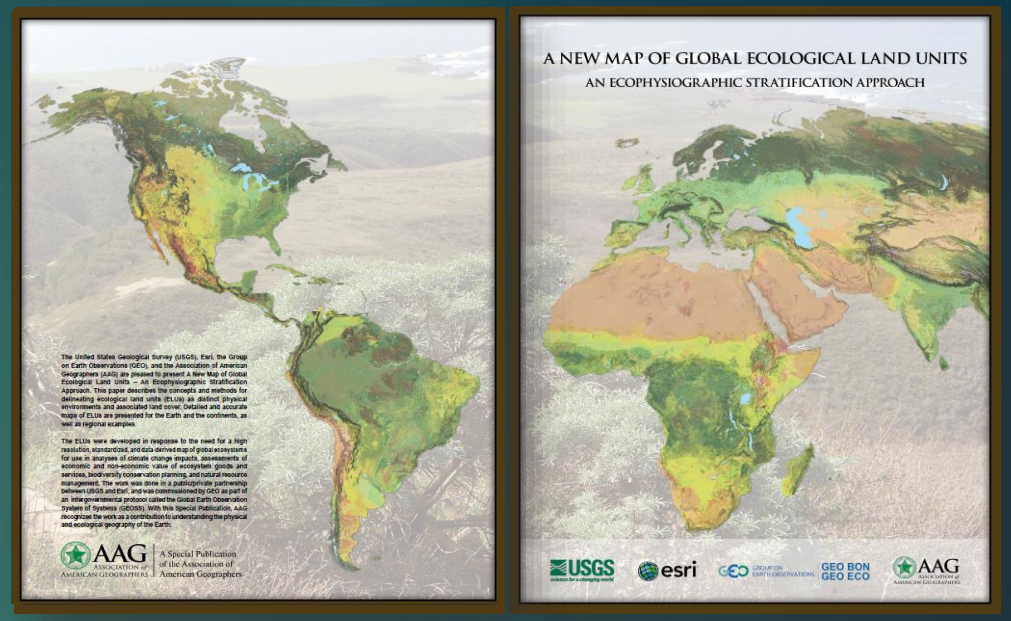
Global Ecological Land Units (ELUs)

Globally comprehensive

~4000 ELUs

Climate/Landform/Geology/Vegetation

250 m spatial resolution



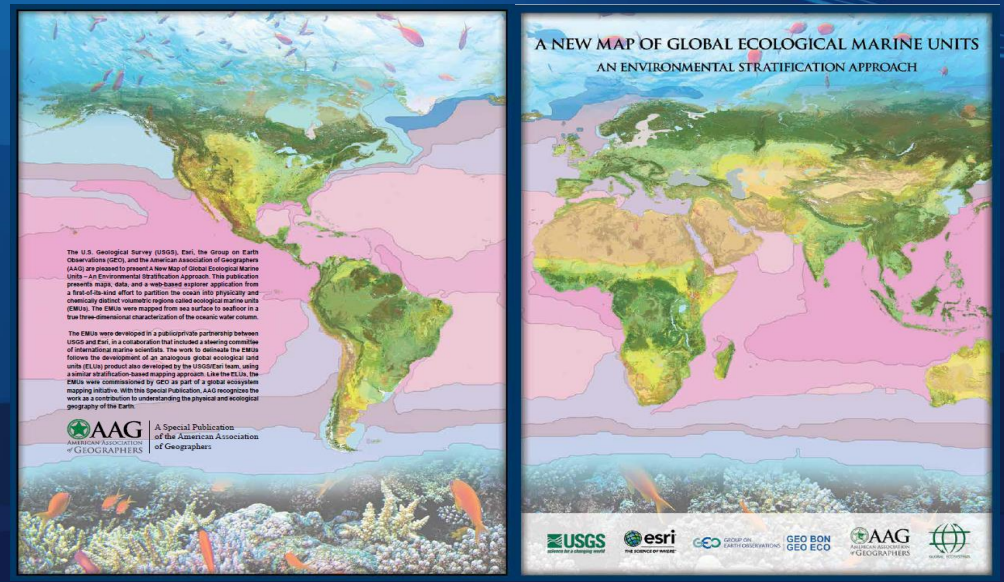
Global Ecological Marine Units (EMUs)

Globally comprehensive and true 3D

37 EMUs

Temperature/Salinity/Oxygen/Nitrate/Phosphate/Silicate

27 km m spatial resolution



A Three-Dimensional Mapping of the Ocean Based on Environmental Data

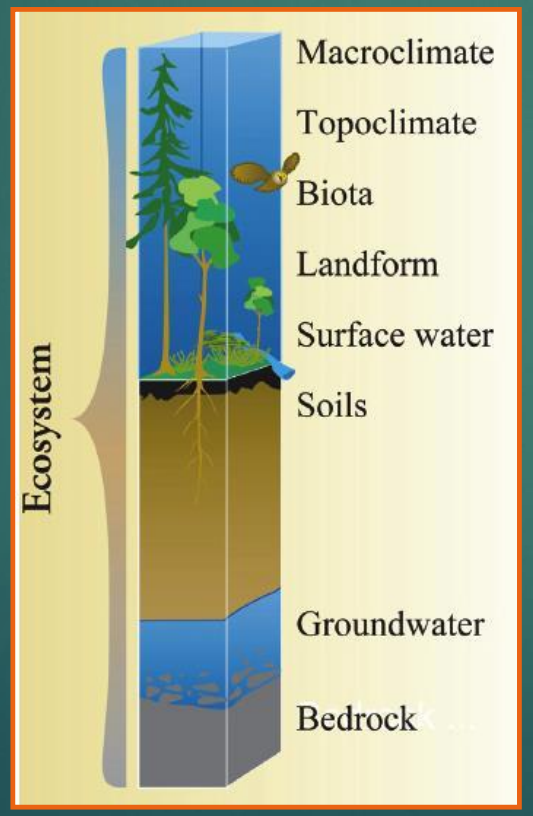
By Roger G. Sayre, Dawn J. Wright, Sean P. Breyer, Kevin A. Butler, Keith Van Graafeiland, Mark J. Costello, Peter T. Harris, Kathleen L. Goodin, John M. Guinotte, Zeenatul Basher, Maria T. Kavanaugh, Patrick N. Halpin, Mark E. Monaco, Noel Cressie, Peter Aniello, Charles E. Frye, and Drew Stephens

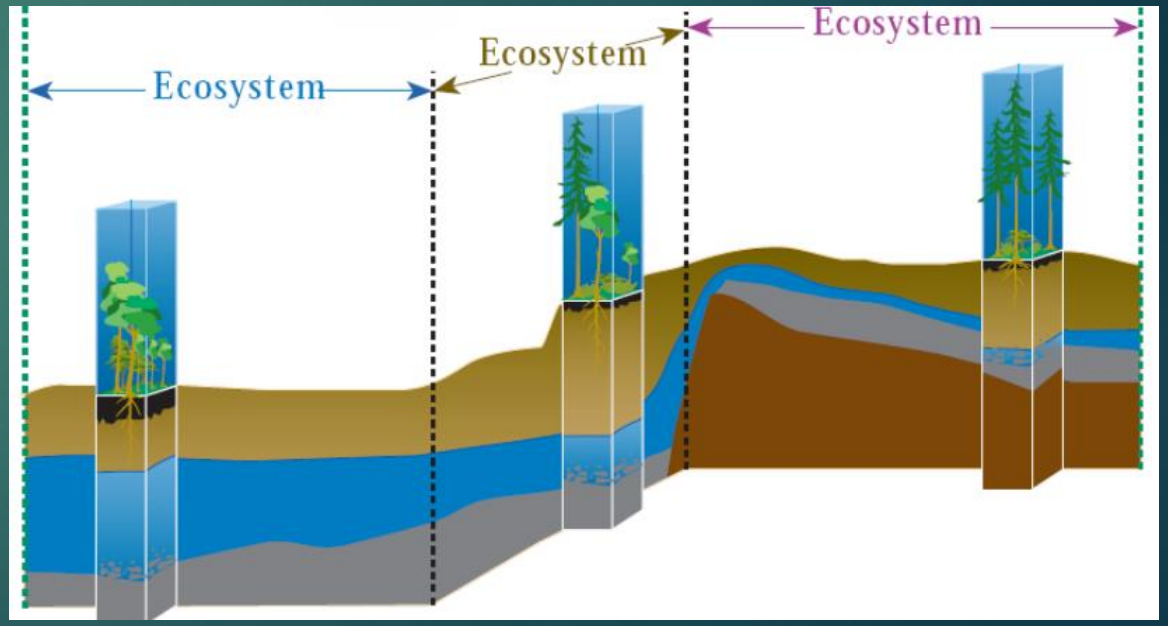
THE OFFICIAL MAGAZINE OF THE OCEANOGRAPHY SOCIETY

Oceanography

What Are Ecosystems?

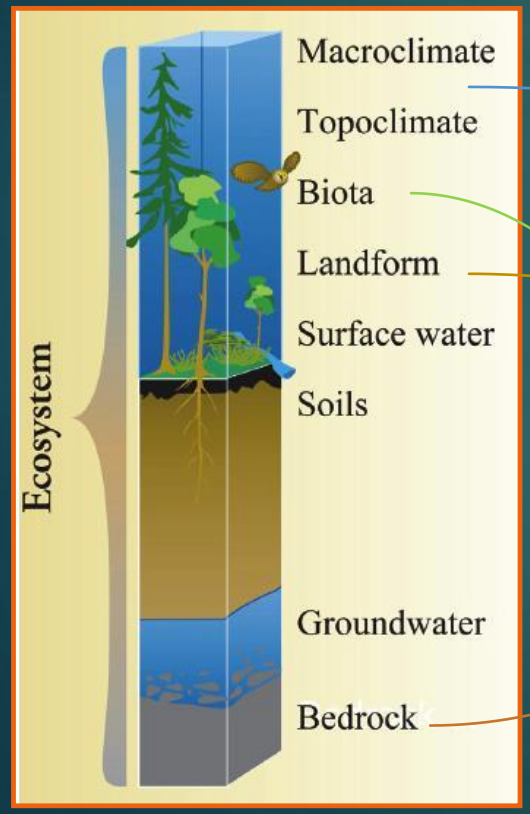
Odum (1953): Systems of biotic communities interacting with their environment.

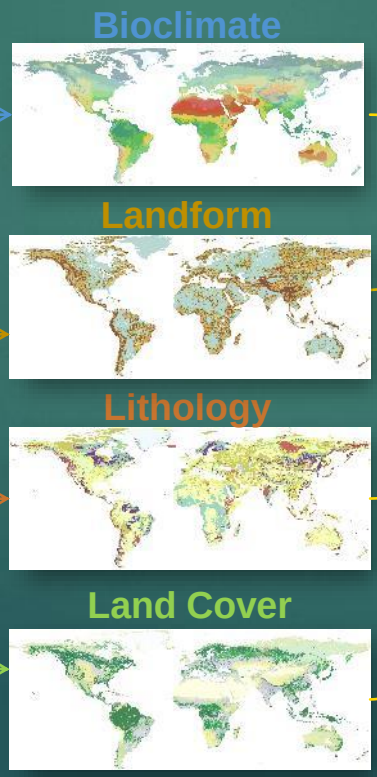




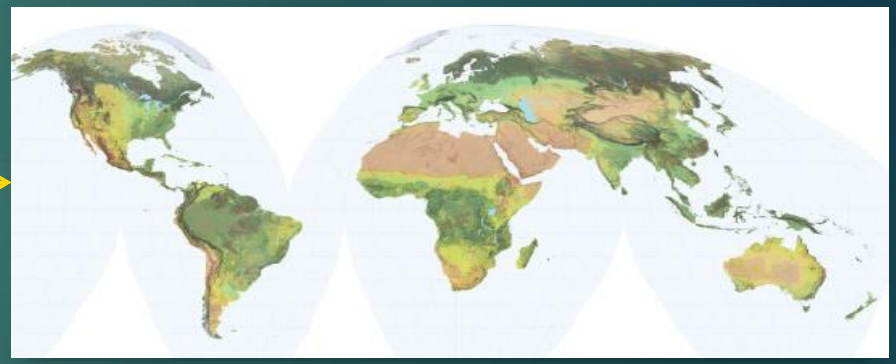
How Can Global Terrestrial Ecosystems Be Mapped in a Standardized, Robust, and Practical Manner?

The Ecophysiographic Stratification Approach



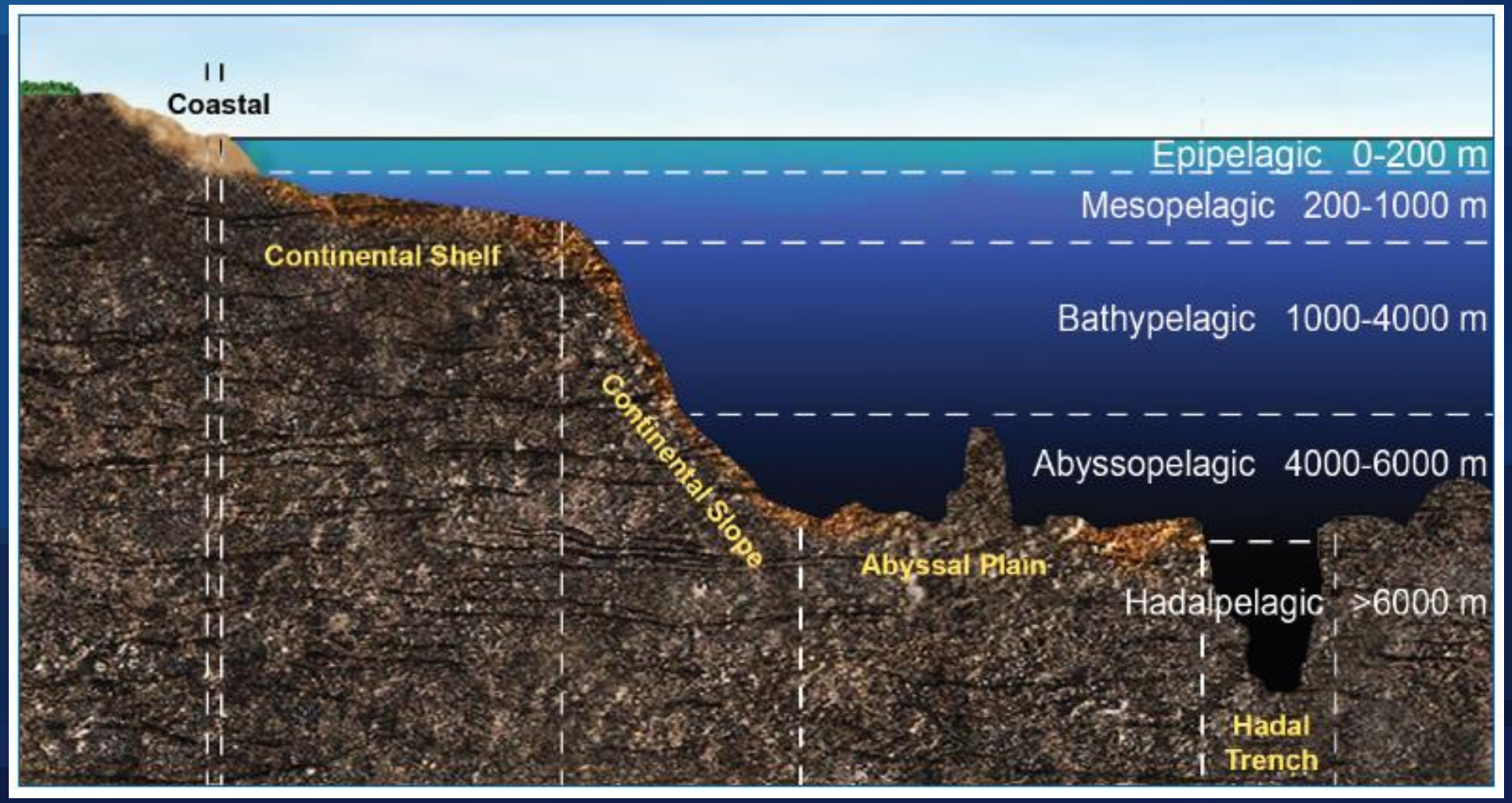


Example: Warm Wet Plains on Metamorphic Rock with Mostly Deciduous Forest



3,639 Ecological Land Unit Classes

What Do We Know About The Ocean?

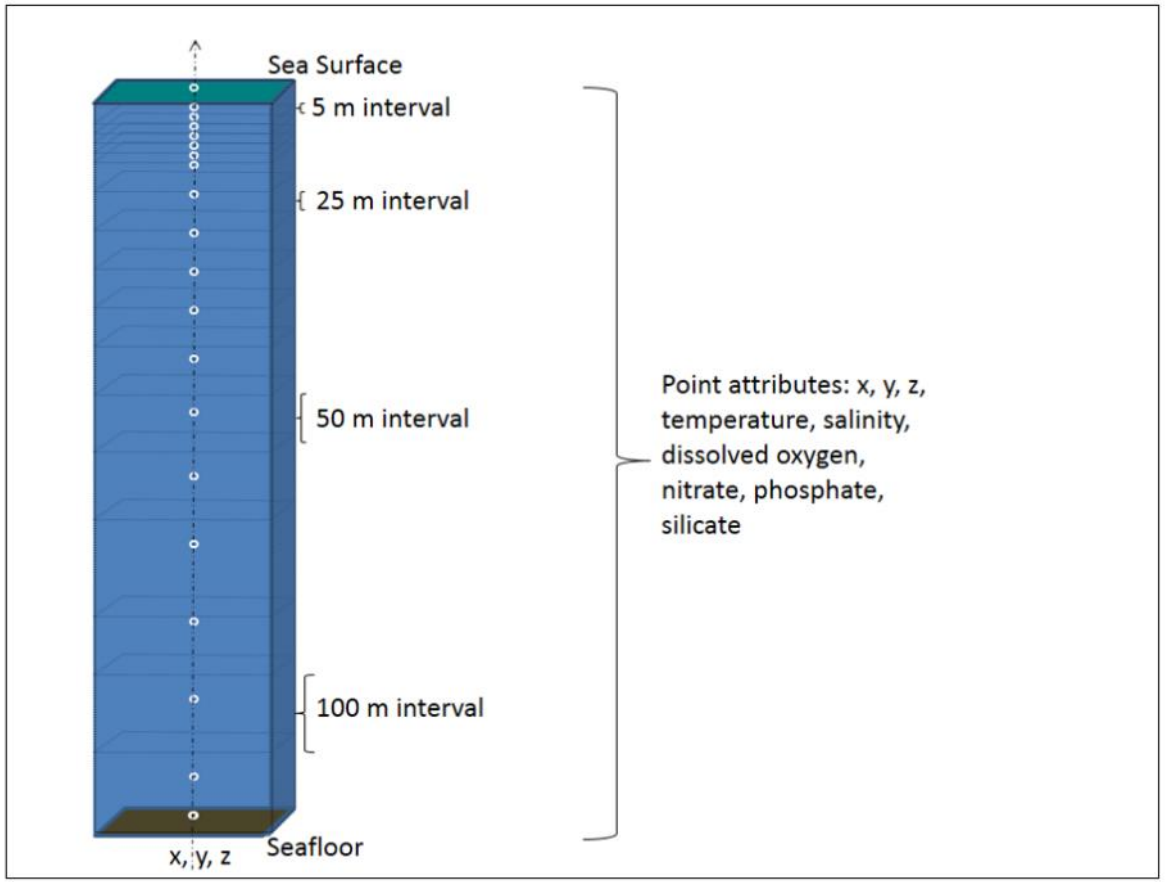


Global Ecological Marine Units (EMUs) - Physically and Chemically Distinct Volumetric Regions

Globally comprehensive ✓

Top-to-bottom true 3D ✓

Objectively derived from data ✓

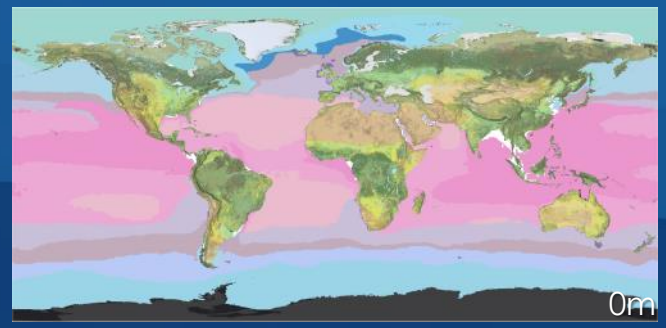


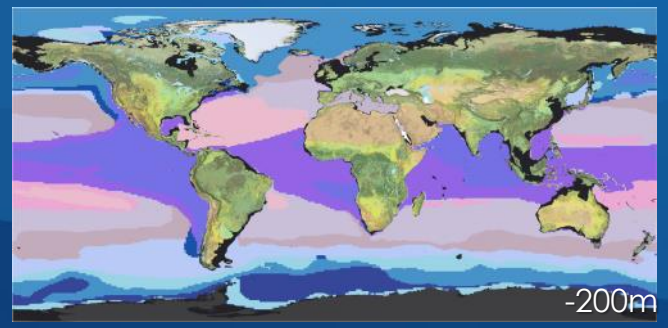
52 million points from NOAA's World Ocean Atlas (WOA 2013) database
k-means statistical clustering in 3D

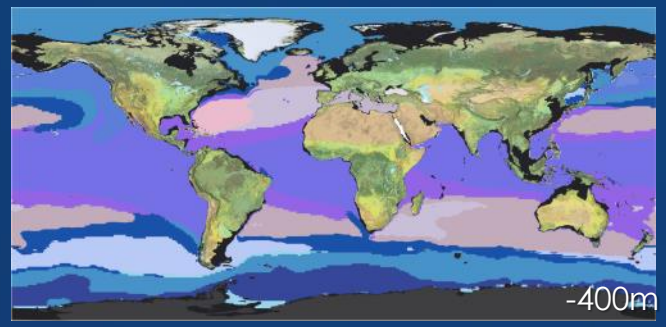
Temperature
Salinity
Dissolved Oxygen

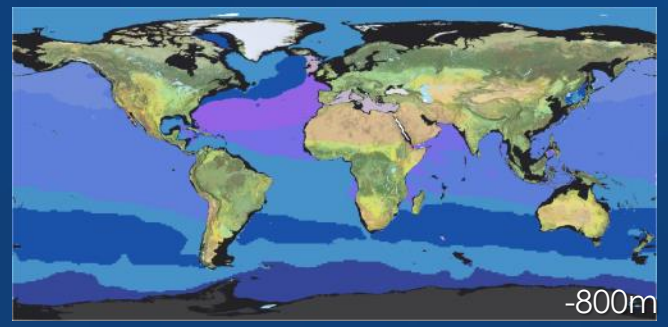
Nitrate
Phosphate
Silicate

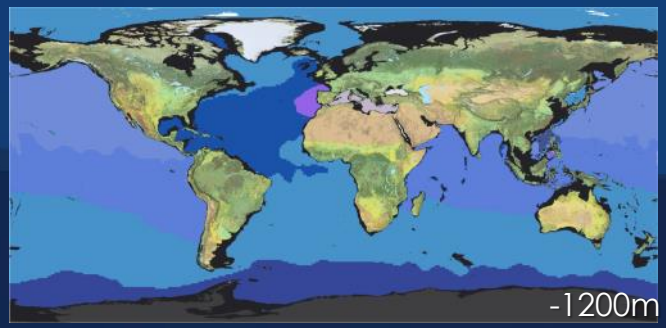
Global Ecological Marine Units (EMUs)

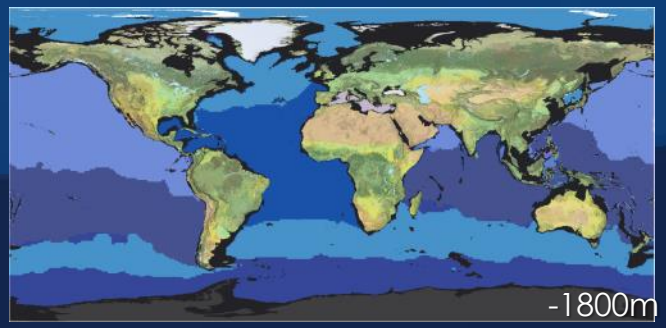


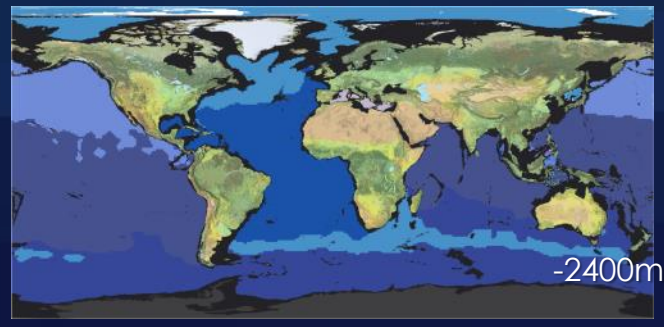


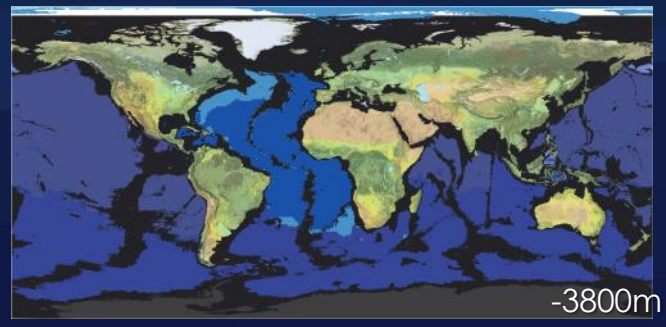


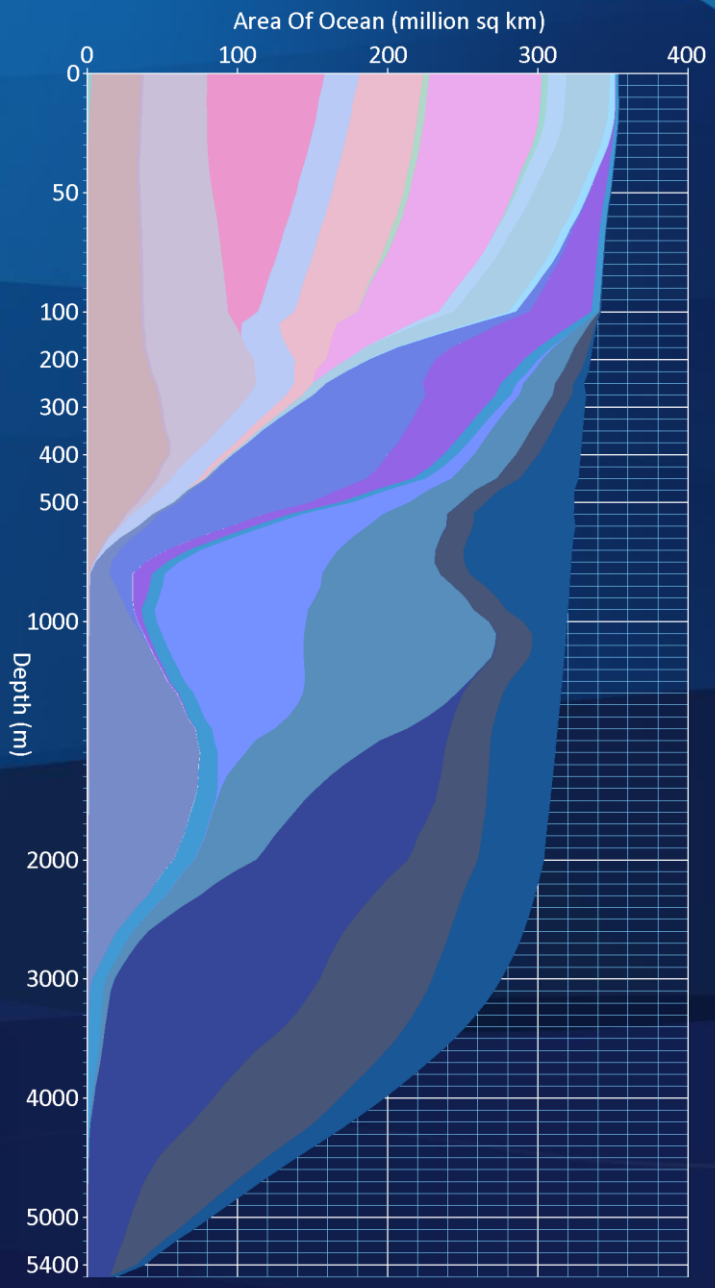




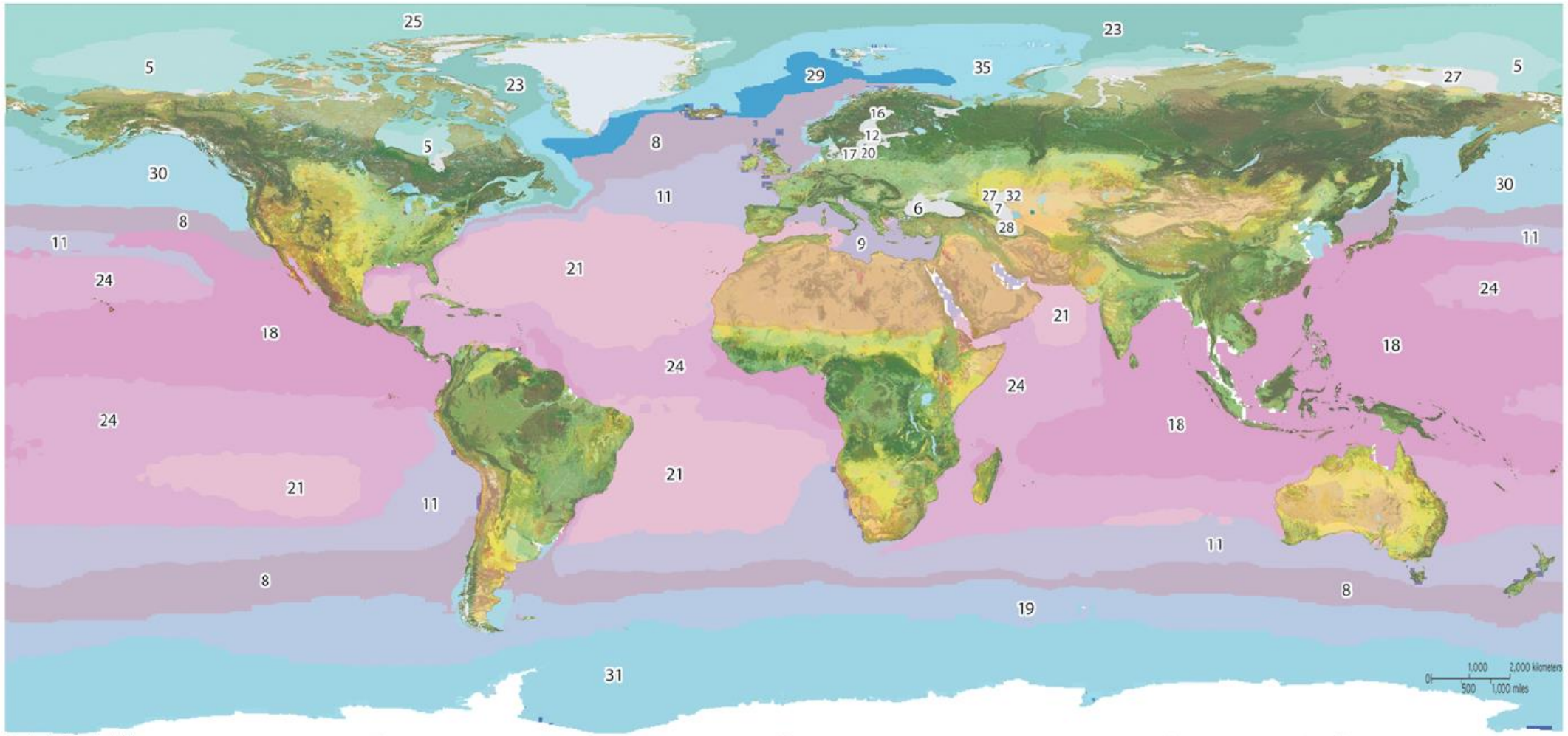








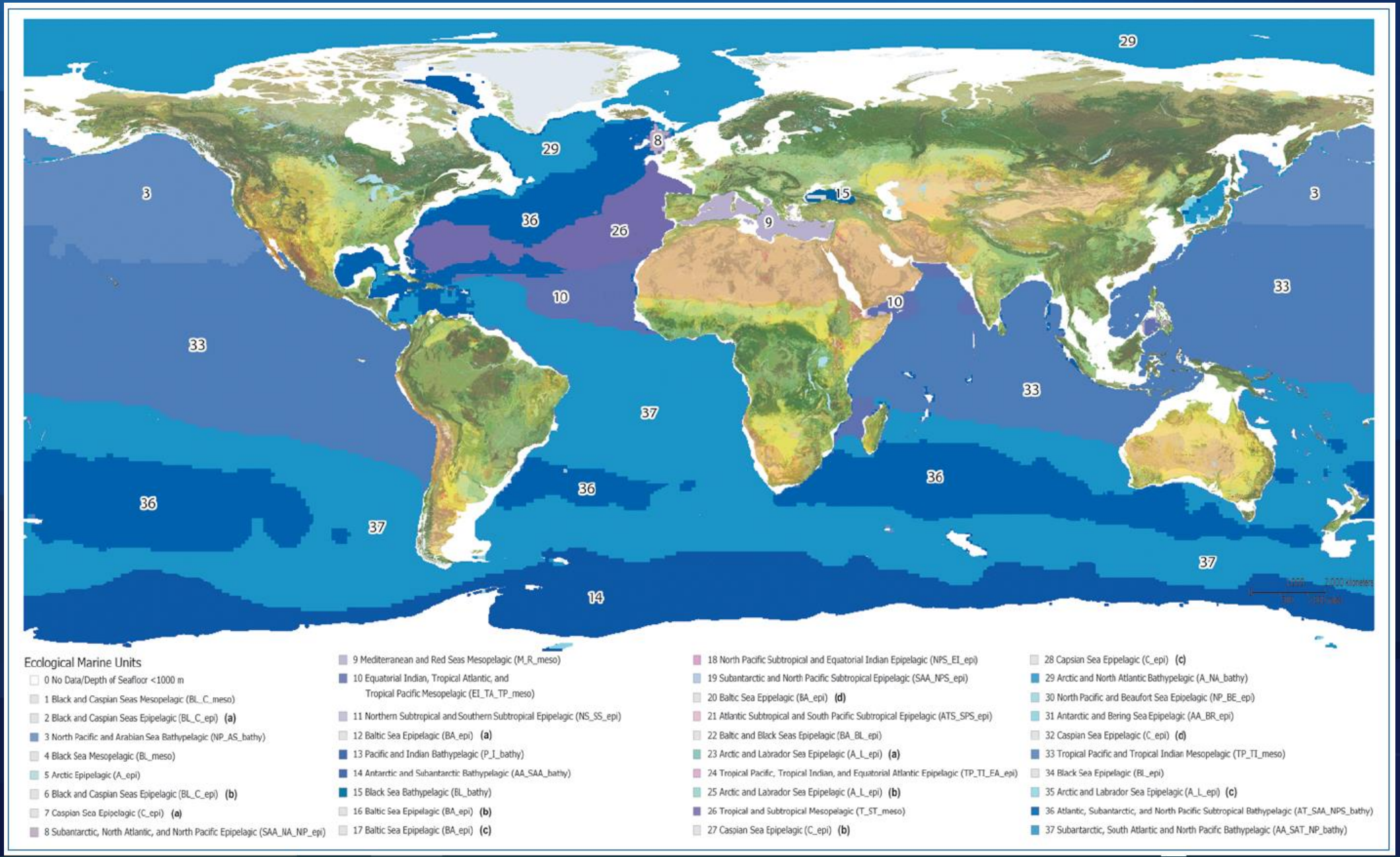
Surface-occurring EMUs



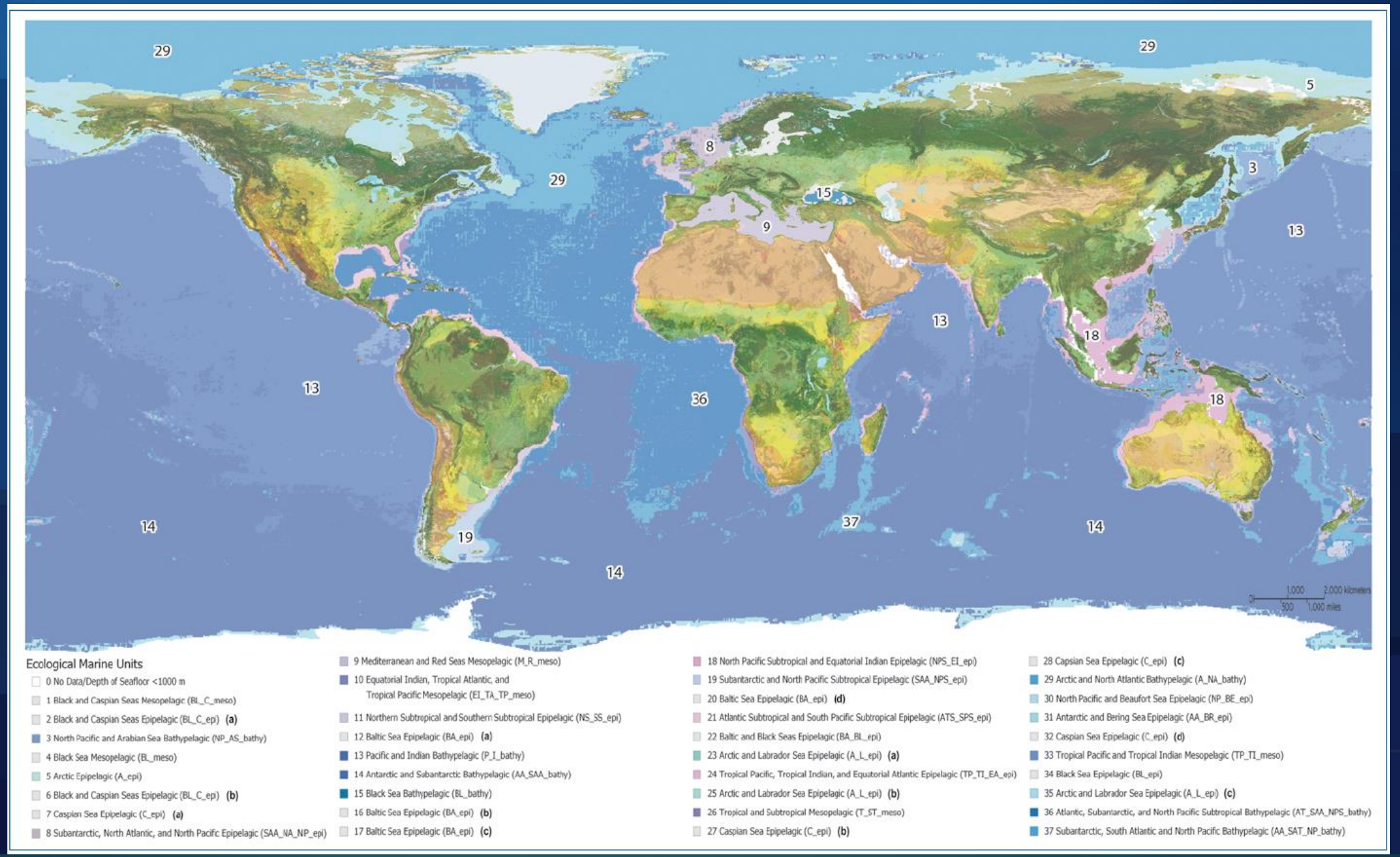
Ecological Marine Units

- 0 No Data
- 1 Black and Caspian Seas Mesopelagic (BL_C_meso)
- 2 Black and Caspian Seas Epipelagic (BL_C_epi) **(a)**
- 3 North Pacific and Arabian Sea Bathypelagic (NP_AS_bathy)
- 4 Black Sea Mesopelagic (BL_meso)
- 5 Arctic Epipelagic (A_epi)
- 6 Black and Caspian Seas Epipelagic (BL_C_epi) **(b)**
- 7 Caspian Sea Epipelagic (C_epi) **(a)**
- 8 Subantarctic, North Atlantic, and North Pacific Epipelagic (SAA_NA_NP_epi)
- 9 Mediterranean and Red Seas Mesopelagic (M_R_meso)
- 10 Equatorial Indian, Tropical Atlantic, and Tropical Pacific Mesopelagic (EI_TA_TP_meso)
- 11 Northern Subtropical and Southern Subtropical Epipelagic (NS_SS_epi)
- 12 Baltic Sea Epipelagic (BA_epi) **(a)**
- 13 Pacific and Indian Bathypelagic (P_I_bathy)
- 14 Antarctic and Subantarctic Bathypelagic (AA_SAA_bathy)
- 15 Black Sea Bathypelagic (BL_bathy)
- 16 Baltic Sea Epipelagic (BA_epi) **(b)**
- 17 Baltic Sea Epipelagic (BA_epi) **(c)**
- 18 North Pacific Subtropical and Equatorial Indian Epipelagic (NPS_EI_epi)
- 19 Subantarctic and North Pacific Subtropical Epipelagic (SAA_NPS_epi)
- 20 Baltic Sea Epipelagic (BA_epi) **(d)**
- 21 Atlantic Subtropical and South Pacific Subtropical Epipelagic (ATS_SPS_epi)
- 22 Baltic and Black Seas Epipelagic (BA_BL_epi)
- 23 Arctic and Labrador Sea Epipelagic (A_L_epi) **(a)**
- 24 Tropical Pacific, Tropical Indian, and Equatorial Atlantic Epipelagic (TP_TI_EA_epi)
- 25 Arctic and Labrador Sea Epipelagic (A_L_epi) **(b)**
- 26 Tropical and Subtropical Mesopelagic (T_ST_meso)
- 27 Caspian Sea Epipelagic (C_epi) **(b)**
- 28 Capsian Sea Epipelagic (C_epi) **(c)**
- 29 Arctic and North Atlantic Bathypelagic (A_NA_bathy)
- 30 North Pacific and Beaufort Sea Epipelagic (NP_BE_epi)
- 31 Antarctic and Bering Sea Epipelagic (AA_BR_epi)
- 32 Caspian Sea Epipelagic (C_epi) **(d)**
- 33 Tropical Pacific and Tropical Indian Mesopelagic (TP_TI_meso)
- 34 Black Sea Epipelagic (BL_epi)
- 35 Arctic and Labrador Sea Epipelagic (A_L_epi) **(c)**
- 36 Atlantic, Subantarctic, and North Pacific Subtropical Bathypelagic (AT_SAA_NPS_bathy)
- 37 Subantarctic, South Atlantic and North Pacific Bathypelagic (AA_SAT_NP_bathy)

EMUs at 1000 m Depth



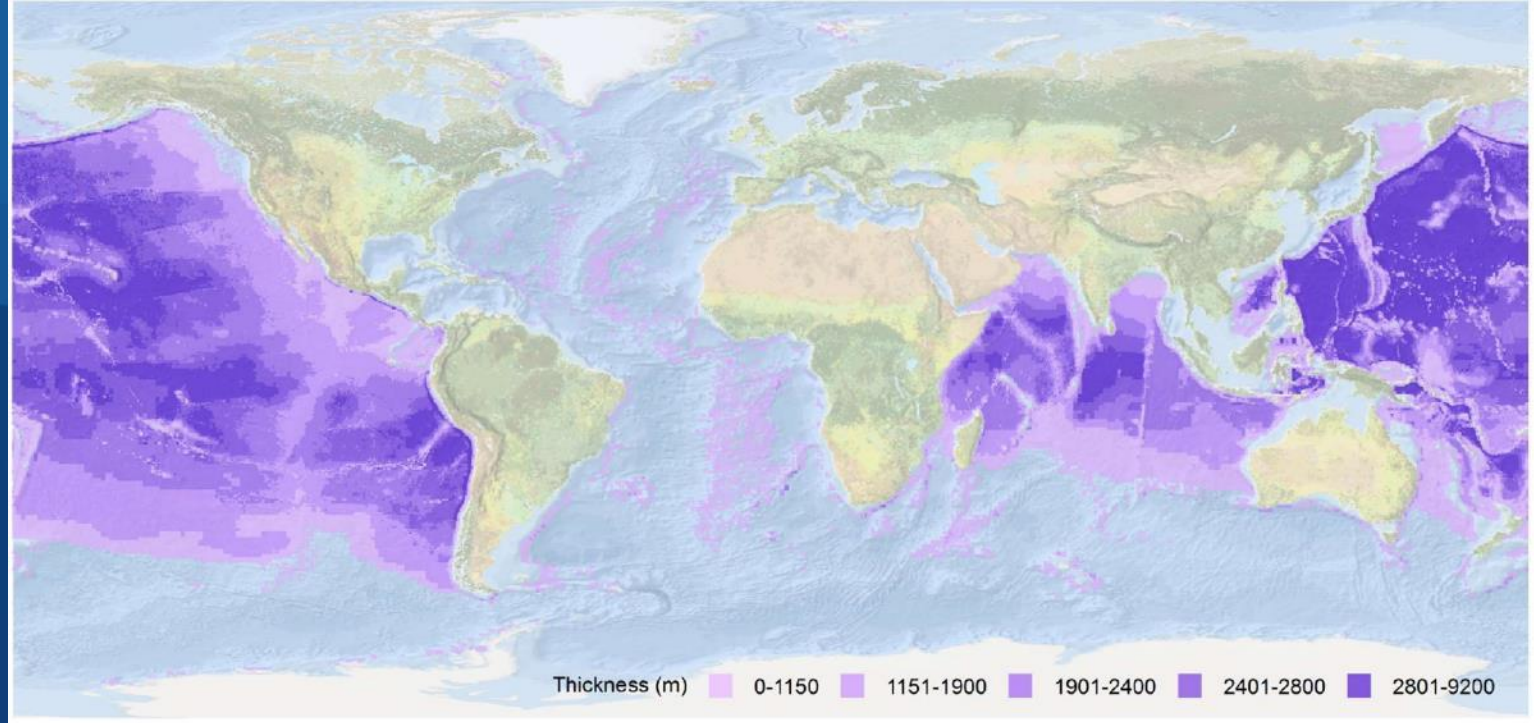
Bottom-occurring EMUs



EMU 13 Summary

Technical Name:
- Bathypelagic
- Very Cold
- Euhaline
- Hypoxic
- High Nitrate
- Medium Phosphate
- High Silicate

Common Name:
- Deep
- Very Cold
- Normal Salinity
- Low Oxygen
- High Nitrate
- Medium Phosphate
- High Silicate



EMU 13 Summary Statistics

	Minimum	Mean	Maximum	Standard Dev.
Temperature (°C)	-0.38	1.93	5.54	0.51
Salinity (unitless)	33.43	34.67	34.93	0.05
Dissolved Oxygen (µmol/l)	1.69	3.26	4.33	0.43
Nitrate (µmol/l)	25.26	37.03	48.49	1.08
Phosphate (µmol/l)	0.53	2.60	3.36	0.12
Silicate (µmol/l)	88.01	138.03	189.63	19.05
Thickness (m)	0.00	90.34	5323.00	36.76
Unit Top Depth (m)	-5500.00	-2955.62	-10.00	998.83

EMU Volume (km^3)	347060603.65
Percent of EMU to Global	25.40%

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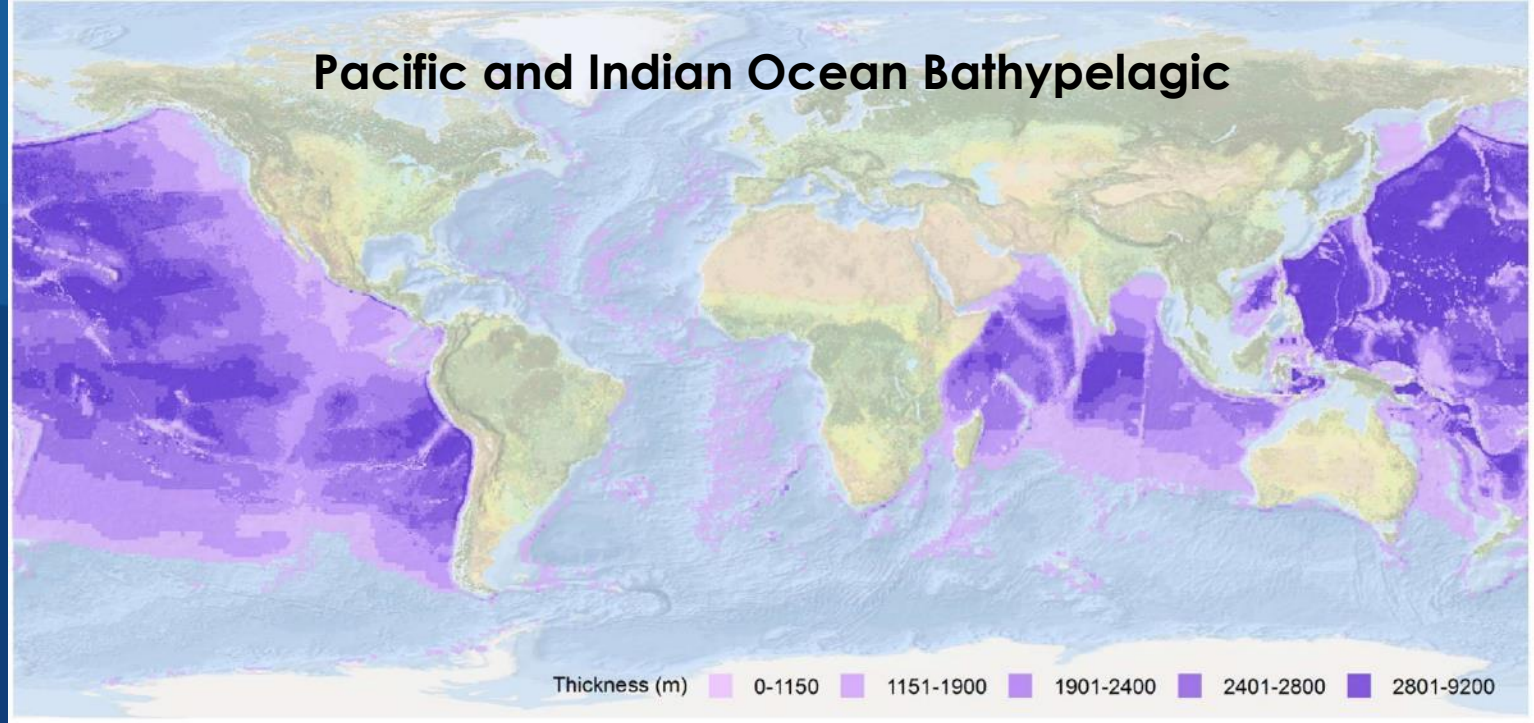

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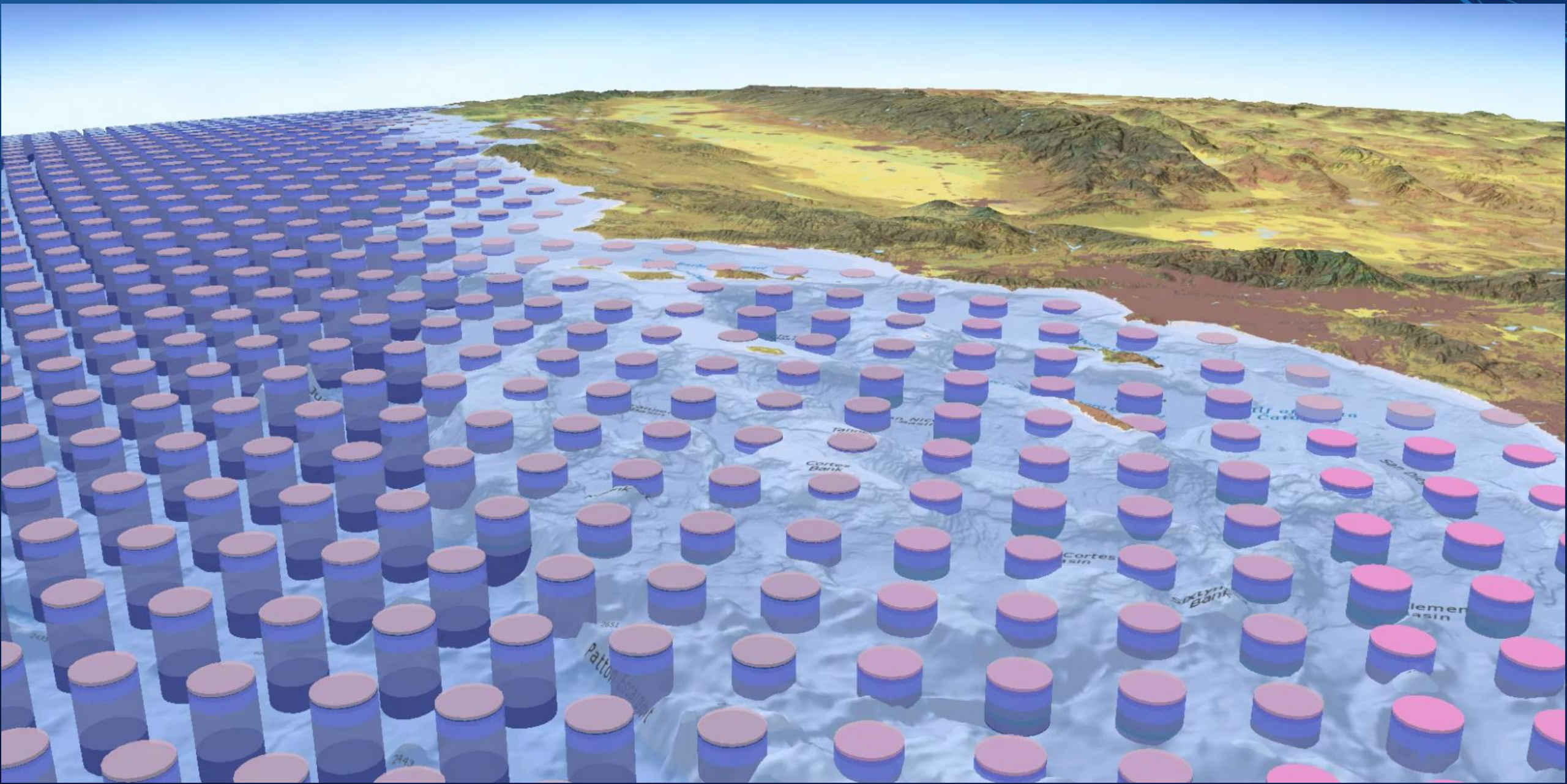
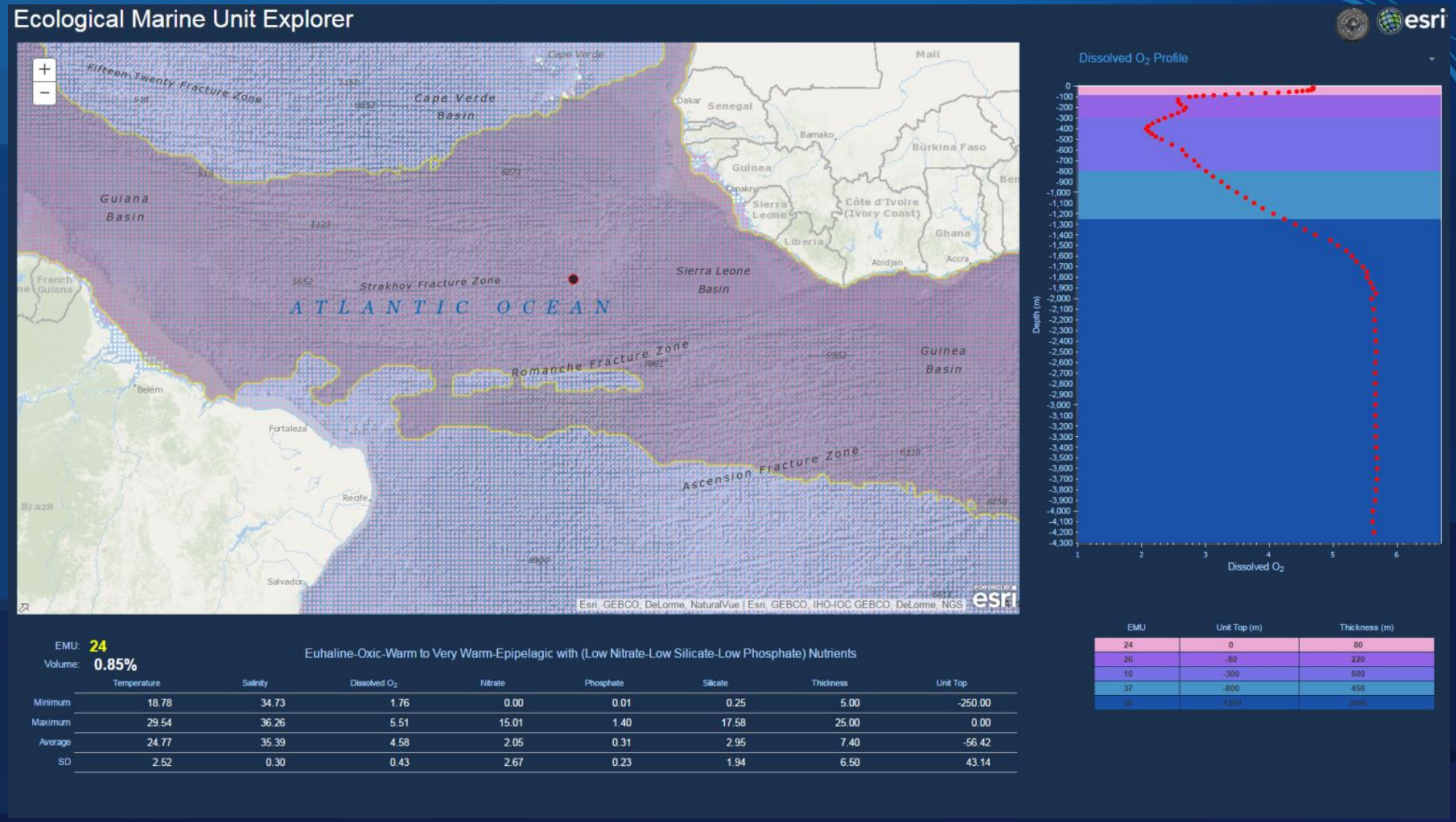
Visualizing ELUs and EMUs



Vertical Profile App

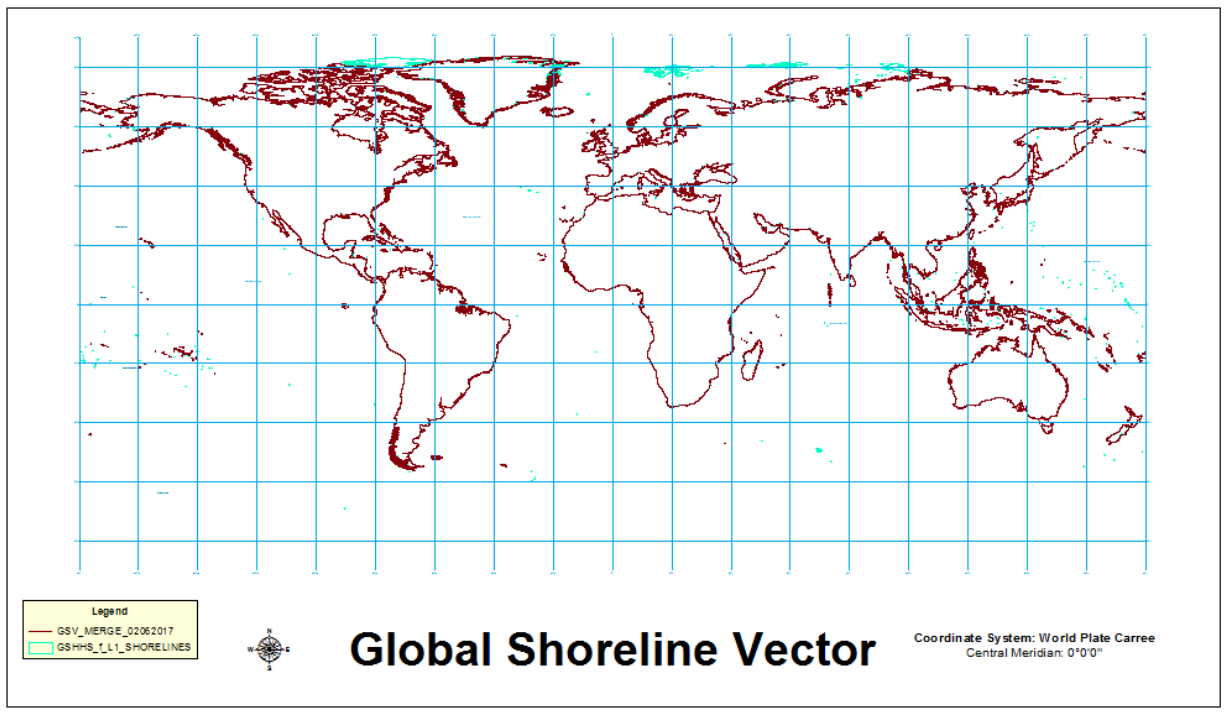


	Temperature	Salinity	Dissolved O_2	Nitrate	Phosphate	Silicate	Thickness	Unit Top
Minimum	18.78	34.73	1.76	0.00	0.01	0.25	5.00	-250.00
Maximum	29.54	36.26	5.51	15.01	1.40	17.58	25.00	0.00
Average	24.77	35.39	4.58	2.05	0.31	2.95	7.40	-56.42
SD	2.52	0.30	0.43	2.67	0.23	1.94	6.50	43.14

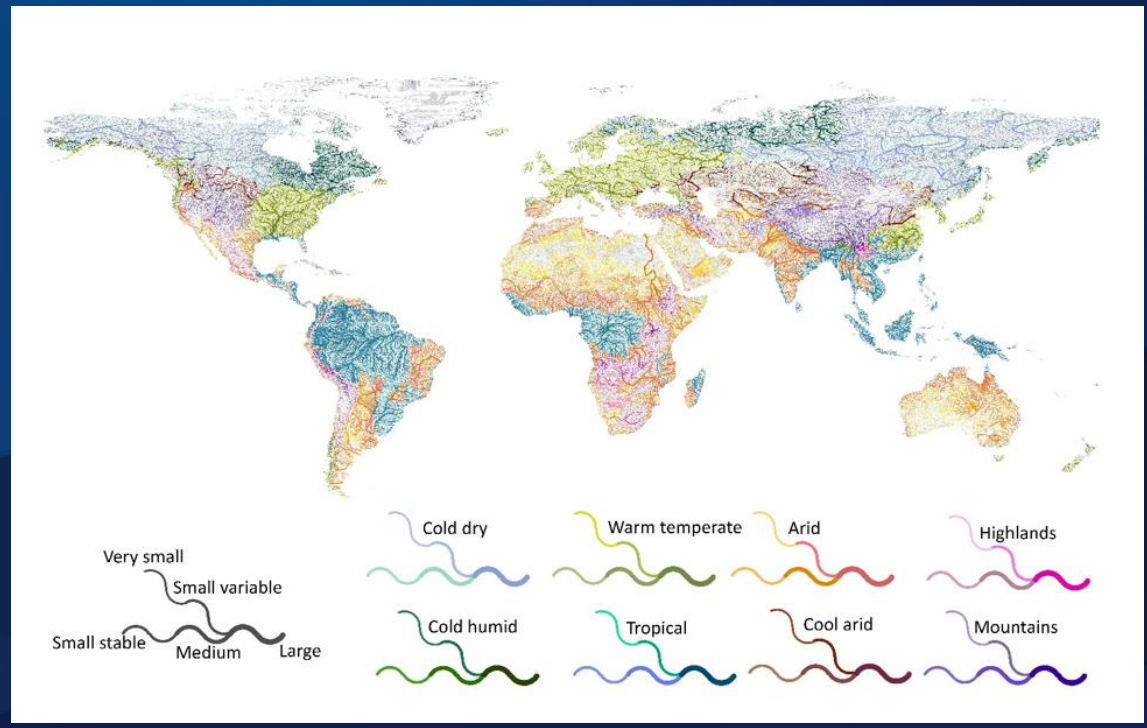
livingatlas.arcgis.com/emu

Next Set of Global Ecosystem Maps: ECUs and EFUs

Ecological Coastal Units (ECUs)



Ecological Freshwater Units (EFUs)



Data

www.esri.com/ecological-marine-units

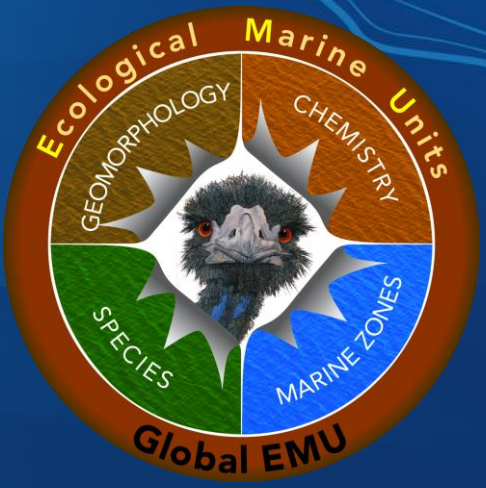
Pubs

Sayre et al., 2017, *Oceanography*, 30(1): 90-103.

AAG Booklet: http://www.aag.org/cs/global_marine_ecosystems

Exposure

Nature News feature, 3 January 2017



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