Ocean Sciences Meeting 2022 | Virtual Plenary, March 1

Our Ocean, Our Future

Dawn J. Wright, Ph.D.

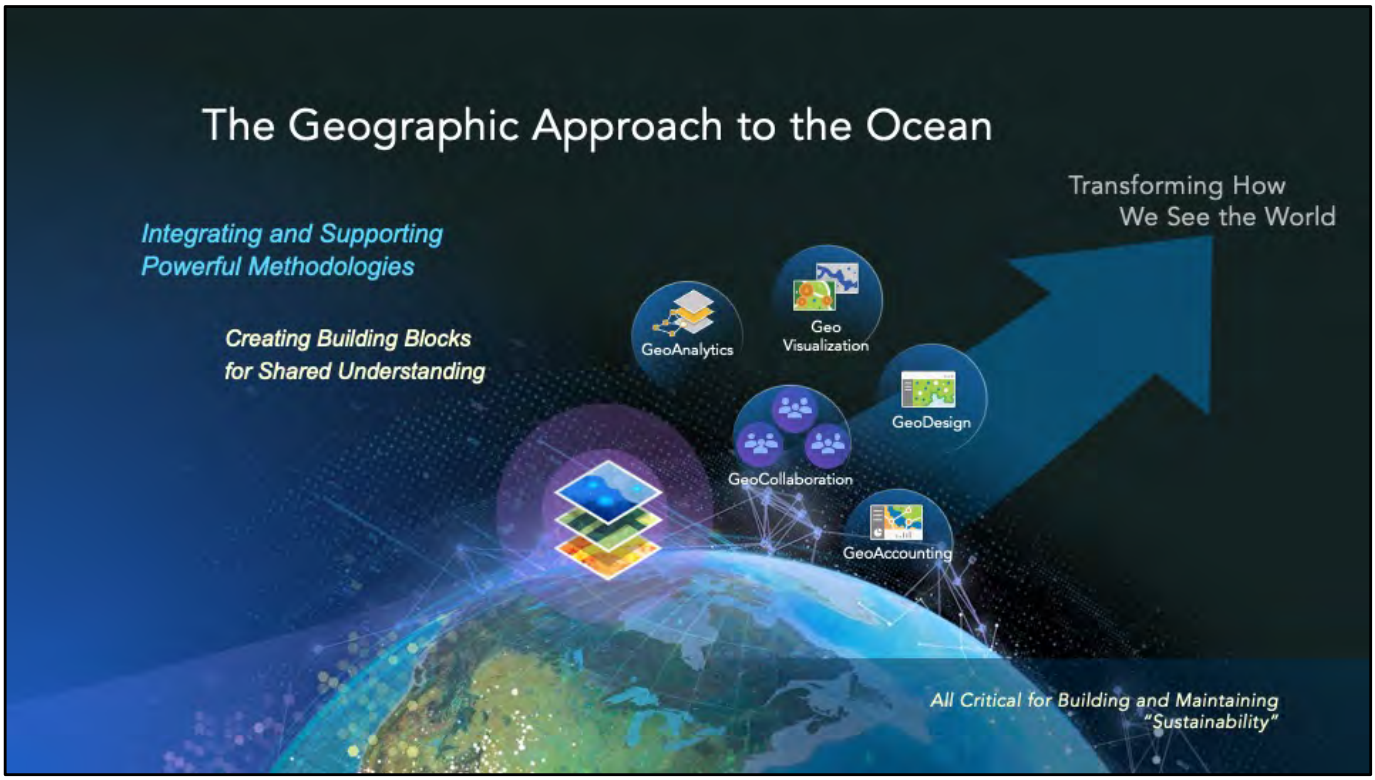
Chief Scientist, Environmental Systems Research Institute
(aka Esri)

Courtesy Professor, Oregon State University

@deepseadawn

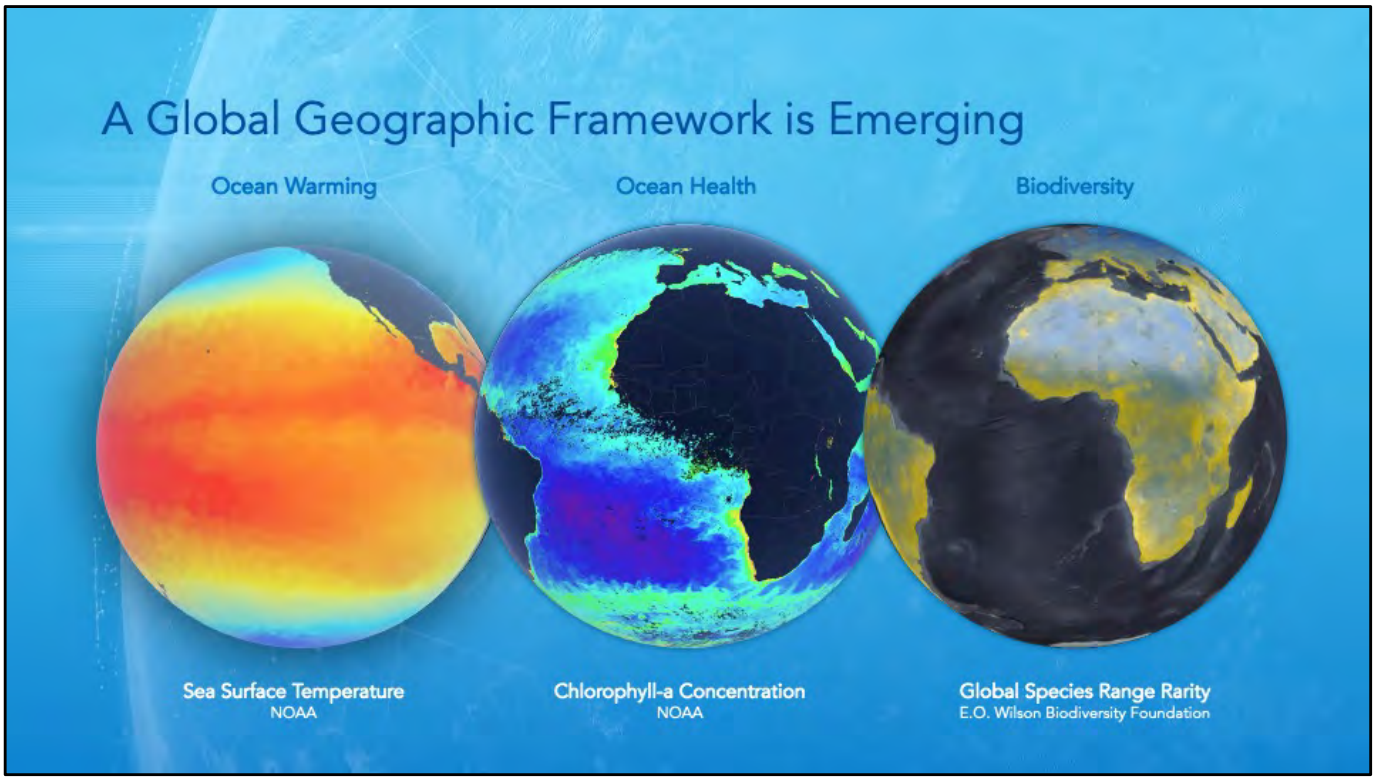
esri

As we have been discussing ALL throughout this event, the FLUIDITY of our ocean planet is our FUTURE. It is essentially what gives it life. And yet, as we know, our world today is simply, IN TROUBLE. It's safe to say that what we've done with environmental degradation and the issues of social instability are creating a significant amount of uncertainty for all of us, and then there is the unthinkable situation in Ukraine and with the associated crisis in the Black Sea. These issues are overwhelming. And somehow they're all interconnected — climate change, natural disasters, loss of nature in the ocean, overpopulation along the ocean. Addressing these issues with equitable SOLUTIONS is going to be challenging for all of us for the rest of our lives, requiring new governance, new policies, new market approaches, and certainly new technologies which I will be focusing on today.



ONE MAJOR SOLUTION I would argue is GEOGRAPHIC, where a so-called Geographic Approach can come to the rescue to help us organize and optimize our knowledge of the ocean (ALL OF OUR KNOWLEDGE, FROM ALL CULTURES, and GEOGRAPHIES) to solve these challenges and to SAVE it. And what I mean by a Geographic Approach is really a Way of Thinking and Problem Solving …

… that Integrates spatial data Science & Information Into How We Explore, Designate, Understand, Manage and Communicate about the ocean This approach integrates and supports powerful methodologies: **geoanalytics**, creating insights and understanding; **geovisualization**, a language through maps and visualization for communicating the content and the context of our world; **geodesign**, designing sustainable and inclusive futures; **geocollaboration**, engaging all the community; and **geoaccounting**, being able to account for all the factors, setting up balanced measures that are driven by our shared value of the ocean, our knowledge, climate financing and much more.



Indeed, it's so exciting now to see the emergence of a globally interconnected system of sensors and data based on literally hundreds of years of ocean exploration, involving and supporting many organizations and communities, all seeking to share data sets and services, dramatically extending the impact of geographic information, often embodied in geographic information systems or GIS, which provides a geographic FRAMEWORK toward helping ocean data achieve its full benefit

This is about spatial and because spatial is special. Spatial lies at the heart of just about everything that matters to us in the ocean such as

WHERE to best establish and enforce additional marine protected areas, especially in the high seas

WHERE and HOW to sustainably feed a rapidly growing population with ocean-based protein?

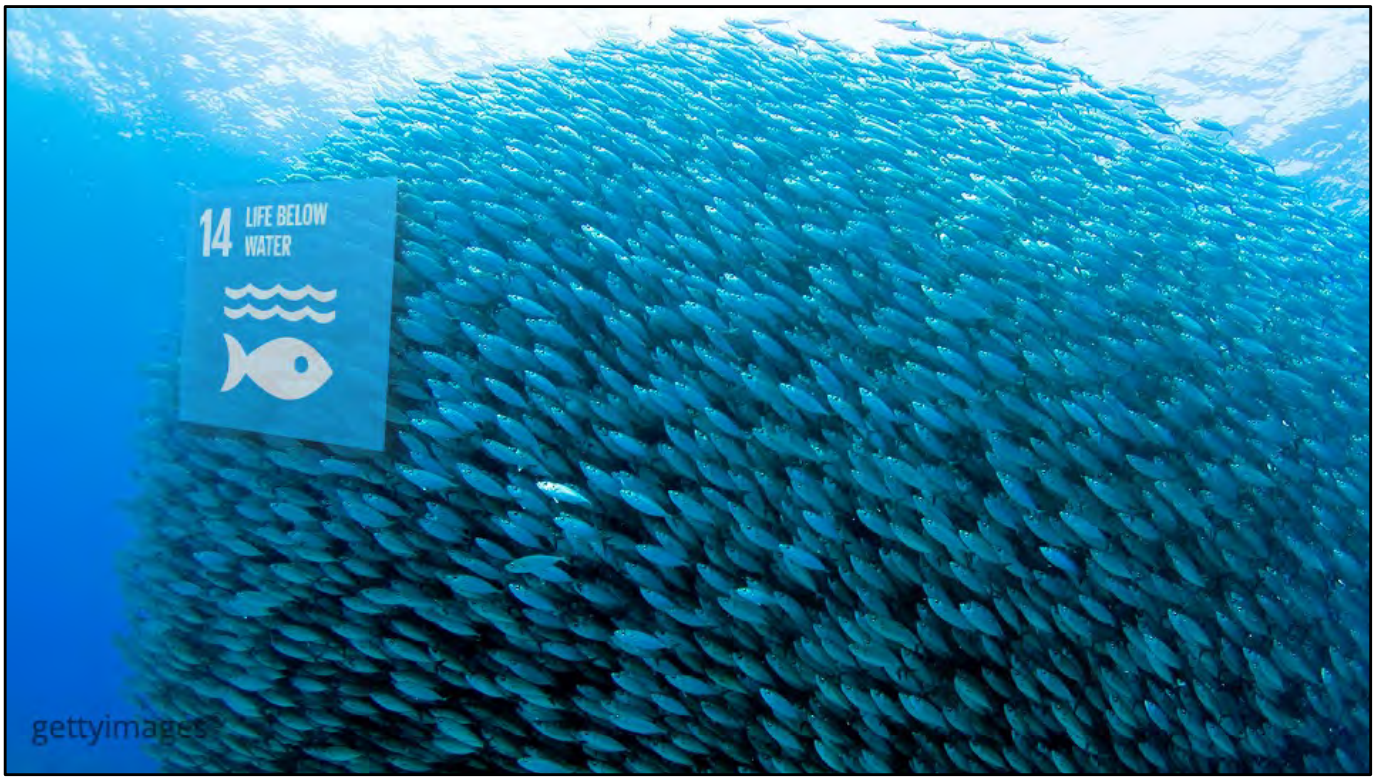
WHERE to address hot spots of rapidly declining ocean oxygen and increasing ocean acidification?

WHERE to mitigate and adapt to a changing climate? All of these are inherently spatial and thus geographic issues.

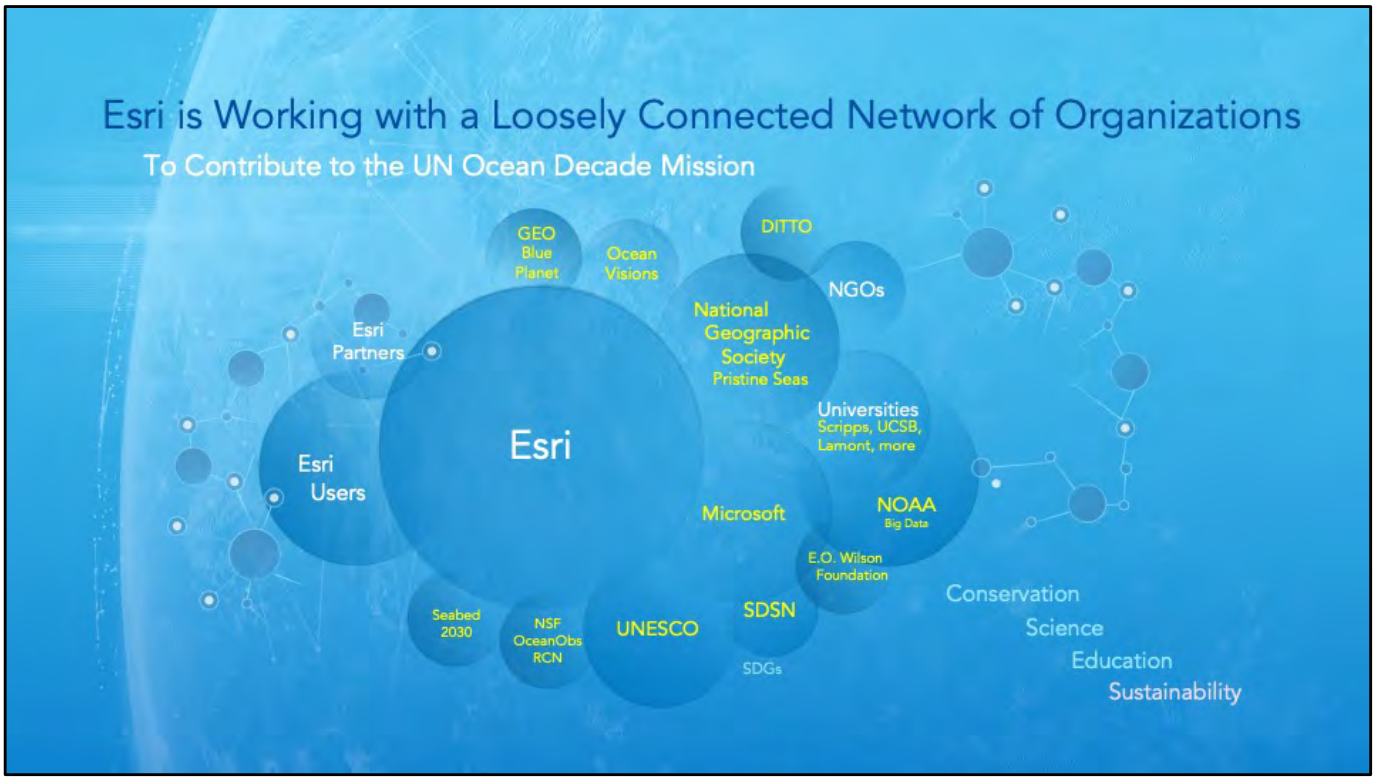
As we run out of time for all of us on Planet Earth/Planet Ocean we have come to realize indeed that the ocean desperately needs more of our attention. ENTER the United Nations Decade of Ocean Science for Sustainable Development (aka the “Ocean Decade” or the “UN Decade,” which is a once-in-a-lifetime global cooperative program to expand scientific and industry partnerships that will support ground-breaking science, management, conservation, and sustainable development of the ocean. The vision and tagline for the Ocean Decade, which officially began in June and runs until 2030, is “the science we need for the ocean we want.”

To in turn give us the OCEAN we need for the FUTURE we want

Ocean Decade https://www.oceandecade.org
Ocean Decade US - https://www.nationalacademies.org/our-work/us-national-committee-on-ocean-science-for-sustainable-development-2021-2030



The overall mission of the new Ocean Decade is a wonderful extension of the existing UN Sustainable Development Goal SDG 14, which is of course is all about “Life Below Water” . The mission of the Ocean Decade is to bring to bear transformative ocean science SOLUTIONS for sustainable development, and in so doing to connect people and our ocean under 7 themes: (1) a clean ocean; (2) a healthy and resilient ocean; (3) a biologically productive ocean; (4) a predicted ocean, especially to ensure; (5) a safe ocean; (6) an accessible ocean; and (7) an inspiring and engaging ocean.



My organization Esri, with our long history of support for conservation, science, education, and sustainability is “ALL IN” on this. Our CEO is super psyched! Our normal mode is to work with a loosely-connected NETWORK of organizations, leveraging our millions of GIS users and business partners along the way. So some of our special ocean collaborations are indicated here in yellow

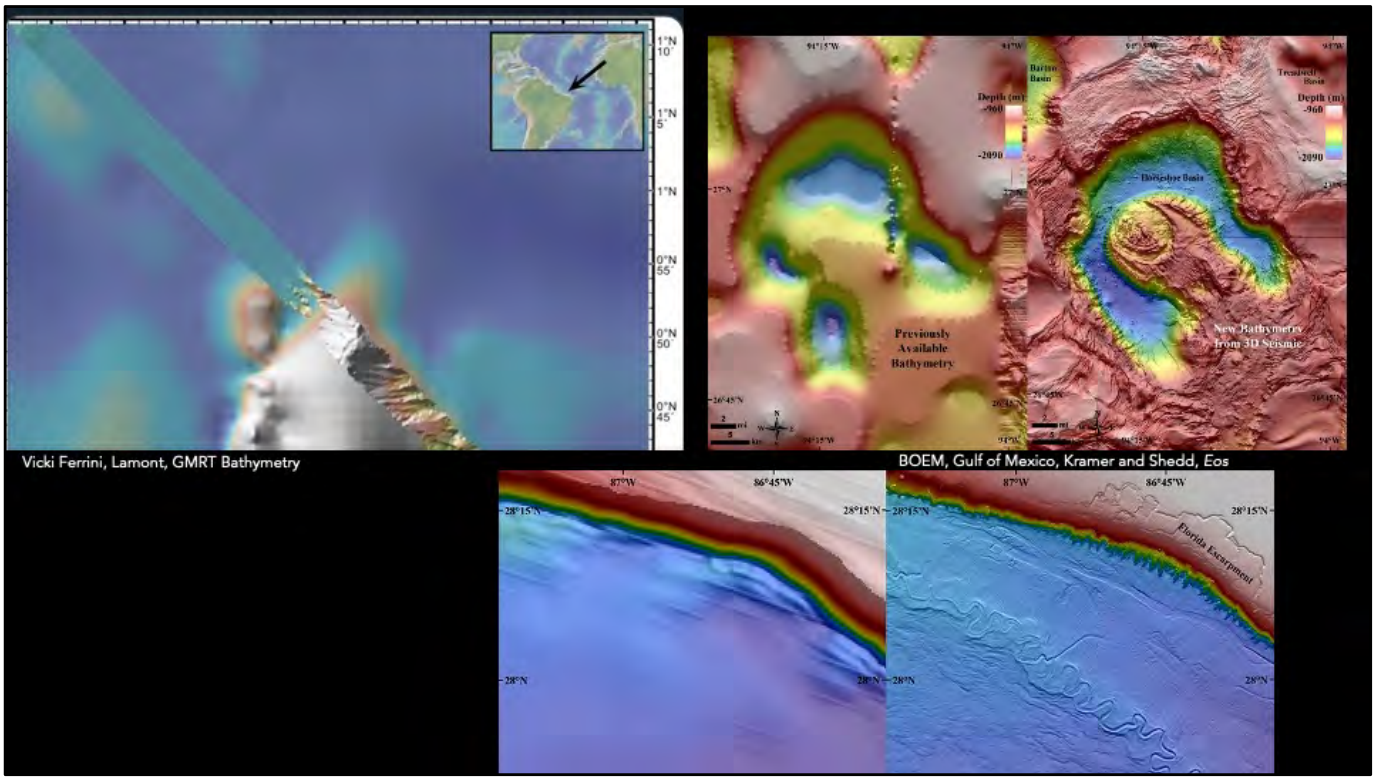
For example, see https://www.esri.com/en-us/about/science/initiatives/ocean-science

Acronyms:
GEO = Group on Earth Observations
SDSN = Sustainable Solutions Development Network
DITTO = Digital Twins of the Ocean
RCN = Research Coordination Network
E.O. Wilson Foundation in building the Half Earth Map
Microsoft in building their Planetary Computer and partnering in AI for Earth

I'll just mention a couple of the initiatives that we are involved in and how we are building solutions in concert with these partners. The UN Sustainable Development Solutions Network (SDSN), was established in 2012 under the auspices of the UN Secretary-General and today is led by Prof. Jeffrey Sachs of Columbia University. The SDSN recently launched SDGs Today: The Global Hub for Real-Time SDG Data in partnership with Esri and the National Geographic Society, to advance the global community toward the aforementioned geospatial framework for sustainable development. SDGs Today, an open access data platform, aims to advance the production and use of real-time and geospatial data for all 17 of the SDGs, and certainly a growing cadre of material for SDG14. There are tons of curated, authoritative datasets, story map collections, as well as education and training resources to support countries, institutions, and civil society members to produce, share, and engage with the data to help meet the global goals by 2030. Please check out this amazing solution-oriented resource.

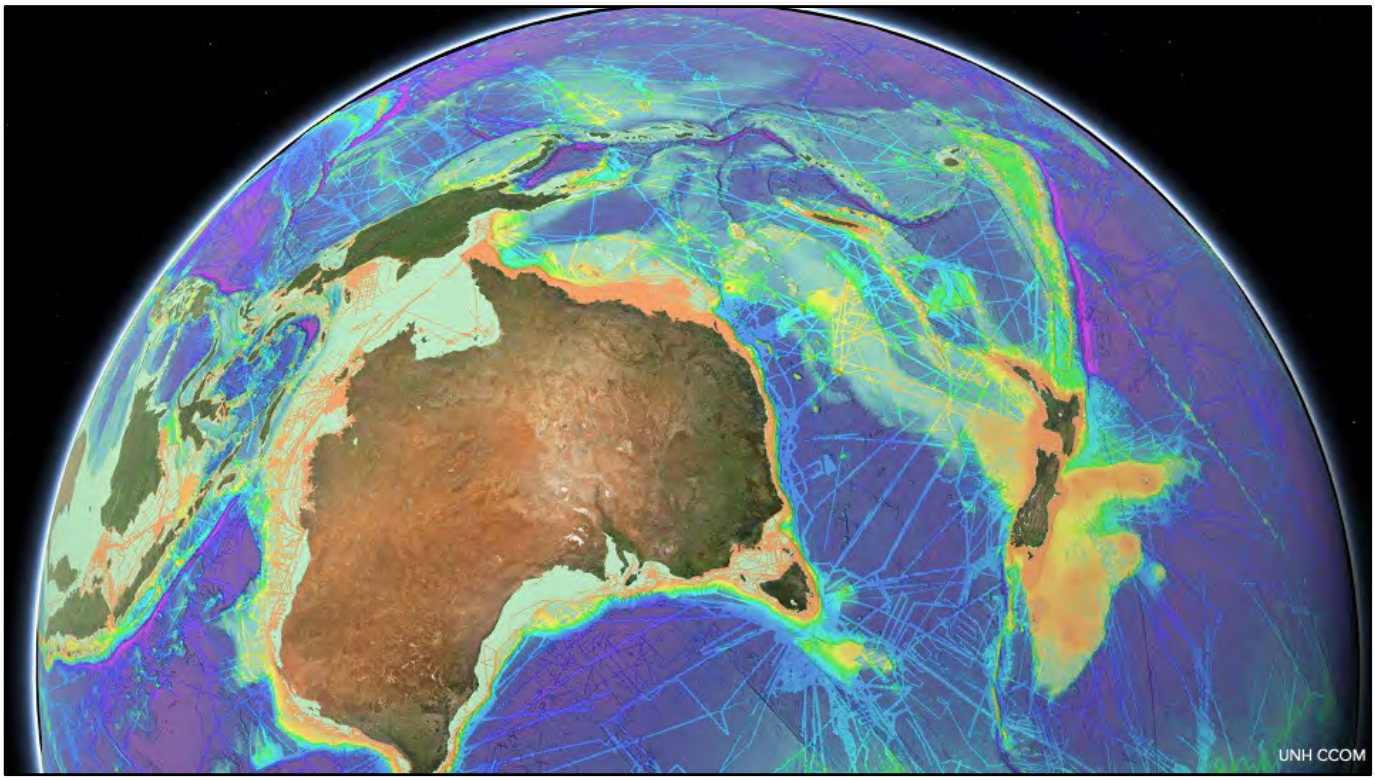
Esri is also involved in several of the first set of fully-endorsed UN Ocean Decade ACTIONS. These Decade Actions are substantive multi-collaborative PROGRAMs meant to give the Ocean Decade real teeth, true implementation rigor, and a huge amount of momentum. One of these is Seabed 2030 which is a global program to map 100% of the ocean floor at a level of detail similar to what we already have on land. To date, only 20.6% of the ocean floor has been mapped …

https://seabed2030.gebco.net/news/gebco_2020_release.html
https://storymaps.arcgis.com/stories/a0122ef457dd435294e44a2a83dfbd7e
https://columbia.maps.arcgis.com/apps/webappviewer/index.html?id=24698aca0b4847528f0c5036d196a515

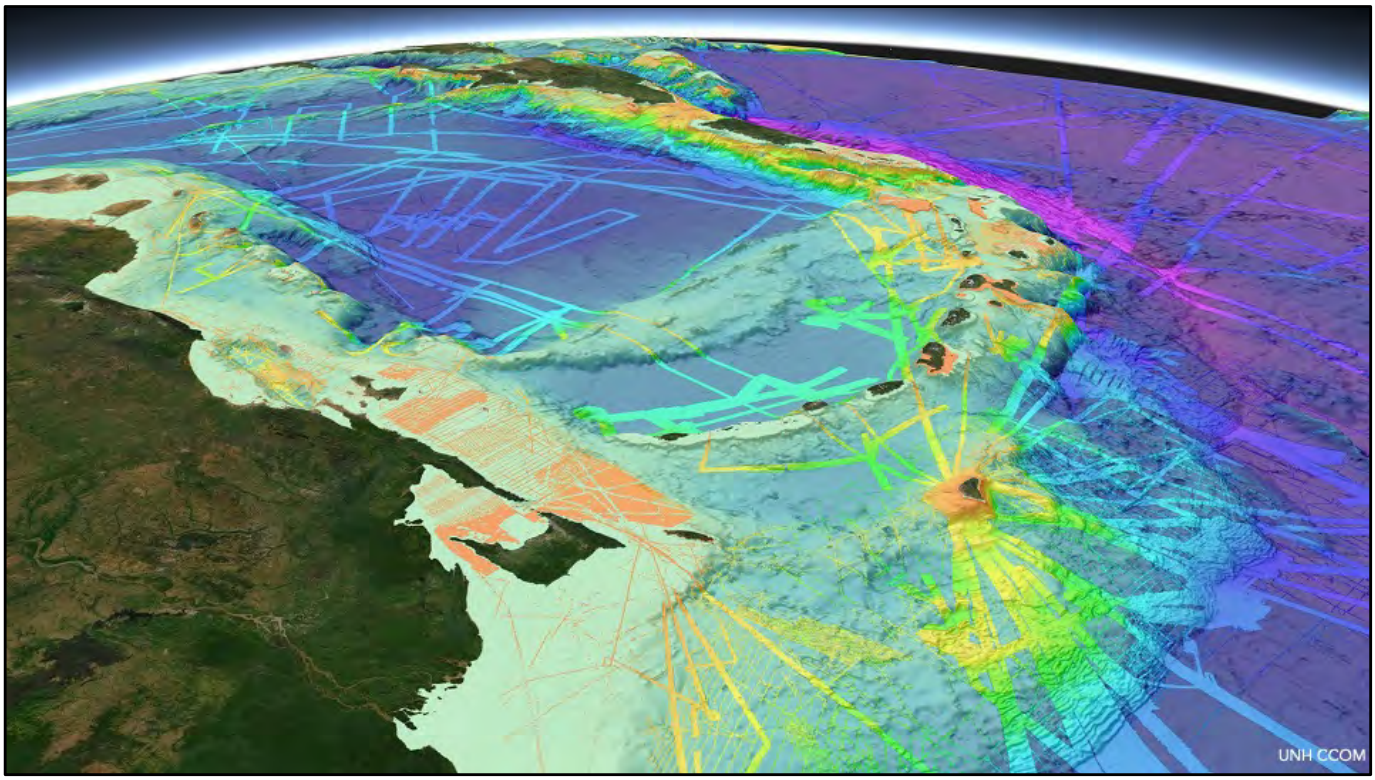


… in the DETAIL we need for the OCEAN we WANT, in the detail we need for the FUTURE we want. When Seabed 2030 was launched in 2017, only 6% of the seafloor had been mapped to modern standards. Now in the last couple of year that coverage has risen from 13 to 20% (this type of surveying takes time), bringing the seafloor more into FOCUS as you can see from these snippets. But it's still only 20.6% and this is 2022.

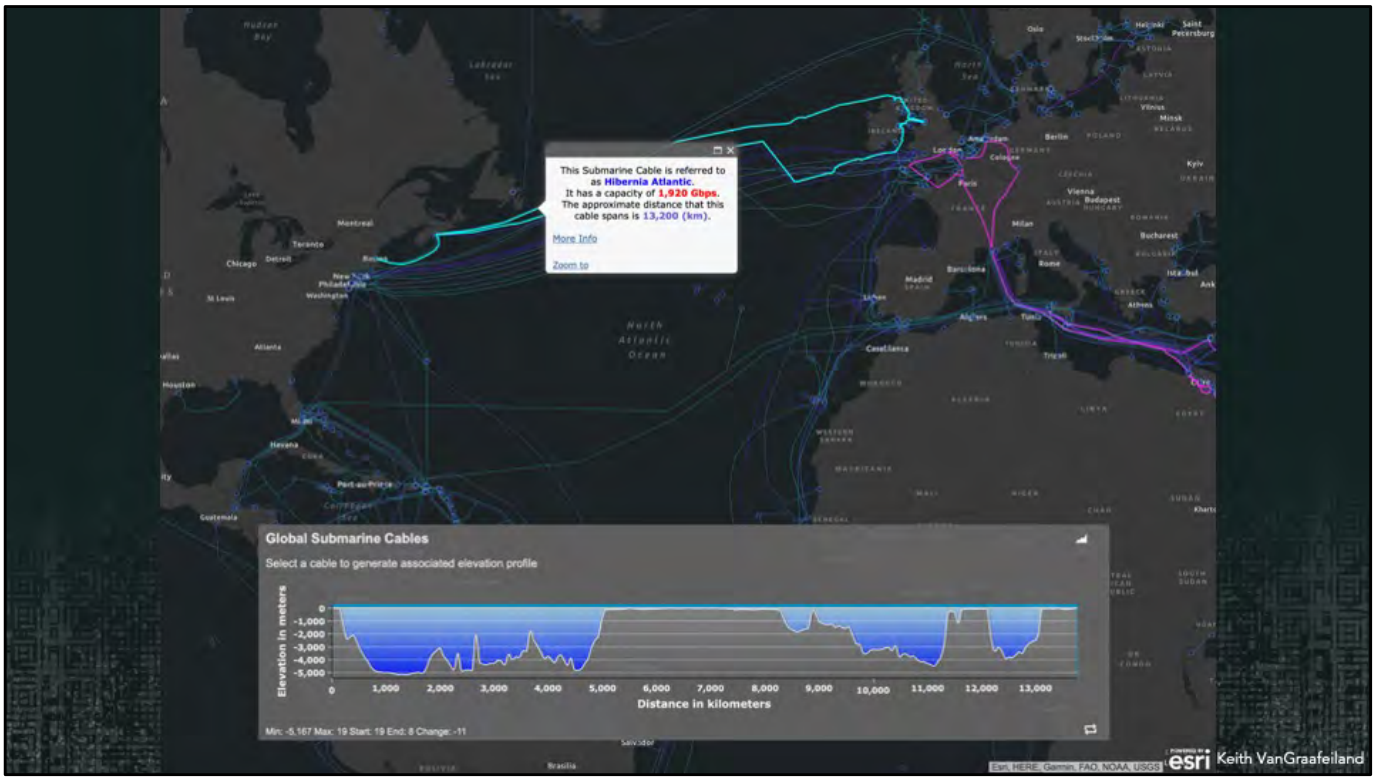
https://eos.org/science-updates/a-1-4-billion-pixel-map-of-the-gulf-of-mexico-seafloor



Here is a visualizations in ArcGIS Earth by the U. of New Hampshire of parts of the ocean floor showing the tracklines representing that 20.6% that we have, with the remaining “gaps to be mapped” are in the bluish purple underlay. The payoff in getting to 100% stands to be tremendous – for everything from ship navigation to climate modeling.



As we know, a clear view of ocean bathymetry would, for example, allow for optimal siting of offshore wind turbines, or where deep-ocean fishing can be done safely and sustainably, and where it cannot or SHOULD not. And with a clear three-dimensional understanding of ocean volume, underpinned by the ocean floor, meteorologists could better understand how typhoons and tsunamis travel and intensify as they cross the ocean, bringing storm surges to the shoreline. Climate scientists could better measure the circulation of heat in the ocean and thus build better models of climate change.

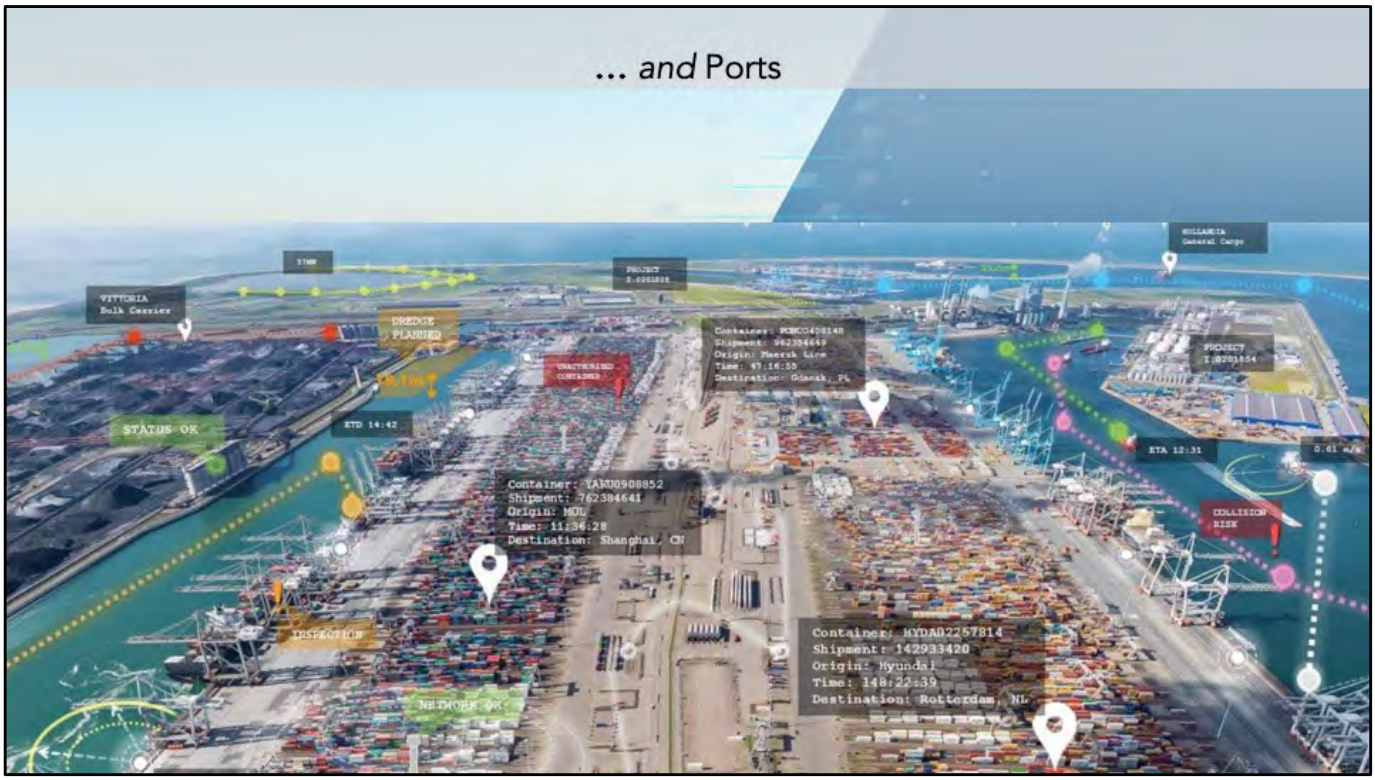


And lest we forget, we need this map in order to best site and maintain submarine cables. We wouldn't have the Internet without them! We couldn't have virtual conferences like this without them! These cables carry signals across the ocean in fractions of a second; enabling telephone, public and private private data transmission, and internet including streaming video (in this case my must-see programs from the BBC or Britbox or my underground anime from Japan)!

https://www.arcgis.com/home/item.html?id=5ba169ff89fe4328933c828e0c290f92

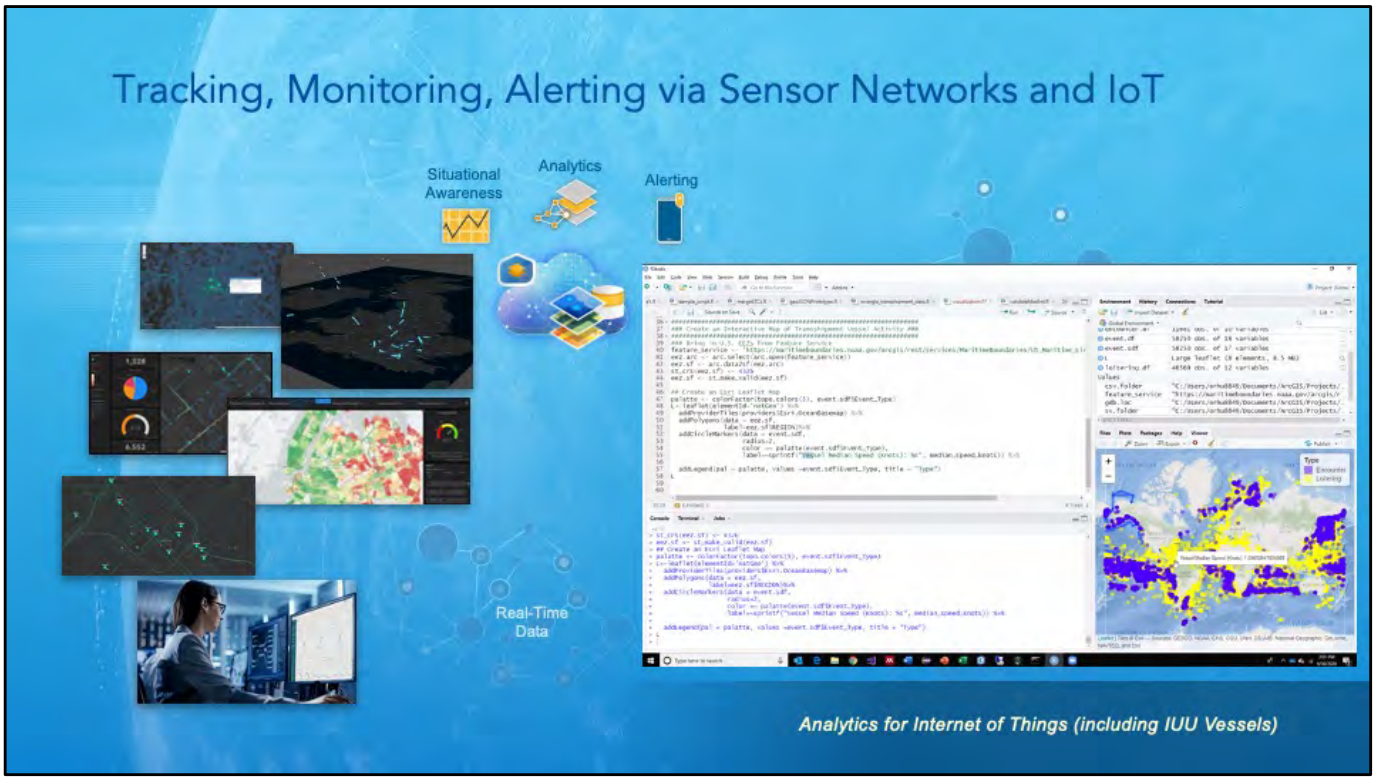
There is also the emerging concept of a "digital twin," a virtual representation of an object, process, or system that bridges the gap between the physical and digital worlds. However, it is MORE than just a visualization, as when implemented with Internet of Things (IoT) and artificial intelligence (AI) it can accelerate innovation, build consensus, and save time and money by iteratively modeling changes, testing how components or systems function, and troubleshooting malfunctions inexpensively in a virtual world, even improving business supply chains

Esri has actually been writing about digital twins in the geospatial realm since 2017, especially with regard to ports (e.g., https://www.esri.com/about/newsroom/publications/wherenext/digital-twin-for-supply-chain-management/)
See our current overview at https://www.esri.com/en-us/digital-twin/overview



With regard to the coast, the port of Rotterdam in the Netherlands wants to become the first port in the world to accept autonomous (self-sailing) ships. Their calling this their “moonshot.” So the port is already working with Esri to create a GIS-powered digital twin to provide port managers with a more accurate picture of everything from the weather to how many ships are sailing about, their speed, and where they’re headed. Digital simulations of the future scenarios within the port will forecast optimal water depths and berth vacancies to pinpoint the best times for ships to berth and offload or take on cargo, all with an eye toward improved efficiency and cost savings.

https://www.esri.com/about/newsroom/podcast/port-of-rotterdam-the-digital-transformation-of-europes-largest-port/
https://www.esri.com/about/newsroom/publications/wherenext/rotterdam-autonomous-ships-and-digital-twin/



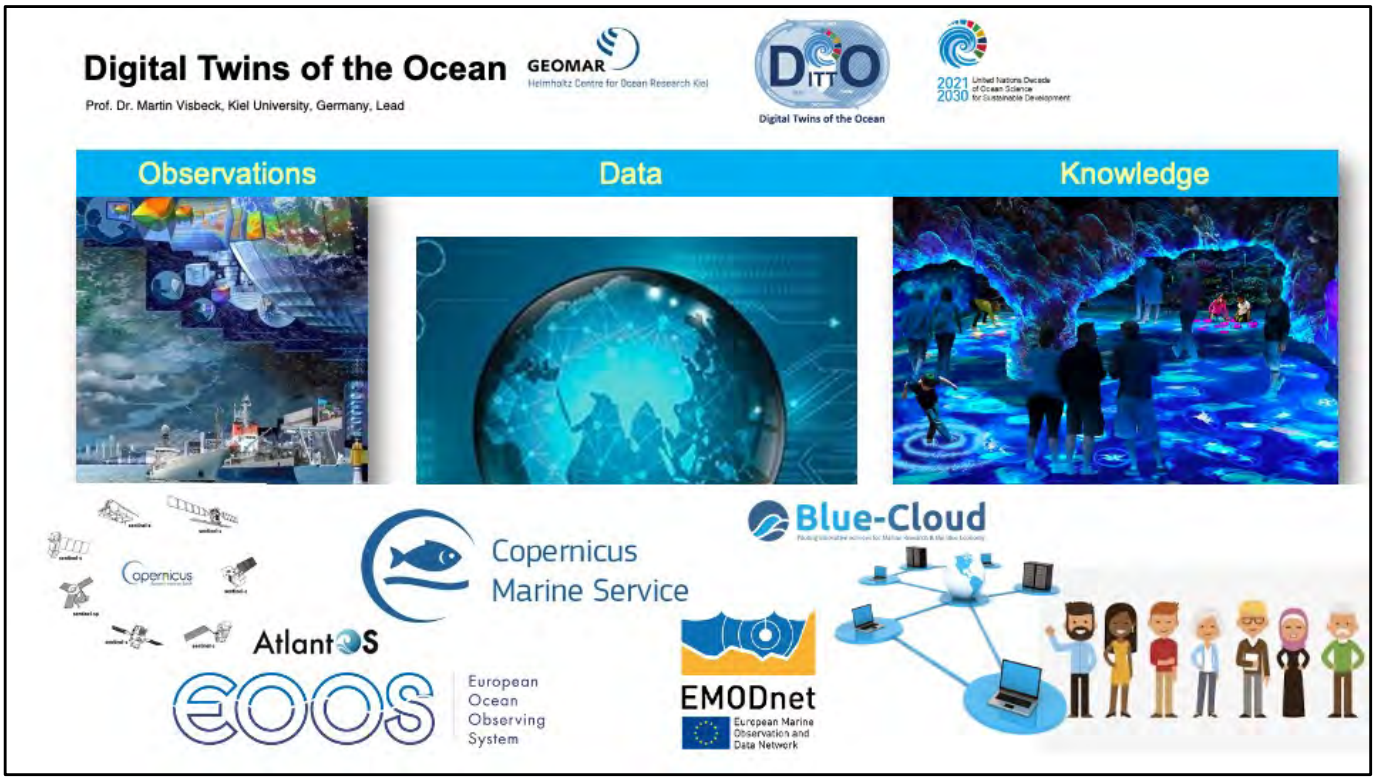
And these digital twins rely on sensor networks and IoT especially to monitor and track just about anything that is moving. If you'll allow me to geek out here a bit, here is an example of the tracking of illegal, unreported, unregulated (IUU) fishing via automatic identification system (AIS) and precise radio frequency signals. (2) This is a serious issue as IUU fishing costs $23B per year in lost revenue; (3) and this is an R Studio session bridged with ArcGIS where appropriate feature services, image services, REST APIs, JSONs, and geodatabases can be more fully analyzed and *interactively* mapped

Data provided by HawkEye 360, a Radio Frequency (RF) data analytics company. https://www.he360.com/about/. They operate a first-of-its-kind commercial satellite constellation to identify, process, and geolocate a broad set of RF signals. They extract value from this unique data through proprietary algorithms, fusing it with other sources to create powerful analytical products that solve hard challenges for our global customers. Their products include maritime domain awareness and spectrum mapping and monitoring; their customers include a wide range of commercial, government and international entities.

And now there is an endorsed UN Ocean Decade Program called DITTO. Certainly digital twins will be powerful for natural environments such as the ocean, especially as a way to provide more intuitive access to the existing vast stores of ocean data, models, and simulations, including those of air-sea interactions that affect weather and climate. The current ecosystem of ocean-observing platforms, buoys, robots, ships, satellites, does allow us to answer the questions, “What is the state of the ocean today? How will it change tomorrow?” But a well-constructed digital twin of the ocean will not only enable a wider range of users to interact with these digital assets, but to explore scenarios farther into the future….

https://twitter.com/TwinDitto and
https://twitter.com/GreenBiz/status/1433814997491019787?s=20

A recent news article in Science reports that the European Union is finalizing plans for an ambitious “digital twin” of planet Earth that would simulate the atmosphere, ocean, ice, and land with unrivaled precision, providing forecasts of floods, droughts, and
fires from days to years in advance.



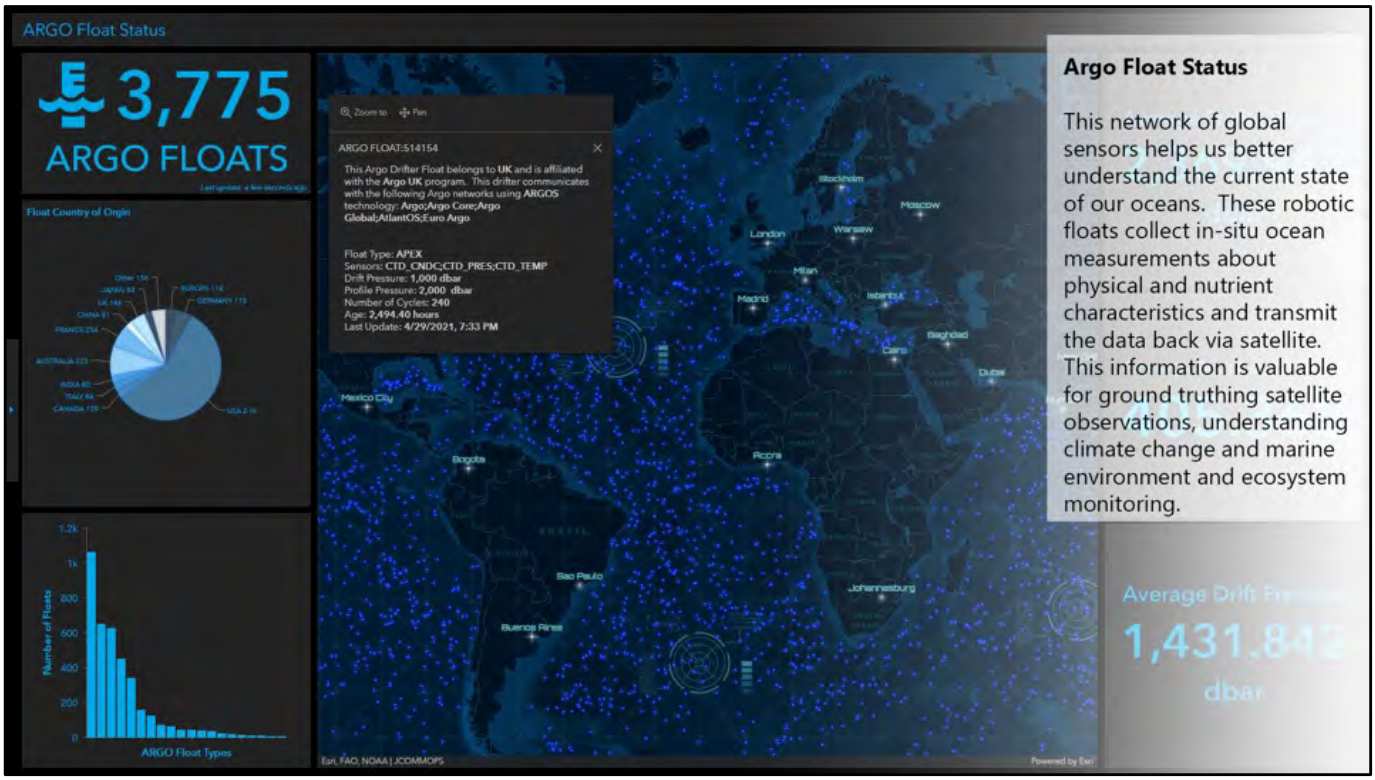
… especially related to human interactions with the ocean (i.e., how will the ocean change over the next few years depending on certain human actions?).

So we're thinking especially of fisheries and mariculture, marine protected areas, ocean-based tourism, ecological forecasting, weather forecasting, marine infrastructure development, and the interactions between all of these with an ever-growing collection of data streams. The UN Ocean Decade is seeking a Transparent and Accessible Ocean "**whereby all nations, stakeholders and citizens have access to ocean data and information technologies and have the capacities to inform their decisions."** This is what DITTO is aiming for.

If you missed the DITTO Town Hall #50 that took place last Thursday, I'll hope you'll catch the recording.

Esri's contribution to this effort is a new global, 3D "digital ocean" called the Ecological Marine Units. As we zoom in the cylinders represent data points from NOAA's World Ocean Atlas, made up of 52 million observations globally over a span of 50 years about the primary characteristics that enable life in the ocean - salinity, temperature, dissolved oxygen, nutrients. This 3D basemap extends from the ocean surface down through 102 depth zones to the ocean floor at 5000 m. This has been a fantastic project, that we are very pleased to continue developing in collaboration with over 10 academic and conservation partners. The project is already published in these outlets, and available in apps for the web, phone, or tablet with a number of use cases underway to build biological/biodiversity data INTO the EMUs themselves and to use them in part for marine protected area design and evaluation, as well as for reporting of conditions in zones of coastal ocean governance. The data here are open, free, but more importantly with documentation and learning modules, use cases, and other guidance to help you implement this LOCALLY for your organizations.

The natural follow on from Ecological Marine Units are Ecological Coastal Units which were just released this spring. With this resource, every 1 km stretch of coastline on the entire planet can be queried for the values of eleven variables that characterize water-side, land-side, and coastline properties. In fact, 4 million global coastline segments were classified into 81,000 coastal segment units (CSUs) and clustered to produce 16 ecological coastal units (ECUs). This new standardized data can be used by site-level and networked resource managers to better understand physical shoreline characteristics, coastal flooding impacts, and community-level social vulnerabilities.



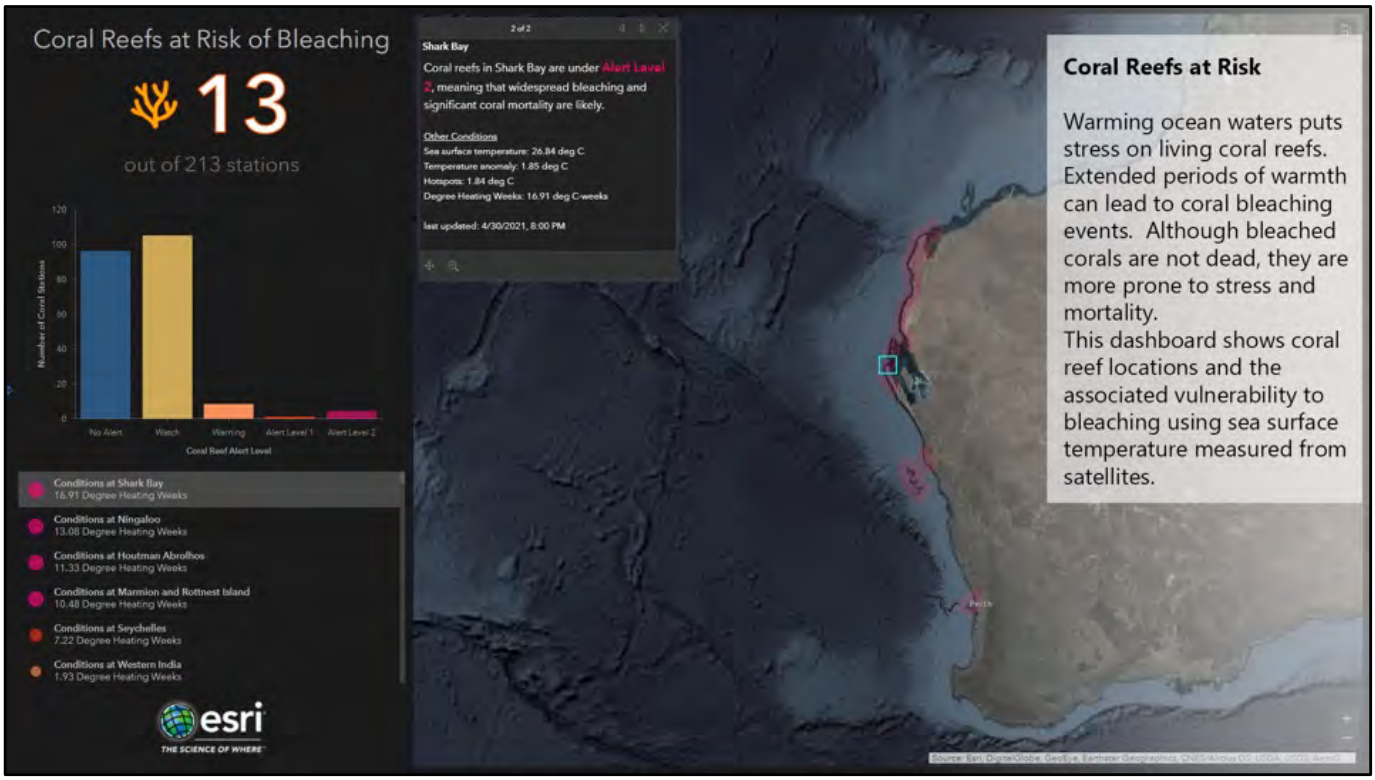
The wonderful thing about these global characterizations of the coast and ocean is that the data come in large part from this global Argo float system, the status of which of we at Esri in collaboration with IOC/UNESCO's OceanOPS have built as a DASHBOARD. This is so organizations of the world can track what data are coming from these 1000s of Argo floats.

Let me quickly define a DASHBOARD for you as a view of geographic information and data that allows you to show, on a single screen, near-real-time displays for monitoring instruments, events, or activities, oftentimes for "at-a-glance" decision-making or to see trends.

For those of us who are providers of information technology we are now providing these as "configurable user experiences," requiring no programming, so that YOU can build these easily as apps that work on desktops, tablets, and smart phones.
https://www.esri.com/arcgis-blog/products/ops-dashboard/mapping/create-first-arcgis-dashboards/
https://learn.arcgis.com/en/gallery/#?q=dashboard

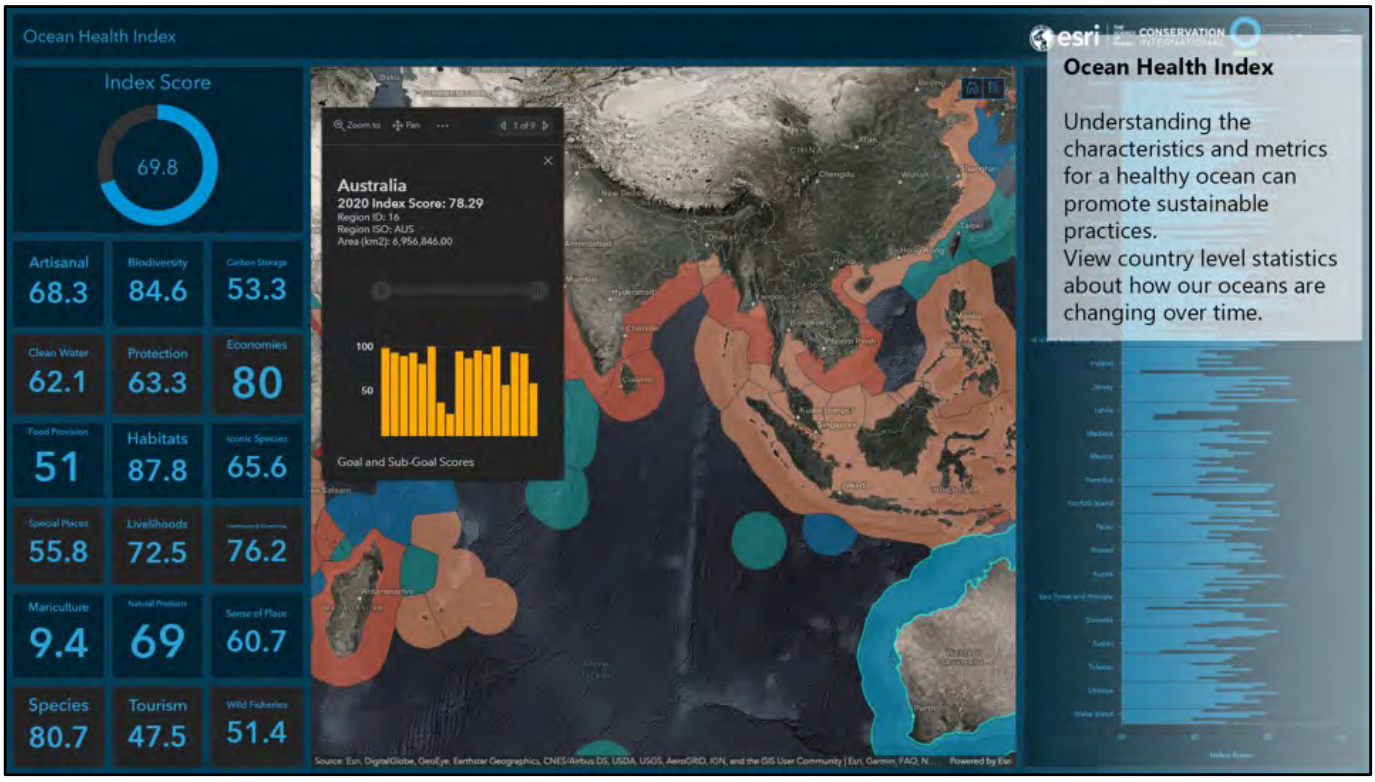
https://esrioceans.maps.arcgis.com/apps/dashboards/7665489fbc6d44bc95d47dc041c1c034

Initiative of the UNESCO IOC OceanOPS https://www.ocean-ops.org/



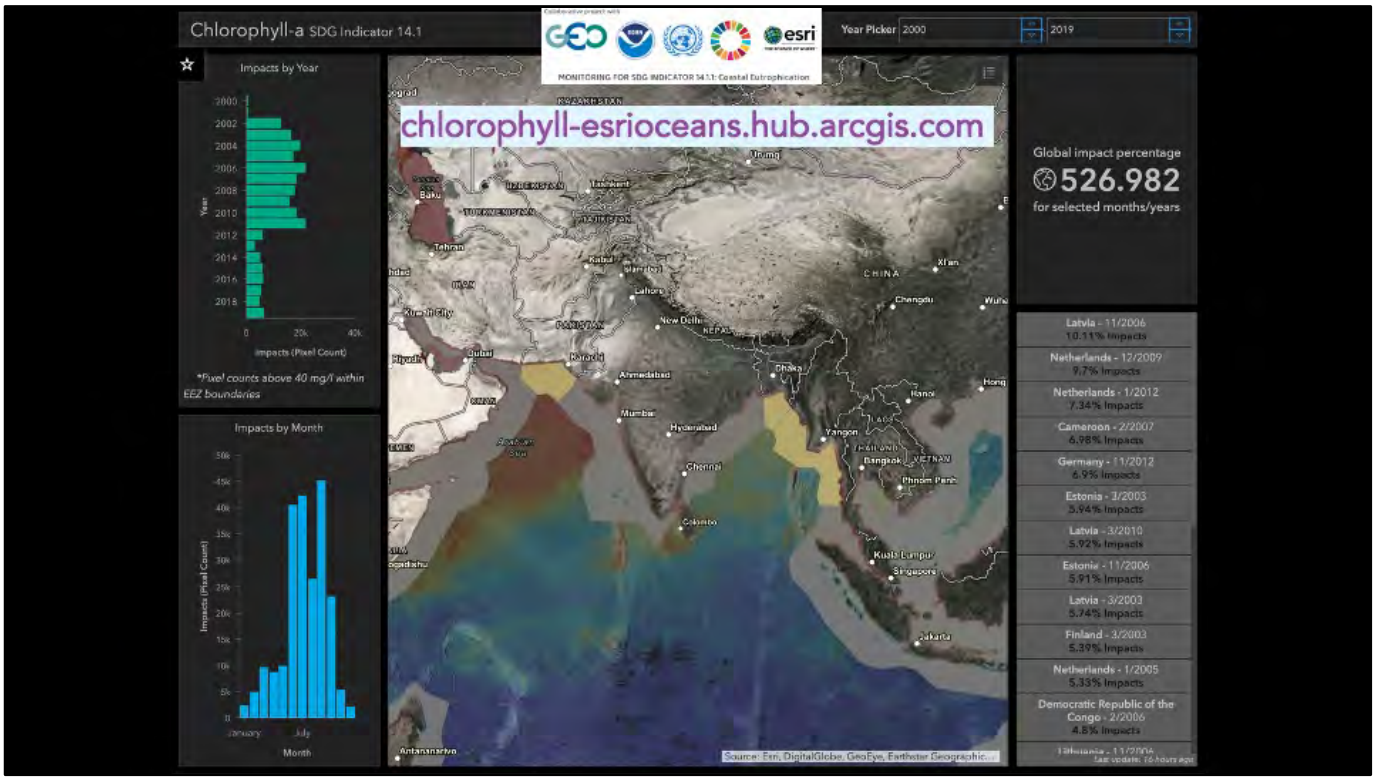
https://www.arcgis.com/apps/opsdashboard/index.html#/84ba9c03786e462d960e3172bc1b2204

At Esri we're also involved with a number of partners in tracking the status of coral reefs, particularly reefs at risk of bleaching. This is another DASHBOARD, which was also featured on the BBC's Blue Ocean 2 series, showing coral reef locations and associated vulnerability to bleaching using SST measured from satellites, Argo floats, and local diver surveys.



https://www.arcgis.com/apps/dashboards/2e3b22ff3a1147628defc9d5005b8eab

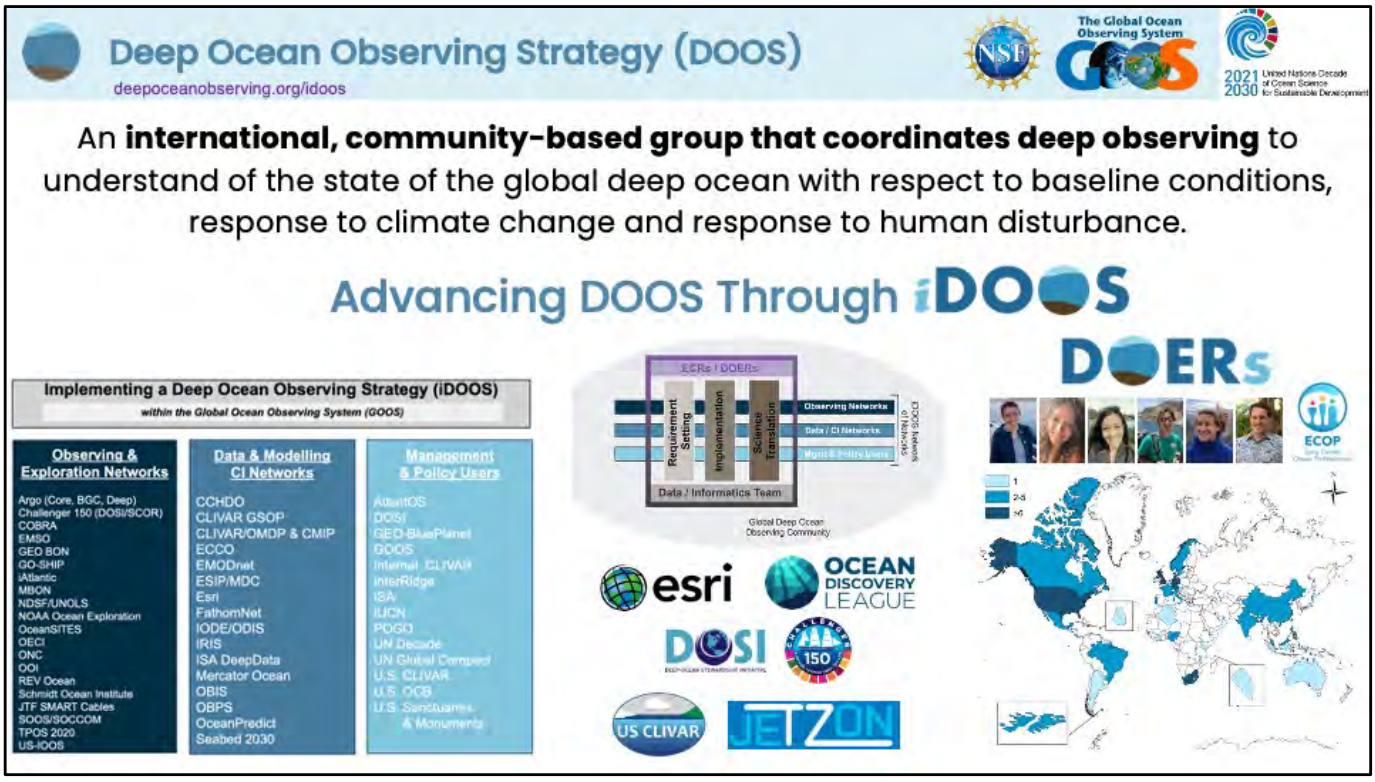
This is a DASHBOARD by the US National Center for Ecological Analysis and Synthesis, Conservation International, and others, reporting on their Ocean Health Index effort. It tracks the status of various ocean health metrics, coming in from most all of the world's coastal countries, so that all can see and compare regarding how their territorial oceans are getting better or worse with time.



This is a DASHBOARD built by GEO Blue Planet in partnership with Esri, and UNEP tracks the results of a new statistical approach and GIS workflow to help nations report on eutrophication in their territorial waters and to identify potential hot spots. This is all in support of SDG indicator 14.1.1. The workflow couples what data a country itself may have available, along with satellite observations in a useable form FOR that country.

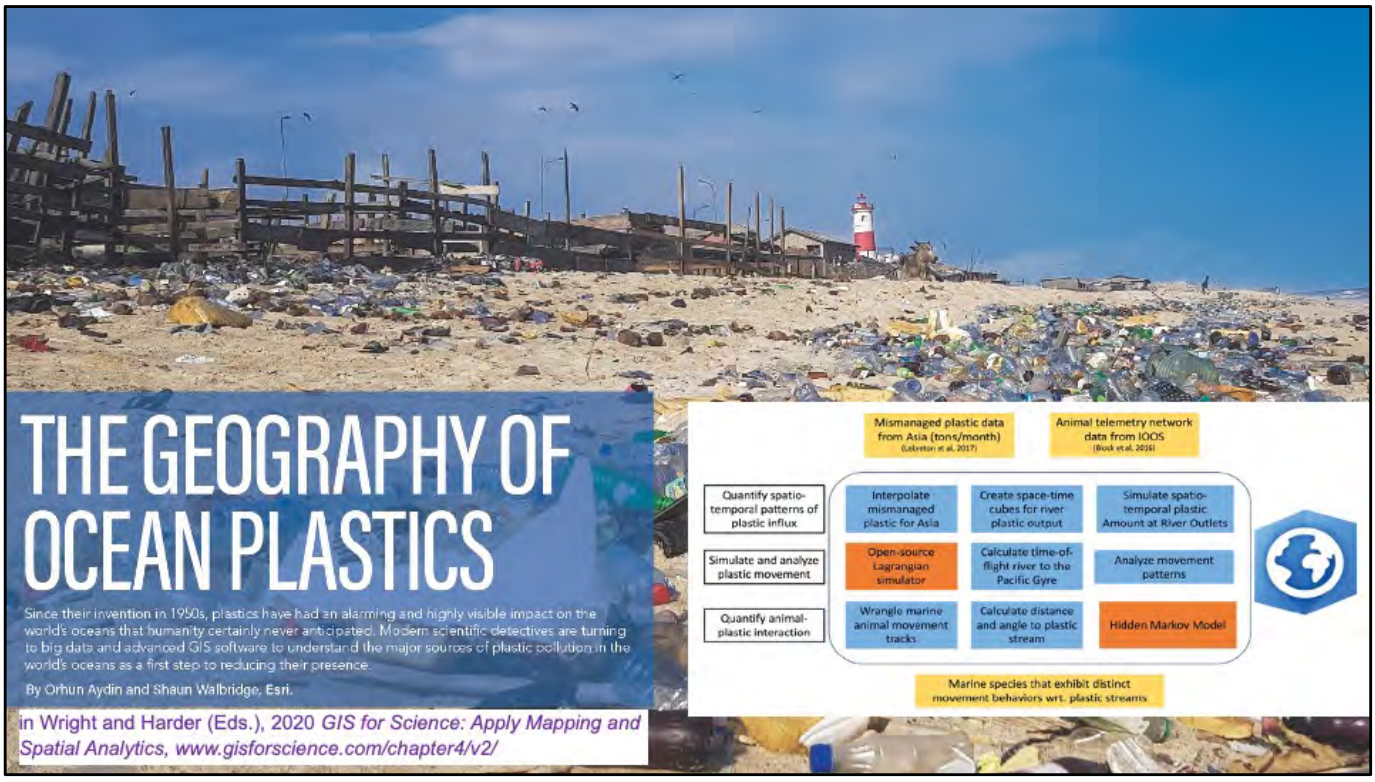
GEO Blue Planet is the coastal and ocean arm of GEO (the Group on Earth Observations), connecting ocean and coastal information with society, especially as part of the UN Decade of Ocean Science for Sustainable Development. This initiative delivers usable data and information services to support informed decision-making toward reaching Sustainable Development Goal (SDG) 14, which in part is aimed at reducing the impacts of ocean pollution, particularly from land-based activities such as agricultural runoff. To address this gap, GEO Blue Planet partnered with a team from Esri, and the United Nations Environment Programme, to develop a new statistical approach and GIS workflow using what data nations have, coupled with satellite observations to report on eutrophication in their waters and identify potential eutrophication hot spots. Initial results, workflows, dashboards, and other products are in **geospatial portal or HUB** that you can see at the address in purple

The methodologies resulting from this partnership are also now included in the UN's Global Manual for Ocean Statistics (download final manual at https://wedocs.unep.org/handle/20.500.11822/35086;jsessionid=6AF497F4052EF99CFE3FC7DE5BD4D042) and the UNESCO IOC IODE's Ocean Best Practices repository (https://repository.oceanbestpractices.org/handle/11329/1508). They can be applied in other environments where needed and modified to work on many geographic scales.



A new HUB is also helping this project to take a geographic approach. This project is called iDOOS or IMPLEMENTING DOOS, implementing the Deep Ocean Observing Strategy, which seeks to build a network of networks (including **undergraduate** institutions, as well as industry, non-profits, govts,) across disciplines and communities related to the field of deep ocean observing (i.e., the ocean below 200 m depth).
The project is also funding 6 Early Career Researchers or ECRs who are co-LEADERS in each of our working groups – this is absolutely KEY to our success. Those of you who attended last Friday's Town Hall saw that wonderful early career leadership in action.
There are also 120 DOERS (Deep Ocean Early-Career Researchers) in the project's professional development program, 2/3 from outside of the US, with several from small island states and developing countries

This project funded for 4 years under the NSF's AccelNet and to that end we are closely watching and connecting with the other ocean AccelNet, which is COBRA, the crustal ocean biosphere research accelerator.



And just to mention a couple of online technology resources that are a bit more complex, this web app by our Living Atlas of the World Team provides probability scenarios through the year 2100 for high tide flooding in the US. High-tide flooding mostly affects low-lying and exposed assets or infrastructure, such as roads, harbors, beaches, public storm-, waste- and fresh-water systems and private and commercial properties. At present it is likely more of a nuisance than catastrophic. But over time the danger will grow, and we're seeing how cumulative effects are already becoming a serious problem in several locations with strategic importance to national security such as Norfolk, Virginia, San Diego, California and in the U.S. Marshall Islands.

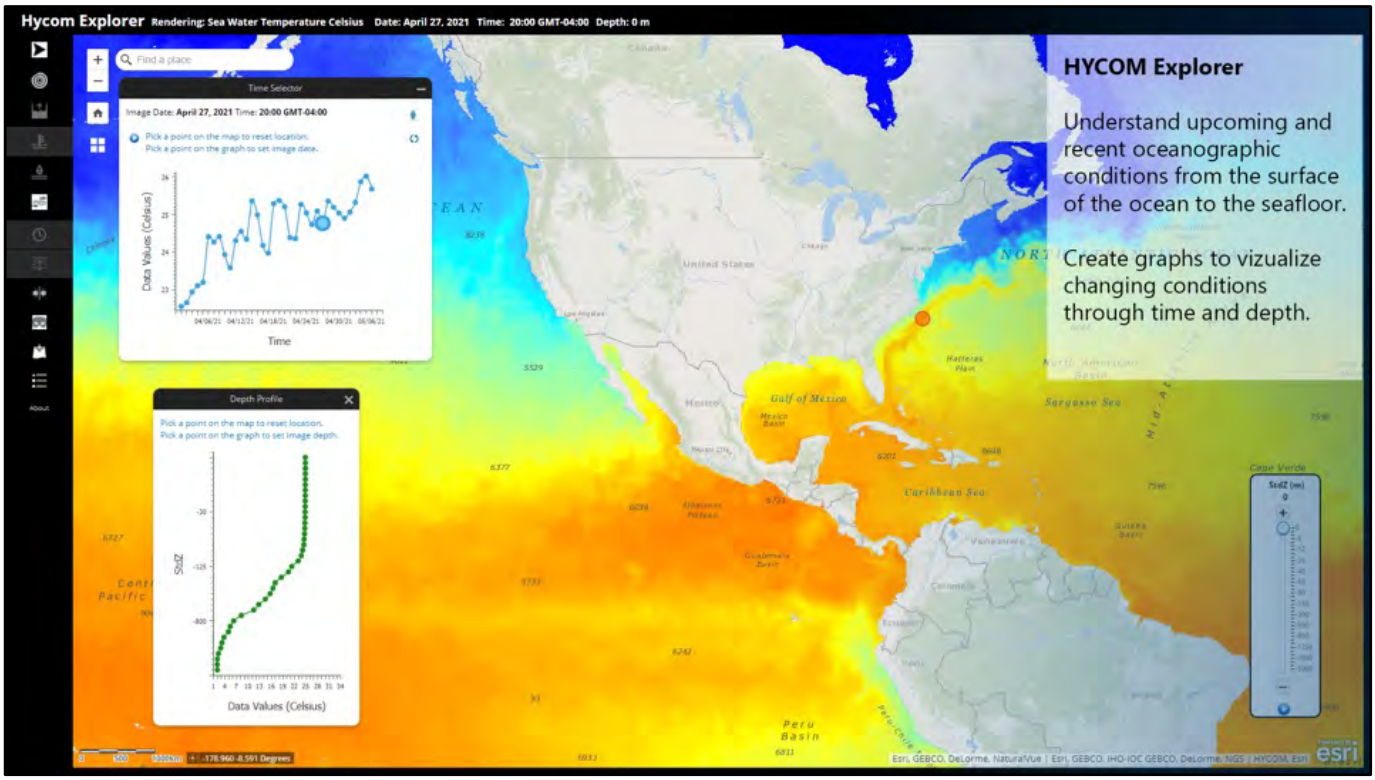
Data come from the NOAA National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (COOPS) which provides the national infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and tidal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes.

Digital supplement at https://www.gisforscience.com/chapter4/v2/ . Contact Dawn for full book chapter

https://apl.esri.com/jg/HighTideFlooding/index.html

This web app by our Living Atlas of the World Team provides probability scenarios through the year 2100 for high tide flooding in the US. High-tide flooding mostly affects low-lying and exposed assets or infrastructure, such as roads, harbors, beaches, public storm-, waste- and fresh-water systems and private and commercial properties. At present it is likely more of a nuisance than catastrophic. But over time the danger will grow, and we're seeing how cumulative effects are already becoming a serious problem in several locations with strategic importance to national security such as Norfolk, Virginia, San Diego, California and in the U.S. Marshall Islands.

Data come from the NOAA National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (COOPS) which provides the national infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and tidal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes.

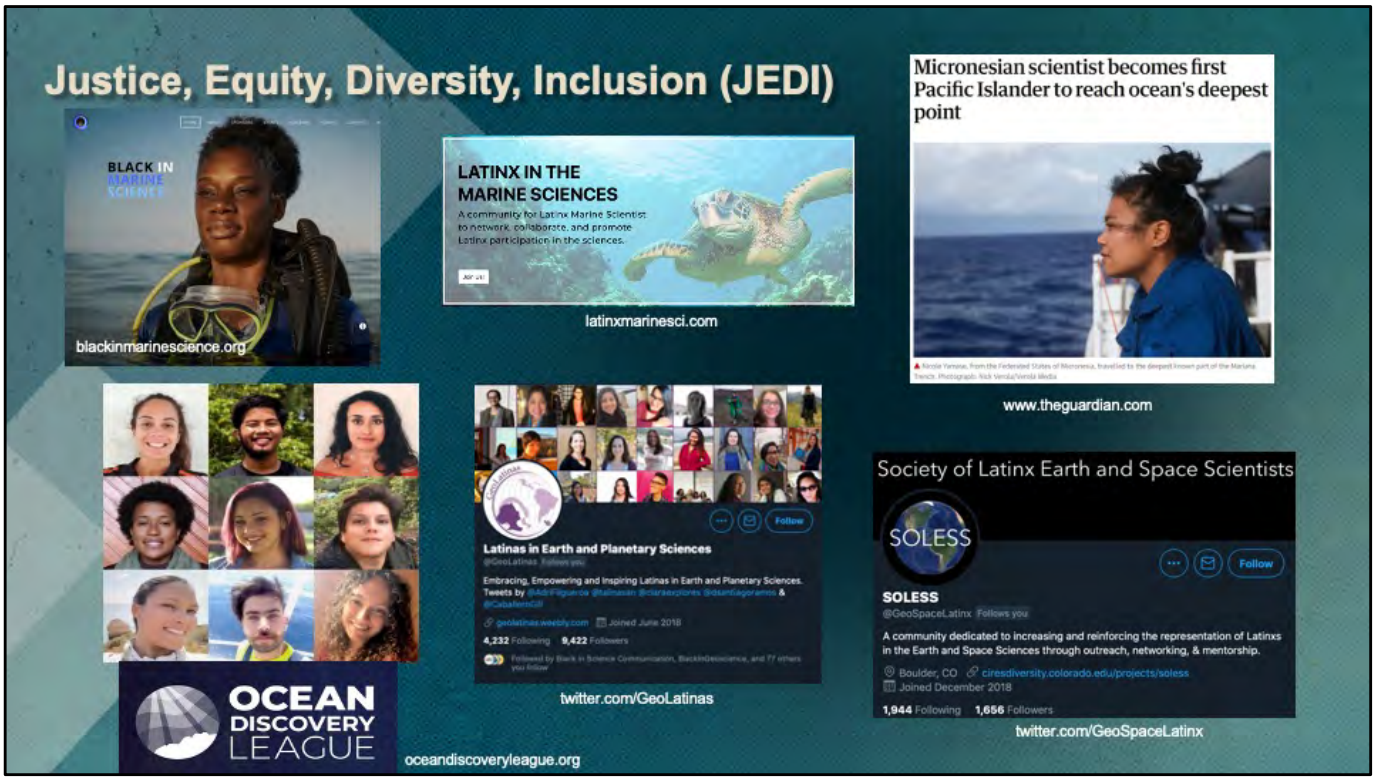


https://livingatlas2.arcgis.com/hycomexplorer/

The online Hycom Explorer (where HYCOM = HYbrid Coordinate Ocean Model) offers global oceanographic data at your fingertips. It leverages a 7-day forecast and a 30-day hindcast to help you better understand the state of the ocean. And there are web tools to view and compare individual time and depth slices for sea water temperature, sea surface height, sea water salinity, and ocean currents, all with data from the ArcGIS Living Atlas of the World.

To build your own web app similar Hycom Explorer, visit http://developers.arcgis.com.

For information on Esri's full imagery capabilities, visit http://www.esri.com/imagery.



Not just the WHERE and the WHAT but the WHO or by WHOM.
Twitter campaigns, one that has spun off into its own nonprofit, great individual accomplishments such as Nicole Yamase's dive to Challenger Deep, and I love this picture of the Global Deep Sea Capacity Assessment team of Katy Croff Bell's Ocean Discovery League that includes research assistants from countries all over the globe.

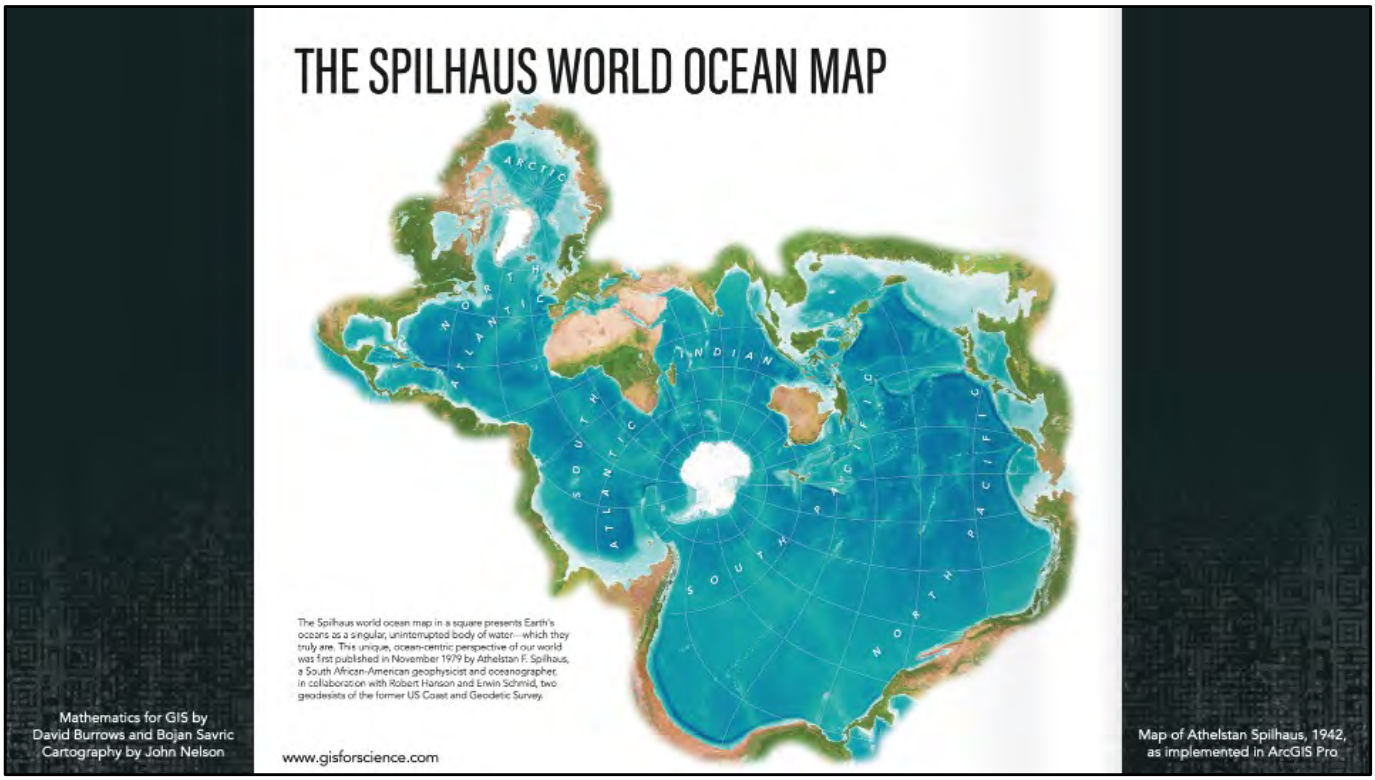
AGU's NEW indigenous action committee - https://www.agu.org/Learn-About-AGU/About-AGU/Governance/Committees/Diversity-Committee/Indigenous-Action-Subcommittee
AGU Landing - https://www.agu.org/AGU-LANDInG

Ocean Discovery League Global Deep Sea Capacity Assessment team includes Research Assistants from countries all over the globe. We at Esri are so excited to be working with them!
Alanna Smith, Cook Islands
Titus Cañete, Philippines
Harriet Baldwin, United Kingdom
Tyler-Rae Chung, Fiji
Drew Lira, USA
Sergio Cambronero, Costa Rica
Bahia Brady, South Africa
Otmane Sarti, Morocco
Diana LaScala-Gruenewald, USA

Also check out National Geographic Explorer Tara Roberts' new six-part podcast series, *Into the Depths* - https://www.nationalgeographic.com/podcasts/into-the-depths -
on her historic journey documenting some of the thousand slave ships wrecked in the Atlantic Ocean. It follows a group of Black divers dedicated to finding
and helping document the wrecks. Tara is also on the cover of the March 2022 issue of *National Geographic*, the first Black explorer ever featured on the cover.

See the story map from this great UN Ocean Decade Event at https://storymaps.arcgis.com/stories/757405c2ee6742a59929711684e0c593

We are SO all in this together and as President ReMENgesau said last night, we really need to be in one canoe, rowing in one direction, in harmony, getting the answers and solutions to the challenges we face.

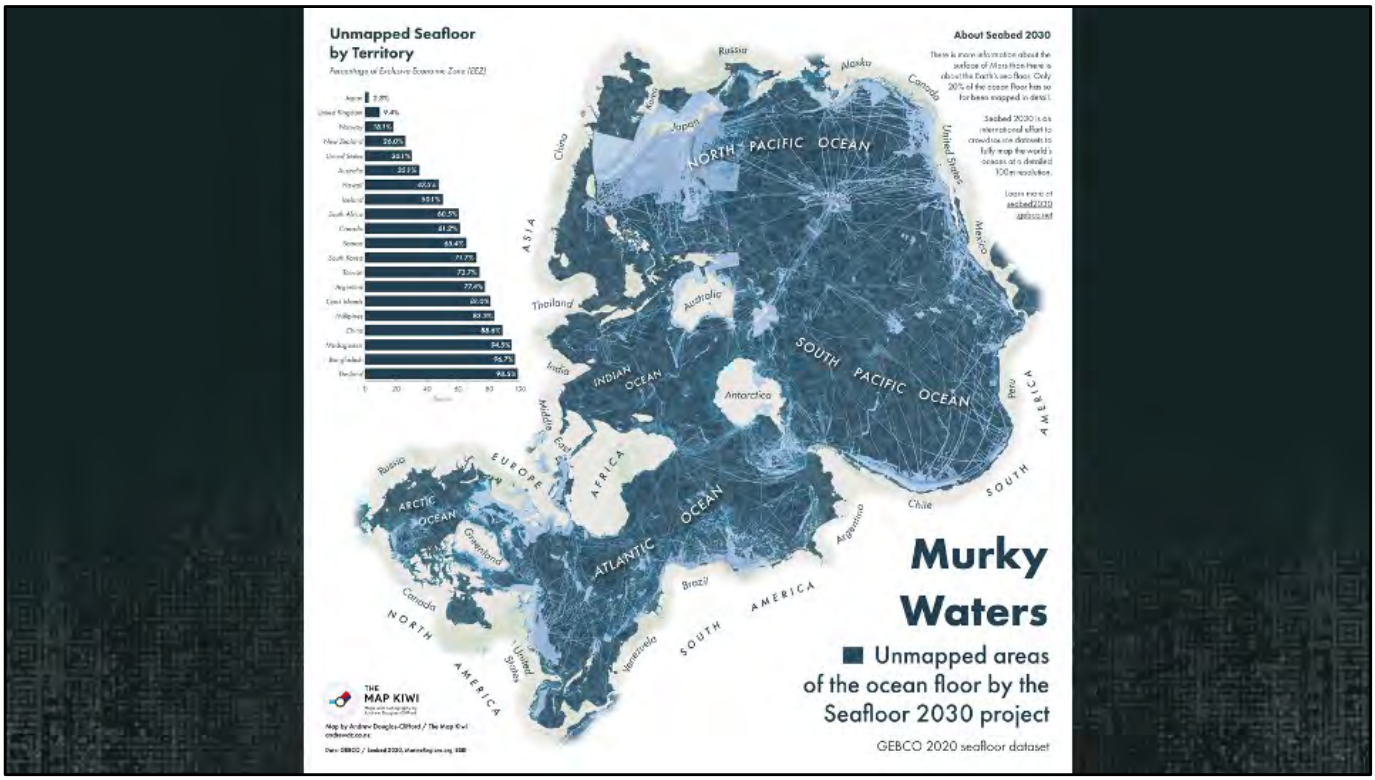


In this spirit I show what is referred to as a Spilhaus map, showing the ocean as ONE UNIFIED body of water centered around Antarctica. It is named after the distinguished meteorologist, oceanographer, and inventor Athelstan Spilhaus who developed the idea for this map in 1942, released it to great popularity in 1979 but never exposed the underlying mathematics for a coordinate system so that others could replicate it in a modern GIS. Our projection geometry team at Esri did the necessary mathematics required to create a Spilhaus projected coordinate system based on the Adams Square II map projection. And this is now available in both ArcMap and ArcGIS Pro to be used with all kinds of data. **Could it be that this unifying view of the ocean could be just what the ocean needs to get the attention its problems deserve? The UN Ocean Decade seems to really like it and has adopted it in part.**

Did you know? Athelstan Spilhaus designed the bathythermograph, as well as the weather balloon that was mistaken for a UFO over Roswell, New Mexico, and the skyways of Minneapolis, MN.

In the weeds cartographically: The Adams Square II projection can be used to re-create the Spilhaus map. It is actually based on work done by Oscar Adams in the 1920's, but David Burrows of Esri's Projection Geometry team has extended the equations to be fully oblique, which allows for the Spilhaus configuration, while also ellipsoidal, which allows for true conformality on an ellipsoid.

See also https://dusk.geo.orst.edu/Pickup/Esri/Science_flipbook/



To wit, and coming back full circle here is how cartographer Andrew Douglas-Clifford is using a Spilhaus map to show how much work is ahead of us for Seabed 2030.

Ocean Sciences Meeting 2022 | Virtual Plenary, March 1

Our Ocean, Our Future

Dawn J. Wright, Ph.D.

dwright@esri.com, @deepseadawn

esriurl.com/osm22

esri