Are We Delving Any Deeper? An Update on EMB Position Paper 22

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Future deep-sea research priorities taking into account developments in the EU maritime economy

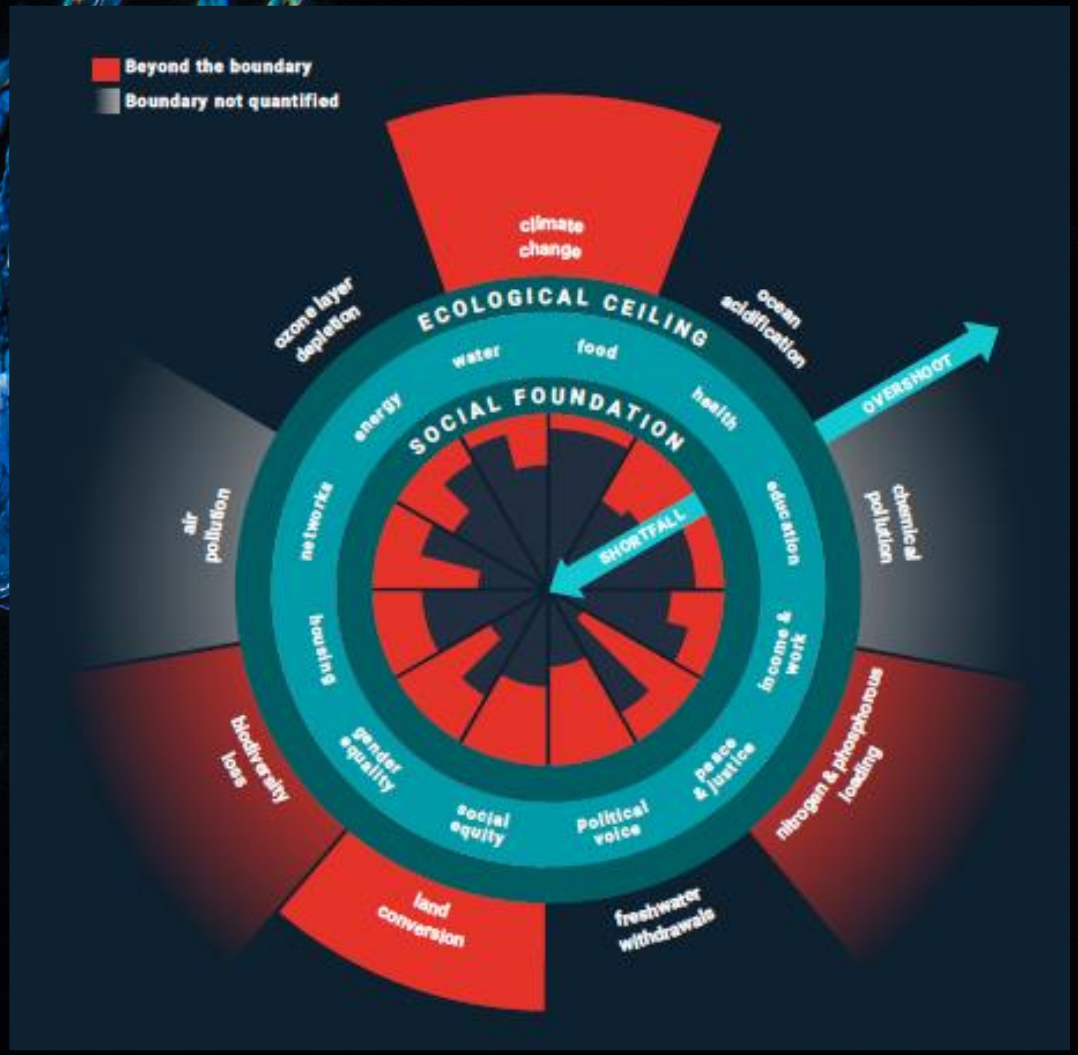
- Increasing fundamental knowledge
- Assessing drivers, pressures and impacts in the deep sea
- Cross disciplinary research to address challenges
- Innovative funding mechanisms
- Technology and infrastructure
- Human capacity in deep-sea research
- Data access
- Governance
- Ocean literacy

How the blue economy is changing: the blue doughnut

- **The Blue Economy recognises and respects the ecological limits which determine the safe operating space for economic activities and the minimum social standards that a fair economic model should address.**

- **The triple bottom line objectives of environmental sustainability, economic growth and social equity (Voyer et al., 2018).**

- **It should decouple socio-economic development from environmental and ecosystem degradation (Smith-Godfrey, 2016; World Bank, 2017).**

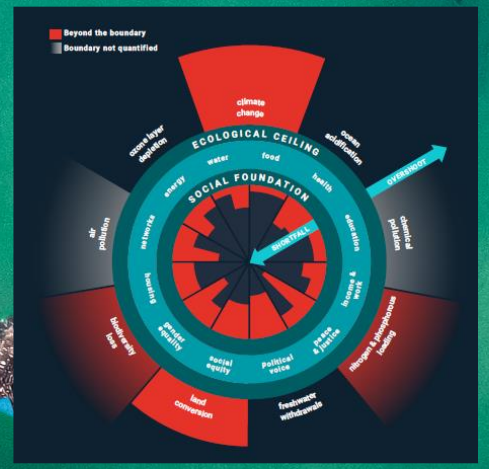


The doughnut of planetary and social boundaries. After Raworth K. (2017) Doughnut Economics.

21.10.2021 Image Richard Barnden

The triple bottom line

Sustainable economically



Equitable for People

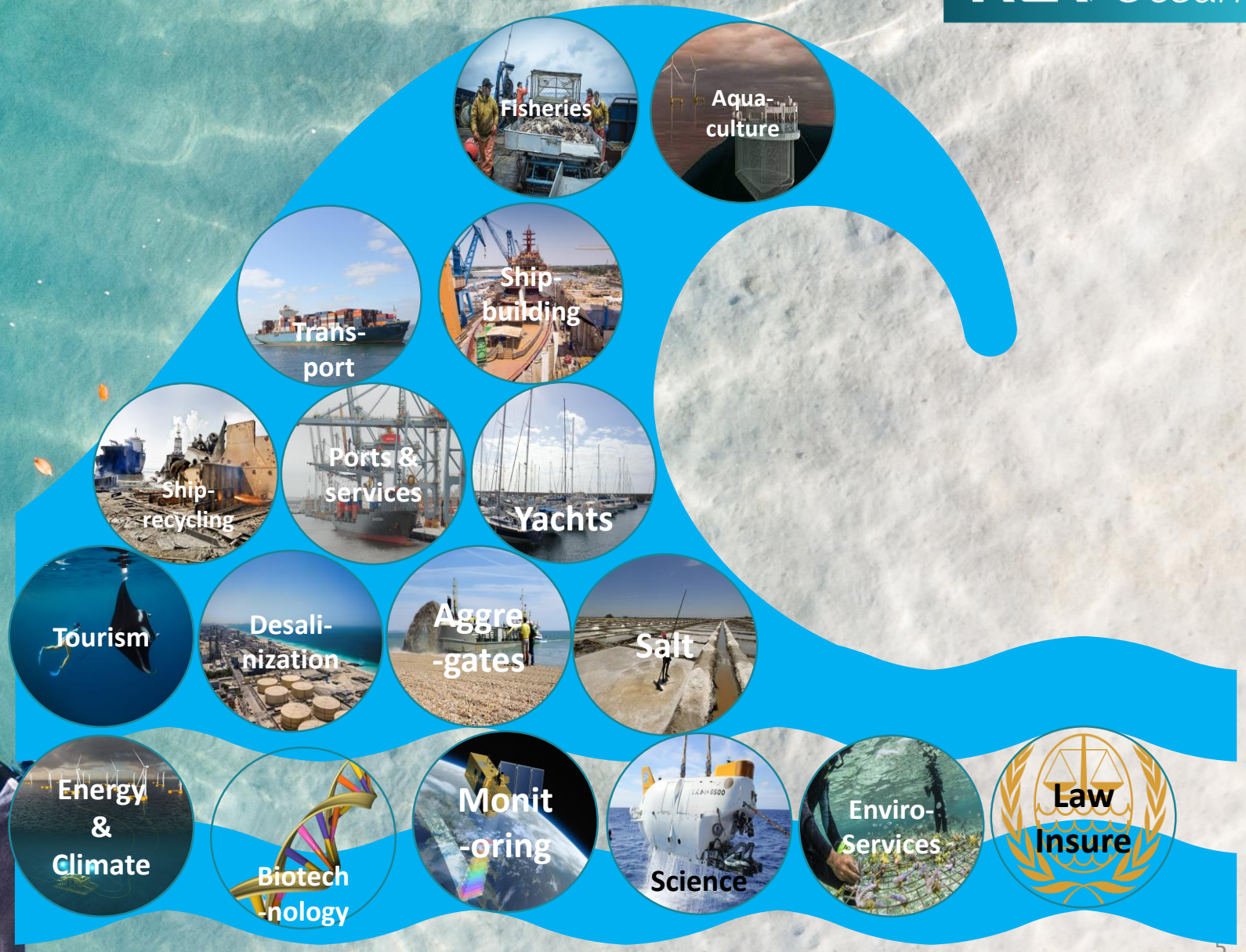
- Inclusive
- Distributive
- Just

Positive for the Environment

- Climate
- Biodiversity
- Ecosystem services

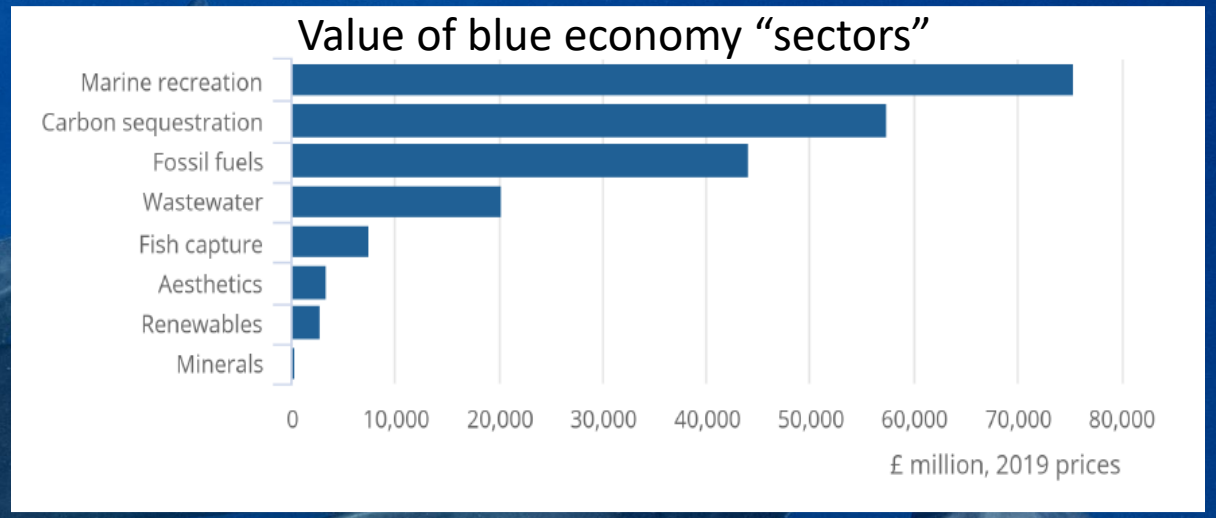
Elements of the ocean economy / blue economy

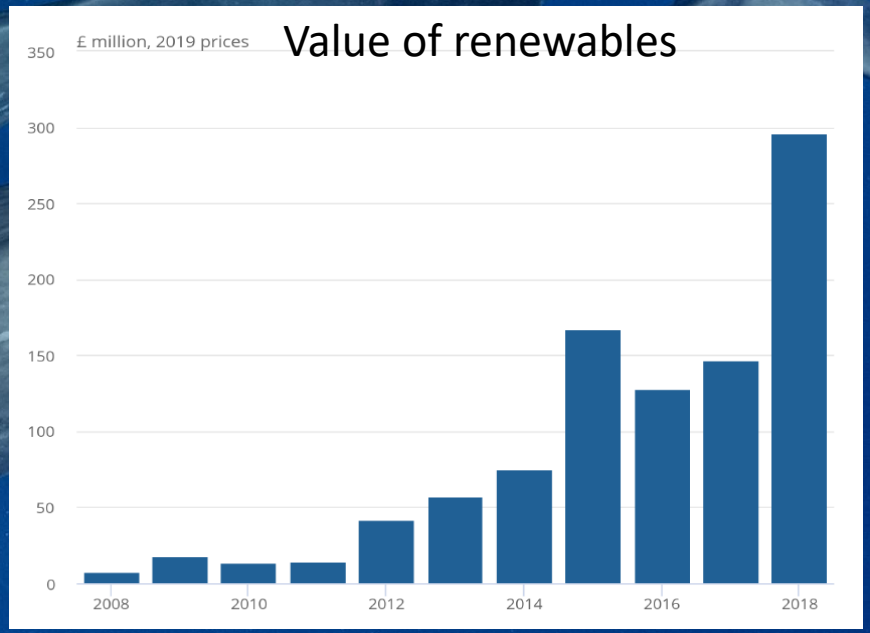
- Ocean economy = $1.5US trillion.
- ~ 33% oil & gas, 26% tourism, 13% ports, 11% marine equipment, 5% other.
- 31 million employed; industrial fishing ~ 36%, tourism 23%, other industries 1-8% (OECD, 2016).
- However, small-scale fisheries not included (100 million people) & more than half the fish catch.
- Ecosystem services not included.
- Many countries not properly accounting for the blue economy.



Marine Accounts, Natural Capital, UK 2021

- Followed the United Nations System of Environmental-Economic Accounting (SEEA)
- UK marine natural capital assets £211 billion
- CO_2 sequestration 10 – 60 million t per annum
- Value of marine renewable increased 37 times from 2008 – 2018
- Data incomplete for many aspects of natural capital accounting (e.g. more than a third of UK marine habitats classified as unknown).





Decomissioning of oil and gas infrastructure

- Decarbonising the economy is essential
- Means that the offshore oil and gas infrastructure in the North Sea and elsewhere will need to be dismantled
- Deep-sea disposal is likely to be raised as a cheap option
- Relative impacts of various disposal options will need to be understood

© Marten van Dijl / Greenpeace


New Era of Ocean Economy Opportunities
Floating Wind Power
Offshore Aqua Culture
Landfall and power storage/balancing
Subsea Data Centers
Floating and Subsea Power Stations
Critical Infrastructure
Power Hubs
Data and Software
AkerSolutions

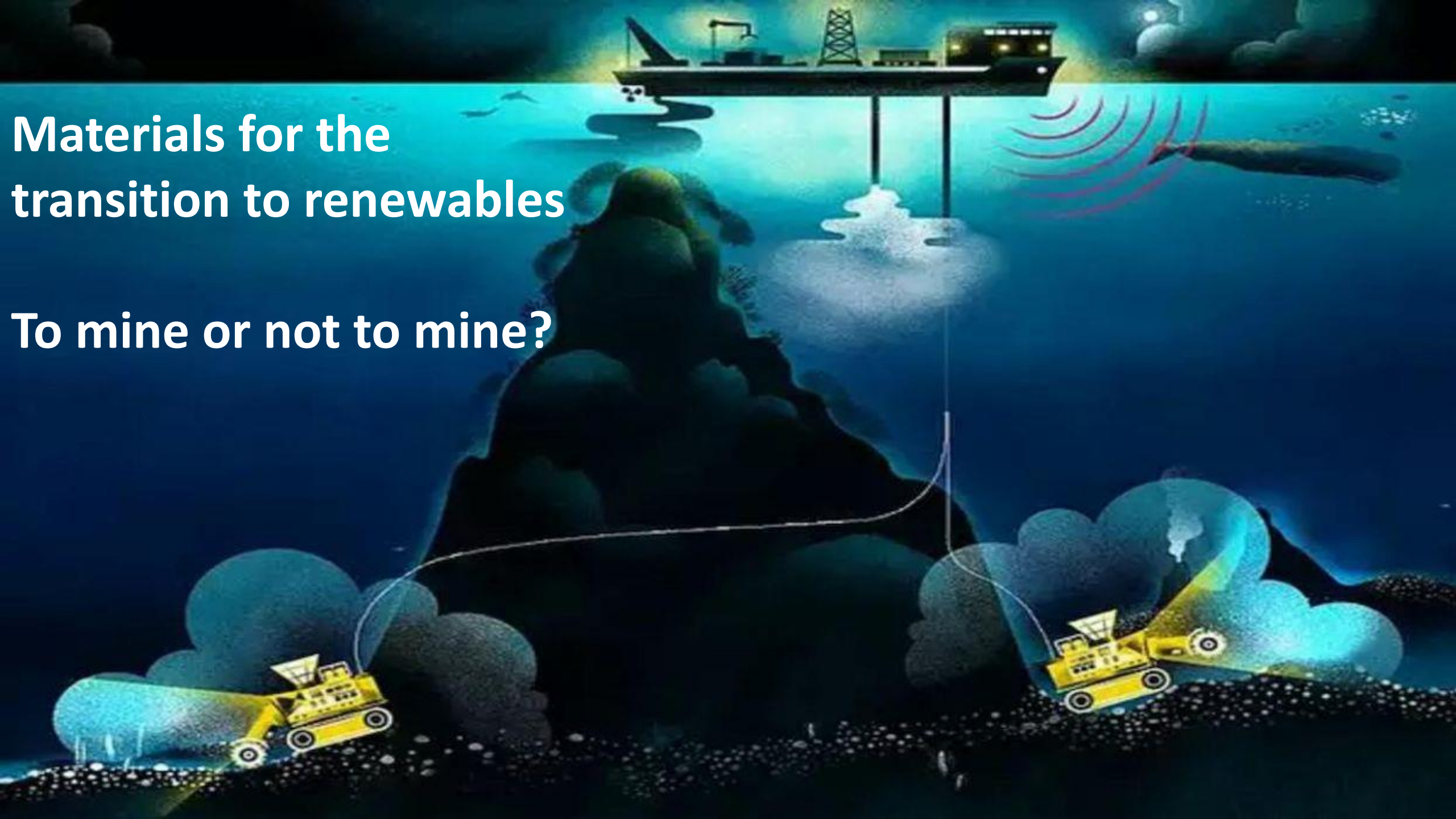
Drivers for Deepwater Wind Power

- 80% of offshore wind resources found in water depths of >60 meters
- Deepwater Technology now available
- Not In My Back Yard (NIMBY)
- More Wind Energy Further From Shore

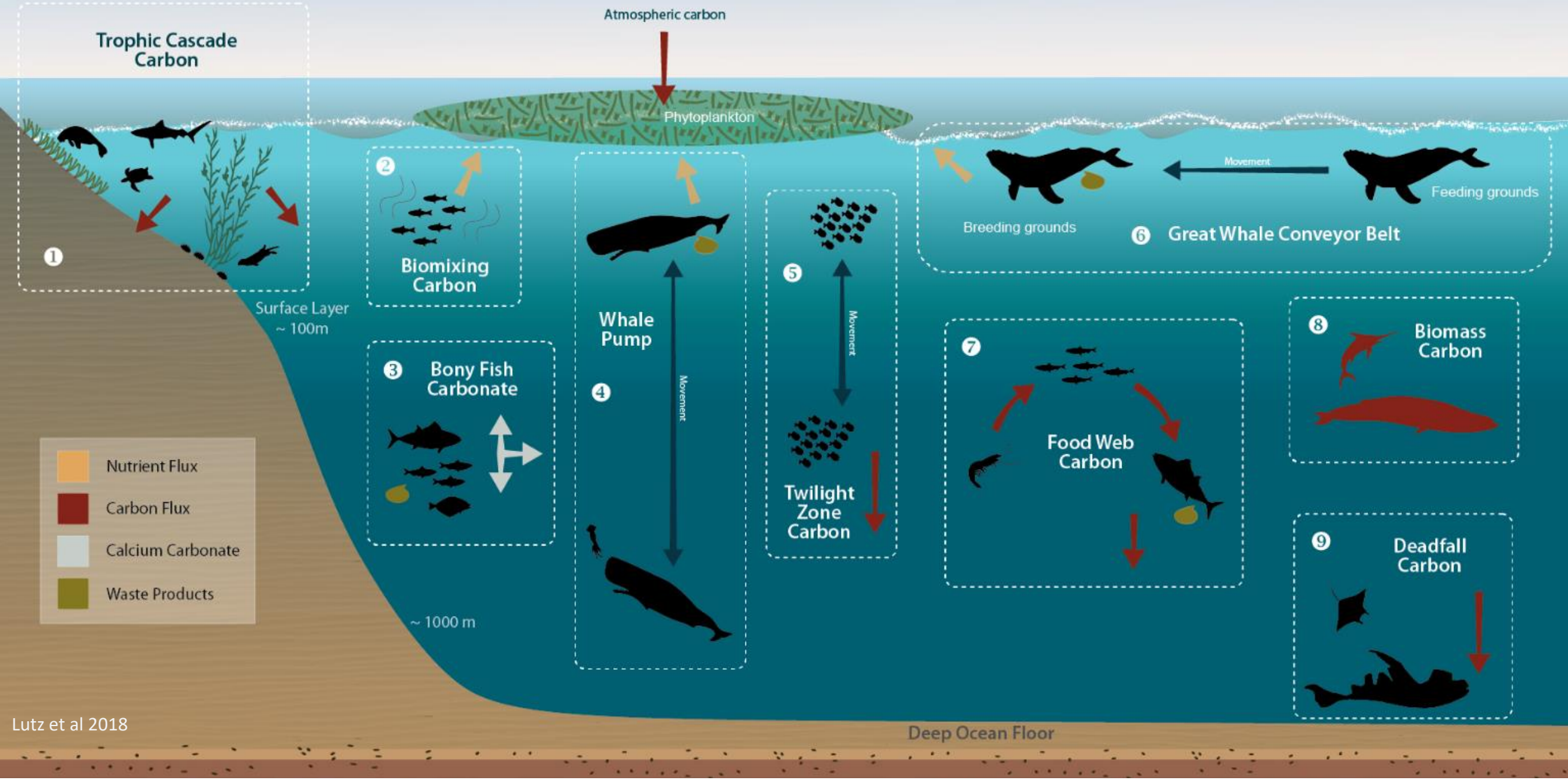
Capacity factor by wind concept:

Onshore Wind ~30% → **Offshore Bottom-Fixed ~40%** → **Offshore Floating ~50%**

Sources: EIC Global Offshore Wind report 2019; Norwep, Equinor, internal analysis


Materials for the
transition to renewables
To mine or not to mine?

The role of the open ocean in carbon sequestration

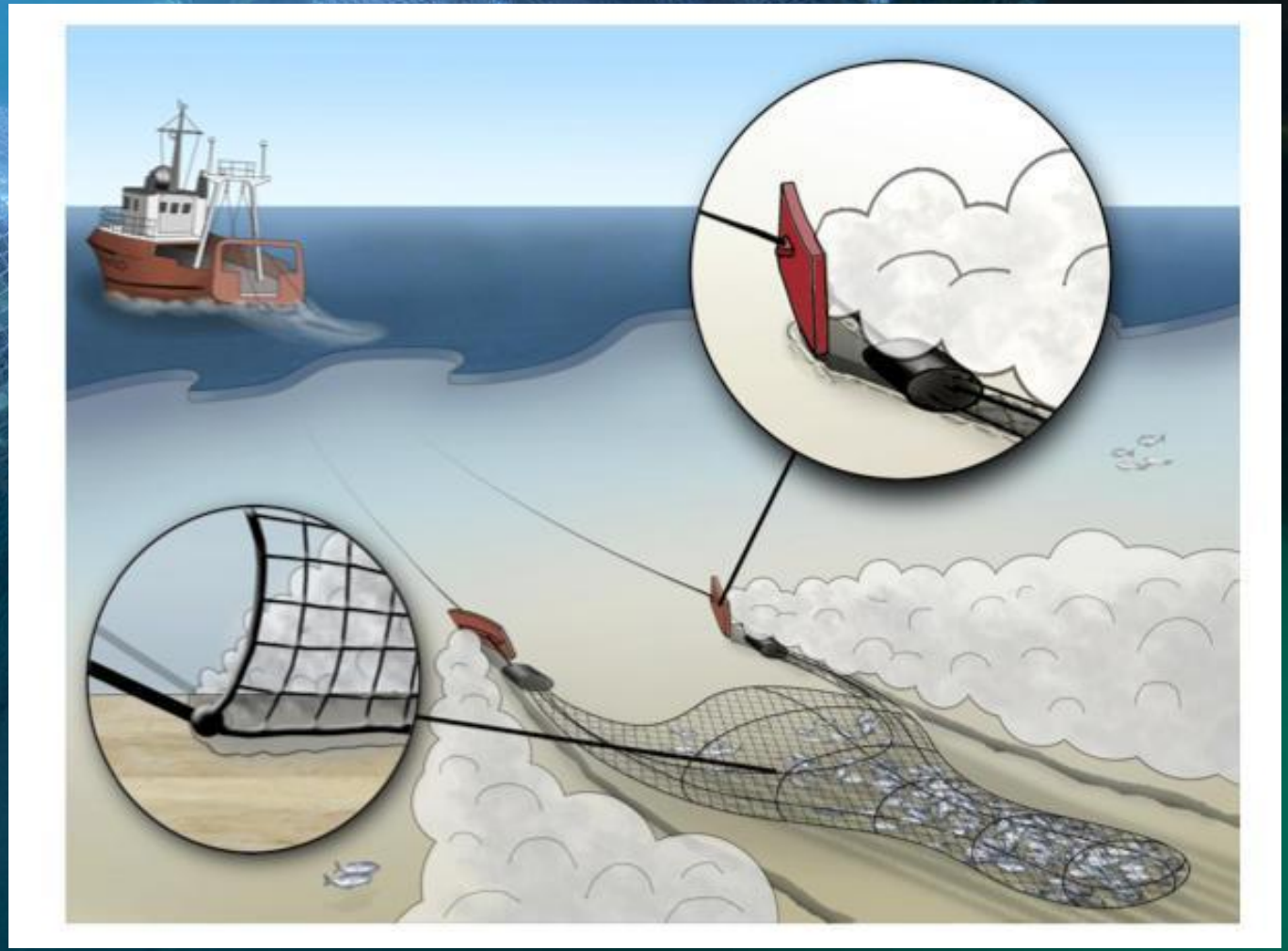


Lutz et al 2018

Bottom trawling resuspends sediment and releases CO_2

- 4.9 million km^2 trawled per annum
- 1.3% of the seafloor
- 1.47 Pg of increased emissions as a result of increased carbon metabolism in sediment
- Emissions decrease in subsequent years for repeated trawling but still 0.58 Pg per annum

Sala et al 2021 Nature https://doi.org/10.1038/s41586-021-03371-z



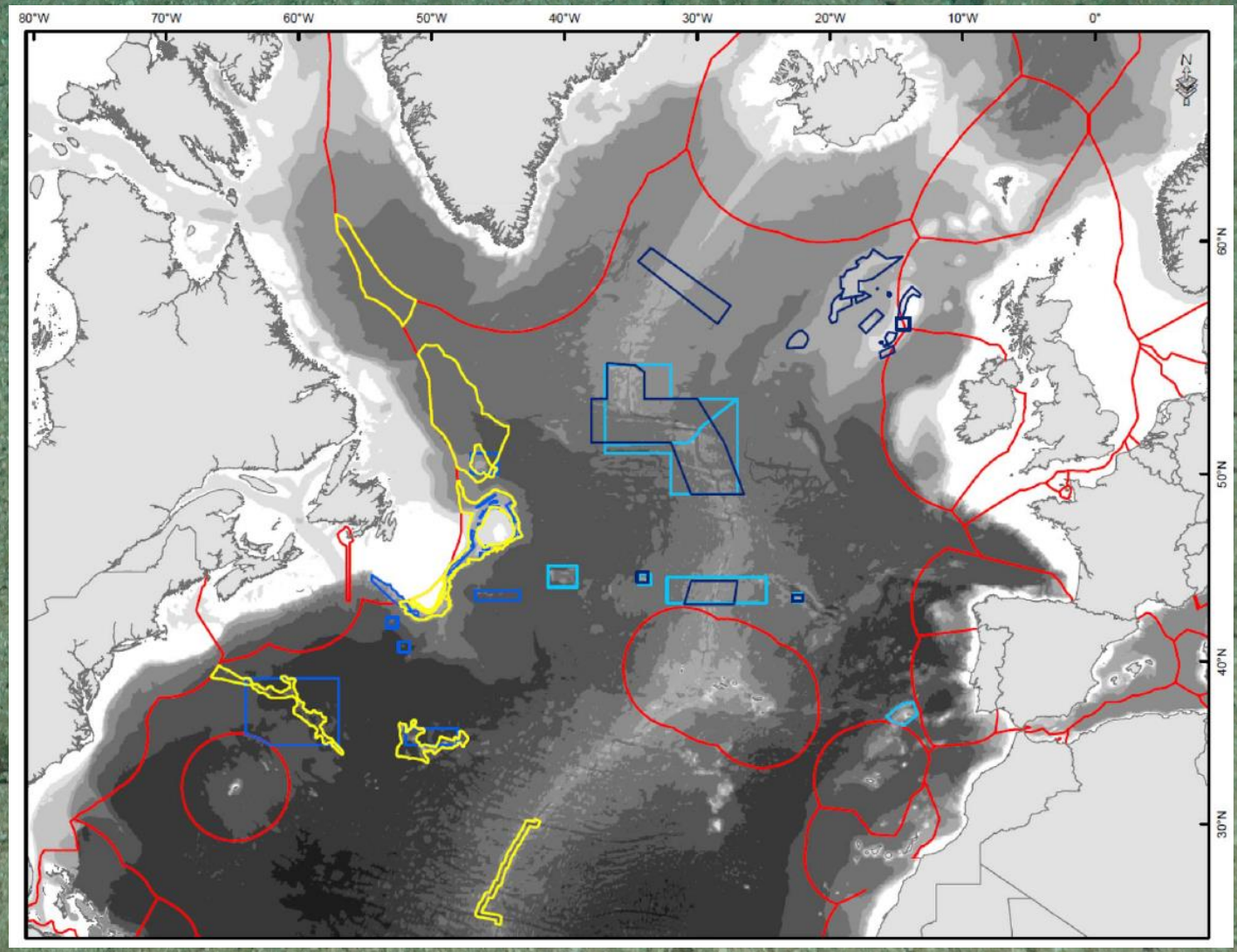
Ferdinand Oberle

Gigatonne disposal of seaweed in the deep sea

Sierra Club

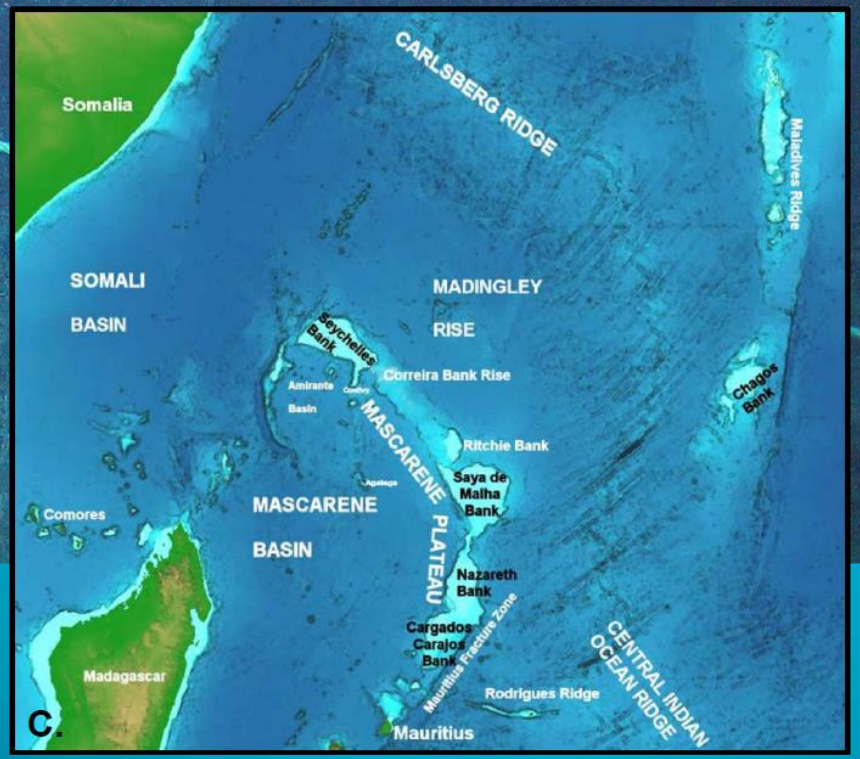
Progress in establishing protected areas by RFMO and other regional agreements

- FAO Guidelines for Sustainable Management of Deep-Sea Fisheries in the High Seas (2008)
- RFMOs and States have implemented EIAs for deep-sea fisheries, move on rules for encounters with VMEs and established areas protected from bottom-contact fishing



Saya de Malha Bank, western Indian Ocean

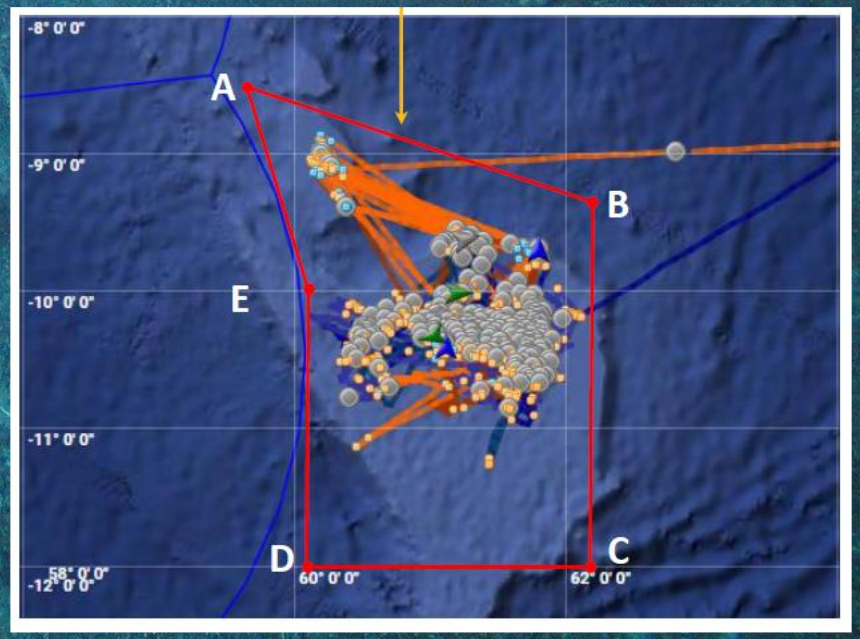
- One of the largest seagrass beds in the world
- Also zooxanthellate coral habitat in shallow water
- Described species include many endemic to the bank or ridge
- Deep-sea ecology poorly characterised
- Candidate World Heritage Site
- Ecologically and Biologically Significant Area



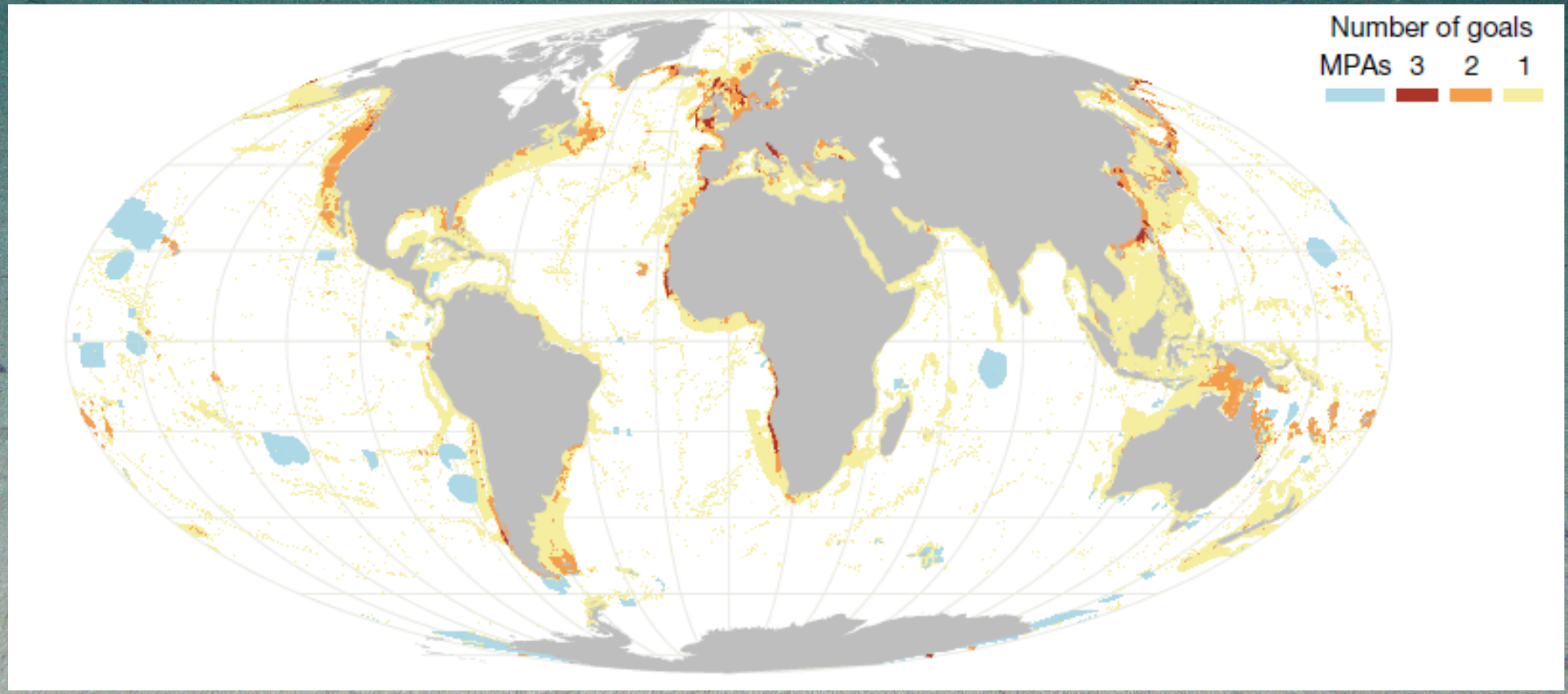
Since 2015 trawled by Thai fleet

- **Russian work summarised in 2008 by Vortsepneva concluded that trawling might *"may irreversibly destroy seagrass and coral biotopes"***
- **In the JMA between Seychelles and Mauritius but fishery managed by the Southern Indian Ocean Fisheries Agreement (SIOFA) an RFMO**
- **No prior consideration of impacts, seagrass not listed on VME list**
- **Year 1 22,729t of fish taken by 56 vessels, catches have since declined rapidly**

Implementation of FAO Guidelines uneven; RFMOs lack expertise in environmental issues

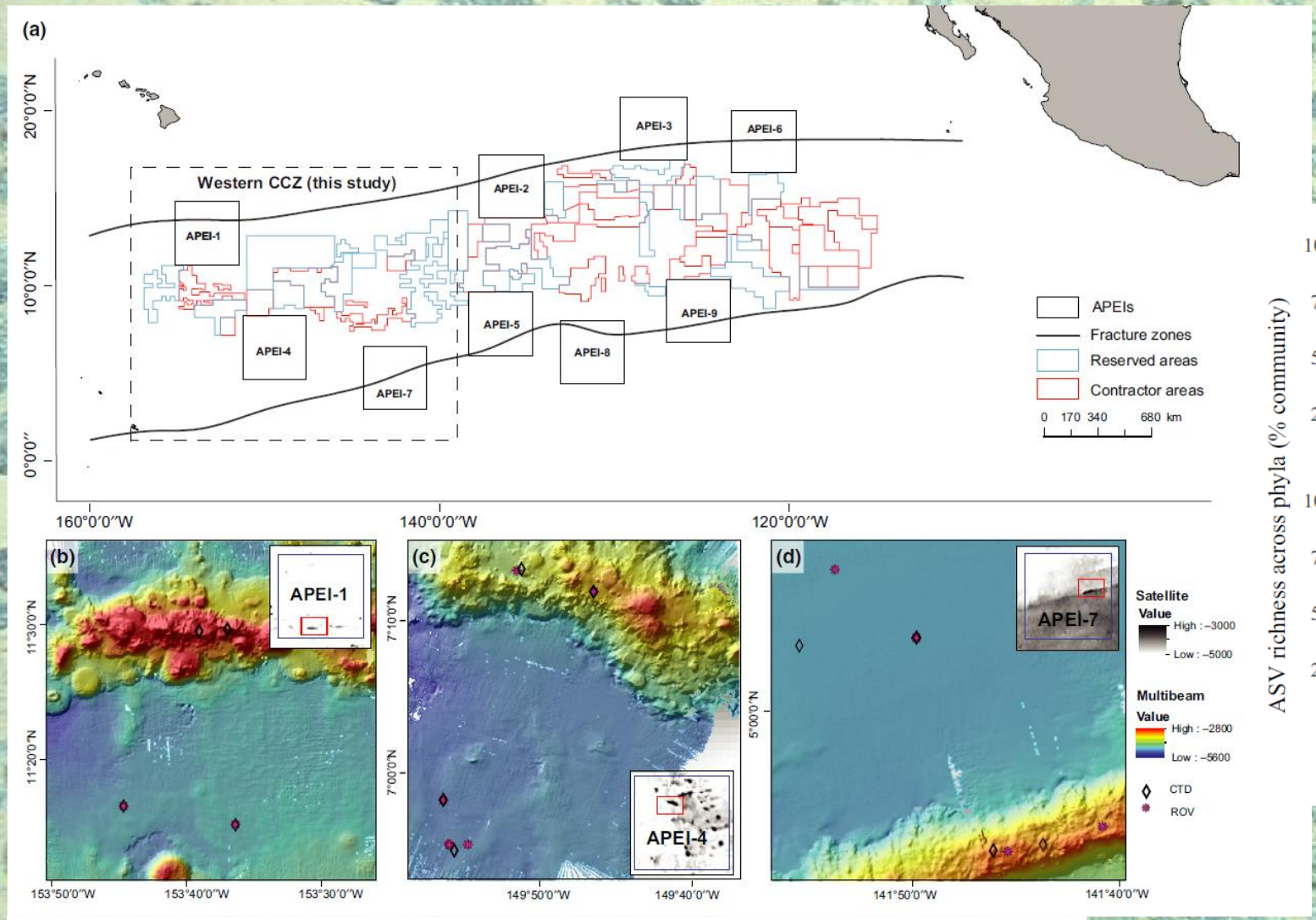


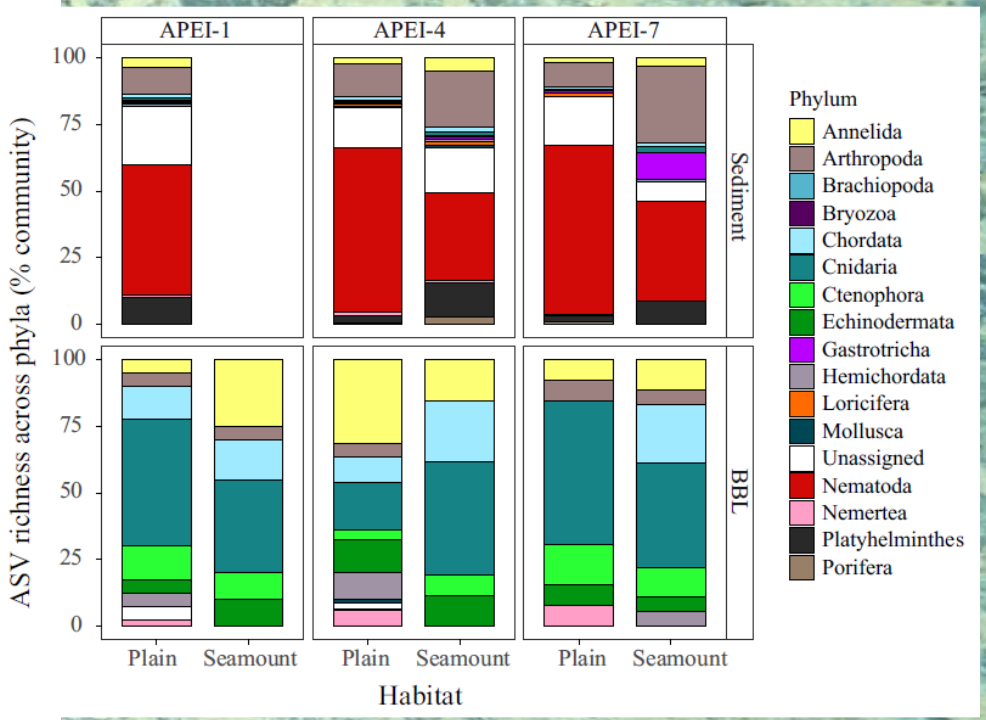
Where to protect the ocean?



Sala et al (2021) Nature 592: 397- 402

Increasing fundamental knowledge

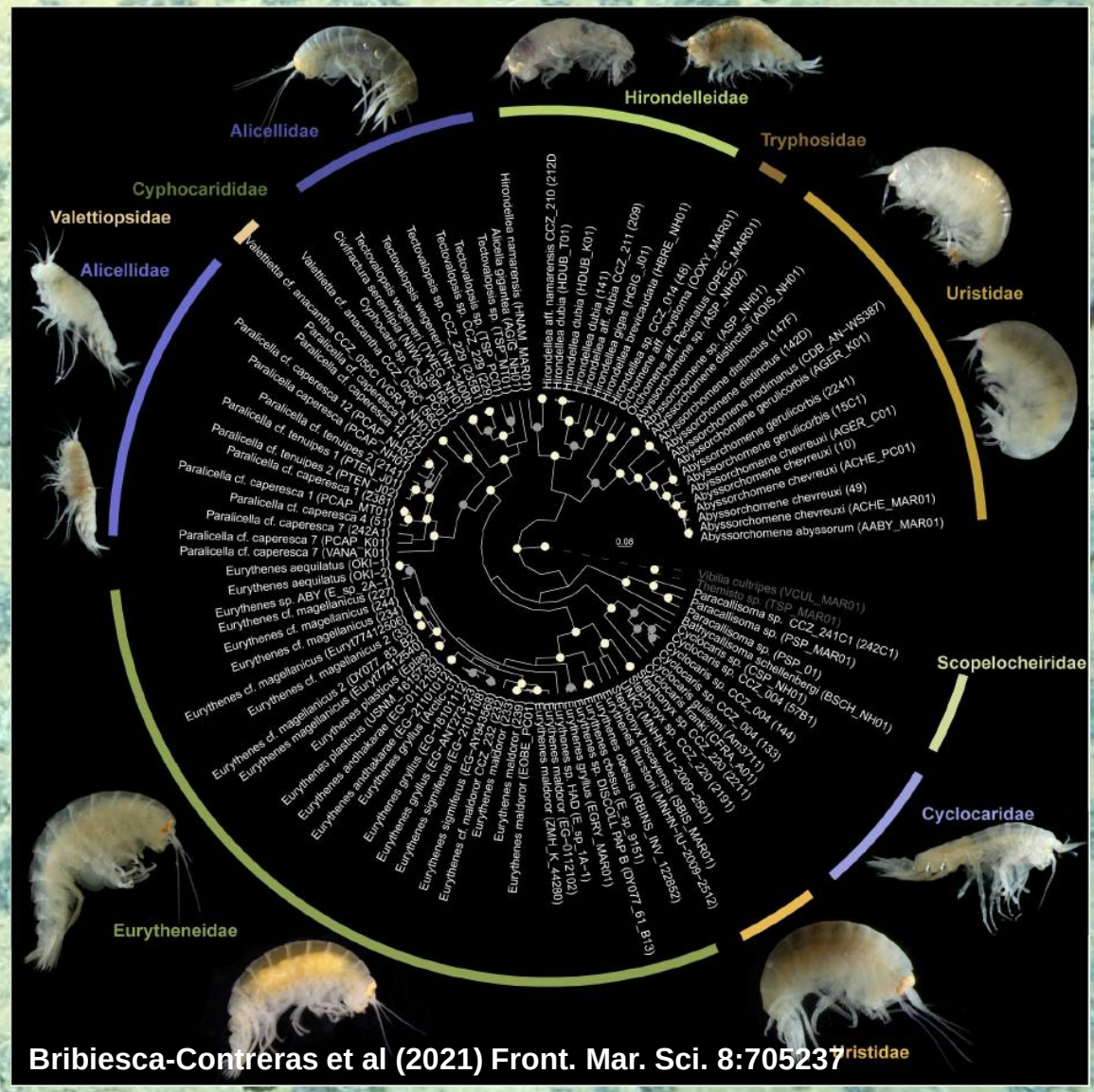




Laroche et al. (2020) Molecular Ecology 29: 4588-4604

Metabarcoding, metagenomics and integrated taxonomy

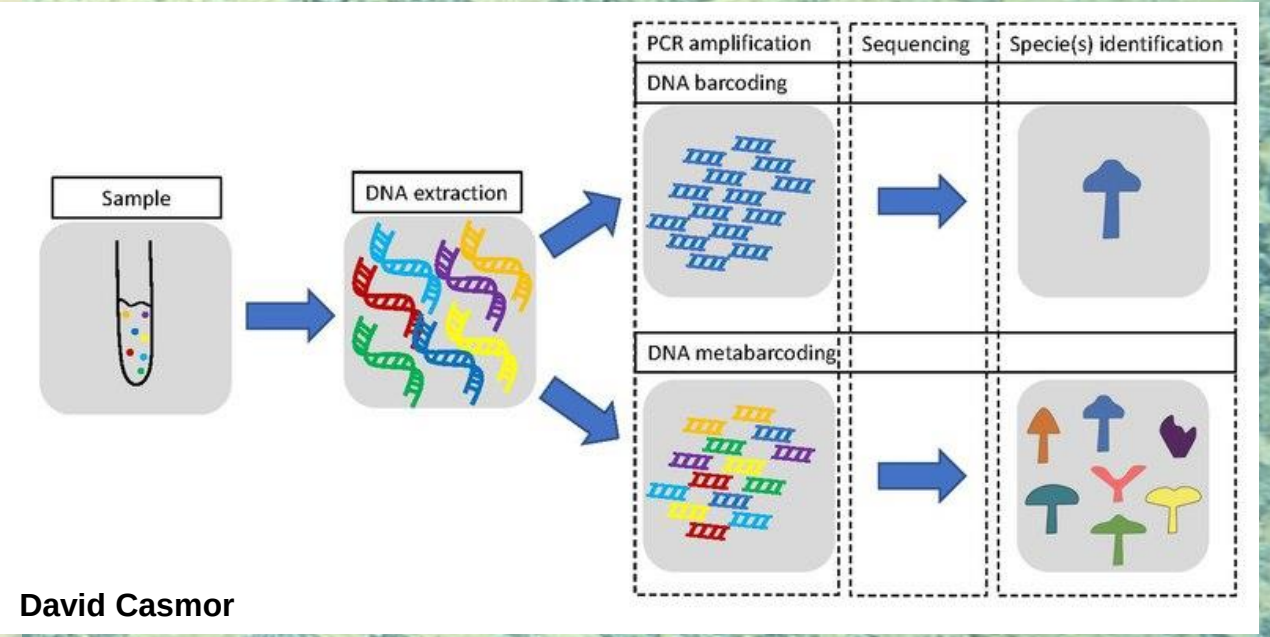
- Barcoding is the use of a short DNA sequence to identify taxa
- Metabarcoding is where environmental (e)DNA is used to amplify and sequence the barcoding molecule
- Third generation sequencing now enables sequencing of entire genomes at sea from eDNA
- Genomic skimming enables pulling key genes out to identify taxa (e.g. mitochondrial genome and nRNA genes)



Bribiesca-Contreras et al (2021) Front. Mar. Sci. 8:705237

Issues with the genetic approach

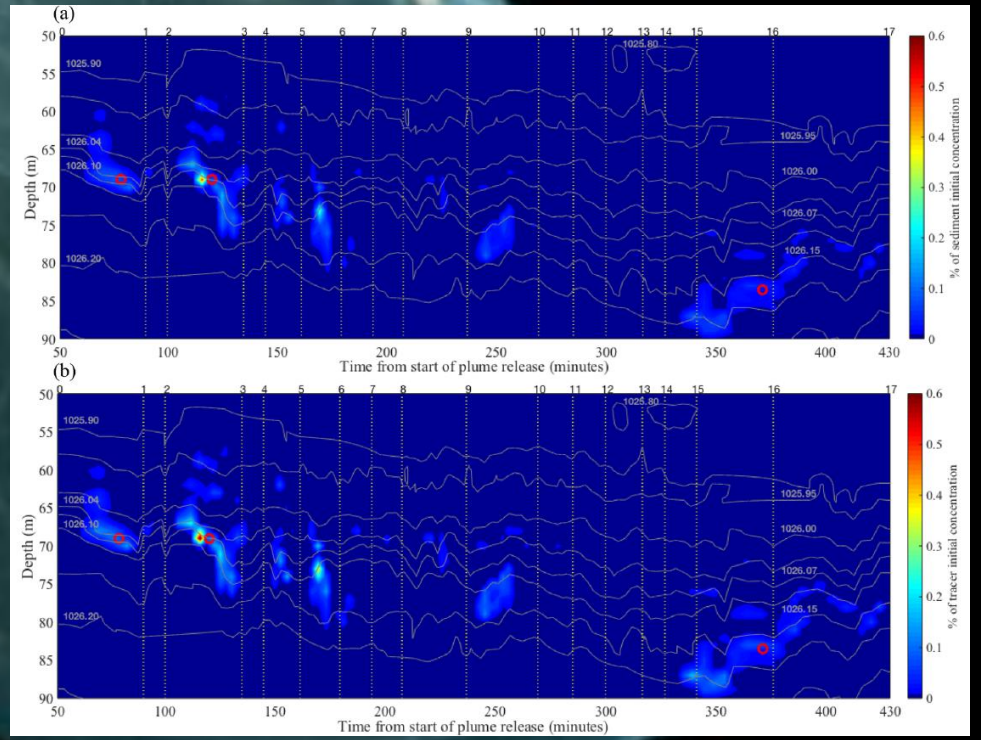
- Barcoding libraries have high error rate and only a small proportion of species represented (~14% in shallow water)
- Limitations not fully understood
- Methods, including of data analysis need standardisation
- Without species identification / description no additional information on biology / ecology
- Linking data across biodiversity databases an issue



David Casmor

Assessing impacts e.g. plume dispersal modelling for deep-sea mining

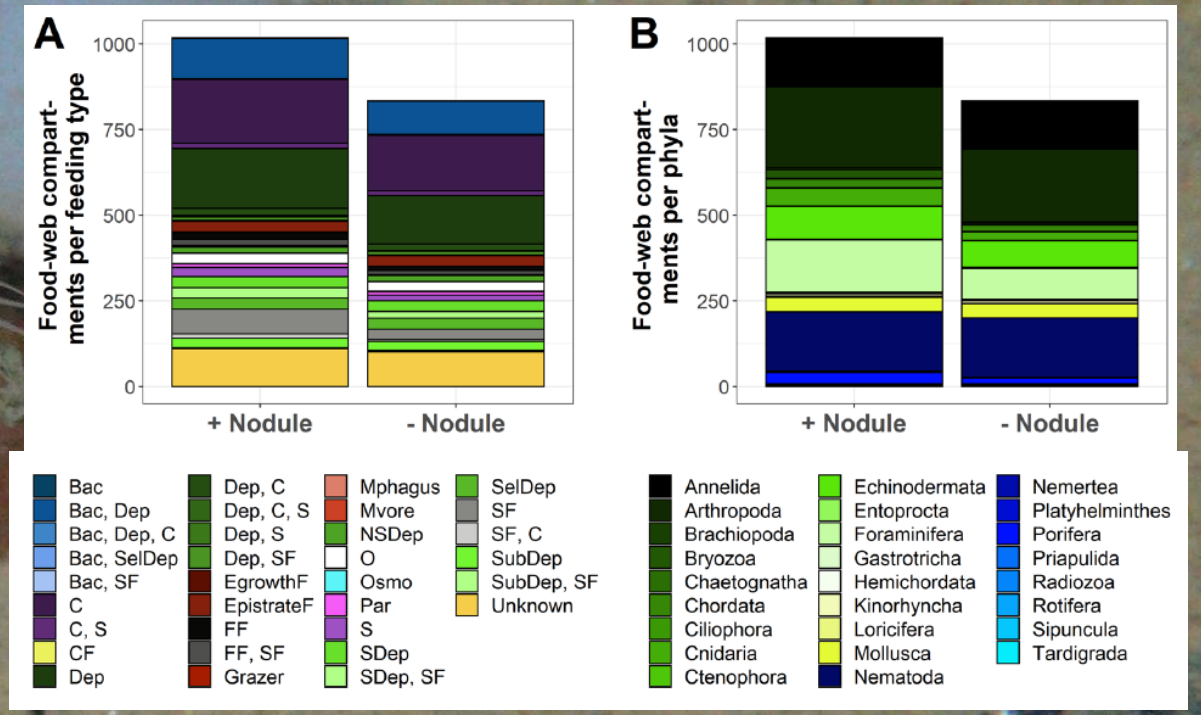
- Sediment release with at sea measurement of dispersal using a phased array doppler sonar and a CTD mounted with a combined turbidity sensor and fluorimeter (to measure rhodamine dye added to sample)
- Results used to validate a plume dispersal model(s)
- Shows that the sediment plume settles across more than 1000km of seabed in various directions over a year of a typical mining operation

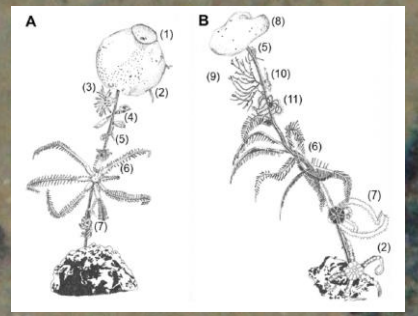


Muñoz-Royo et al (2021) Comms Earth Environ 2: 148

Assessing impacts: Food-web integrity & deep-sea mining

- Combination of literature research and analysis of deep-sea videos
- Identified trophic and non-trophic interactions in CCFZ and Peru Basin
- Knock-down effects of nodule removal were estimated to be 17.9%(CCFZ) – 20.8%(PB) loss of taxa and 22.8%(CCFZ) – 30.6%(PB) loss of network links
- Most impact taxa were stalked sponges





Stratmann et al (2021) Sci Reps 11: 12238

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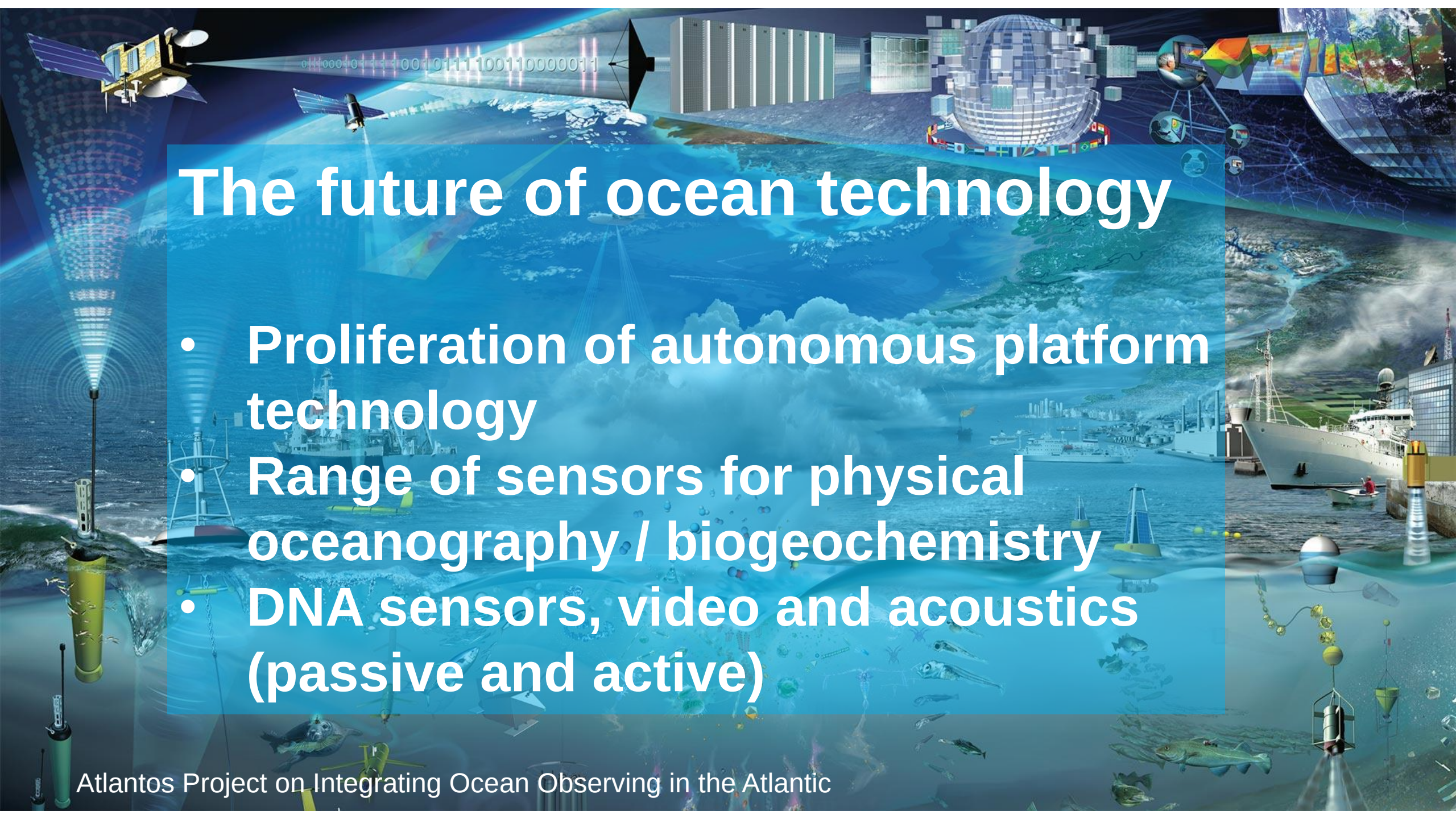


The future of ocean technology

- Proliferation of autonomous platform technology
- Range of sensors for physical oceanography / biogeochemistry
- DNA sensors, video and acoustics (passive and active)

The future of marine science still has ships

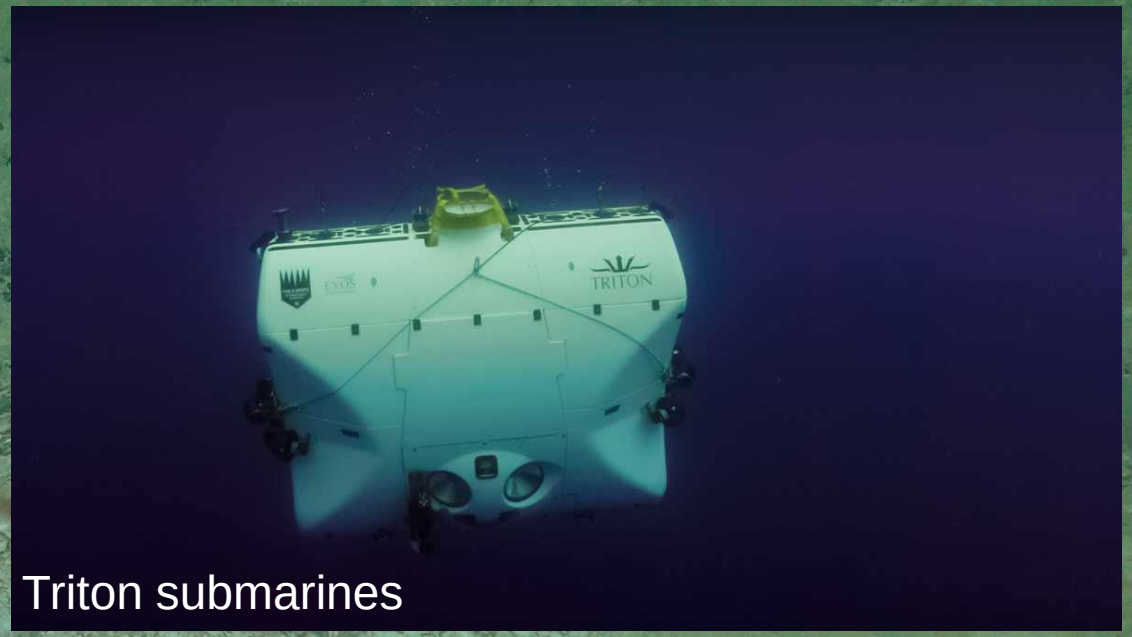
- Using “mother ships” to deploy a variety of other platforms & sensors will massively increase data collection
- Still a need to interact with the seafloor (esp. for biology)
- Technology to sample mid-water / deep-pelagic ecosystems
- Communications in real time ship to shore and back (virtual participation in cruises; adaptive management of ops; real-time data collection and delivery to user)
- Renewable power sources for vessels and platforms
- Autonomous vessels likely to supplement crewed fleet

Baird Maritime

Marine Insight

Funding has diversified

- Philanthropic funding of ocean science growing but also novel sources such as crowd funding
- More public-private partnerships
- More industry funding for deep-sea science (e.g. marine mining)
- Post Covid many demands for government funding but a recognition of the importance of science / technical advances driving knowledge-based industry
- Increasing prevalence of blue economy = higher demand for ocean science?
- Data – should it remain free for all?

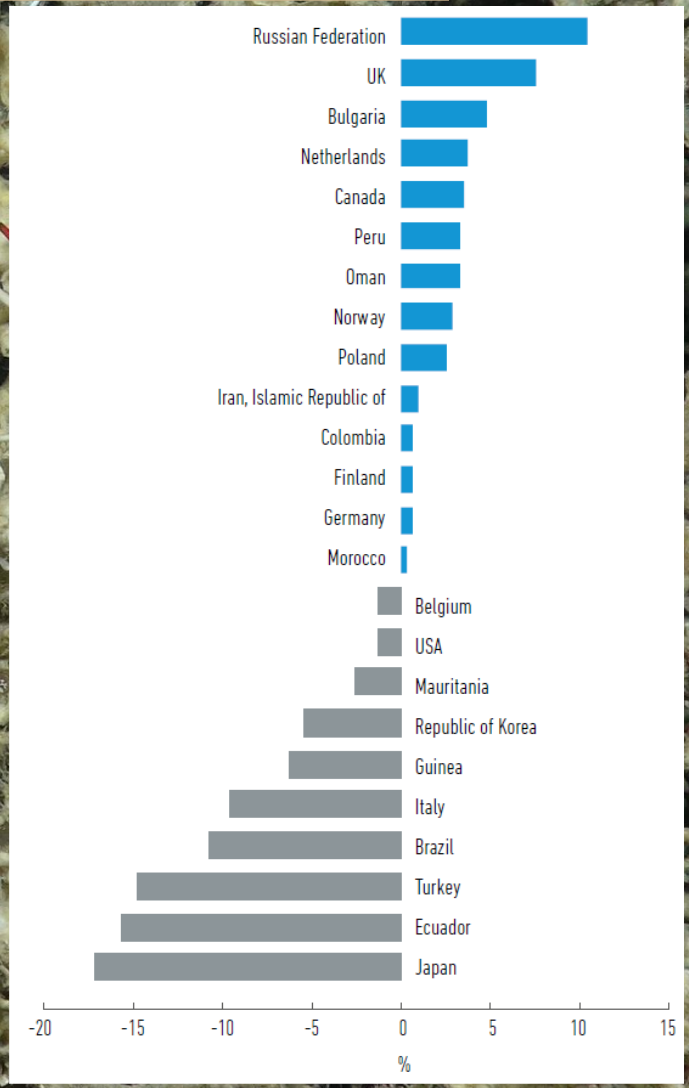


Triton submarines

Schmidt Ocean Institute

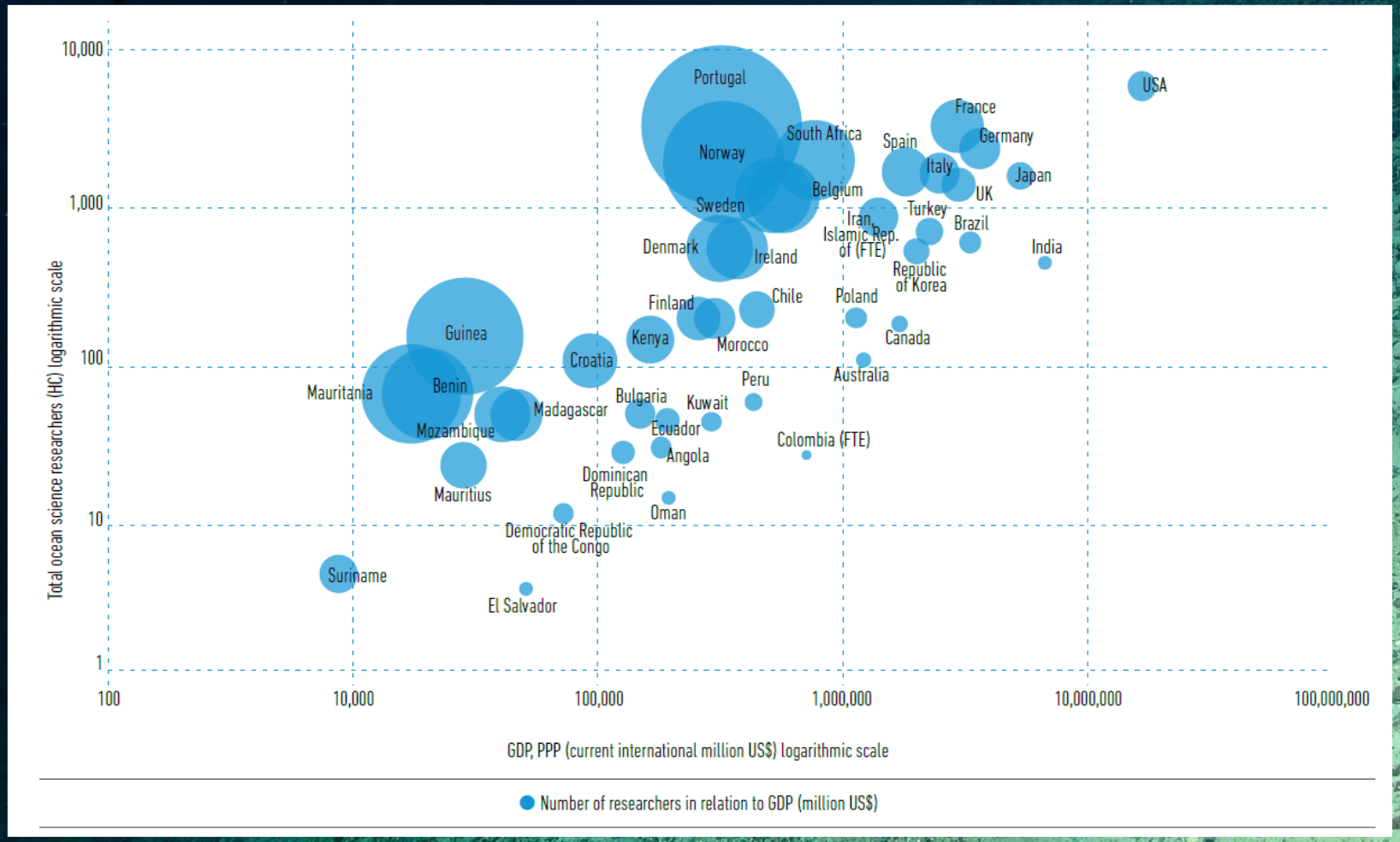
Ocean science expenditure over time indicates a mixed picture

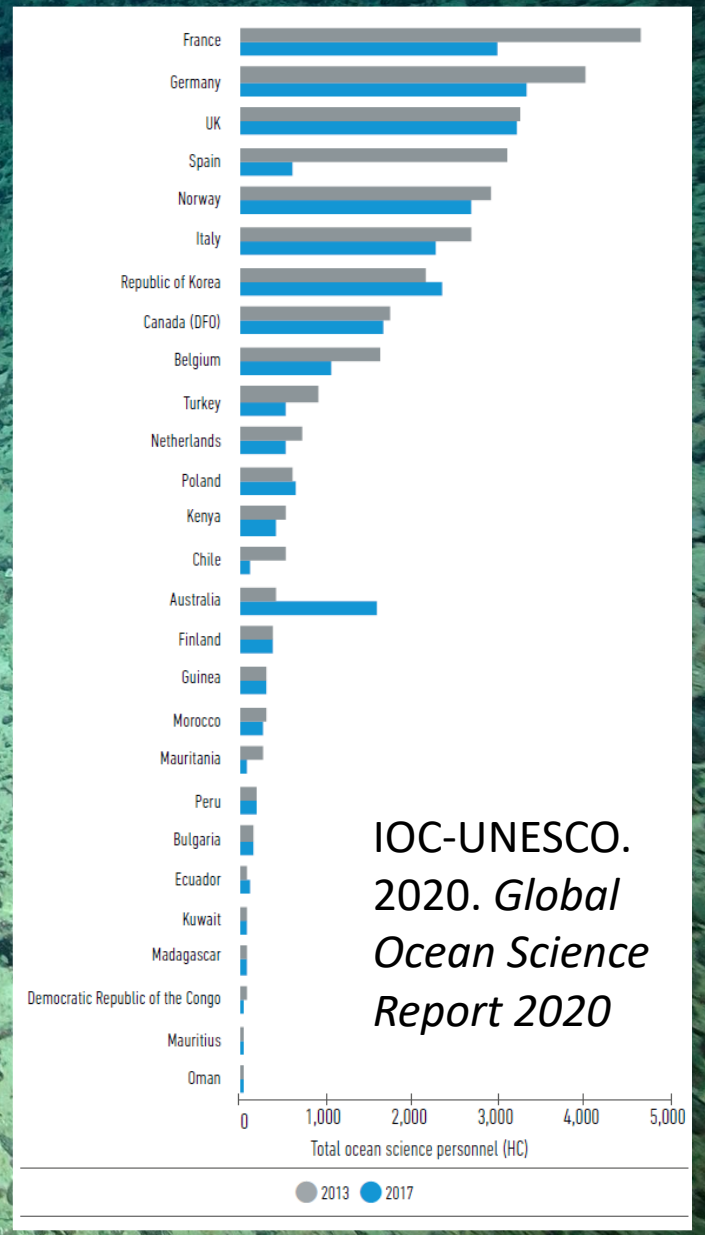
- The picture for government funding of science is mixed
- Figures from 2013 to 2017 show some countries increasing funding but other decreasing, some such as Japan by a substantial amount (>15%)
- The share of government R&D money spent on marine science is small compared to other fields
- Science budgets in developing countries much lower than in developed



IOC-UNESCO. 2020. *Global Ocean Science Report 2020*

Human capacity





IOC-UNESCO. 2020. *Global Ocean Science Report 2020*

Human capacity versus GDP generally much lower in developing countries.
Significant loss of capacity in many countries including in Europe.
Will see increased competition for ocean scientists as blue economy grows.

UN Decade of Ocean Science for Sustainable Development

REVOcean

- Declared by UN 2017, initiated 2020
- Aimed to generate the global ocean science to support the SDGs
- 335 Approved actions to date
- Many are relevant to deep-sea science (e.g. Challenger 150)
- Important opportunity for capacity building

Howell et al (2020) Front Mar Sci 7:584861

Governance

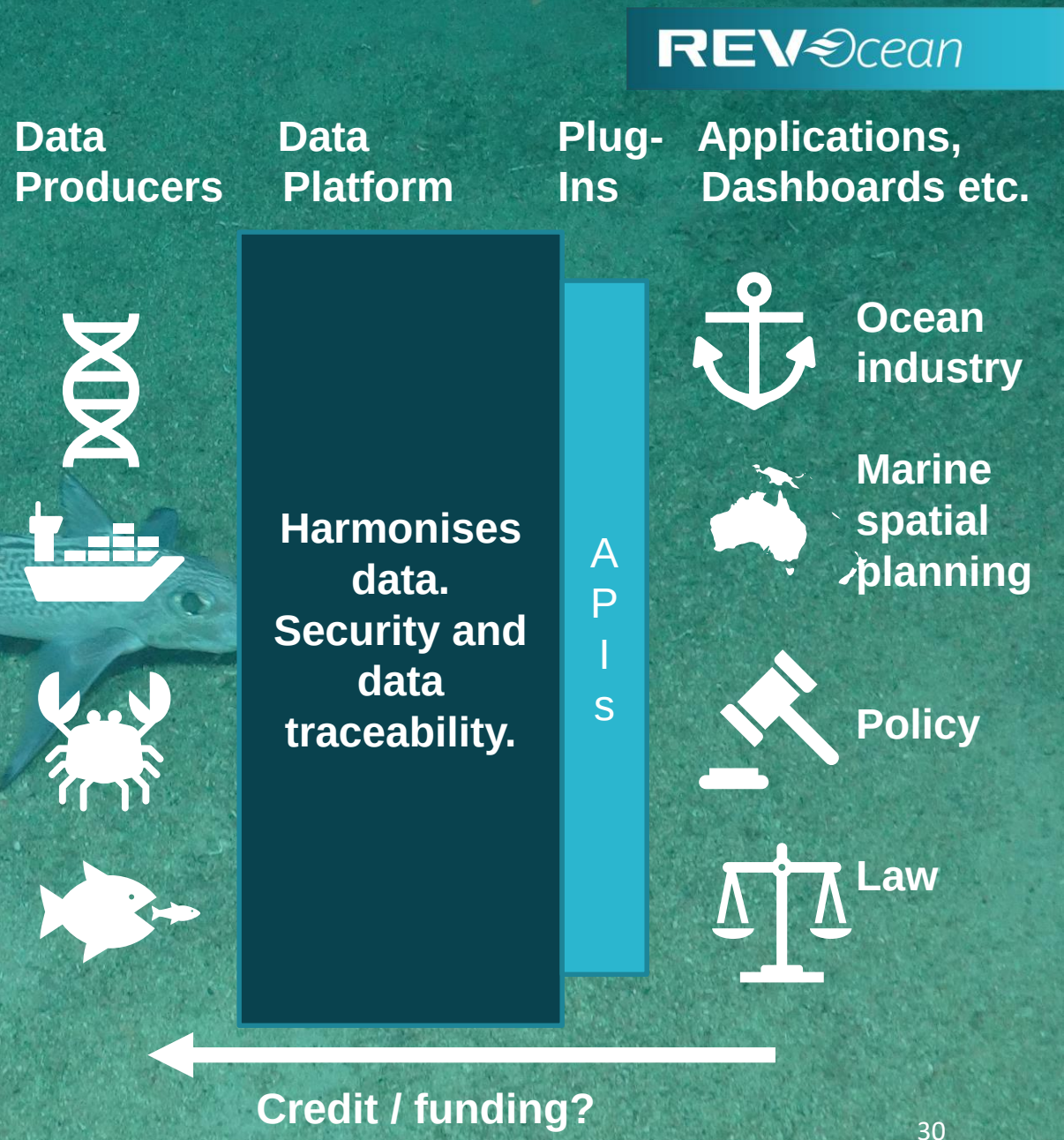
- **Biodiversity Beyond National Jurisdiction Treaty**
  - Protected areas, EIAs, MGRs, capacity building & knowledge transfer
- **Climate negotiations (COP26)**
  - Increasing role of the oceans in mitigating CC and as being effected by CC
- **Convention for Biological Diversity**
  - 30% of the oceans in MPAs or other effective area-based conservation mechanisms
- **Sustainable Development Goals**
  - Human well-being, equity, environmental sustainability

Photo credit: Earth Negotiations Bulletin, IISD

Direct roles for marine scientists: Delegations; Advising Governments, IGOs / NGOs; Informal Contact Groups for Delegations; Writing synoptic papers / reports; talking to media

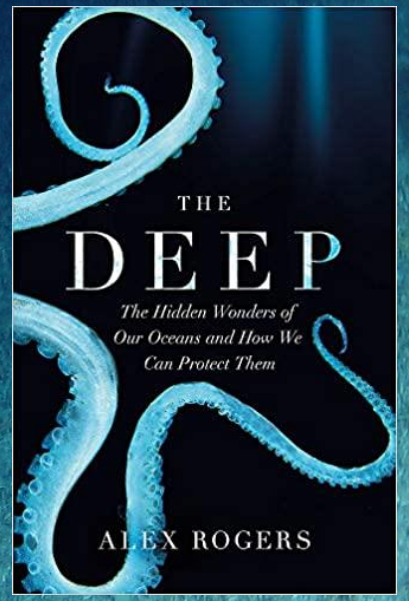
Data

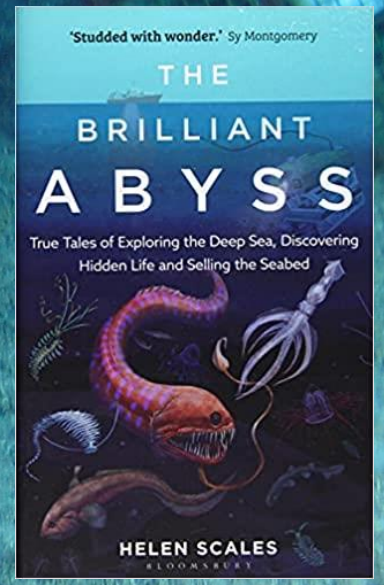
- Trend of vastly increasing data production
- Many ocean databases still fragmented, not interoperable, not suited to machine – machine communication (therefore not FAIR)
- Translation of data to actionable knowledge for decision makers
- Data platforms (e.g. https://www.oceandata.earth/)
- Digital twin of the ocean (e.g.https://ec.europa.eu/info/sites/default/files/research_and_innovation/green_deal/gdc_stakeholder_engagement_topic_09-3_digital_ocean.pdf)

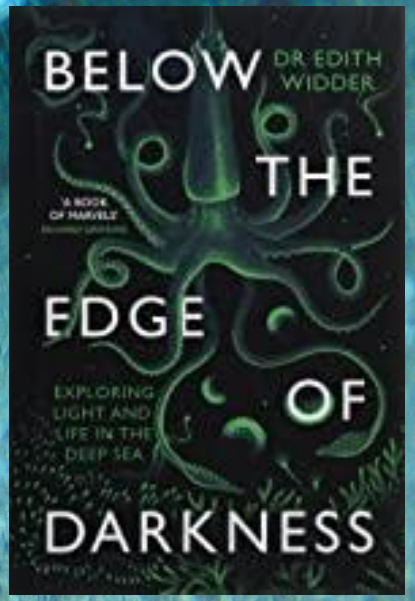


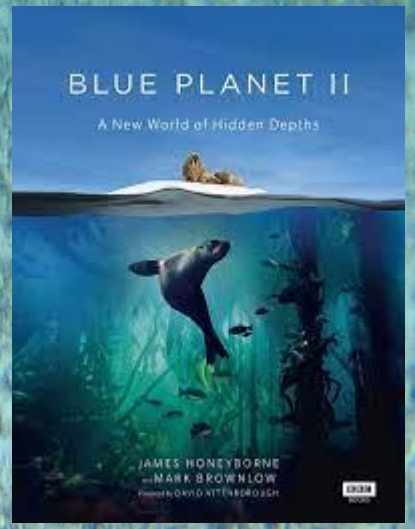
Ocean literacy

- Traditional forms of outreach are popular but readership is likely to be the “converted”
- Octonauts reached children with factual content about the oceans
- Blue Planet II had a strong effect on the UK public especially regarding plastics
- Film / video now generally comes with other digital content









Engaging and inspiring the public

- Immersive experiences
- Citizen science (e.g. iNaturalist)
- Campaigns run on social media
- Celebrity involvement
- Crowd funding
- Sponsorship
- Giving the opportunity to engage and be involved

Summary

- Alot has changed in the last 6 years!
- New scientific approaches and technology are providing new insights into deep-sea ecosystems and the impacts on them.
- Development of blue economy makes deep-sea science more important than ever (translation of data to knowledge).
- Funding and capacity are at risk.
- Significant equity issue in ocean science.
- Importance of engaging public & other stakeholders.