Bio-prospecting and underwater mining

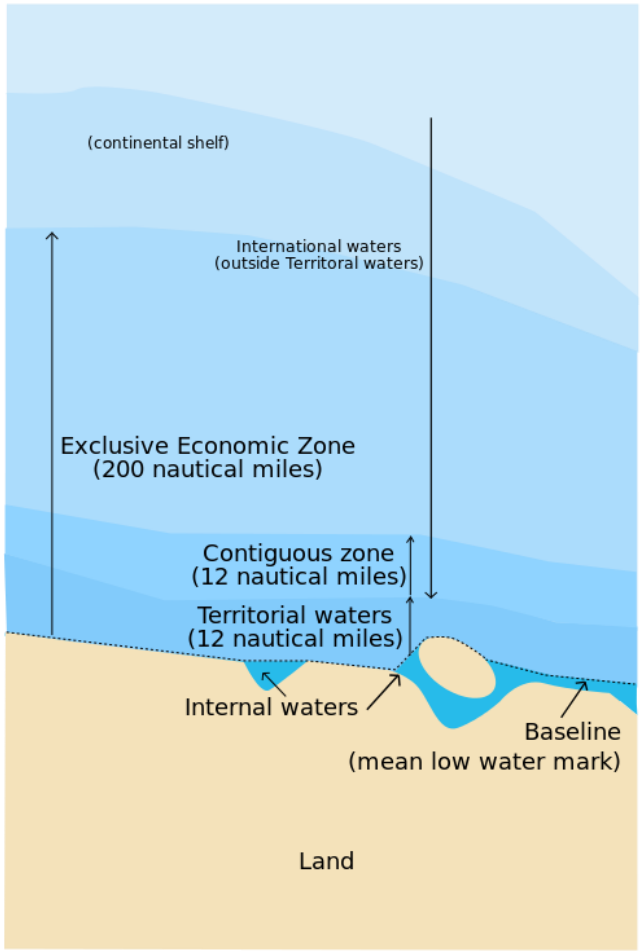
Stephen Hall*

Chief Executive

Society for Underwater Technology

*Also Vice-Chair Intergovernmental Oceanographic Commission of UNESCO

UN Convention on the Law of the Sea



- A Sovereign State can, under some circumstances, claim as far as 350 nautical miles offshore for exclusive access to seafloor resources (normally a maximum of 200 nm) but so far the Mediterranean Sea has not seen large offshore claims.

- In the Mediterranean region, the challenge for exploitation of new resources is **not technological – it is the requirement for adequate legal and policy frameworks.**

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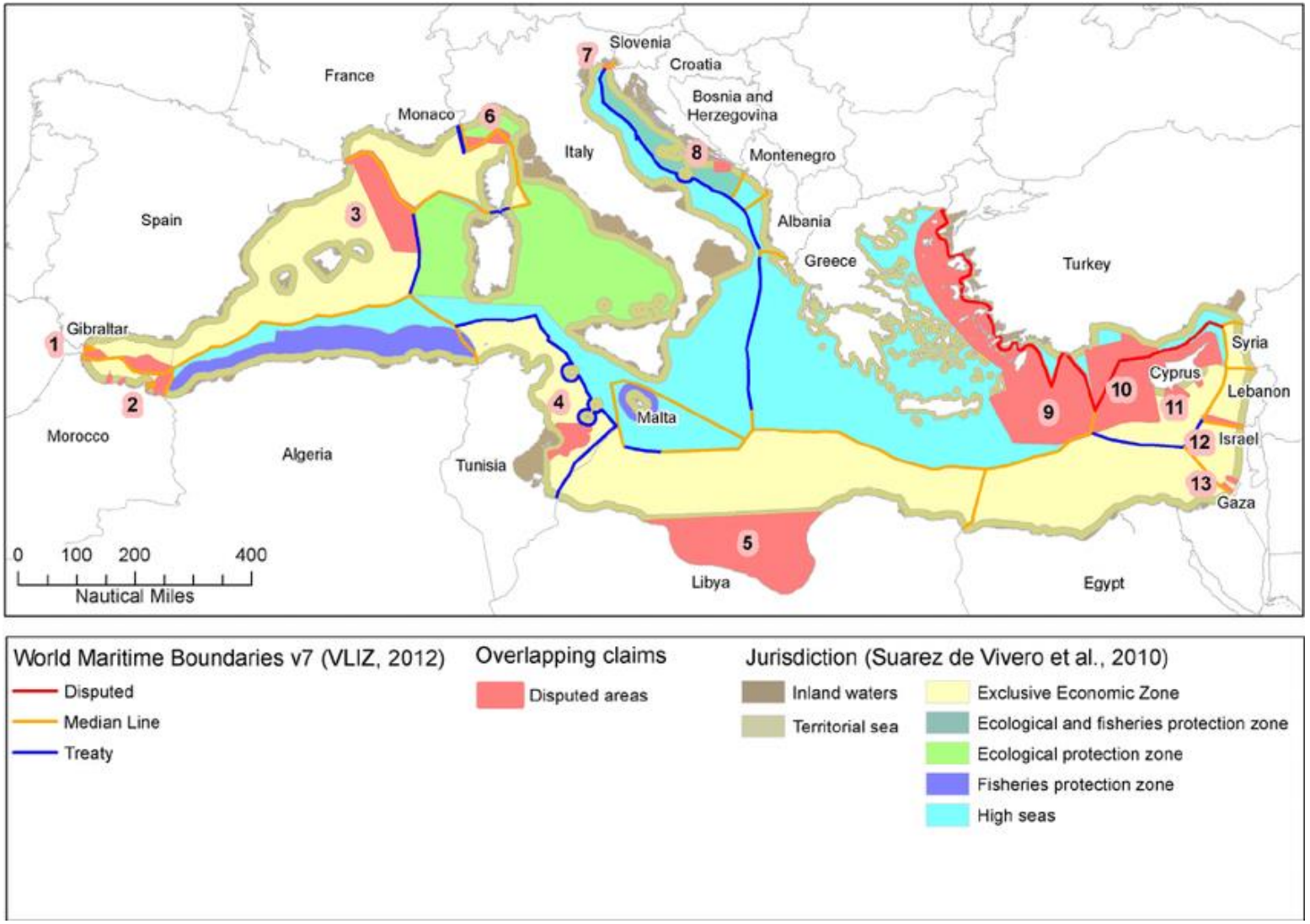
EEZ claims in the Mediterranean



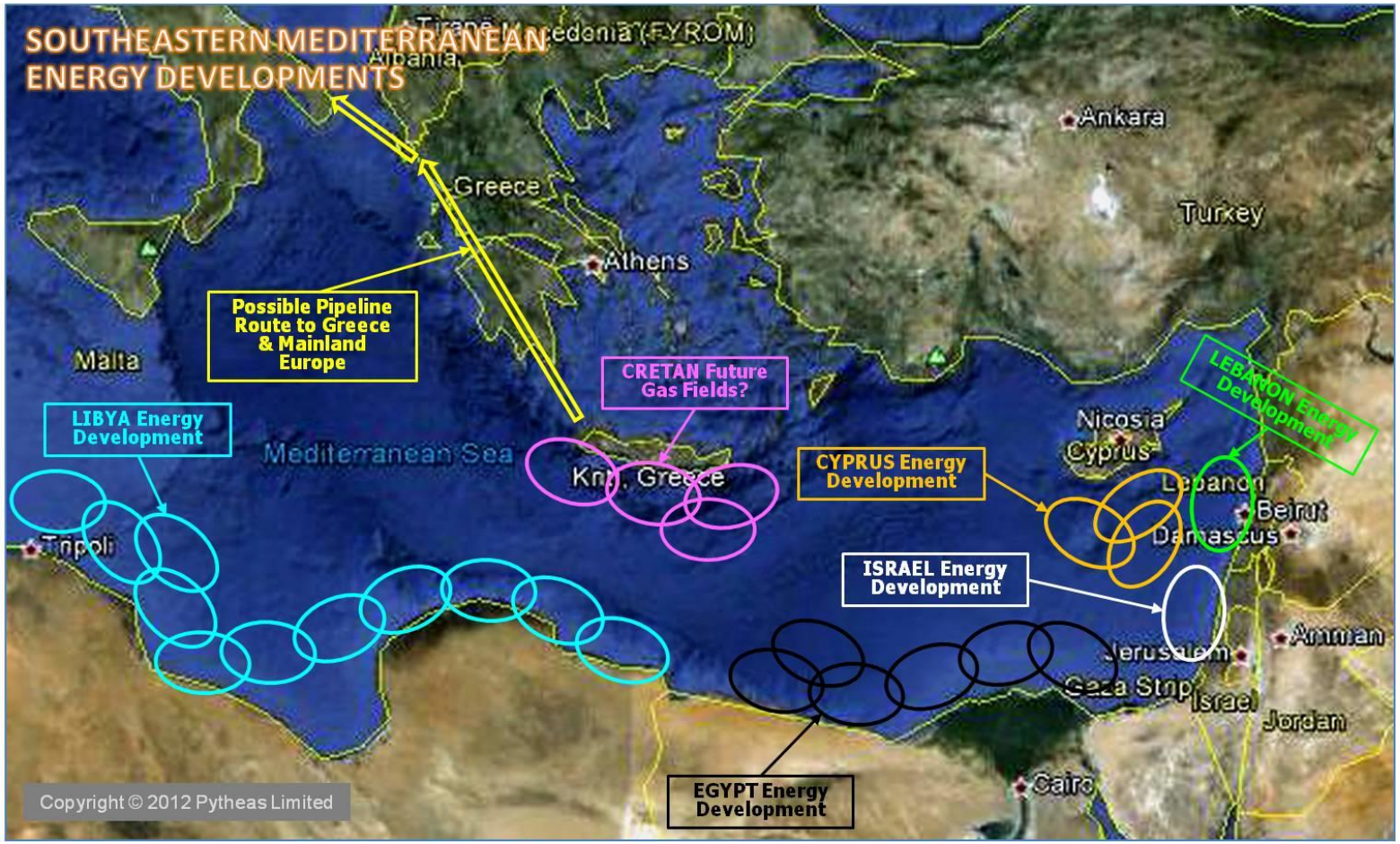
- The Barcelona Convention, the Convention on Biological Diversity, the UN's Sustainable Development Goal 14 and the EU's Marine Strategy Framework Direction all place an obligation on Mediterranean States to deliver a clean, biologically diverse and sustainably-managed Sea. Growing the Blue Economy without causing harm is a challenge that needs cooperation between policy makers, science, and industry.

- Deep sea mining presents similar challenges to offshore oil and gas exploration and production, but is likely to be less damaging to the environment than deep-sea trawling or the consequences of rising temperatures on Mediterranean ecosystems.

‘Good Environmental Status’ Descriptors

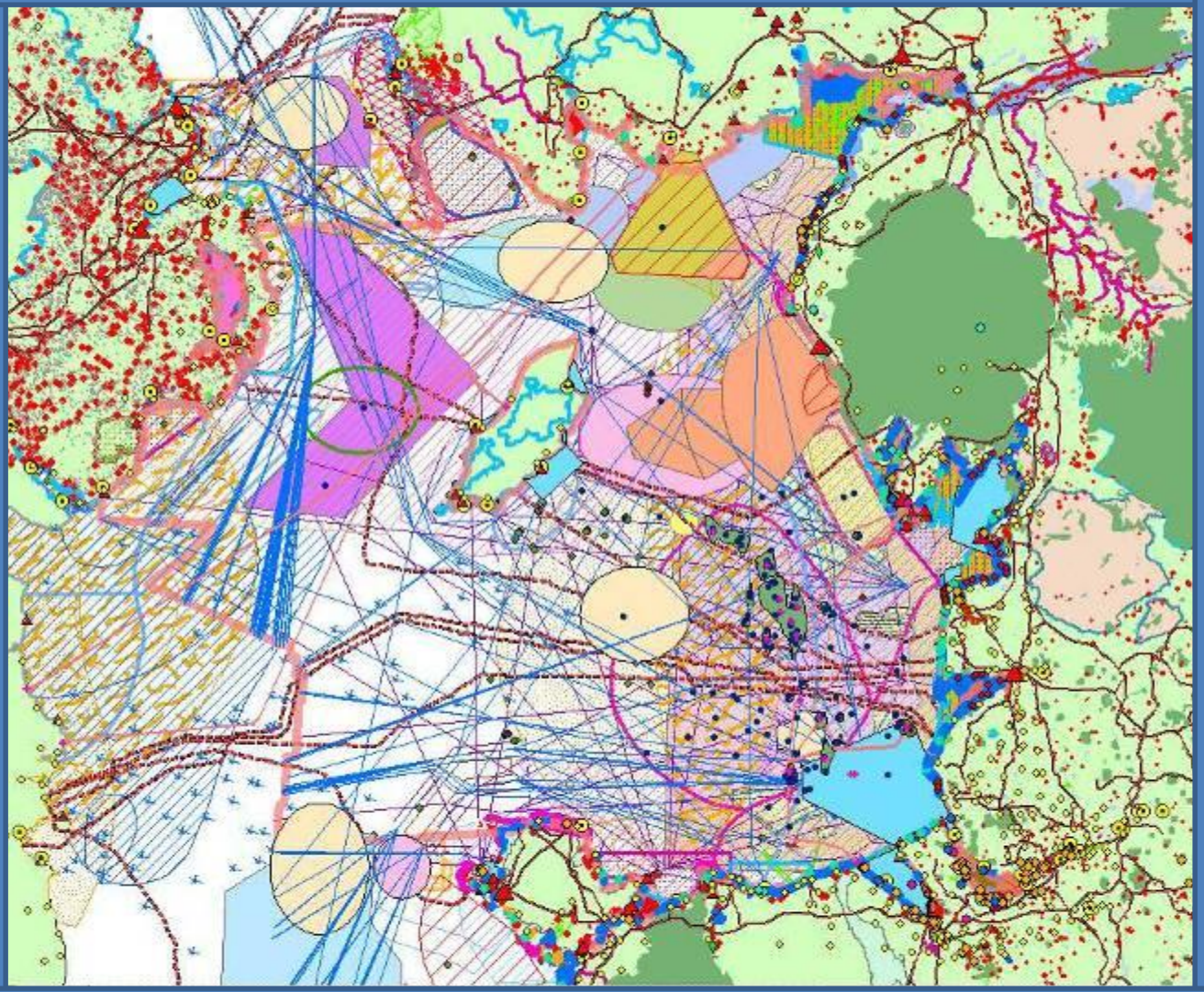
No.	Descriptor
1	Biological diversity
2	Non-indigenous species
3	Commercial fish & shellfish
4	Food-webs
5	Eutrophication
6	Sea-floor integrity
7	Hydrography
8	Contaminants
9	Contaminants in seafood
10	Litter
11	Energy, incl. underwater noise

The Eastern Mediterranean is already an active zone for oil & gas extraction



Multiple uses in a confined maritime space – Irish Sea example

- Landuse
- Tourism
- Oil &Gas
- Mariculture
- Coastal Defence
- Ports & Navigation
- Military Activities
- Culture
- Conservation
- Dredging & Disposal
- Submarine Cables



- Fishing
- Renewable Energy
- Marine Recreation
- Mineral Extraction

Seeding the ocean with technology & harvesting the data

Global Ocean Observing System

http://www.goosocean.org/

Europe's eyes on Earth

http://marine.copernicus.eu /

International Oceanographic Data and Information Exchange

http://iode.org/

http://geoblueplanet.com/

BLUE PLANET Oceans and Society

OFFSHORE MINING

Based on a Presentation given to the Marine Industries Liaison Group

DEFRA Offices, London, June 29, 2016 – by Stef Kapusniak, SMD.

Subsea Mining…

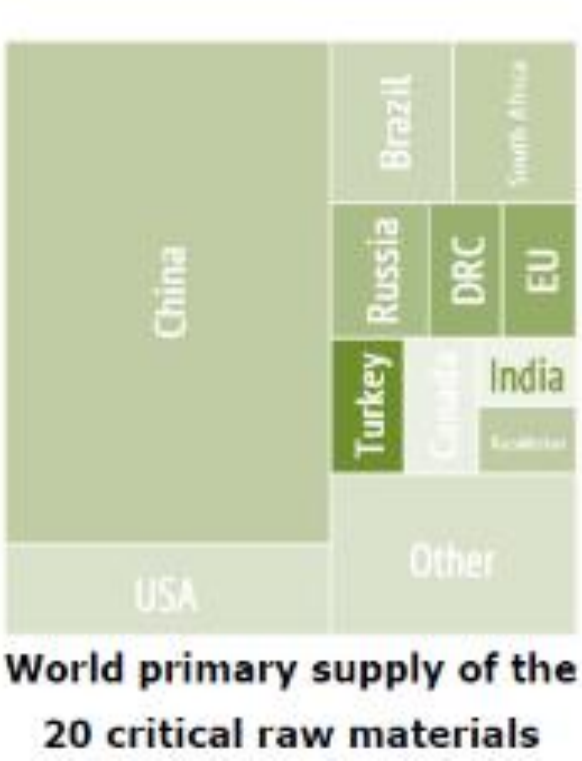
History…

- Subsea mines for **lead** and **zinc** in ancient Greece at Laurium – stil one of the only examples of ining in the Mediterranean Sea
- **Coal** was first mined offshore in 1575 in Scotland, early extraction too in Japan.
- 30 years of **Amber** mining from 1860 in the Baltic Sea
- **Tin** and **copper** has been mined underneath the Cornish coast
- Blasting and underwater dredging of **Barite** off Alaska
- **Polymetallic nodules** have been mined/dredged in the Bay of Finland
- Subsea **iron** ore off Finland and off Elba island, Italy and Cockatoo Island, NW Australia

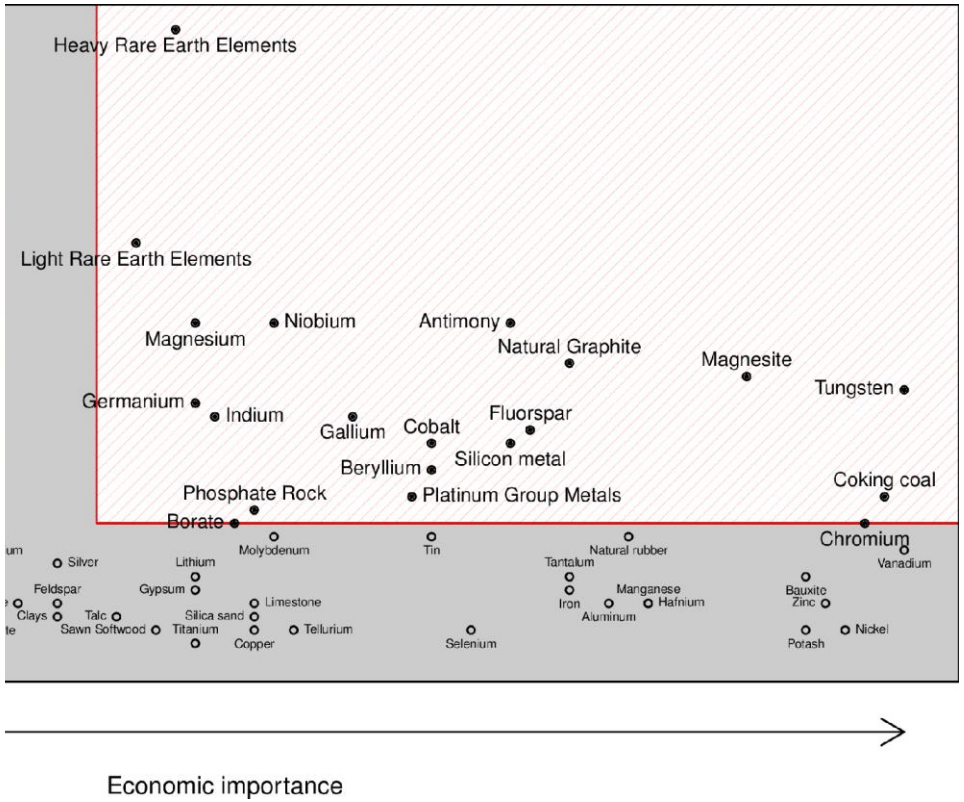
Today…

- Placer deposits of **diamonds**, tin, **gold**, **magnetite** and various construction **gravels** are being mined/dredged at various locations around the world
- This is being done in shallow waters with semi-conventional dredging equipment and using seabed crawlers in the case of diamonds

The EU faces challenges in the strategic supply of some critical Raw Materials…



World primary supply of the 20 critical raw materials



H2020-SC5-2014-2015:
Growing a Low Carbon, Resource Efficient Economy with a Sustainable Supply of Raw Materials

EU funded consortiums

The overall objective of Blue Mining is to provide breakthrough solutions for a sustainable deep-sea mining value chain. The project aims to develop the technical capabilities for accurate and cost-effective **discovery, assessment and extraction** of deep-sea mineral deposits from water depths up to 6,000m

The MIDAS project - Managing Impacts of Deep-seA reSource exploitation - is a new, multidisciplinary research programme that will investigate the **environmental impacts** of extracting mineral and energy resources from the deep-sea environment. This includes the exploitation of materials such as polymetallic sulphides, manganese nodules, cobalt-rich ferromanganese crusts, methane hydrates and the potential mining of rare earth elements.

EU funded consortiums…

GEOMAR
Helmholtz Centre for Ocean Research Kiel

JPI Oceans Ecological aspects of deep-sea mining

Three-year research project involving 25 European research institutions with specialists in deep-sea ecology, marine mining and deep-sea observation . The project involves **investigating the potential impact of ore mining on the deep-sea environment**. The project is coordinated by GEOMAR

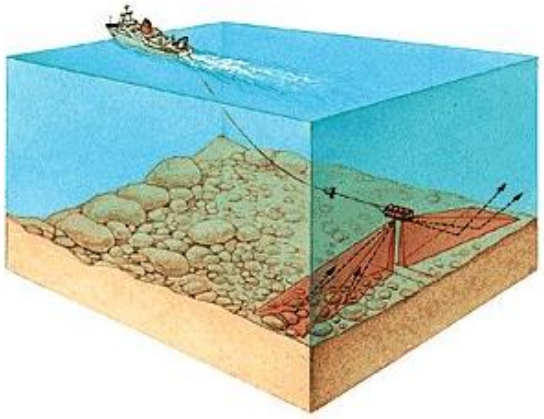
¡vamos!

"Viable Alternative Mine Operating System". A project to **design and build an underwater mining prototype, test it and conduct key technology research at four sites – three inland flooded and abandoned mines and one offshore site**. The project includes the development and application of advanced underwater robotic excavation tools, navigation, monitoring and sensing systems.

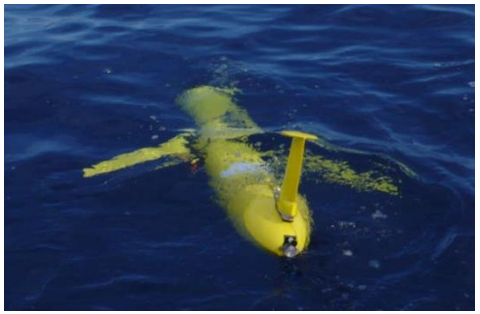
bluenodules

Design of an automated and technologically sustainable deep-sea nodule mining system

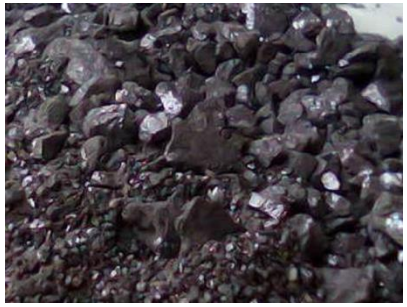
Exploration Techniques…



- Side-scan and multi-beam sonar mapping
- Buried object scanning sonar (BOSS)



- Underwater magnetic resolution/resonance
- Move from towed systems to AUV
- Automated guidance and return of gliders
- Improved mission capability (time and distance)
- Docking systems and induction charging
- Renewable power (sun and ocean thermal gradient)
- Addition of light intervention systems



Lead

Zinc

Coal

Amber

Tin

Copper

Barite

Polymetallic nodules

Iron

Diamonds

Gold

Magnetite

Deep-sea Resources…

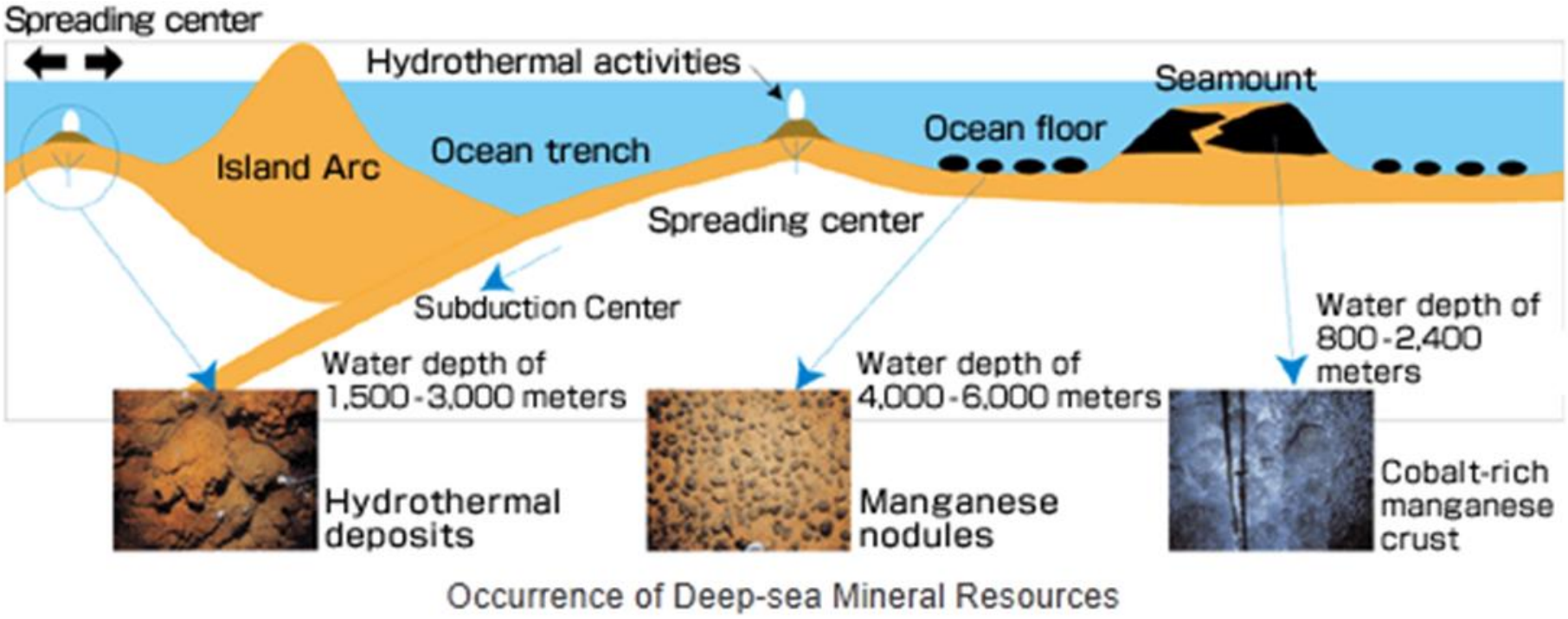
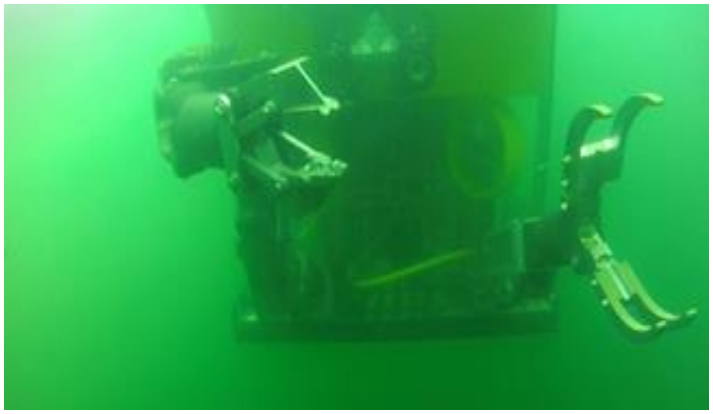


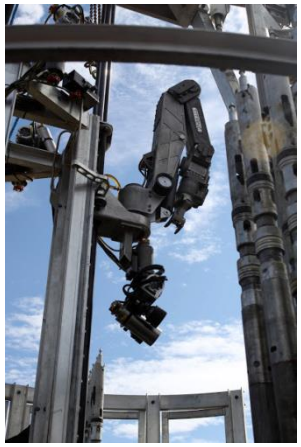
Diagram from JOGMEC

Sampling Tools…

Seatools' Grab-sampler



Tooled ROV with basket collection



FUGRO seafloor corer

Benthic's PROD system

SMD Tracked corer

Sampling, coring, geotechnical tools…

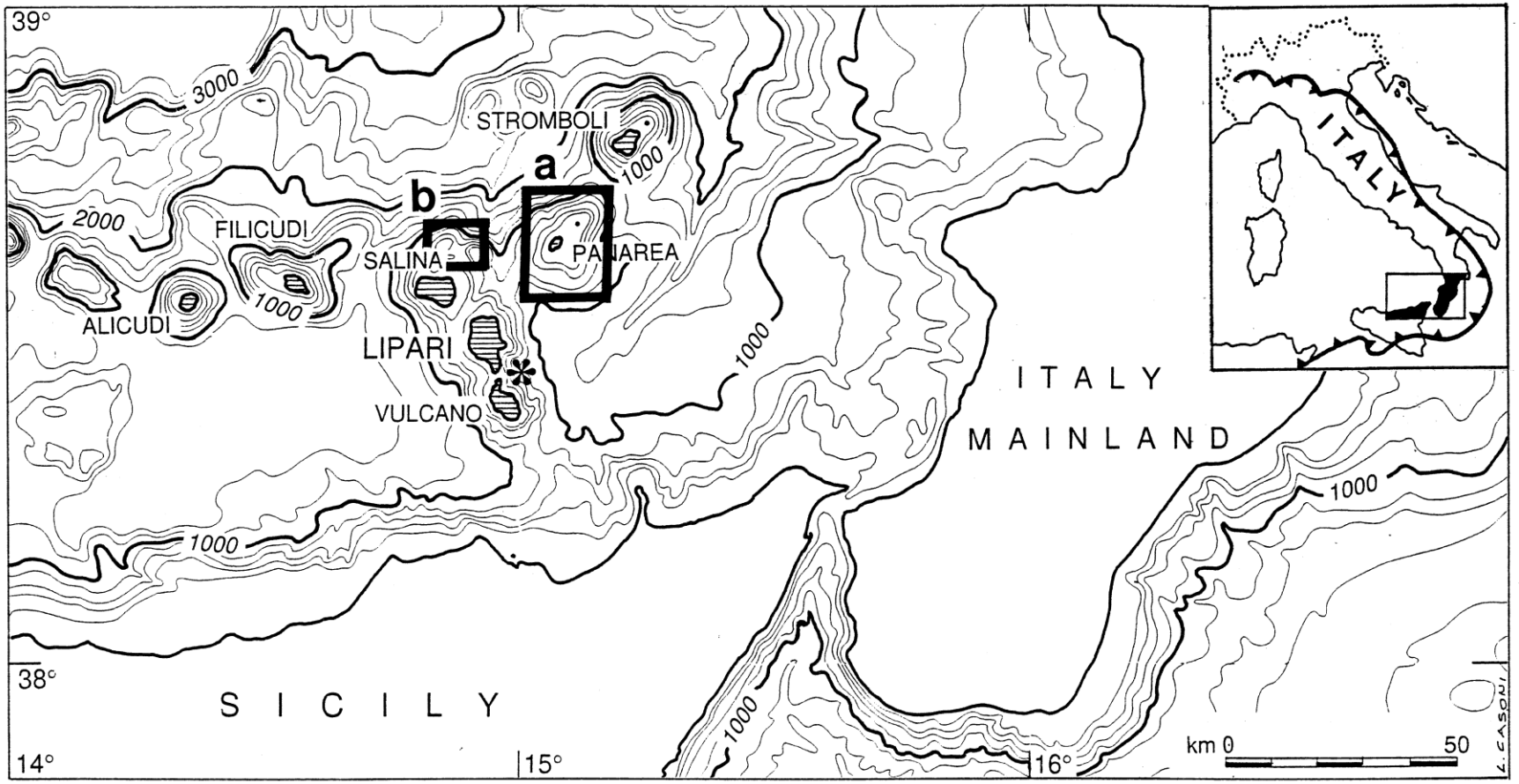
IHC Sword

MKII RovDrill

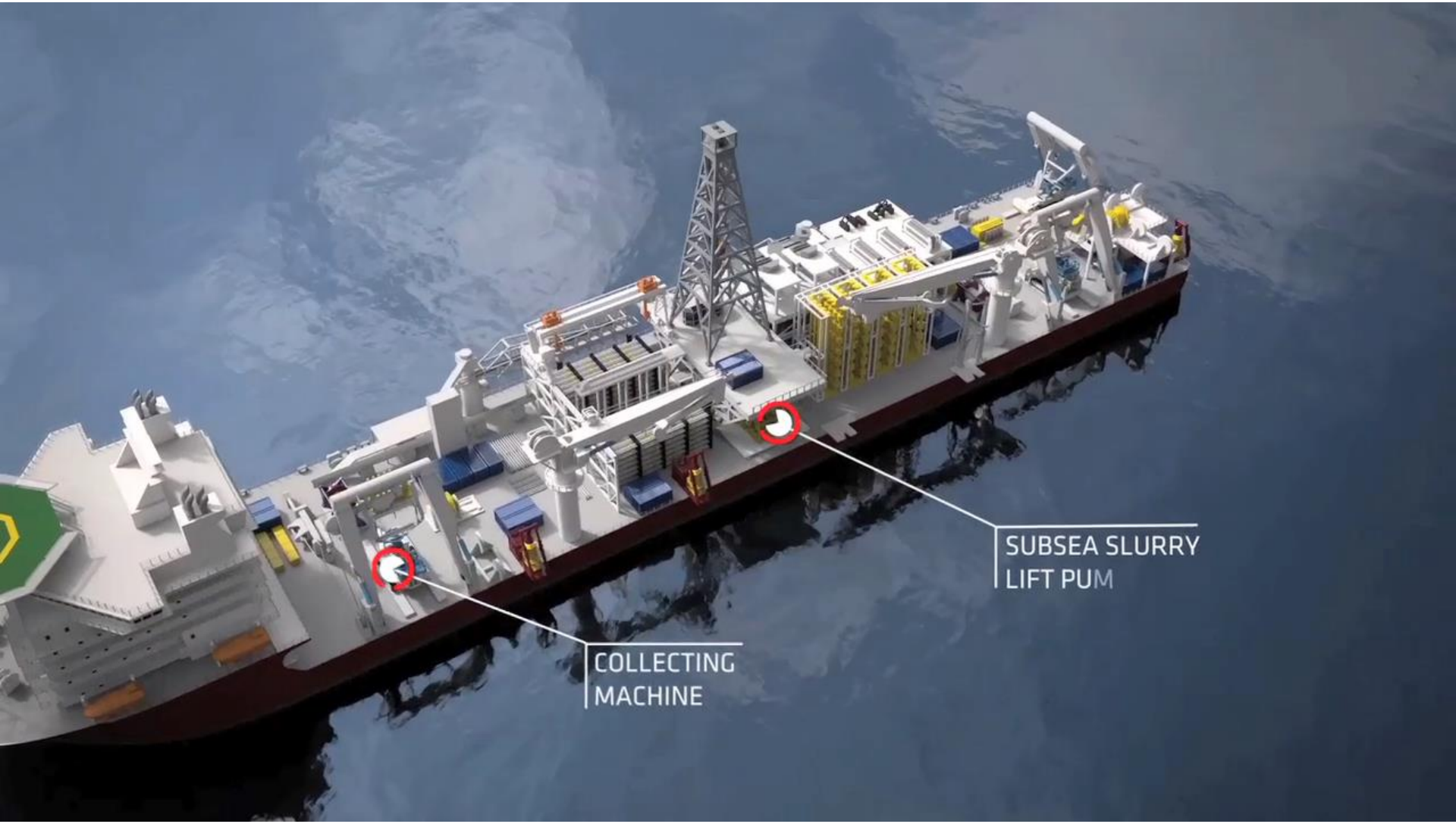
Fugro SeaDevil

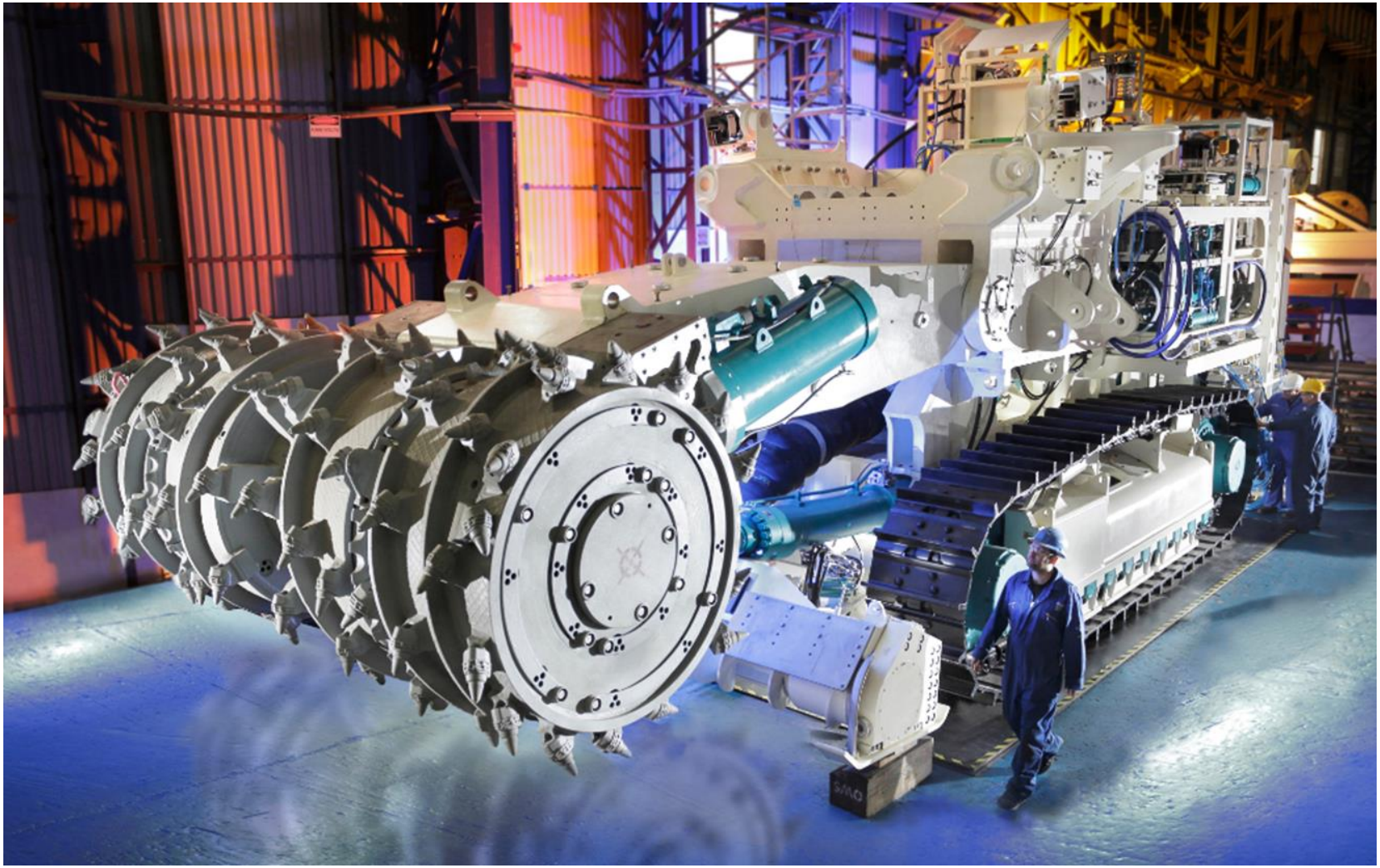
Bauer’s MEBO

Areas with high metal content in Aeolian volcanic arc (see Savelli et al 1999)



Nautilus Minerals, SMS mining system…





Very deep (polymetallic nodules)…

- Potato-picker design
- Tested to 1400m

MineRo 2

MineRo 1 test robot

Very deep (polymetallic nodules)…

- Some sub-assembly tests carried out at 5,000m

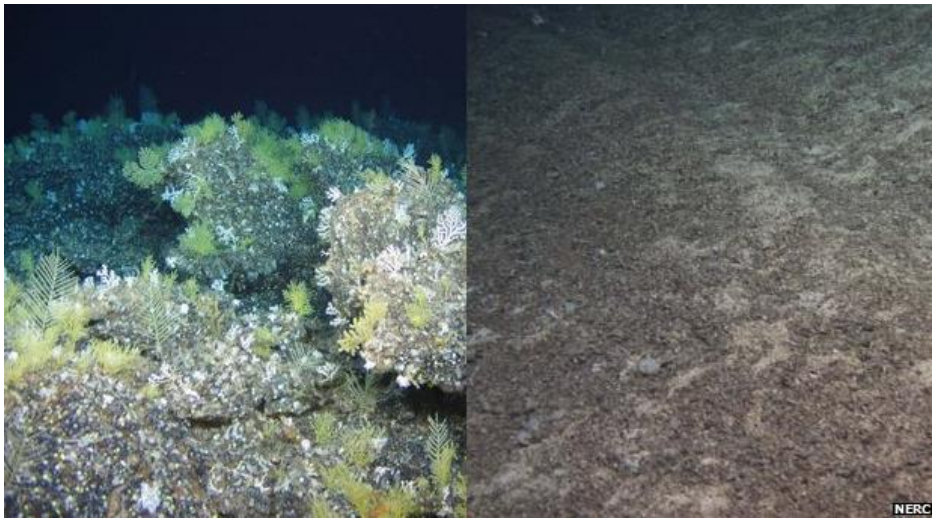
Ukraine – nodule miner concept…

Environmental considerations…

- Loss of or damage to habitat
  - Need to avoid sensitive areas or ensure species survival/re-colonisation strategy – as is the case in any mining activity
  - But some areas are abyssal plains with species density similar to the Sahara desert
  - The creatures that congregate around hot vents are very hardy and can be classed as poly-extremophiles. They survive in an environment with no oxygen, no light, high acidity, extreme temperature, extreme pressure.
  - You would not want to mine an active vent – the machine would melt
- Pollution risk
  - Small volumes of biodegradable oil
  - Risks extremely low compared to offshore oil extraction
- Carbon footprint?
  - Can be much lower than other sources of minerals

UNKNOWNS – e.g. What about impacts of oxygen saturation in deep water of exposing fresh rock faces to oxidation?

Mining may be less damaging to the environment than some types of fishing



before **after**

- Many seamounts have been bottom-trawled.
- One trawler unit can scour 10km^2 per **day**
- Leaving approximately 4 million tonnes of unpopulated and exposed crust.
- Sufficient for approximately **2 years** of mining!

Regulatory framework…

<u>International Waters</u>

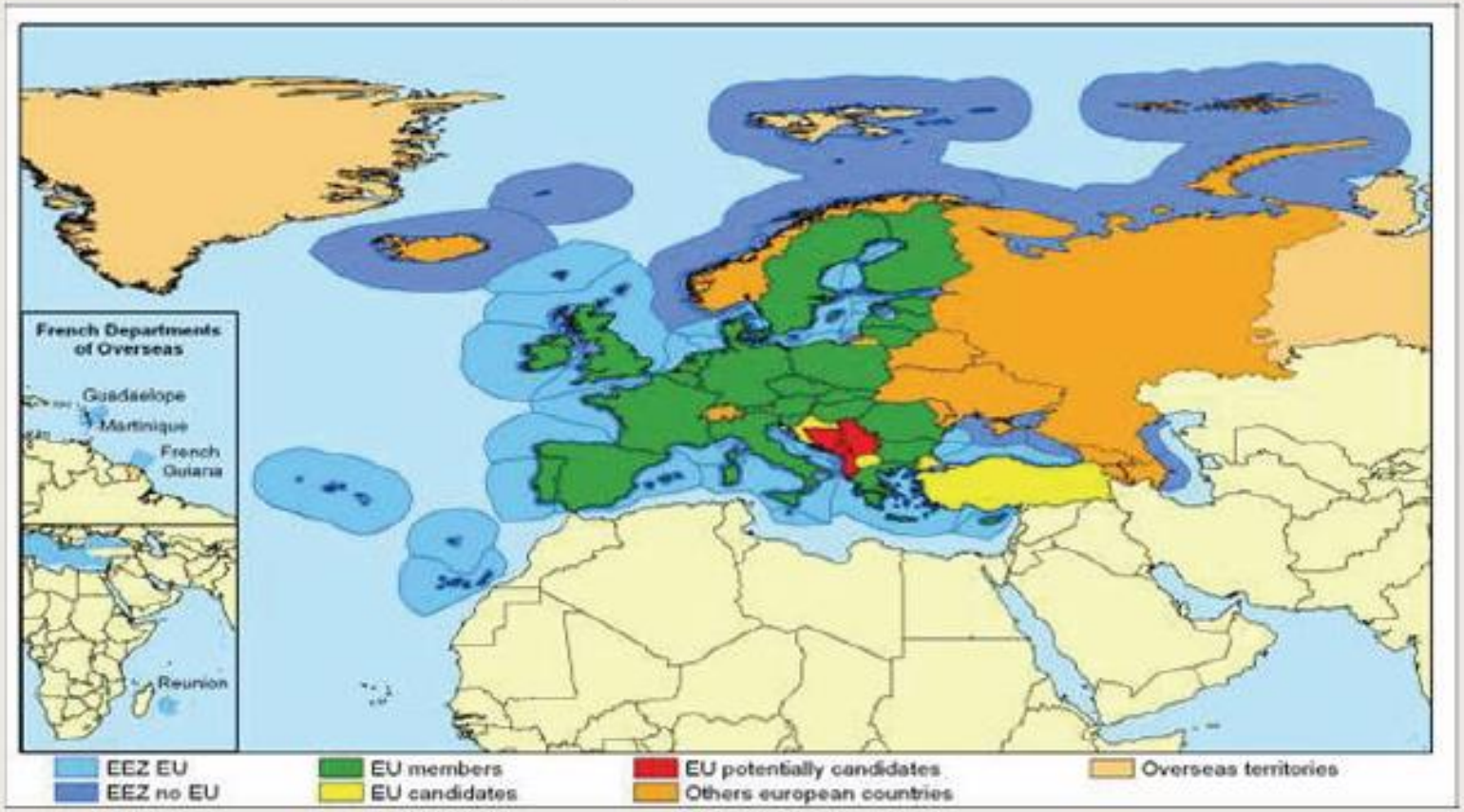
- Authority which oversees mining in international waters
- Those requiring a lease must have a sponsoring state which has signed up to UNCLOS
- 15-year exploration licences issued
  - 16 Polymetallic Nodules
  - 6 Sulphides
  - 4 Crusts
- "For the **common benefit of mankind**"
- Adopt " the **precautionary principle**"

<u>EEZ's</u>

- Up to that country to legislate
- Although… If the country is signed up to UNCLOS it is expected that the ISA's regulations would be followed

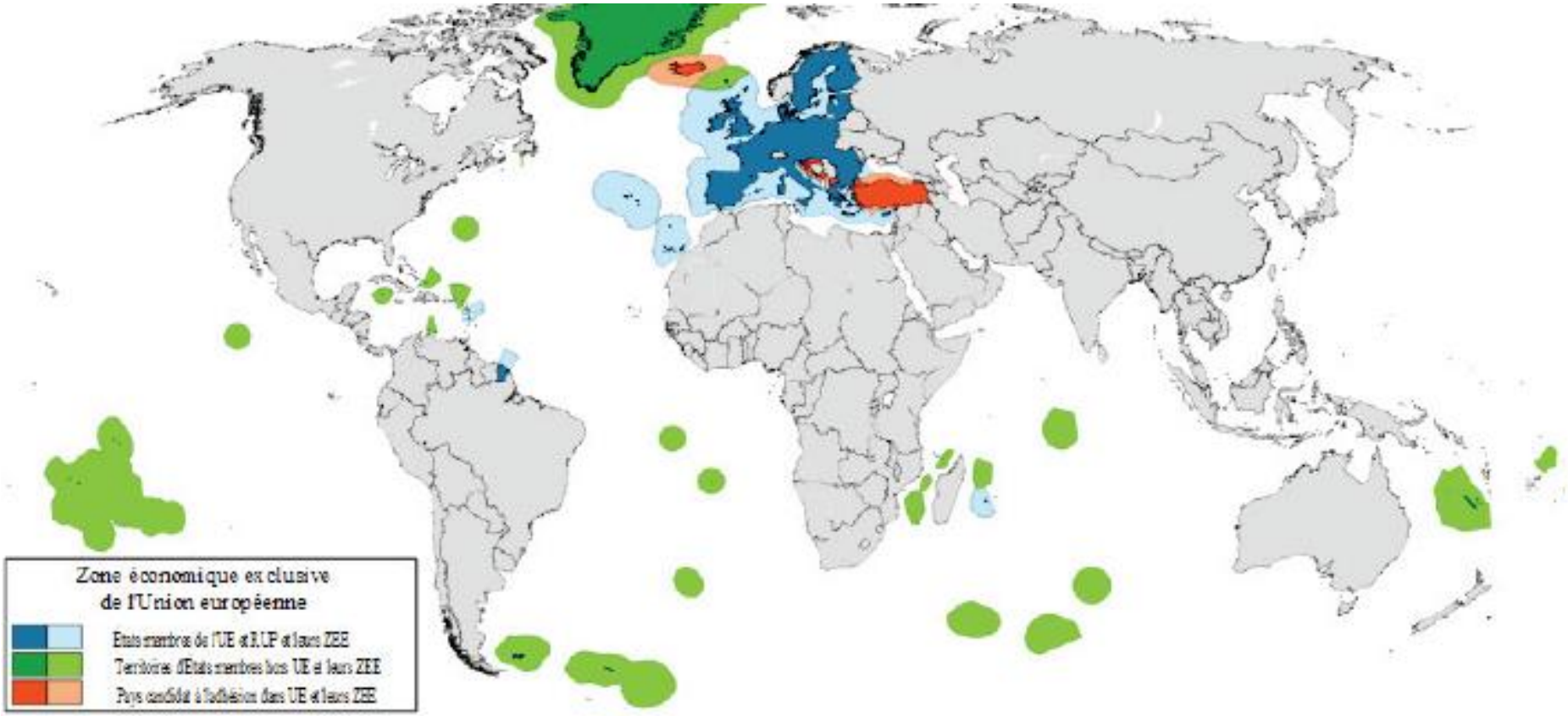
Sea and Land surface areas (Km2)

Europe	5.3 million km^2
Exclusive Economic Zone (EEZ)	7.0 million km^2



From de Jonge – Minex Europe, Nov 2015, Vienna

EEZ of Europe's overseas territories…



From de Jonge – Minex Europe, Nov 2015, Vienna

Marine Medicine isn't new

- Humans have used ocean resources for medicinal purposes since ancient times.
- The Chinese and Japanese were eating a variety of iodine-rich seaweeds by 1400 BCE that accounted for their low incidence of goitre (Leoutsakos, 2004).
- In Ireland, the red algae *Chondrus crispus* and *Mastocarpus stellatus* were used as a folk cure for colds, sore throats, chest infections and bronchitis for several centuries (Dias et al., 2012).
- In the early 20th century cod liver oil was an important nutritional supplement in many northern European countries.
- However it was only after the 1950s, with the advent of scuba diving and new sampling technologies that scientists began to systematically probe the oceans for useful therapeutics.

The antimicrobial potential of algicolous marine fungi for counteracting multidrug-resistant bacteria: phylogenetic diversity and chemical profiling – Gavi et al, 2016

"Marine fungi represent an important but still largely unexplored source of novel and potentially bioactive secondary metabolites. The antimicrobial activity of nine sterile mycelia isolated from the green alga Flabellia petiolata collected from the Mediterranean Sea was tested on four antibiotic-resistant bacterial strains using extracellular and intracellular extracts obtained from each fungal strain."
*Research in Microbiology 167 (2016) 492**e**500*

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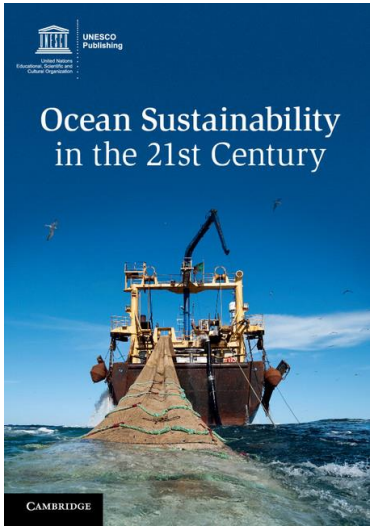
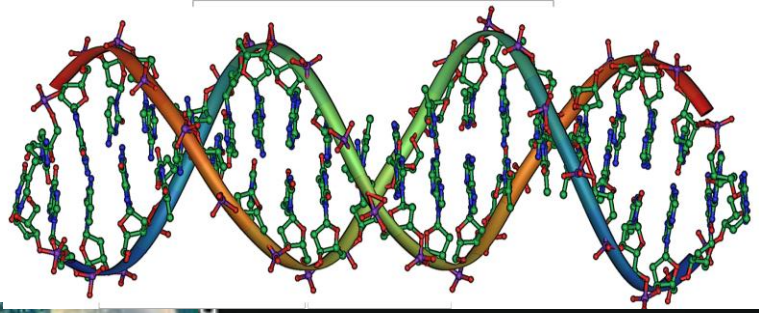
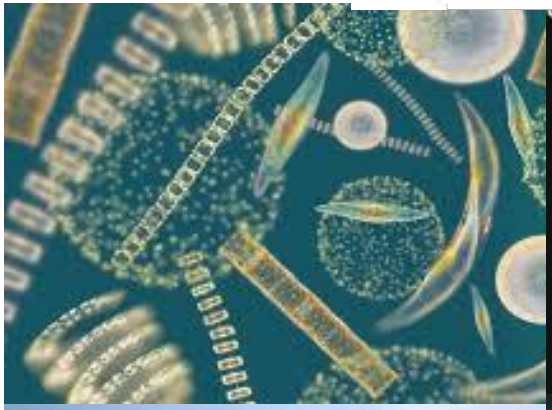
Excellent work also done by
European Marine Board



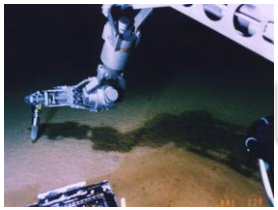
Marine Genetic Resources



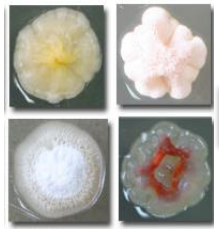
- Biodiversity = genetic and biochemical diversity
- Plants, animals, microbes
- Water column & seafloor
  - Move
- ABNJ diverse
  - Full extent unknown
- *Disconnect between legal and scientific terminology*



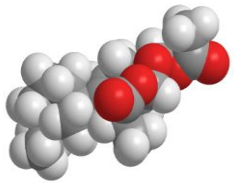
Marine Biodiscovery (potential)



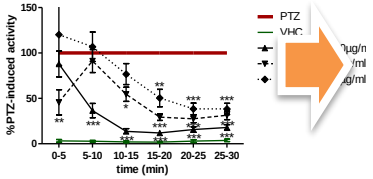
Sampling in ABNJ



MGR



Chemistry



Bioassay

Product

- MGR and derivatives used as inspiration - *not* bioprospecting or mining
- Pharma, enzymes/industrial process, 'cosmeceuticals', 'nutreceuticals'

Science is key to accessing and deriving benefits from Marine Genetic Resources

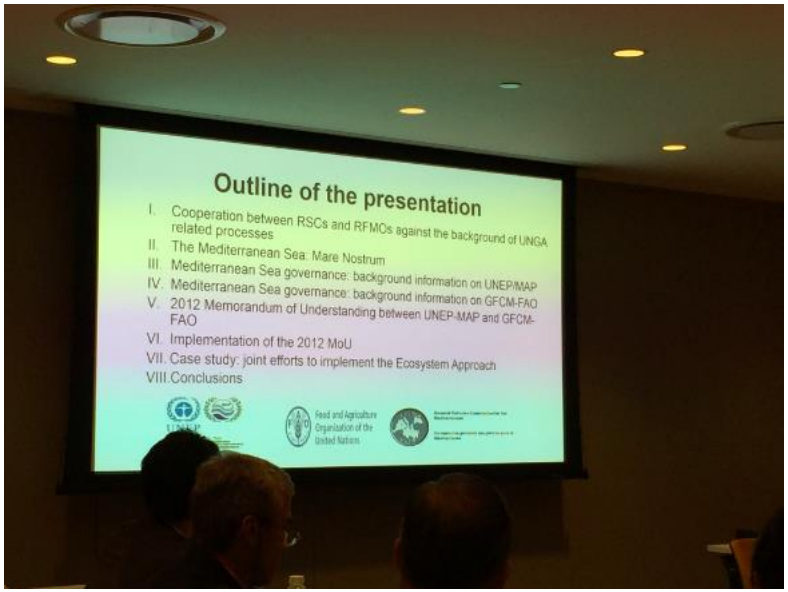
- Access MGR
  - *in situ*
  - *ex situ*
  - *in silico*
- Research & development = benefits from MGR

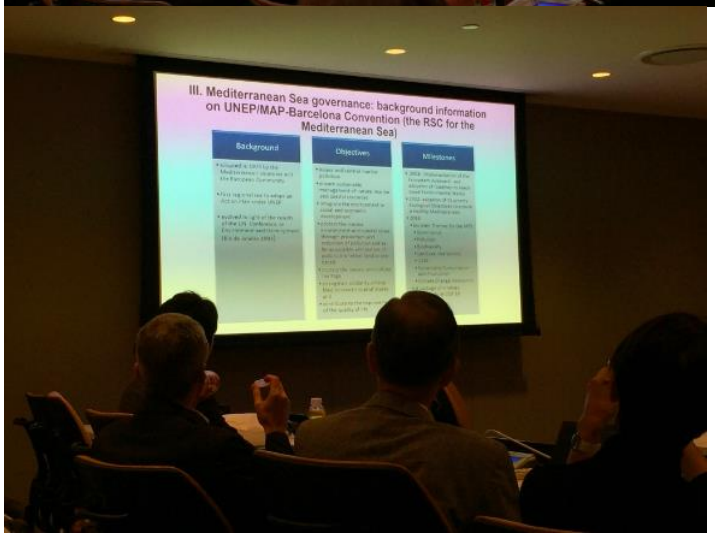
New UN process to govern access to biological resources from areas beyond national jurisdiction


Potential, Process, Governance
PrepCom2: “bridge the divergent views …regarding the application of the high seas freedom and the common heritage of mankind in relation to marine genetic resources of areas beyond national jurisdiction”.
Photo: Warren Keelan

UN PrepCom process, New York


II. The Mediterranean Sea: Mare Nostrum


Outline of the presentation
I. Cooperation between RSCs and RFMOs against the background of UNGA related processes
II. The Mediterranean Sea: Mare Nostrum
III. Mediterranean Sea governance: background information on UNEP/MAP
IV. Mediterranean Sea governance: background information on GFCM-FAO
V. 2012 Memorandum of Understanding between UNEP-MAP and GFCM-FAO
VI. Implementation of the 2012 MoU
VII. Case study: joint efforts to implement the Ecosystem Approach
VIII. Conclusions
Food and Agriculture Organization of the United Nations


III. Mediterranean Sea governance: background information on UNEP/MAP-Barcelona Convention (the RSC for the Mediterranean Sea)
Background
Objectives
Milestones


Regional Ocean Governance in Practice: the Mediterranean Experience
Preparatory Committee established by General Assembly resolution 69/292: Development of an international legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction
31 August 2016 (UN HQ, New York)

Marine Autonomous Systems will play an important role in future monitoring of Mediterranean resources

Conclusions

- **Seabed mining has potential to become a major industry in the Mediterranean**, but depends upon:

(a) market demand sufficient to justify the high level of capital required to commence operations
(b) adequate knowledge about the availability of ore deposits
(c) sufficient knowledge about ecological impacts of mining activity
(d) legal and policy framework that is attractive to investors whilst still protecting the environment.

- Although it may generate high revenue streams**, Seabed mining** is NOT likely to generate large numbers of new jobs, most of the work will be done using robotic machines.

- **Bio-prospecting** for new bio-active compounds is unlikely to be a large-scale industry. The high cost of discovery versus small numbers of compounds that make it to market are significant barriers to growth.
- Nature-inspired compounds developed ‘in-silico’ are the more likely area of industry growth. Very difficult to share profits with coastal states when the biotech company does the bulk of the discovery, rather than breeding/ranching marine organisms offshore.

Thank You

Stephen Hall

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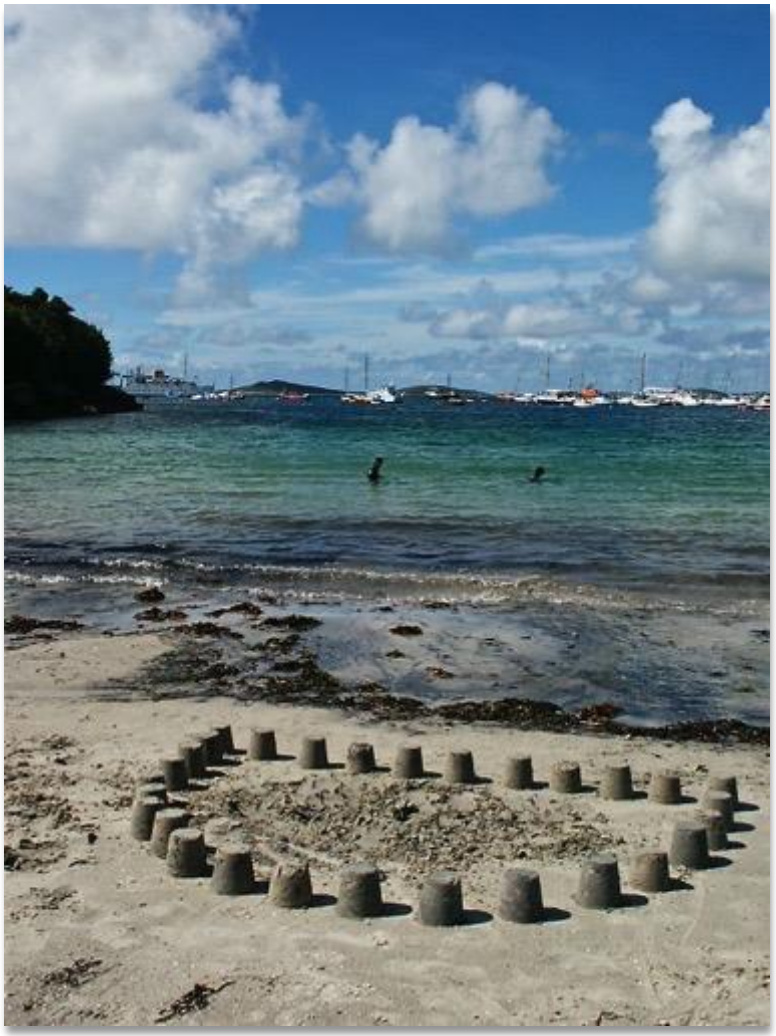

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- http://www.fao.org/docrep/008/y5880e/y5880e09.htm