The Development of **Technology** for the **Mining** of **Polymetallic Nodules** from the Deep Sea

The Blue Nodules project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 688975

Current status of the marine mining industry on the Continental Shelf

- Seabed mining currently takes place in the shallow water and continental shelf.
- These range from small scale gold operations in shallow waters off Alaska, to
- Tin off Indonesia, and Diamonds off Namibia (the deepest at 200 m WD).

IHC has a reference base in both tin and diamond mining.

What will be the first commodity to be mined from the Deep Sea?

- **Polymetallic Sulphides**

  First mover is Nautilus Minerals. Resource identification ongoing for mine life of 20+ years. Mainly gold, silver and copper targeted. First production delayed to 2018/2019.

- **Cobalt-Rich Crusts**

  Resource exploration and identification still at an early stage.

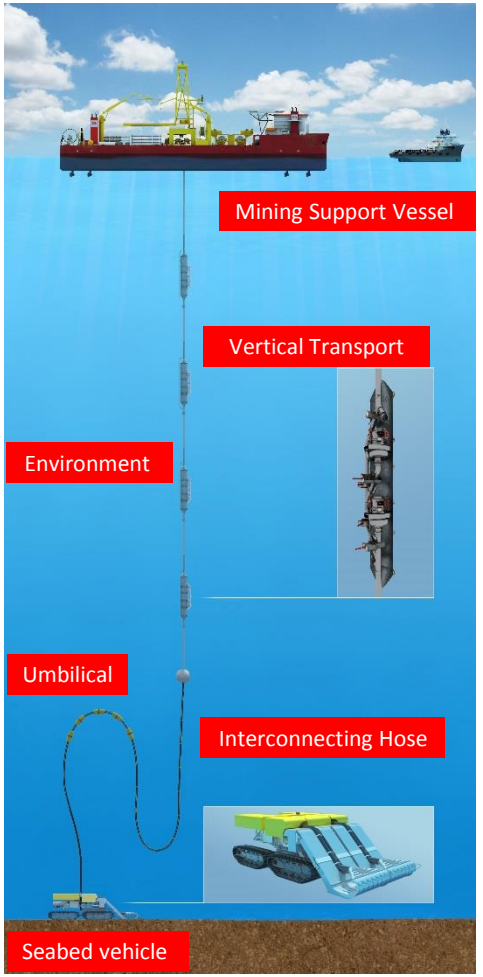
- **Polymetallic Nodules**

  Resource identification advanced. CCZ may host 27 billion tonnes of nodules (ISA 2009) possibly containing 7 billion tonnes of manganese, 340 million tonnes of nickel, 290 million tonnes of copper and 58 million tonnes of cobalt. Target minerals satisfy the EU's requirements for a secure supply of industrial raw materials.

New Caledonia contains about 7 million tonnes of nickel, 10% of the world's reserves, annual production is 100,000 t. Russia 265,000 t; Indonesia 190,000 t; Canada 180,000 t; Australia 170,000t.
CCZ represents 1,283 years of mining at 265,000 tpa.
265,000 tpa would involve 7 vessels each mining 3 mta.

EU Subsidies for Technology development for mining the deep sea

- Blue Mining (Polymetallic Sulphides & Polymetallic Nodules):
  - Polymetallic Sulphides – circa 2 000 m WD.
  - Polymetallic Nodules – circa 5 000 m WD.
- Blue Nodules (Polymetallic Nodules):
  - Seabed vehicle, collector & separator;
  - Interconnecting hose;
  - Vertical transport system;
  - Umbilical for power and control;
  - Dewatering for storage of ROM on board; and
  - Environmental considerations.



Key project Figures

- The Blue Mining project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 604500

- 19 partners from 6 countries

Start date: 1 Feb 2014
End date: 31 Jan 2018
Duration: 48 Months
Total costs: 15 M€
Total EC Funding: 10 M€

Industry

Research Institutes

Service Supplier

Blue Nodules

- The Blue Nodules project has received funding from the European Union's Horizon 2020 Programme for research, technology development and demonstration under grant agreement no. 688975

- 14 leading industry and research partners from 9 different countries in Europe

Start date:	1 February 2016
End date:	31 January 2020
Duration:	48 months
Total EC Funding:	8 M€

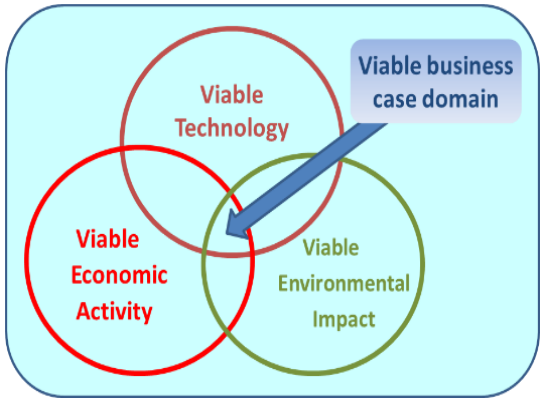
The focus of this presentation is Blue Nodules

Background

- Relevance for Europe
  - The strategic importance of a sustainable supply of raw materials to the EU has been recognized in different strategic policy documents
  - Particular importance is given to the expected supply shortages of Critical Raw Materials (CRM)
  - The European Innovation Partnership on raw materials objective is that by 2020 Europe will have reduced its dependency on raw materials imports by accelerating innovations that secure or prevent wastage of key raw materials
- Polymetallic Nodules in Context
  - Occur on the seabed in most oceans of the world
  - Contain large quantities of 'candidate' critical raw materials: Ni, Cu, Co, Mn as well as sizable amounts of gallium and rare earth elements
  - Techniques for exploitation have been developed since the 1970's
  - Current concepts envisage seafloor, surface and intermediate sub-systems
  - No integrated system for polymetallic nodules harvesting, vertical transport and surface processing has ever reached industrial viability

Objectives

1. Full scale deep sea polymetallic nodule mining system development:
   - Harvesting equipment and control technology for:
     - Vehicle and collector
     - Umbilical
     - Interconnecting hose
   - In-situ seafloor equipment for processing of polymetallic nodules:
     - Pick up mechanism
     - Sediment separation
     - Crushing/sizing
     - Horizontal and vertical transport
   - Sea surface operations and processing equipment for:
     - De-watering/storage
     - Ship to ship transfer
     - Mining platform
     - Process water and tailings discharge
2. Knowledge and Advanced Models for Assessing of Business Cases Representing the Entire Value Chain:
   - A value chain model
   - Corresponding business model
3. Knowledge and Advanced Models/Methodologies for Determining and Minimizing the Overall Environmental Impact of the Deep Sea Mining of Polymetallic Nodules:
   - Identify and assess environmental pressures
   - Ensure protection by implementing risk based methods in engineering and design
   - Engineer and design the systems to allow for adaptive management during operations
   - Acknowledge transparency as a key consideration and disseminate the project results to society and stakeholders



Partners

Industry

IHC

IHC MTI

DE REGT MARINE CABLES
A SERCEL CO

Continental

Dredging International
Marine & Waterway Solutions

Research

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

AARHUS UNIVERSITY

NTNU
Norwegian University of Science and Technology

RWTH AACHEN UNIVERSITY

NIOZ

Service

UNIRESEARCH

BUREAU VERITAS
Move Forward with Confidence

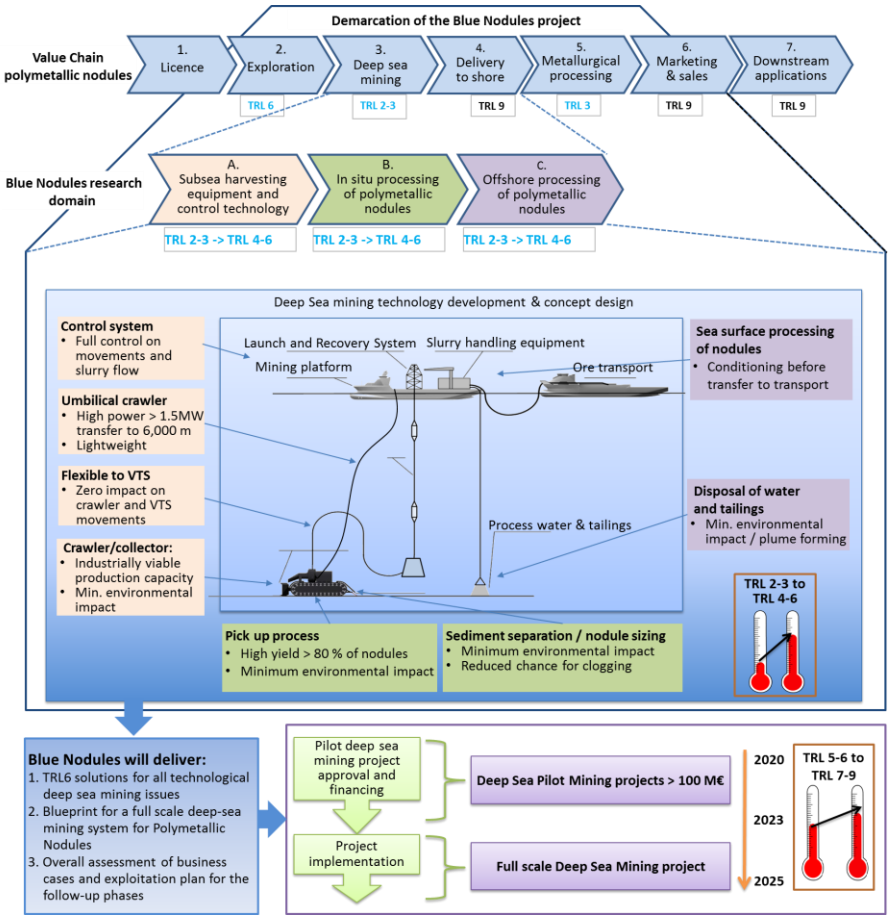
seascape consultants ltd

GSR
Global Sea Mineral Resources

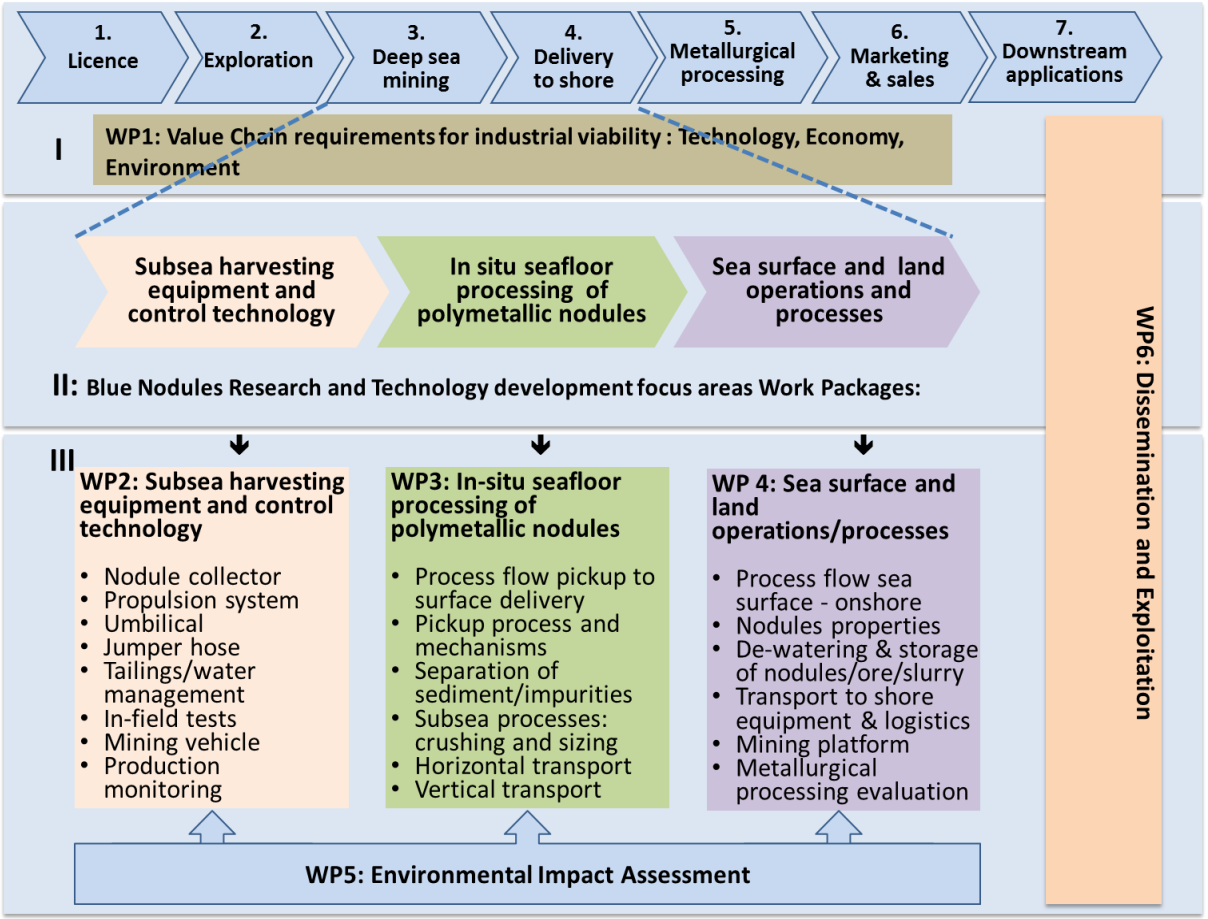
Scope

Blue Nodules will develop a new highly automated and technologically sustainable deep sea mining system for harvesting polymetallic nodules in the seabed. Key features are:

- An industrially viable polymetallic nodule business case;
- In-situ processing of nodules (sediment separation and crushing/sizing);
- Excellent, intrinsic safe working conditions;
- Minimum environmental impact; and
- Compliance with the relevant policies and regulations.

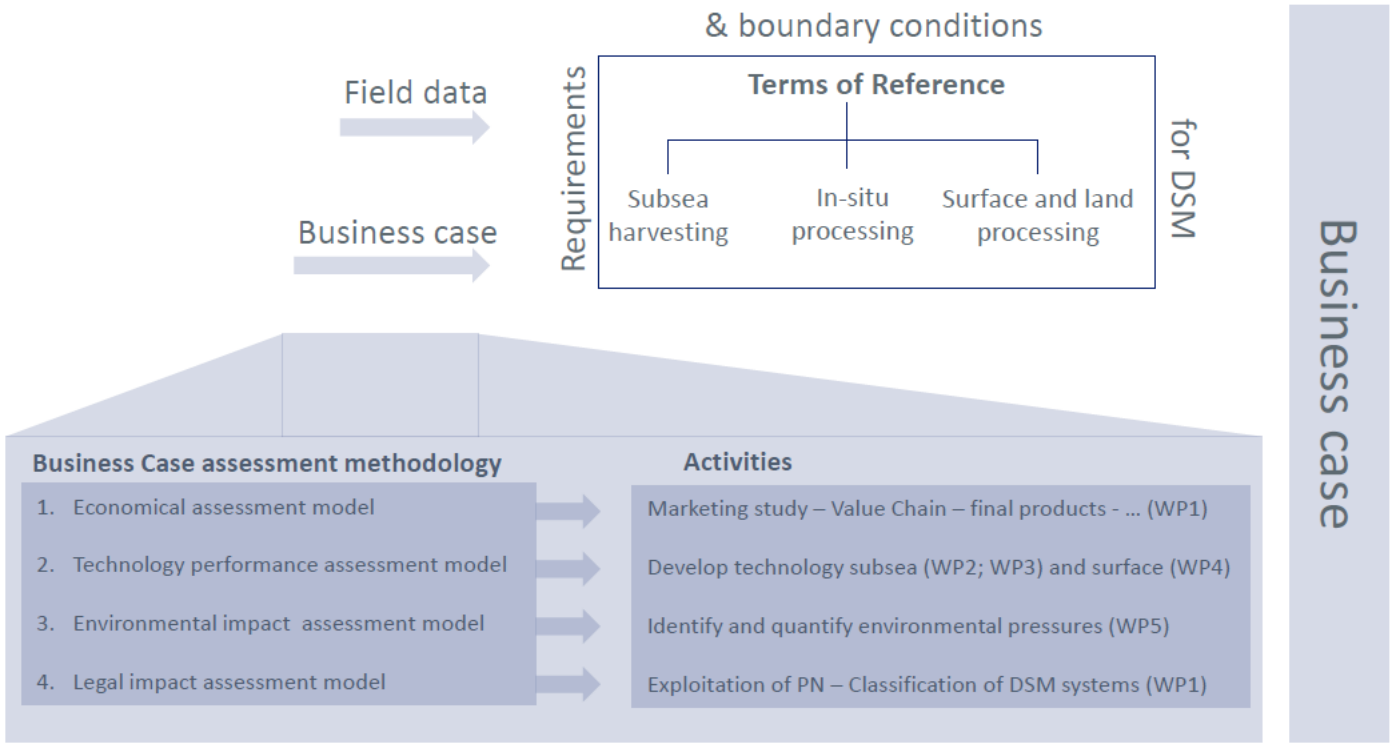


Technical Approach



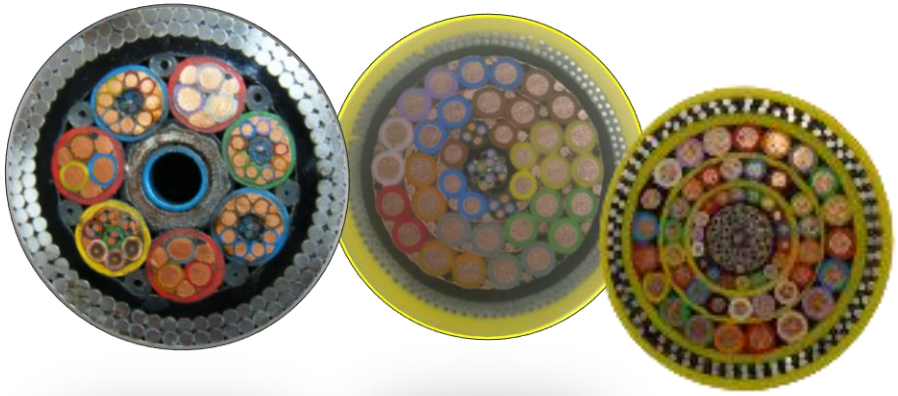
WP1 Business Case Assessment

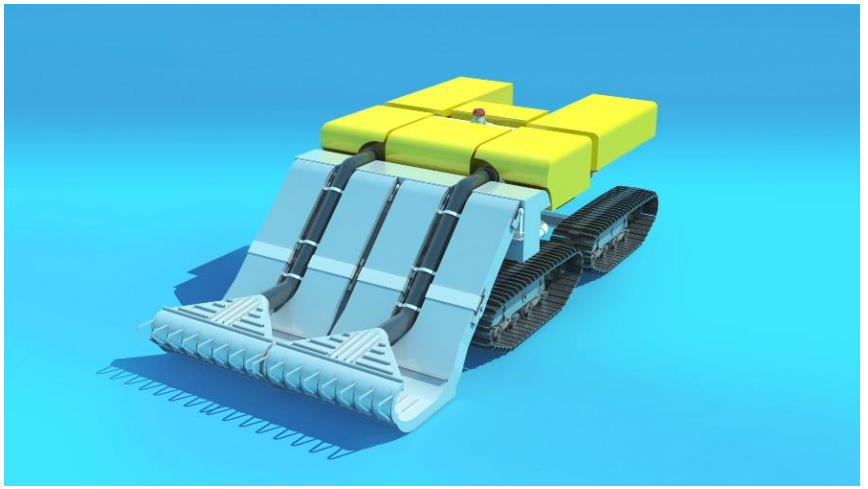
- Assessment and Integration of Environmental, Economical and Technological Aspects into Business



WP 2 Subsea Harvesting Equipment and Control Technology

- Development and testing of essential components for the harvesting of polymetallic nodules in de deep sea.
  - Collector for harvesting polymetallic nodules
  - Propulsion system
  - Umbilical
  - Jumper hose
  - Tailings and water management systems

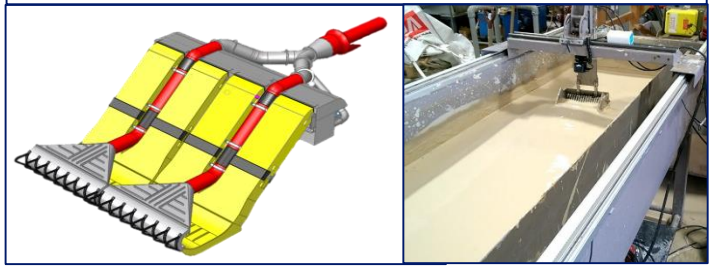




WP 2 Subsea Harvesting Equipment and Control Technology

Tracked Vehicle Development

Collector Development



Prototype Test Vehicle

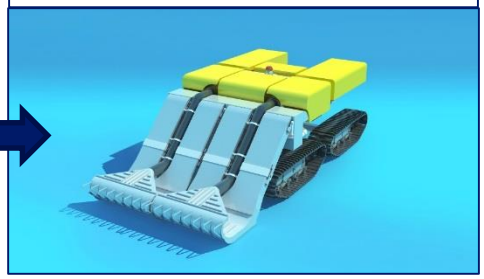
2016 / 2017
- Factory testing
- Autonomous testing
- Laboratory test to validate soil interaction model

2016 / 2017
- Mechanical & hydraulic collector
- Laboratory tests to determine the most suitable

September 2017
- Testing in the North Sea
- Traction & collector tests
- Environmental monitoring

2017 / 2018
- Evaluate North Sea Testing results
- Establish improvements required
- Design and implement improvements

Improved Prototype Test Vehicle



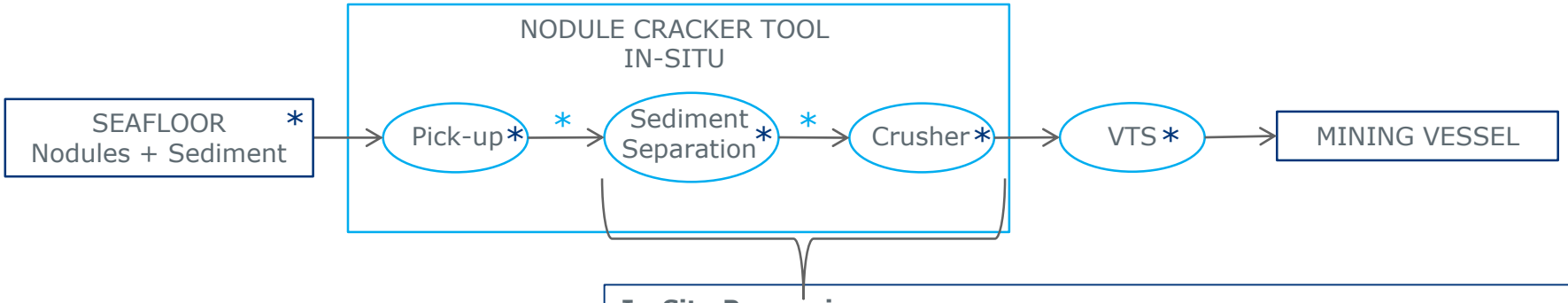
September 2018
- Testing in the North Sea

September 2019
- Testing in the Clarion Clipperton Zone

WP3 In- Situ Seabed Processing of Polymetallic Nodules

Characterization *
- PSD
- Moisture content
- Density
- Control & monitoring
  - Flow/ volume
  - Pressure

→ For designing pick-up process, sediment separation, crushing and VTS



In-Situ Processing
- Sediment Separation
  - To reduce the amount of sediment in the process
  - To reduce the amount of energy needed for transport
  - To relieve the de-watering process
  - To reduce plume created by the water return system
- Acoustic emission measurement *
  - To maintain a constant, reliable and sustainable process flow
    → design if the measurement and control loop
- Comminution
  - Nodule (>100 mm) sizing under water (needs to be proven if necessary)

WP4 Sea Surface & Land Operations and Processes

- Reliable and Sufficient Sea Surface Facilities for the Processing and Storage of Polymetallic Nodules, Sediments, Wastes and Other Effluents.
- Definition of Offshore and Onshore Operations, including the Mining Vessel Layout, the Transfer of Polymetallic Nodules (PN) at Sea, the Transport to (European) shore and the Scenarios for Onshore Processing.

WP5 Assessing and minimizing environmental impacts of deep-sea polymetallic nodule harvesting, processing, and transport

1. Identify the range of environmental pressures arising from the mining of polymetallic nodules, from the harvesting and seabed processing, vertical and horizontal transport and onboard processing, until onshore processing of ore into a semi-finished product.
2. Quantify the most relevant environmental pressures by means of lab- and field experiments, numerical modelling, and available literature data, and provide feedback to the design of seagoing equipment in order to reduce the environmental disturbance.
3. Evaluate technological and operational solutions for reducing environmental impact in the light of current status of scientific knowledge on environmental impacts and compliance to international regulations and industrial standards.

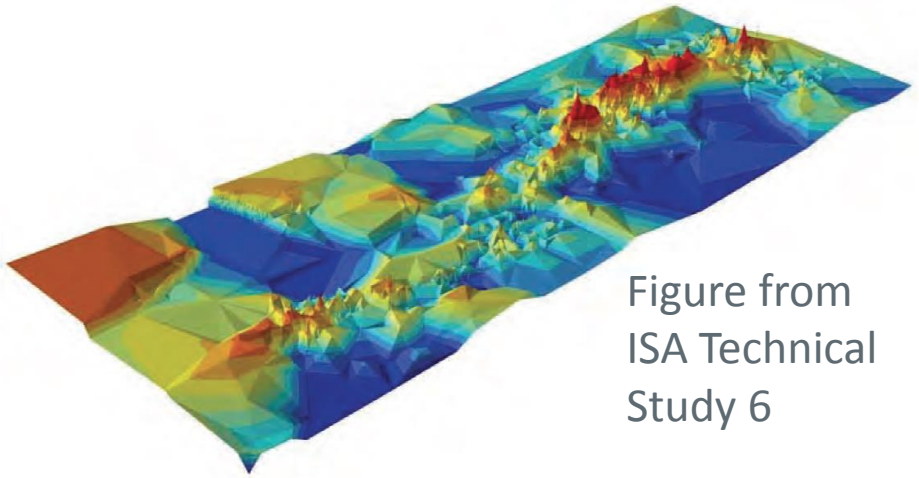
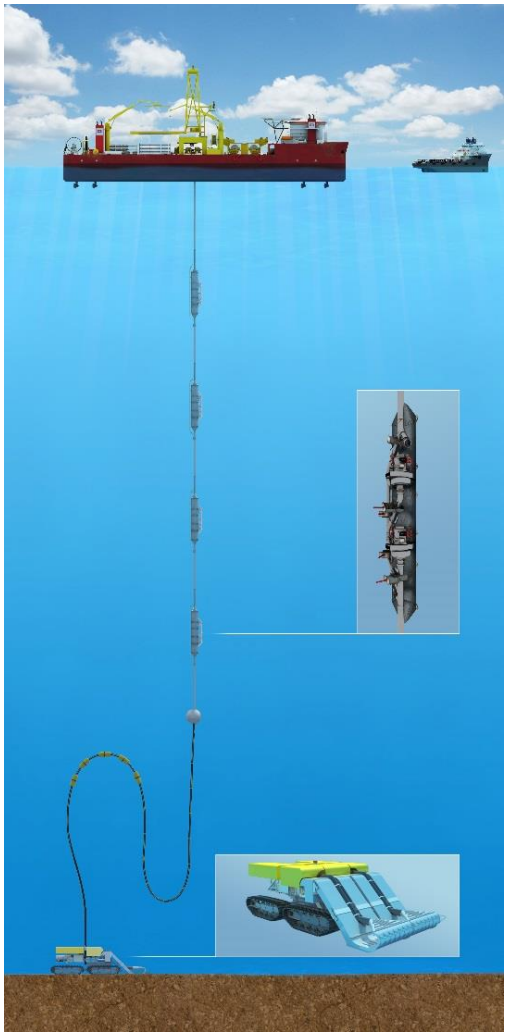


Figure from ISA Technical Study 6

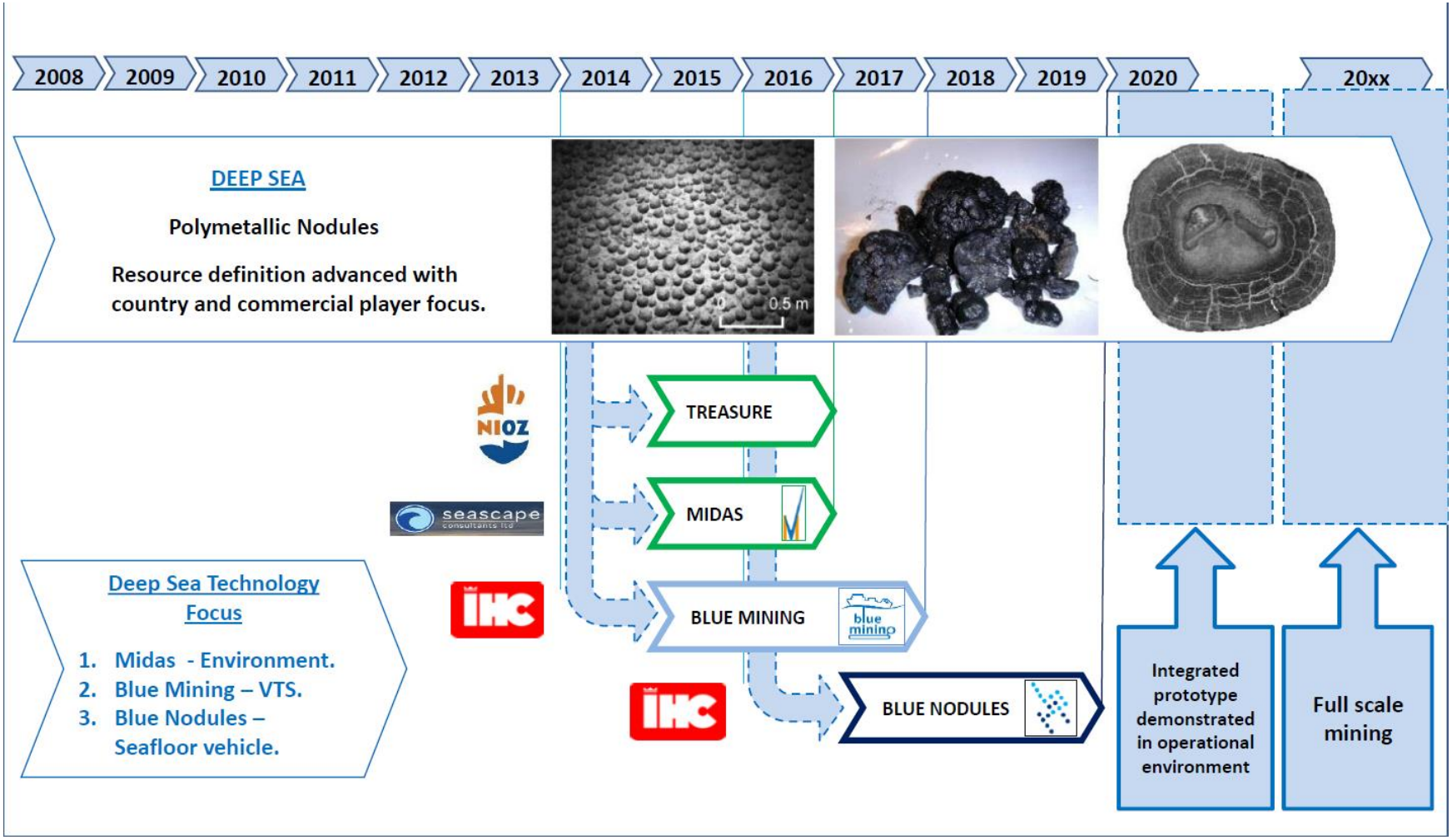
WP5 Assessing and minimizing environmental impacts of deep-sea polymetallic nodule harvesting, processing, and transport



Sources of environmental pressures at the mine site:

- Light pollution from the surface support vessel
- Trans-shipment dewatering plume
- Return water plume
- Noise, vibration
- Large area impacted (connectivity, ecosystem function, recovery, etc.)
- Generation of benthic plume
- Substrate removal (nodules)
- Removal of surficial sediment layer
- Sediment compaction

From Technology Development to Commercial Mining



bluenodules

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Thank you for your attention

Industry

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