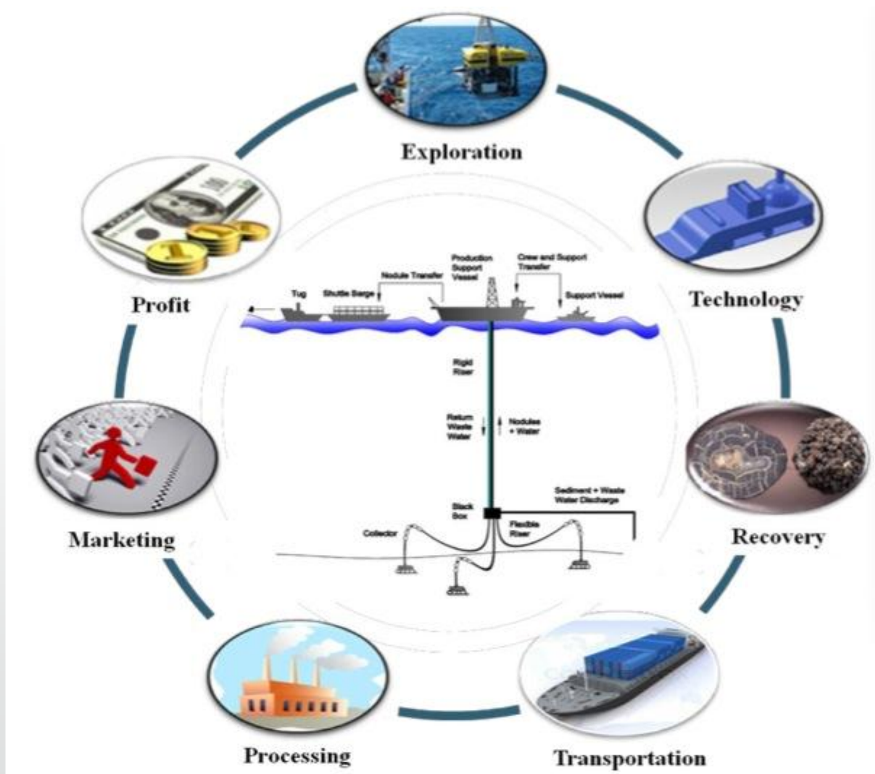
Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

Feasibility Study on Manganese Nodules Recovery in the Clarion-Clipperton Zone



Baivau - Pan - Marco – Harrif - Jenny

Outline

- Motivations & Objectives & Case Study — Pan
- Proposed Engineering System — Baivau
  - Collector
  - Black Box — Marco
  - Noise Assessment
  - Logistic & Commercial Analysis — Jenny
  - Business Model — Harrif
  - SWOT & Conclusion
- Q&A — P - B - M - J - H

Motivations and Objective

Past
Collapse of world metal prices
Controversial UNCLOS III provisions
Insufficient technological advances
Inability to quantify and mitigate environmental damages

- **Promote for full-scale deep sea nodules recovery;**
- **Environmental friendly design.**


University of Southampton Highfield Campu

Land Mining vs. Mn Nodules Recovery

- Smaller footprint as less overburden needs to be dealt with
- Less permanent infrastructure
- Less populated ecosystem to be affected
- Rich in mineral diversity


Source: BHP Billiton


Source: OceanflORE

Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

Existing System for Nodule Recovery

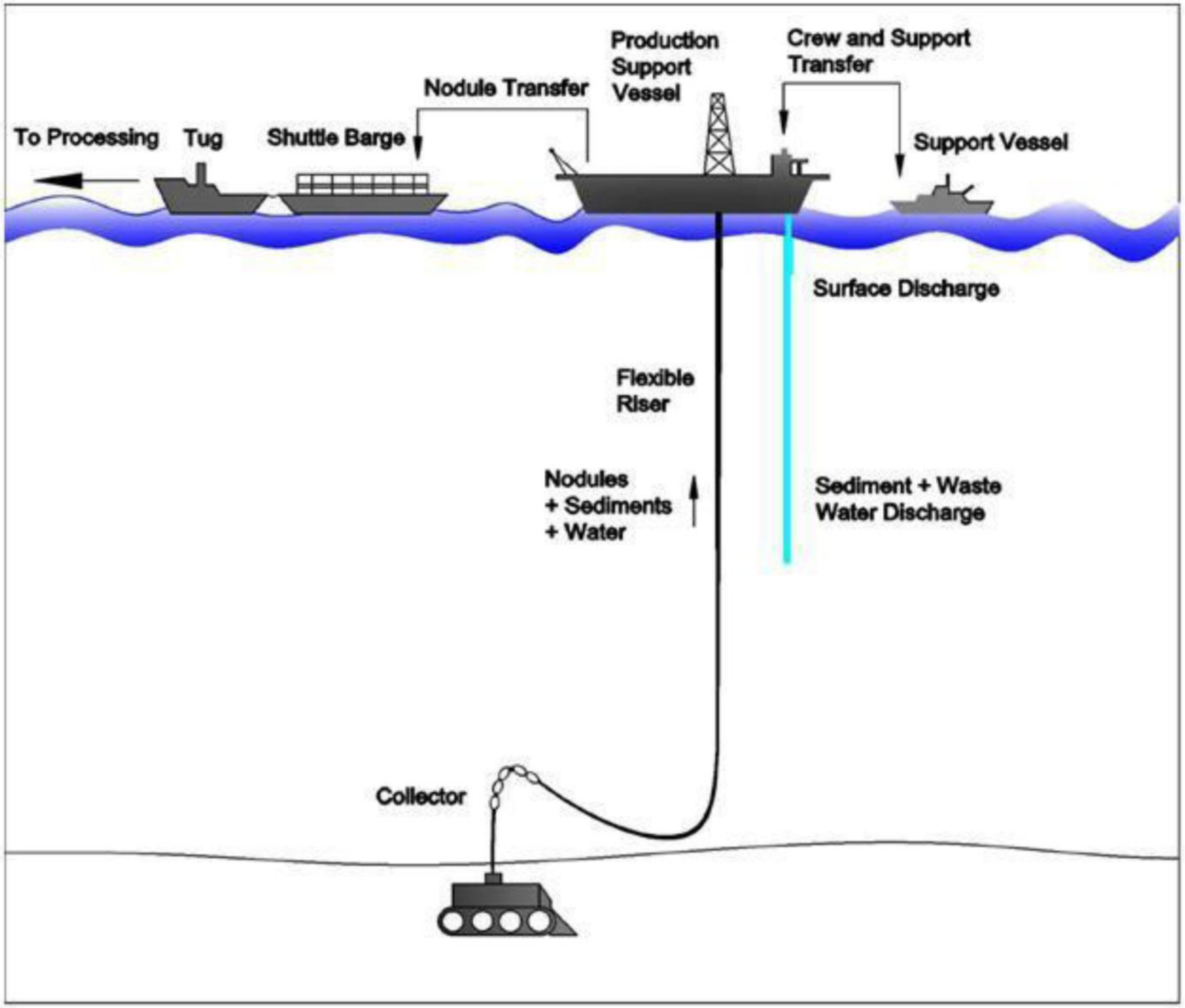


Figure 35: Existing nodule recovery concept

Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

Our System for Nodule Recovery

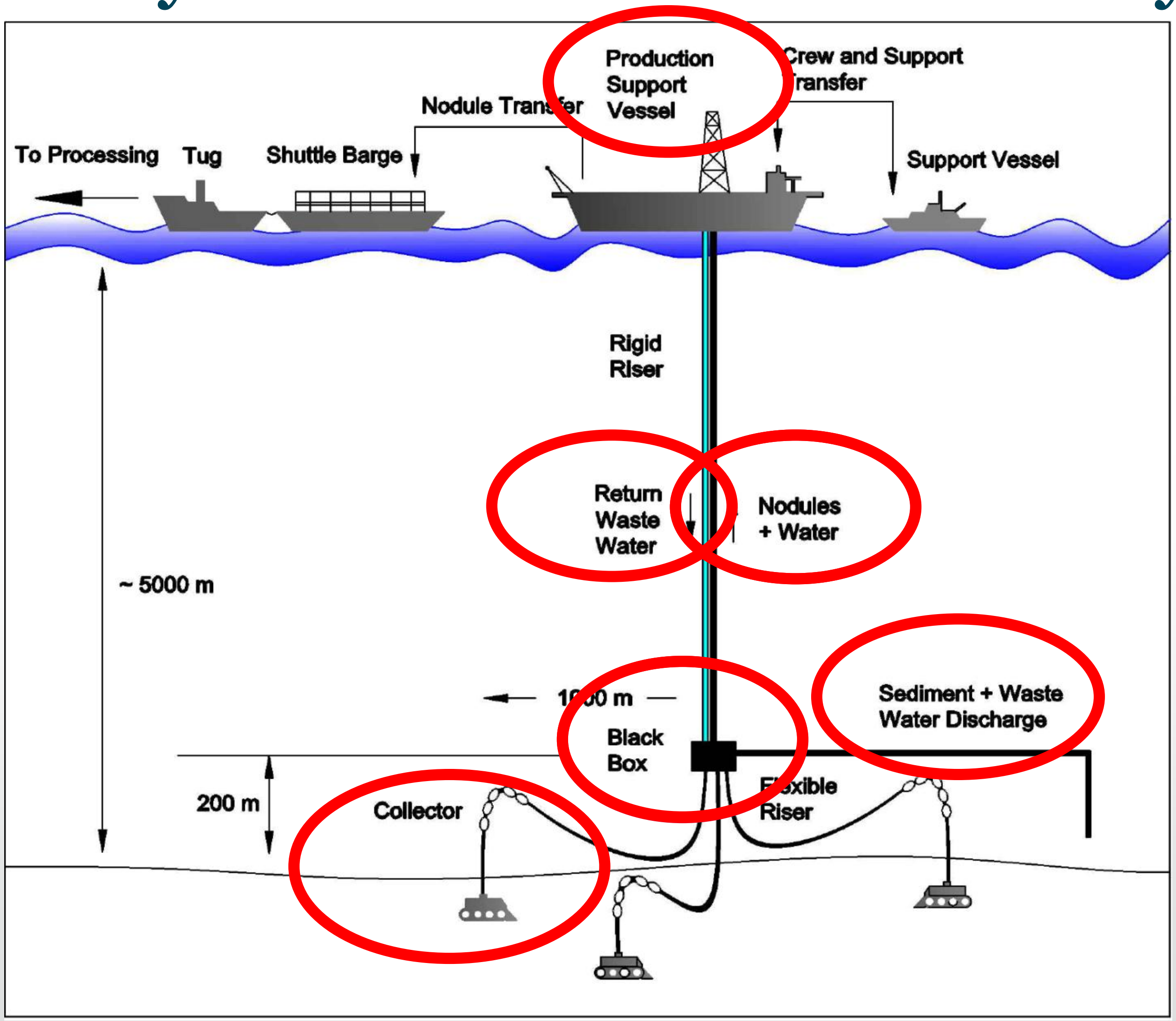


Figure 36: Proposed nodule recovery concept

Collector

- Number of Collectors (mother ship): 3 working + 1 buffer
- Productivity ➔ 274,000 wet tons/year ➔ 180,000 dry tons /year

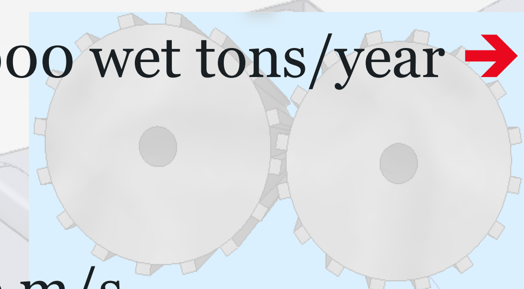


Figure 39: Representation of the crusher

- Collector Speed: 0.20 m/s ➔ High Efficiency
- Collecting width/ Maximum width = 1

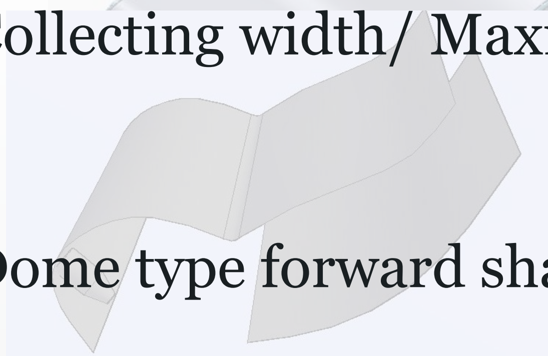


Figure 40: Representation of the crawler subsystem

- Dome type forward shape ➔ Less Sediment Disturbance
- Long & Narrow Collectors

Sediment Disturbance

- Crawler aided movement
- Multiple small units
- Streamlined body

HYDRAULIC:

- Water Jets
- Forward dome shape

Recent Studies	Daily Production of Dry Nodules	Estimated Suspended Sediments from Seafloor	Sediments/Dry Nodules
Herrouin (1999)	6,000 t (dry)	~ [a]19,155 t ~ [b]54,519 t	3.19 9.09
Morgan et al. (1999)	5,500 t (dry)	~ 54,000 t	9.82
The Proposed System	**1,636 t (dry)**	**~ 3,266 t**	**2.00**

(a = 2 cm penetration of the collector; b = 5 cm penetration of the collector)

The Black Box

- Washing process;
- In-situ waste discharge;
- Waste water utilization;
- Mass flow rate regulation;
- Reduce power/cost for vertical transfer

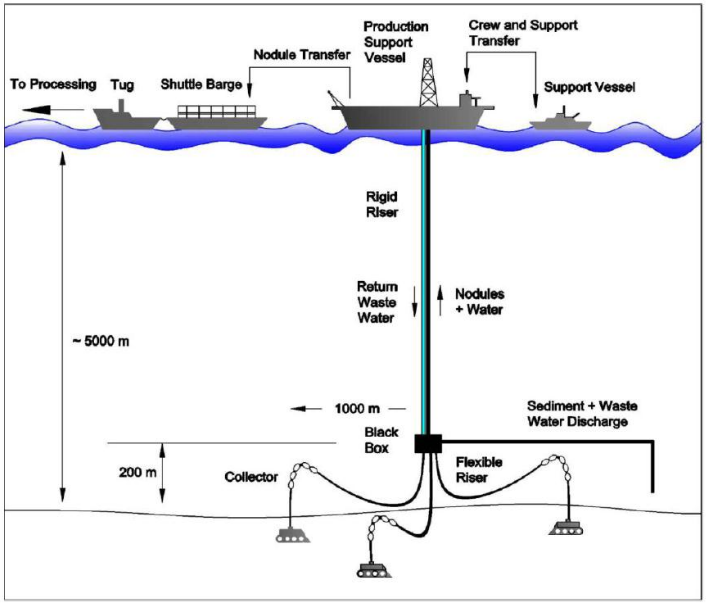


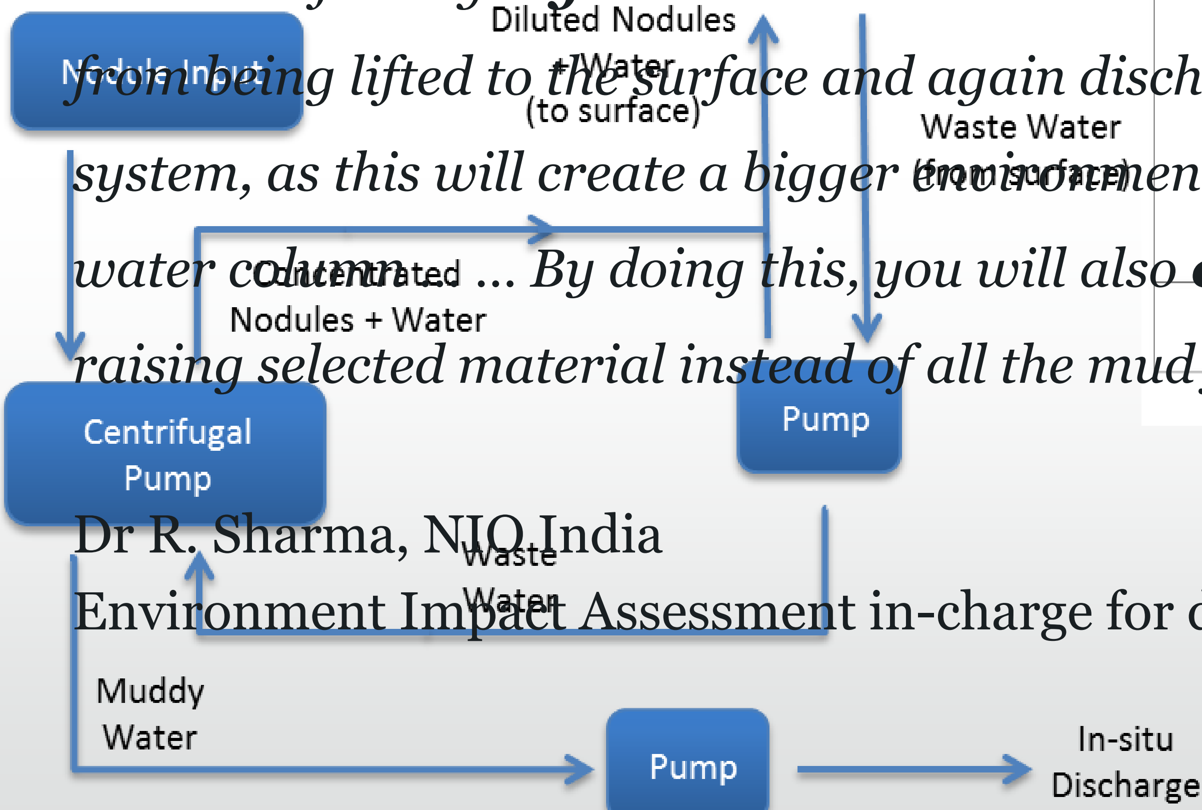
Figure 36: Proposed nodule recovery concept

- 2% saving in Power Consumption
- <2% sediment in the waste water

Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

The Black Box



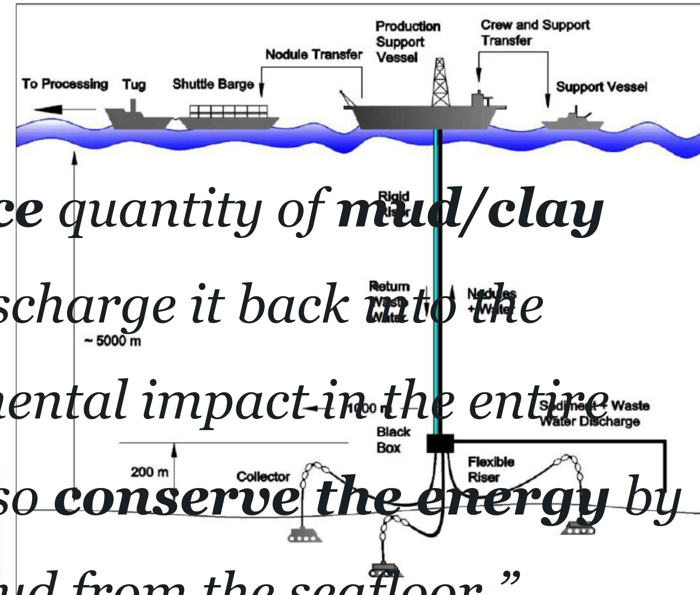


Figure 36: Proposed nodule recovery concept

*"This is definitely **a good method to reduce** quantity of **mud/clay** from being lifted to the surface and again discharge it back into the system, as this will create a bigger environmental impact in the entire water column … By doing this, you will also **conserve the energy** by raising selected material instead of all the mud from the seafloor."*

Dr R. Sharma, NIO India

Environment Impact Assessment in-charge for deep sea mining

Noise Assessment

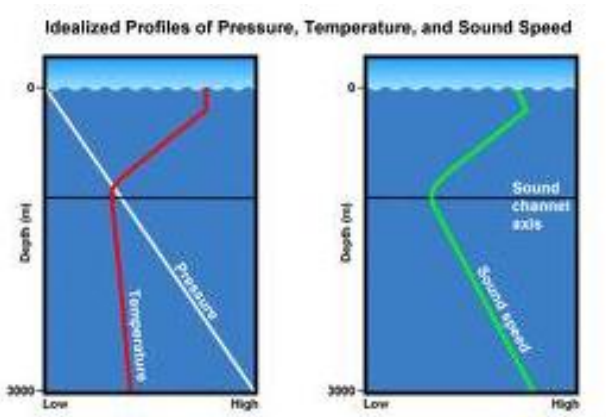


Figure 49: Idealized profiles of pressure, temperature and sound speed (COMET)

- Pressure & temperature
- Varying velocity of sound

Sound Channel

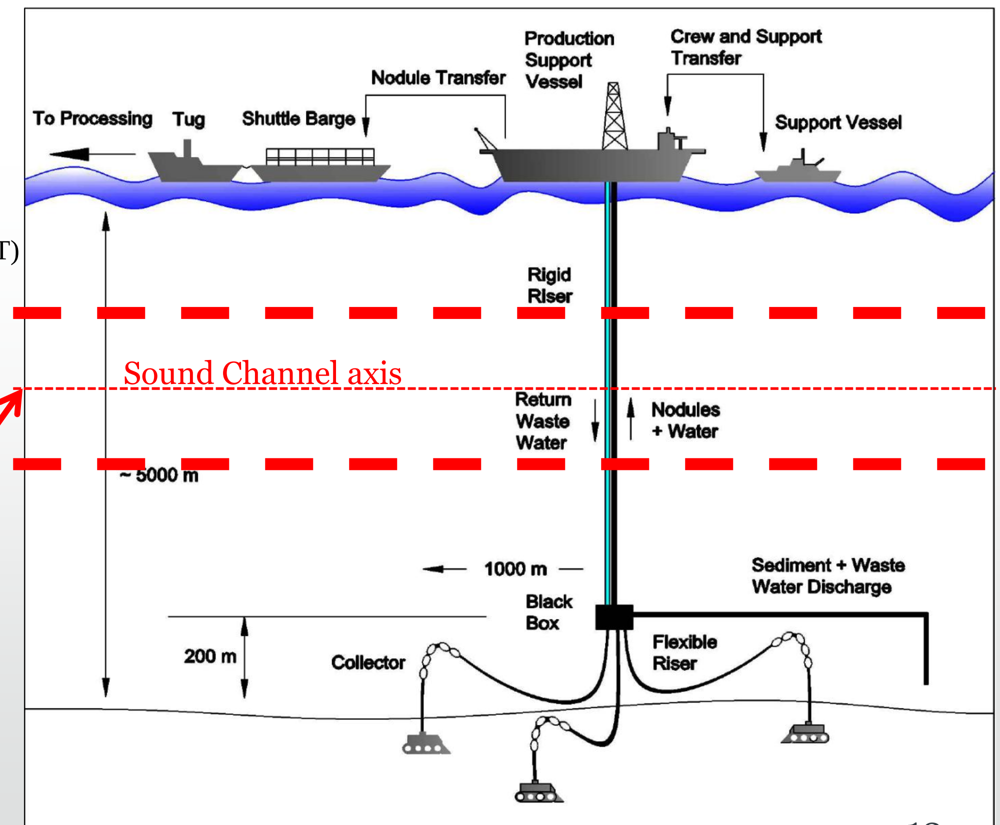


Figure 36: Proposed nodule recovery concept

Power Requirement

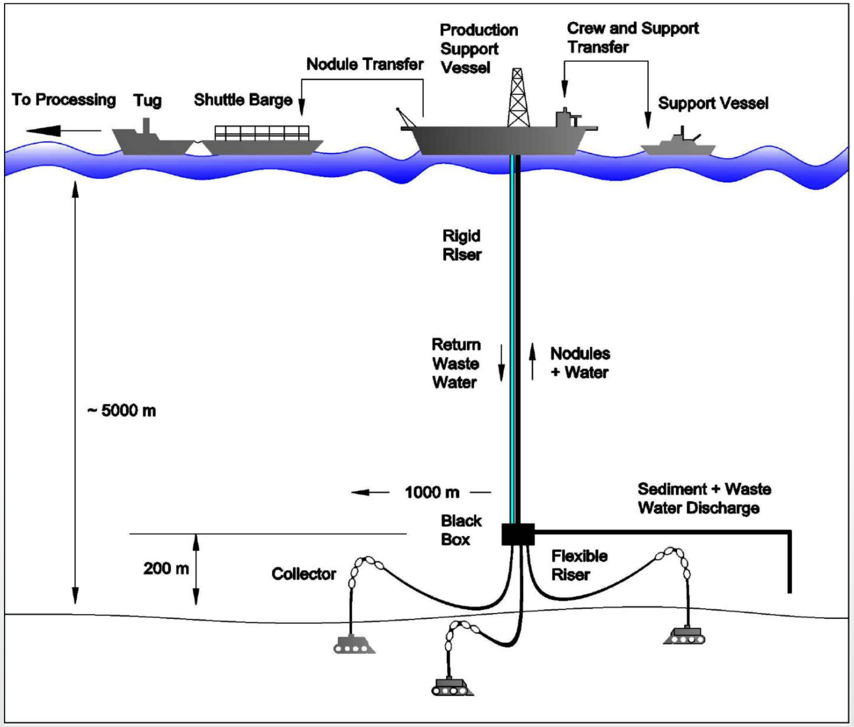
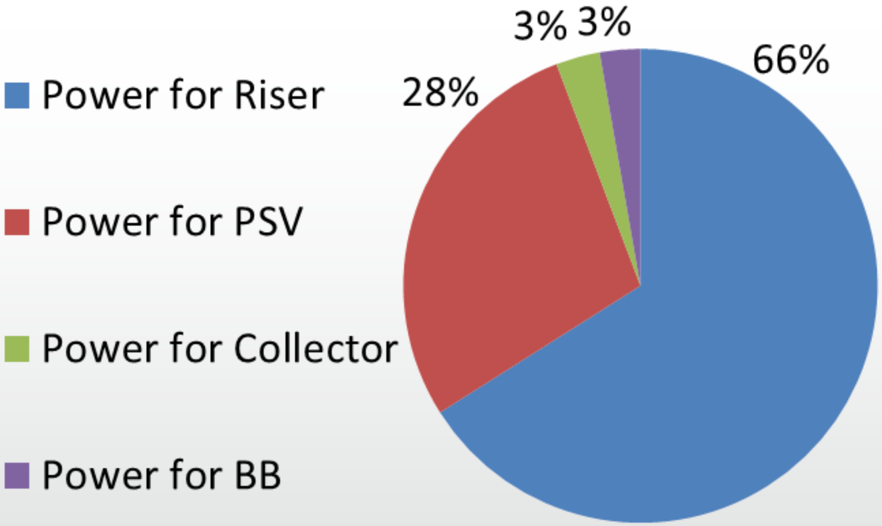


Figure 36: Proposed nodule recovery concept

Total power requirement: ~ 16.7 MW

Power source: diesel generators on PSVs



PSV – Production Support Vessel; BB – Black Box


70°F / 21°C
Clarion-Clipperton Zone

Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

System Productivity

Pre-processing:
0.540 Mton Dry nodules/y

Transport

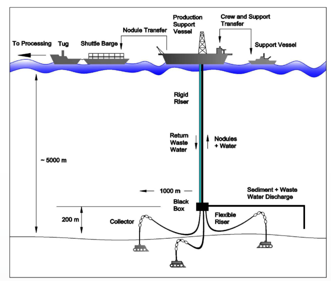


Figure 36: Proposed nodule recovery concept

Metallurgical processing:
0.486 Mton Dry nodules/y

Lifting:
0.822 Mton wet nodules/y

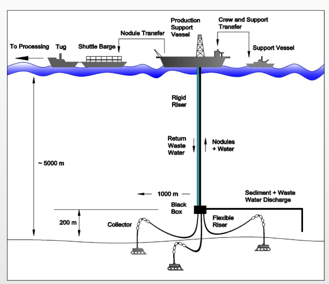


Figure 36: Proposed nodule recovery concept

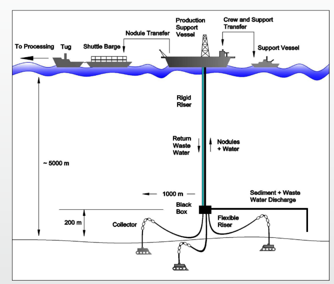


Figure 36: Proposed nodule recovery concept

Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

Commercial Viability

- 0.5
- Thr … Cu
- Ave
  – … ns
  – … s
- Cos

Components	Value
Capital Cost (M $)	660
Operating Cost / year (M $)	145
Revenue (M $)	275
Annual Profit (M $)	130
Profit after Income Tax (M $)	104
Payback Period (year)	10
NPV at 8% Discount Rate (M $)	361
IRR	14.75%

Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

Business Model

2 Potential Customers

Direct (**9 contractors)** — dynamics ⇄ — **End (the public)**

Key risk → **Environmental Impact** ← *Key risk*

Short term problem

- The need for **green** solution
- \+ **comprehensive** & **transparent** EIA

Long term problem

- The need for deep sea mining:
- Scarcity & uncertainty of land based metal supplies

Solution:

- Proposed **green** engineering system
- Both **commercial** and **experimental** purposes in parallel.
- Benefit: Industry + Research institutes
- Possible → small production scale

Direct (9 contractors) ↔ **End (the public)**

↓

Both **short** and **long term problems**

Value proposition of our business model

Lloyd's Register Educational Trust

UNIVERSITY OF Southampton

SWOT Analysis and Conclusions

SWOT ANALYSIS

STRENGTHS

- **Strong commitment to reduce impacts**
- Propose green engineering system: innovative idea of the black box
- Platform for full-scale research

WEAKNESSES

- **Lack of fully integrated solution**: from raw nodules to refined metals
- Requires multiple systems
- Lack of detailed analysis on each aspect

OPPORTUNITIES

- **Favourable market condition**
- Good investment prospect: IRR > 12%
- Recycle tailings for agriculture

THREATS

- **Integrating all components together**
- Loss of commercial interest in Co, Ni, Cu and Mn

INTERNAL

EXTERNAL

POSITIVE

NEGATIVE

Questions & Answers

Baivau Agarwal	*vaibhavaero@gmail.com*
Pan Hu	*panhu@civil.uwa.edu.au*
Marco Placidi	*m.placidi@soton.ac.uk*
Harrif Santo	*ceehs@nus.edu.sg*
Jenny Jin Zhou	*zhou0141@ntu.edu.sg*