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et al.

WWW.CIIMAR.UP.PT/CORAL

CORAL - Sustainable Ocean Exploitation: Tools and Sensors, a combined effort by two Research institutes, CIIMAR and INESC TEC, aims to address the development of technological driven solutions to tackle Deep Sea resource exploitation under an environmental sustainable framework, in addition to the development of Sensor-based technology for marine or marine-related activities This implies the improvement of the knowledge of the natural processes governing ocean dynamics and ecosystem functions, as well as the major forces driving ecosystems changes, both on regional and global scales.

INESCTEC
TECHNOLOGY & SCIENCE
ASSOCIATE LABORATORY
PORTUGAL

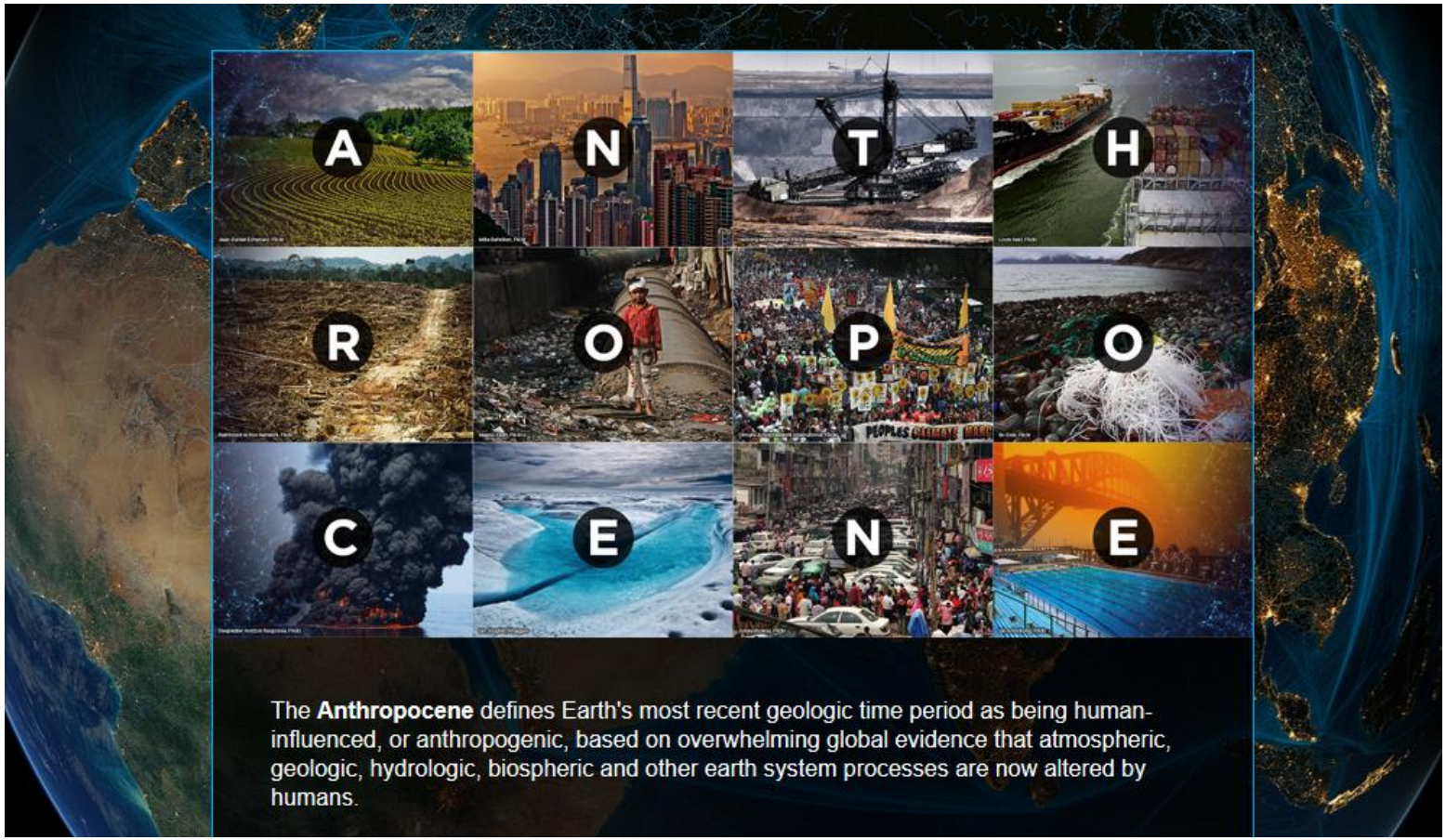
ciimar
Interdisciplinary Centre of Marine and Environmental Research

The Oceans

"…as we know, there are known known's; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also **unknown unknowns** – the ones we don't know we don't know."

Donald Rumsfeld about WMD

The Anthropocene



http://www.anthropocene.info/

Human activity is leaving a pervasive and persistent signature on Earth.

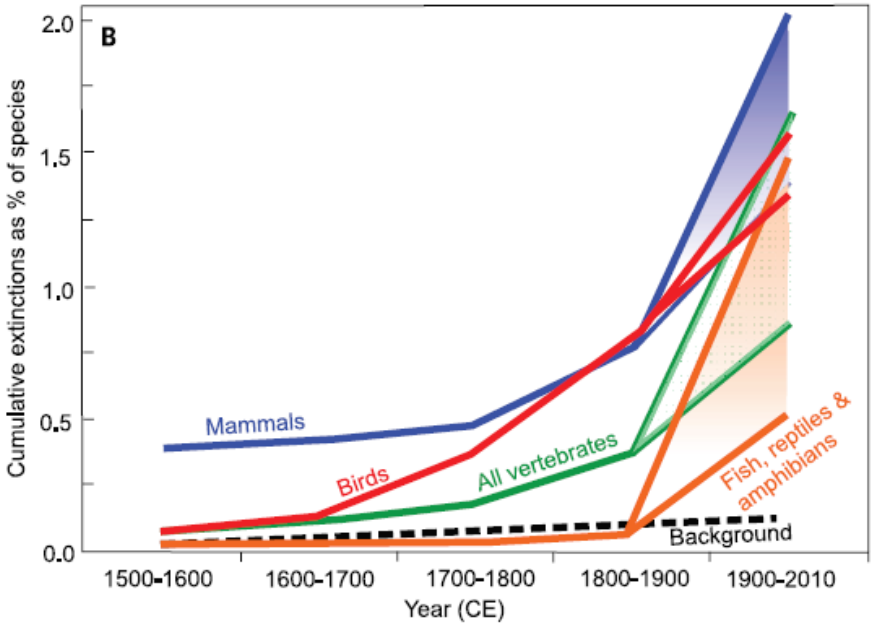
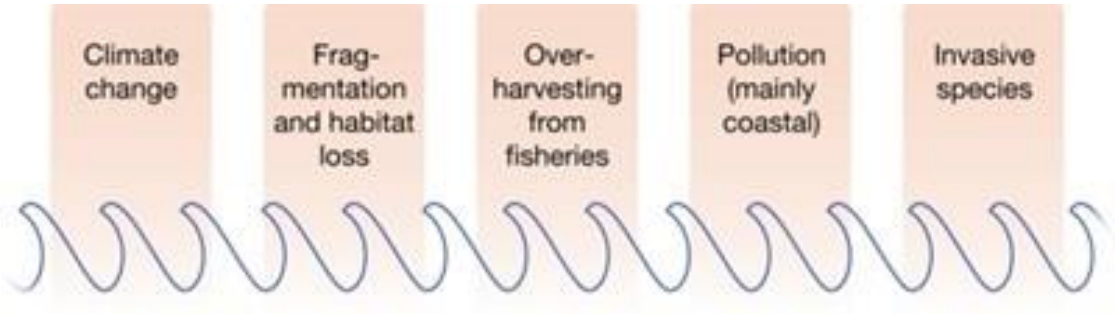


Fig. 7. Increased rates of vertebrate extinctions. (**A**) The approximate rise in mammal extinction rates calculated over varying time intervals, as extended backward from 2010 CE (Ma, millions of years ago). Lines indicate the amount by which extinction rates exceed 1.8 extinctions per million species years (E/MSY) [see (*89*); sourced from (*22*)]. (**B**) Cumulative vertebrate species extinctions as a percentage of total species, with ranges (shaded) between conservative rates (including extinctions, extinctions in the wild, and possible extinctions) and lower highly conservative rates (verified extinctions only). A background rate of 2.0 E/MSY is shown for comparison [after (*89*)].

Waters et al., 2016. Nature

Ocean modulates Earth's climate and provides us with food, coastal protection, clean seawater and oxygen.



Global Changes

Invasive species

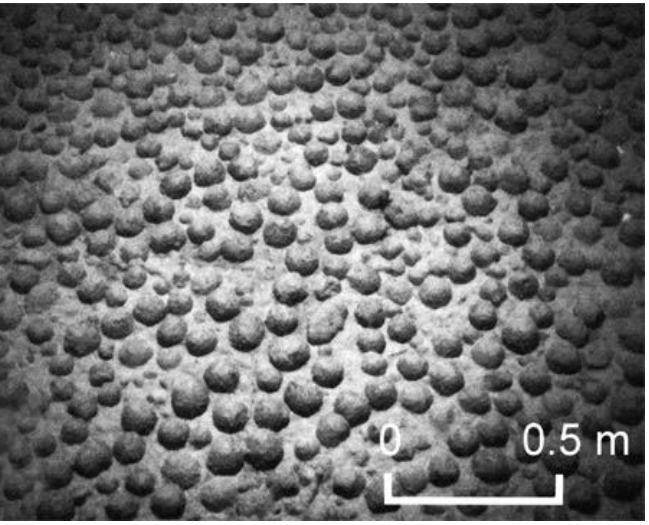
Pollution

Overfishing

- 70% of the world's fisheries are fully- to over-exploited, depleted, or in a state of collapse

United Nations Food and Agriculture Organization (FAO)

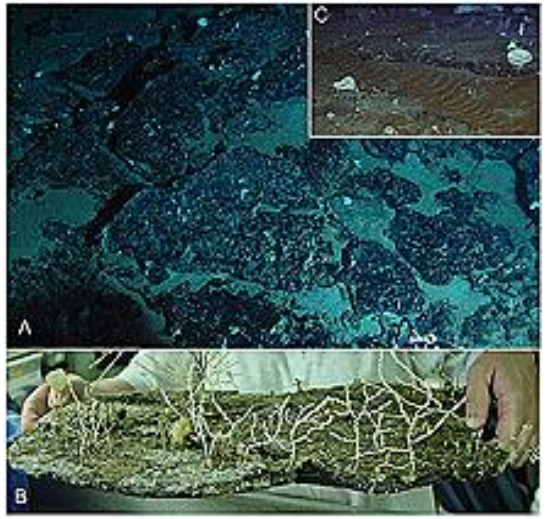
Ferromanganese nodules (Co)



http://www.teara.govt.nz/en/photograph/5513/polymetallic-nodules

Metallic sulphide muds and massive deposits (Cu, Pb, Zn)

Manganese phosphorite deposits



Mineral resource and **mining technology** dependent impacts

Potential impacts are no more potential?

CNBC HOME U.S. NEWS MARKETS INVESTING TECH MAKE IT VIDE

Newest machines for deep sea mining

Nautilus Minerals believes the future of mining lies at the bottom of the ocean. The Australian-Canadian company on Tuesday revealed some of the remote-controlled vehicles that will be cutting up the ocean floor in search of copper, gold, nickel, and other minerals. They are arguably the first machines of their kind in the world.

All three machines are around 50 feet long, 15-20 feet wide, and weigh anywhere from 220 to 340 U.S. tons.

Source: Nautilus Minerals

The collecting machine will draw ground up rock from the surface into the pumps that carry it up to the ship.

Governo quer acelerar mineração no fundo do m dos Açores

LUÍSA PINTO 18/09/2016 - 07:46

Nautilus, a primeira empresa do mundo a extrair minério do fundo do mar, está em negociações c Portugal desde 2008 e quer para iniciar as actividades em 2017. Decisões do Governo só após eleiç regionais de 16 de Outubro.

CNBC HOME U.S. NEWS MARKETS INVESTING TECH MAKE IT VIDE

Deep sea mining company reveals new gear

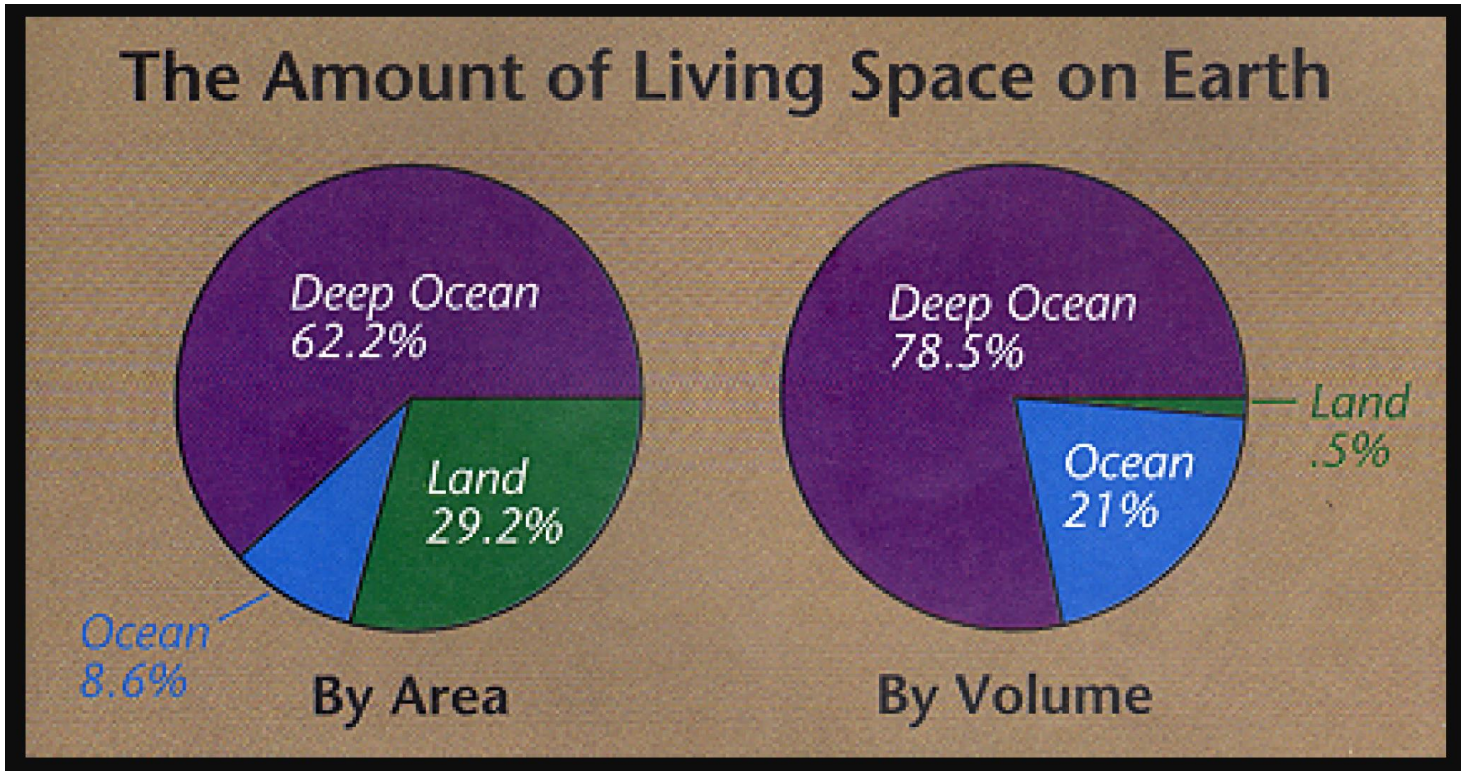
Robert Ferris | @RobertoFerris
Wednesday, 11 Nov 2015 | 3:52 PM ET

CNBC

Nautilus Minerals believes the future of mining lies at the bottom of the ocean. The Australian-Canadian company on Tuesday revealed some of the remote-controlled vehicles that will be cutting up the ocean floor in search of copper, gold, nickel, and other minerals. They are arguably the first machines of their kind in the world.

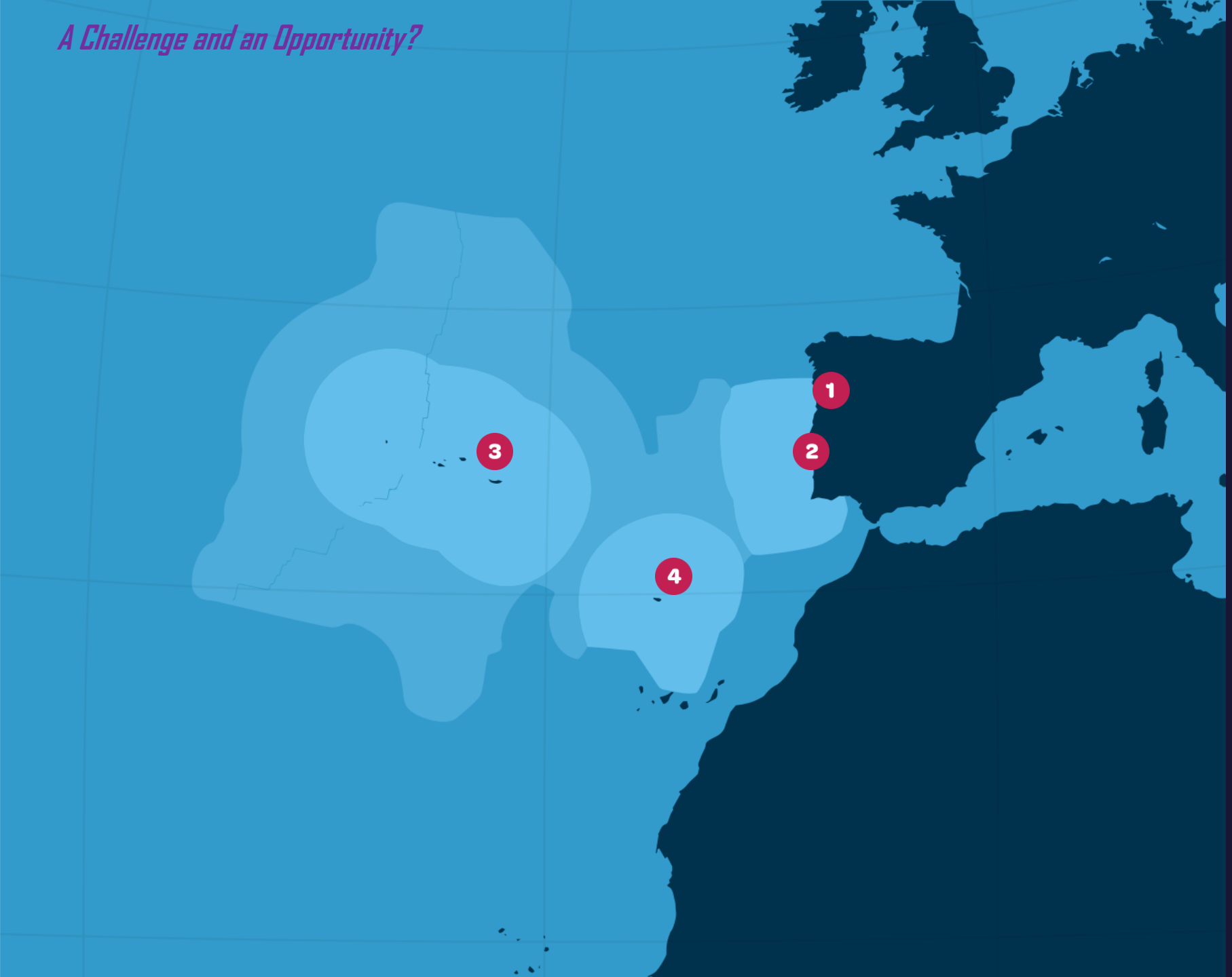
CORAL
SUSTAINABLE OCEAN EXPLOITATION

Biodiversity Scales?



>>> species

A Challenge and an Opportunity?



CORAL – Tools and Sensors

A BLUE FUTURE
Knowledge of the Ocean as a basis for the sustainable management and exploitation of resources.

CORAL

Blue **Tools**

Blue **Sensors**

CORAL
Blue Tools

Research Questions

- Explore the effectiveness of robotic technologies and solutions to achieve lower cost and more efficient, exploration and environmental impact monitoring;

- Provide advanced understanding of biogeochemical processes in deep sea ecosystems;

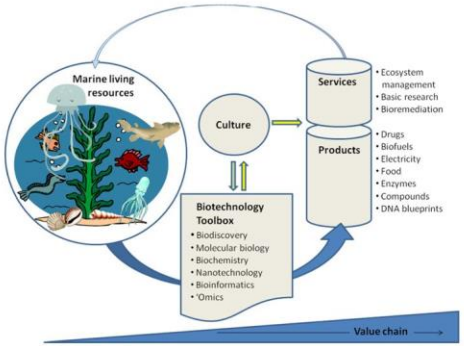
- Develop innovative technologies and methodologies to assess the resilience and biodiversity of deep sea ecosystems under mining extraction;

- Identify potentialities on new biotechnological applications of deep sea organisms;

- Develop a framework and guides for risk and impact assessment for sea floor exploitation;

- Develop modelling tools in support of risk assessment scenarios;

- Develop legal instruments framed in EU regulation to foster an effective management of sea floor resources.



OECD Global Forum on Biotechnology, Vancouver, 30-31 May 2012

CORAL Blue Tools

WP 1 - Exploration and exploitation tools and methods

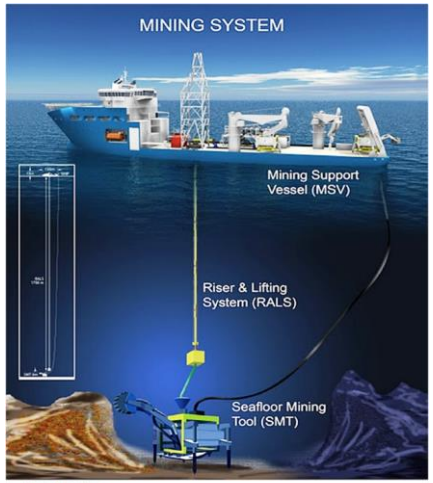
WP2 Perception, Navigation, Awareness

WP3 Risk and impact assessment of deep sea floor mining

WP 4 – Modeling tools

WP 5- Marine Biotechnology "under pressure"

WP 6 – Legal instruments for deep sea mining resources exploitation and exploration

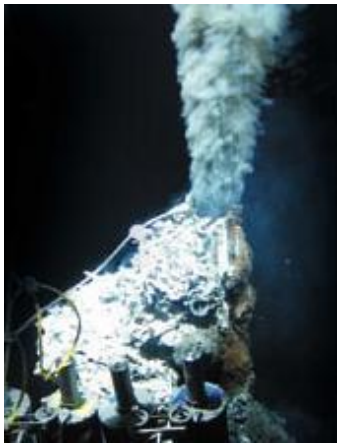


WP3 Risk and impact assessment of deep sea floor mining

sediment laden plumes

trace elements release

ecosystem fractioned



noise

light contamination

Physical impacts

Removal of hard substrates

- Displacement of mega and macro fauna;
- Disruption of detritivorous food chains;

Plumes of organic matter and mineral particles

- Forced resuspension of organic matter, with local increase in primary productivity;
- Physical and ecotoxicological effects on fauna species;

Light, Noise, Temperature

- Changes in predator-prey relationships
- Temperature

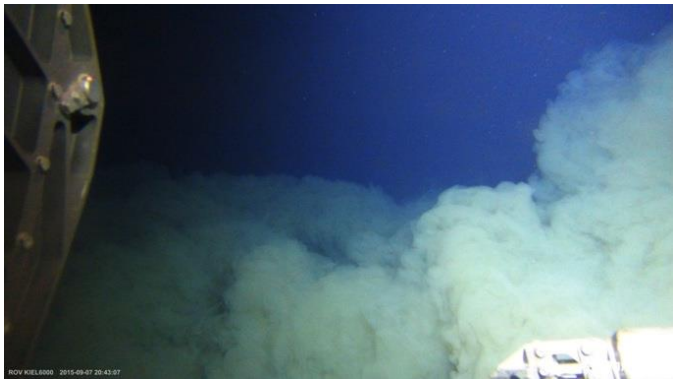
Main Ecosystem Services affected:

- Loss of biodiversity;
- Reduction of carbon sequestered in deep-sea floor;
- Organic matter degradation and nutrients cycling (nitrogen, silica, sulphur, phosphorus and hydrogen);
- Changes in biogeochemical cycles.
- Food provision compromised (nutrition impaired);
- Cultural (educational and scientific) services;

http://earthfirstjournal.org/newswire/2014/04/26/deep-sea-mining-is-about-to-become-a-reality/

Chemical impacts

http://www.deutsche-meeresforschung.de/de/sg_mineralische_ressourcen



Changes in the bioavailability of metals/other contaminants

- Ecotoxicological effects on deep-sea fauna and microbiota
- Impairment of chemosynthetic primary production (reduction of the oxidation of methane)

Transport of metals/other contaminants from the deep-sea

- Bioaccumulation and ecotoxicological effects on pelagic fauna

Main Ecosystem Services affected:

- Loss of biodiversity;
- Reduction of carbon and methane sequestered in deep-sea floor;
- Organic matter degradation and nutrients cycling (nitrogen, silica, sulphur, phosphorus and hydrogen);
- Changes in biogeochemical cycles.
- Loss of the detoxification mechanisms of contaminants;
- Food provision compromised;
- Cultural (educational and scientific) services;

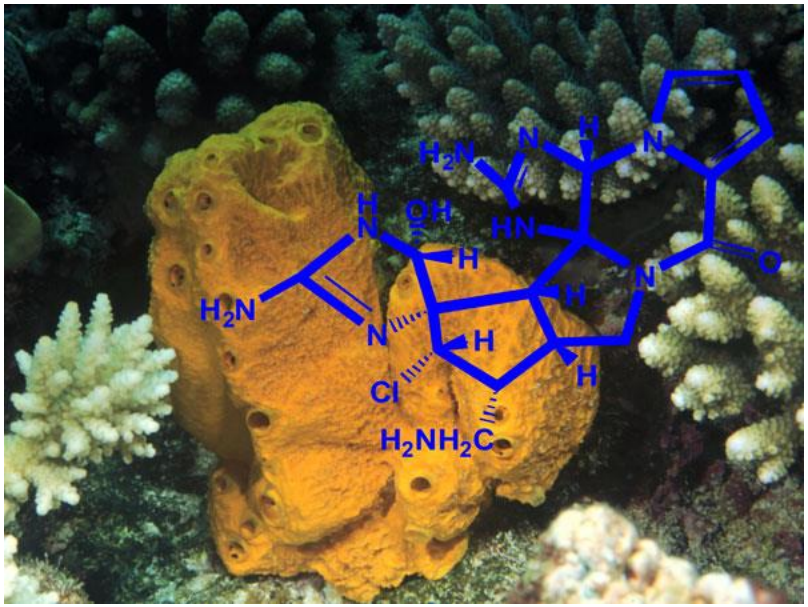
WP3 Hazard of mining activities to marine life

Ecotoxicological studies

a) High –pressure laboratory experiments to test and simulate the impact of multi stressors, i.e, sediment laden plumes, trace elements, noise and light contamination, in deep sea *taxa*;

a) Recovery experiments to test the resilience and recovery of selected deep sea *taxa* after multi stressors' insult.

WP 5 Marine Biotechnology “under pressure”



Genomics of deep-sea marine life adaptations: pinpointing novel bioactive metabolites and their biotechnological relevance

Deep-sea ecosystems are driven by unique physical, geochemical and biological processes.

Life in such extreme conditions is followed by **unique anatomical and physiological adaptations.**

Deep-sea – probably the last frontier in terms of bioprospection

Bacteria – biodiversity <=> chemodiversity
sources of natural antibiotics, other bioactive compounds

APPROACH

Obtain bacterial isolates;
Genome mining (from data obtained in the previous subtask) for biosynthetic gene clusters

Bioactivity (antifungal, anticancer, antibiotic, antifouling) and/or genome-guided isolation of novel molecules; structural elucidation (NMR, MS, etc.)

Genes-to-molecules (or vice-versa) and subsequent biosynthetic studies to identify novel enzymatic functions

WP5

Development of new bioremediation technologies based on deep sea organisms

Research Questions/Objectives :

•Development of biotechnological tools based on the ability of autochthonous microorganisms to remove contaminants, through bioremediation processes.

•Promoting clean and economically reliable tools to mitigate pollution effects and promote ecosystem recovery.

CORAL

Blue SENSORS

- Understand and evaluate impacts on marine biodiversity
- Understanding evolution of water quality,
- Assessing the integrity of operating infrastructures
- …

ciimar

Sustainable management and exploitation of Ocean resources

in-situ real time perception of physical, chemical & biological properties

INESCTEC
TECNOLOGIA E CIÊNCIA
LABORATÓRIO ASSOCIADO

New sensor technology capable of operating in marine like environments

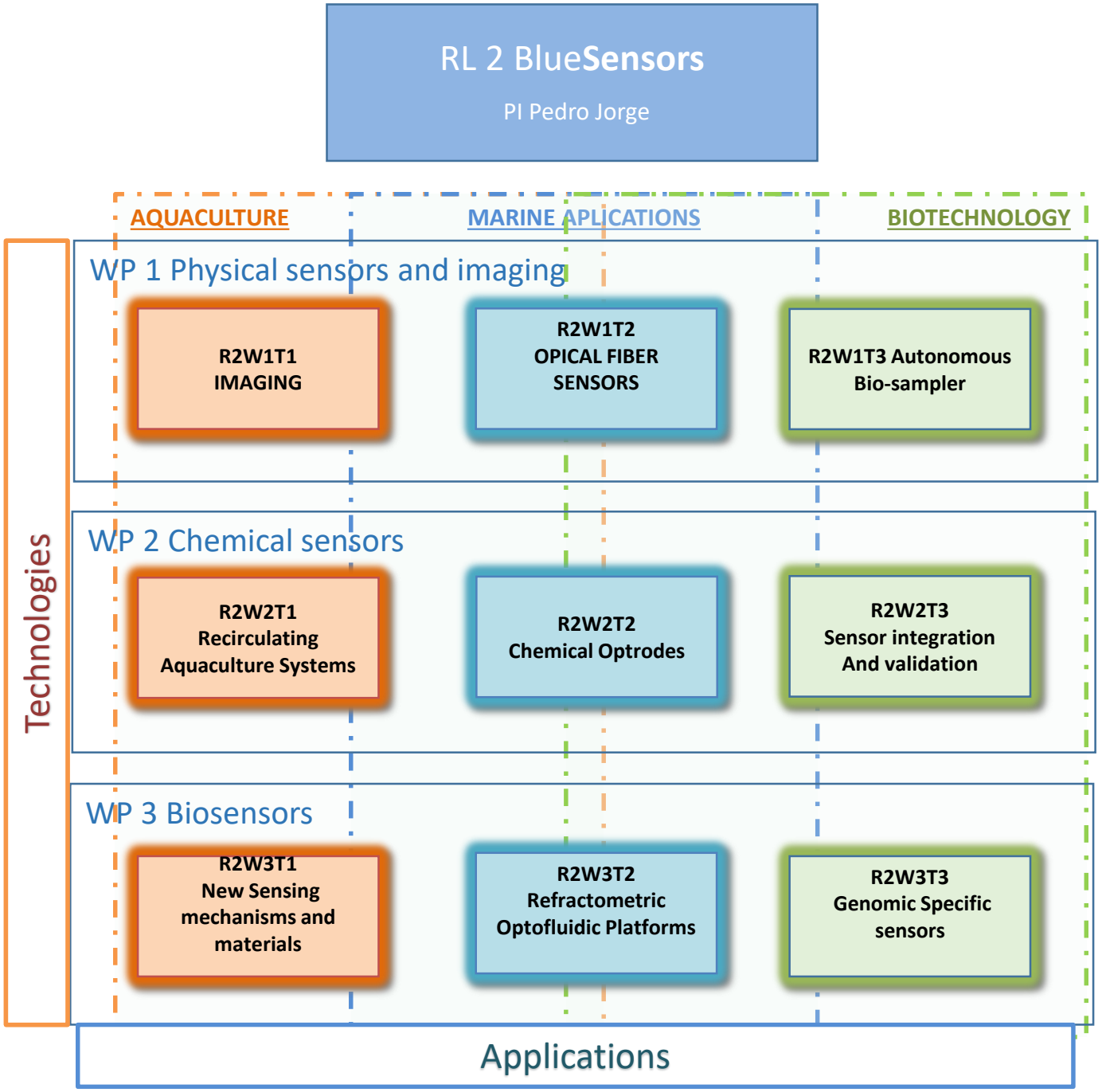
Coral

sensors

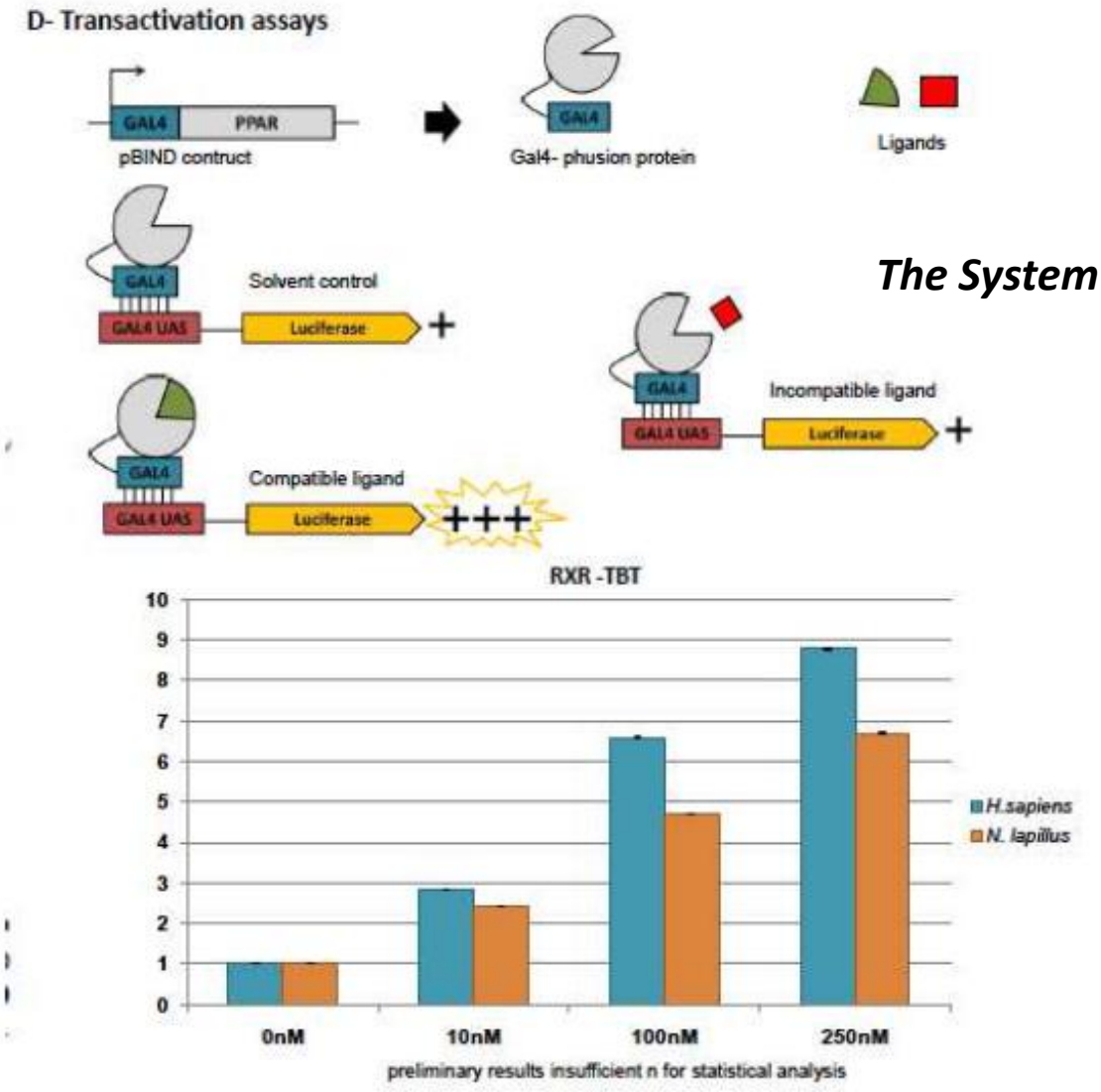
Main Goal

Develop innovative photonic technology for operation in marine like environments

Framed in specific challenges



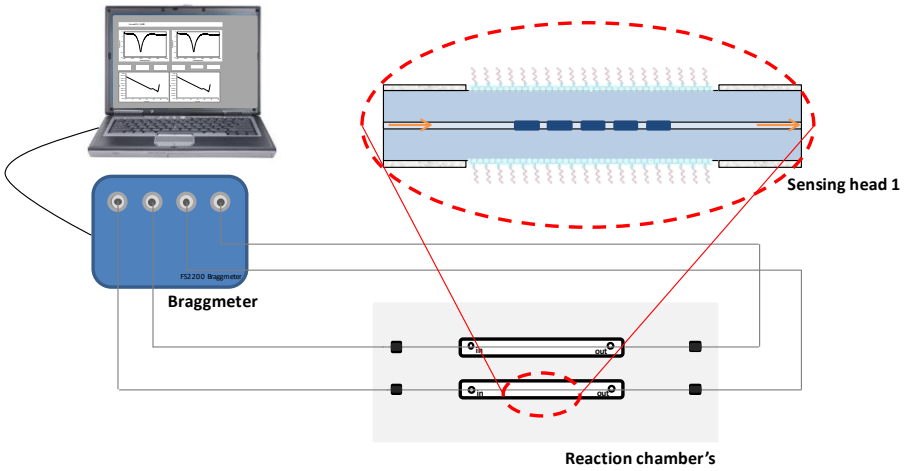
WP3 – Endogenous animal sensors

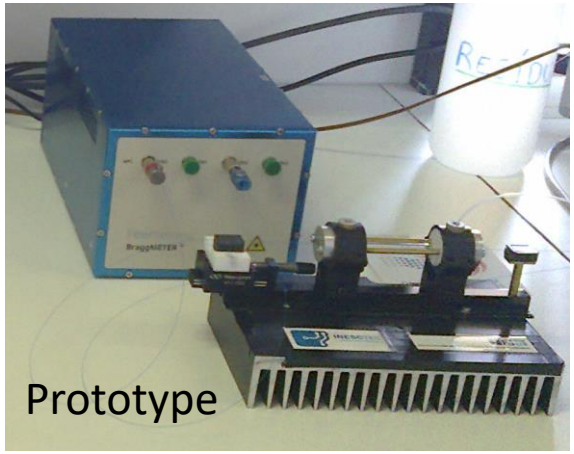


The System

WP3 – Genomic specific sensors

DNA and Aptamer based recognition





- Laser scanning interrogation Unit FS2200 (FiberSensing Sa) – modified for transmission
- Laser scanning unit with 2 channel; Resolution 2.5 pm; 0.5 sample/s
- Constant temperature
- Constant applied axial strain
- Special algorithms for LPG resonance spectral position determination with increased resolution

System validated in Genomics:

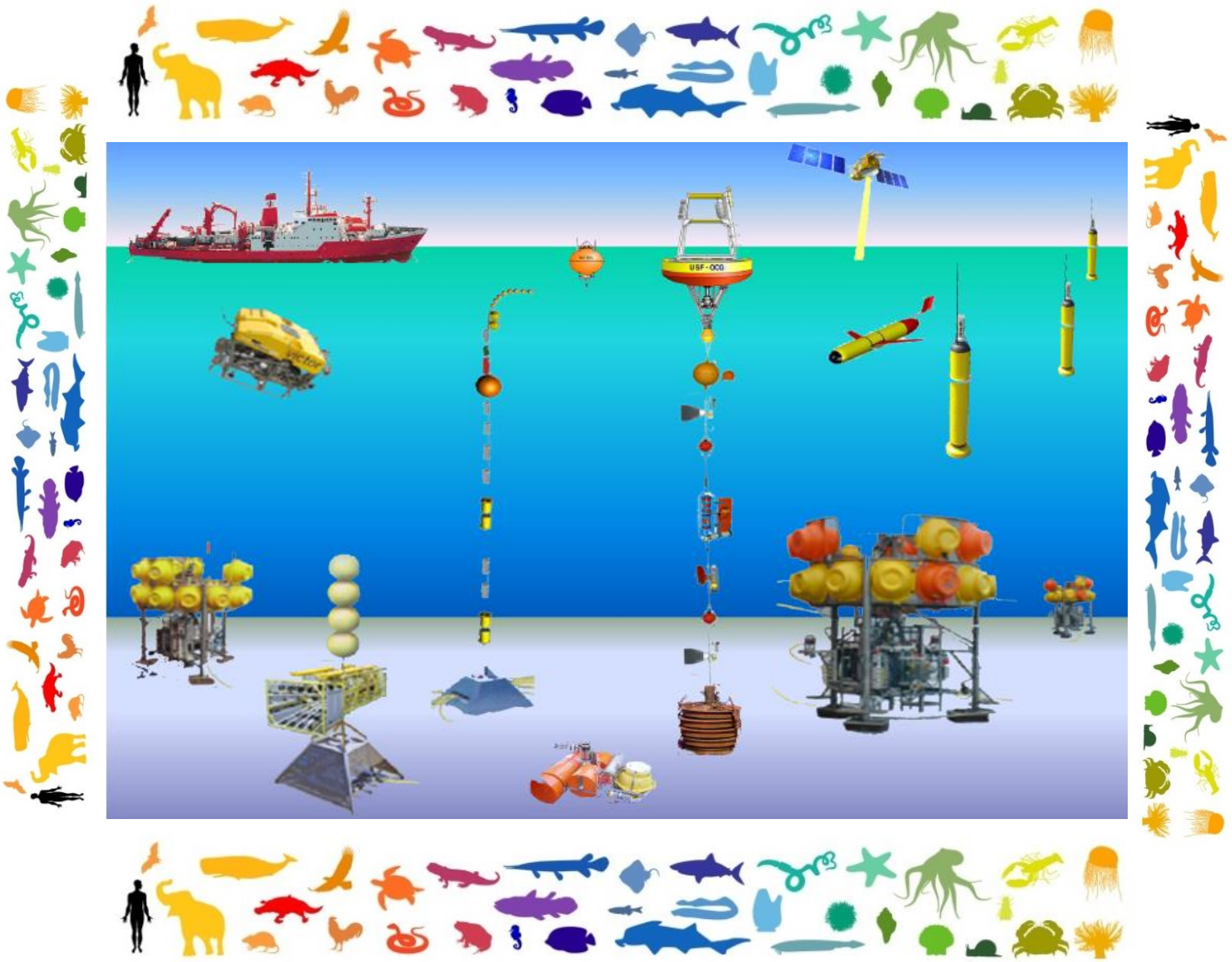
- DNA recognition by hybridization *(vitis vinifera*), with single base mismatch selectivity. No PCR needed.
- Regeneration and specific binding observed in more than 40 cycles on the same sensor
- Highly specific – able to detect up to one base mismatch
- Tested with synthetic DNA and real DNA extracted form *vitis vinífera* (leaf, grape and wine)
- Usable by non specialized technicians (without specific formation in optics or optical sensors)

Gonçalves et al "Biosensor for Label-free DNA Quantification based on Functionalized LPGs". Biosensors & Bioelectronics (**2016**). In Press

Queirós et al "Evanescent wave DNA-aptamer biosensor based on LPGs for the specific recognition of E. coli outer membrane proteins". Bios.& Bioelect. (**2014**). 62, 2014, Pages 227–233.

A BLUE FUTURE

Knowledge of the Ocean as a basis for the sustainable management and exploitation of resources



Thanks for your attention and to all the CORAL Team

NORTE 2020 PORTUGAL 2020 UNIÃO EUROPEIA