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Insights and future research into the impacts of deep sea mining

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WODCON XXI

Introduction #1

The pressure on resources of rare earth minerals and other resources like phosphate, together with improvements in technology, are leading to increased interest in the mining of deeper waters.

The Prime Minister of the UK has said that deep-sea mining could be worth 40 billion pounds to the UK alone over the next 30 years (*The Guardian, 2013*).

This interest in turn has generated concern about the potential environmental consequences of large scale deep-sea mining.

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Introduction #2

A number of environmental impact assessments have recently been made for deep-sea mining (and shallow sea mining) projects with varying success.

The deep-sea projects range over water depths of 100-1600m and encompass typical (albeit slightly modified) dredging plant as well as bespoke mining plant for very deep waters.

This experience has highlighted several common issues which have arisen during the EIA studies and consent process and which can be expected to arise again in future mining proposals.

Solwara (PNG)
- Massive sulphides
- Consent but not started

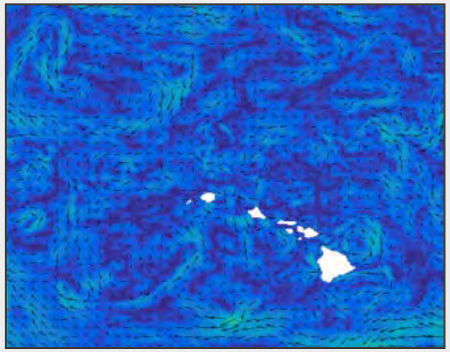
Chatham Rise (NZ)
- phosphate
- Not given consent:
- Direct impact rare coral
- Larger scale dispersion and settling fine sediment
- Risk to commercial fisheries

Don Diego (Mexico)
- phosphate
- Not given consent
- Turtles

Typical problems

Reasons why projects struggle to gain consent:

- Uncertainty in the distribution and sensitivity of flora and fauna, particularly benthic
- Lack of regulatory experience
- Lack of a clear process for consent
- Potential effects of noise on fish and marine mammals
- Uncertainty in physical processes
- Over-conservative modelling approaches
- Expectations of ocean-current models
- Requirements for validation prior to consent



HYCOM model of Hawaiian waters (NOAA, 2013)

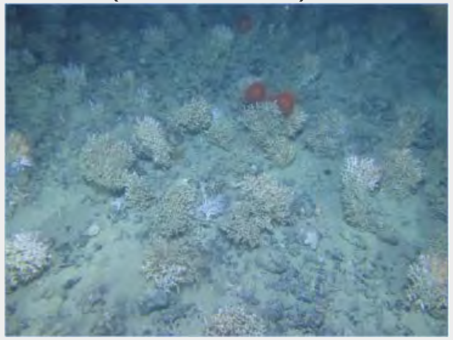


Photo: Wikipedia

Photo: iStock

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Problems for EIA #1

The locations where deep sea mining is being considered:

- often occur in areas of the world where there is little history of ocean mining or even shoreline development
- background knowledge and acceptance of what may be normally held as standard science/engineering may not be present

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- There will be an additional burden on the EIA to educate and build confidence.
- The approach whereby the developer puts together a EIA and presents it to the regulator and stakeholders as a *fait accompli* is likely to encounter difficulties.

Problems for EIA #2

The applications for offshore mining take place in the context of

- less well known environments (long recovery times);
- without the benefit of decades of monitoring;
- with sensitive environmental issues;
- often without a clearly defined path for gaining consent.

Monitoring of aggregate dredging sediment plumes in the English Channel

Problems for EIA #3

The sheer cost of deep sea surveying means limited surveys

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species observed at the site may be presumed to be rare and unique …

… but in reality may be distributed widely over a large area which remains unexplored

(e.g. NZEPA, 2015)

Management of the EIA process

Crucial to make a distinction between **fundamental science** and **EIA studies**

- Fundamental science opens up questions
- EIA closes questions down

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Validation

Deep sea mining can be caught in a ***CATCH-22*** situation

Plume behaviour cannot be verified against measured data until **after** consent is given and mining starts.

Regulator would like *in situ* verification of the plume model **before** consent

The absence of verification can play a significant negative role in the outcome of a mining EIA process (NZEPA, 2015).

Identifying a process by which plume models can be adequately verified prior to consent, is a key issue which needs to be addressed by industry.

Photo: KDM

Depth of release

ISA intends to prevent the surface discharge of tailings for future applications for deep sea mining and to limit them to below the oxygen minimum zone (below depth of ~1200 m).

Minimises impacts to primary production and food-web dynamics due to increased turbidity, nutrient-enrichment and through release of heavy metals.

Chatham Rise, NZ, and Don Diego, Mexico

- National waters
- relatively shallow (400 m and 80 m water depth)
- release close (~10 m) to bed

Solwara

- release at 25-50m above the bed
- (also over-burden removal pumped locally)
- release low discharge

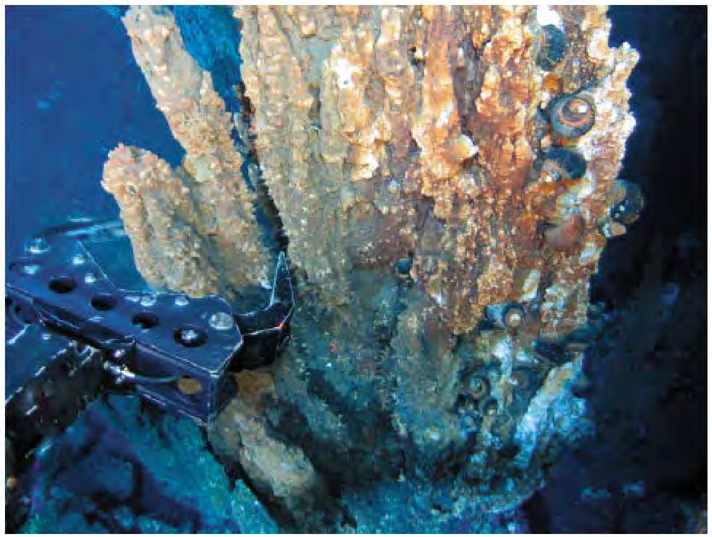


Photo: Nautilus Minerals

Processes potentially leading to physical effects

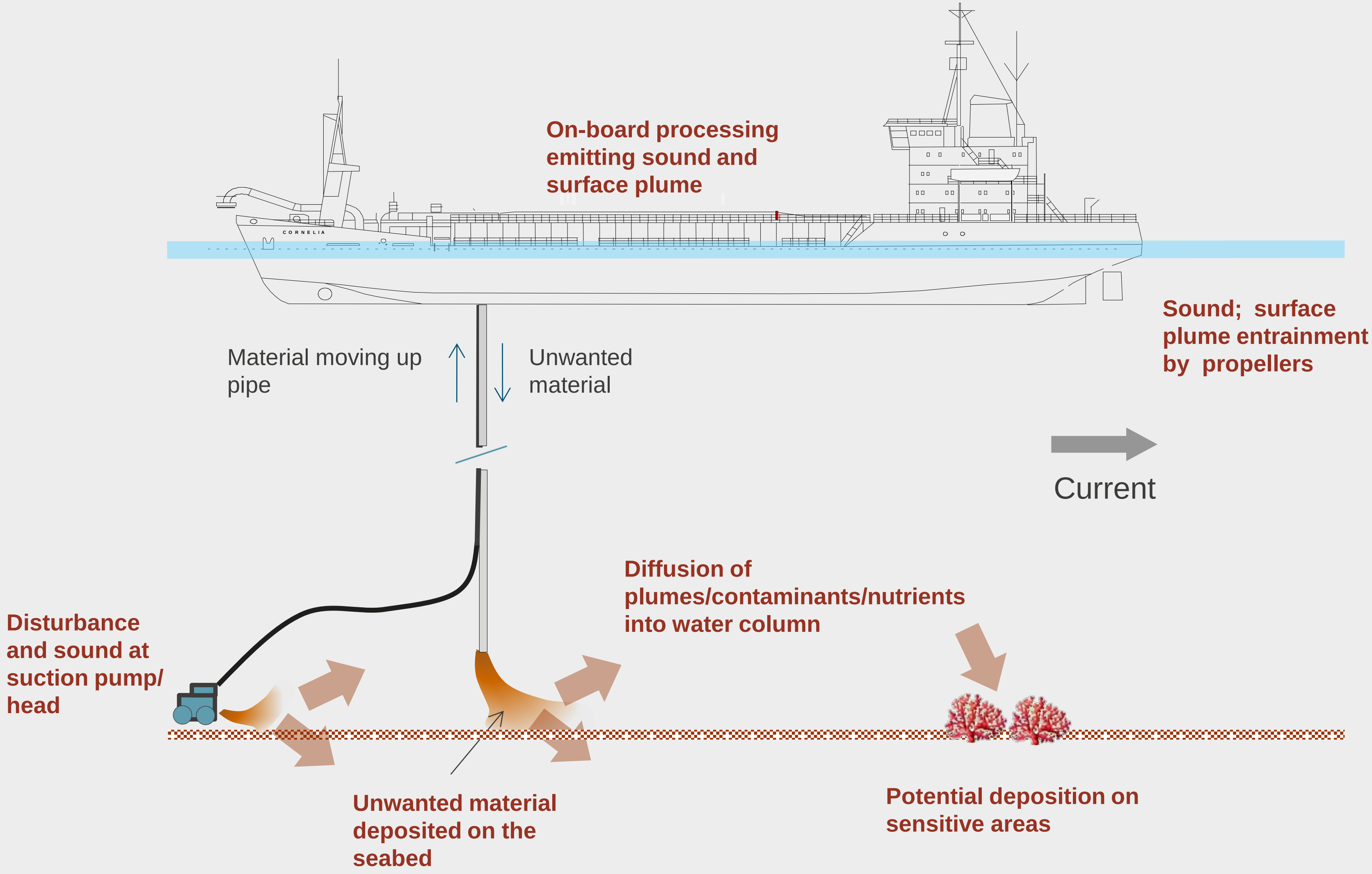


Image: HR Wallingford

Discharge and near-field mixing of mine tailings

Discharge of tailings are typically implemented **near bed** where possible to reduce the dispersion of fine sediment into the upper water column.

The pipe discharge has momentum and negative buoyancy and plume will move rapidly downwards, entraining water and diluting as it does so.

The plume very soon impinges on the bed forming a density current which will spread radially outwards (Boot, 2000; Spearman, 2007, 2011).

Mixing of this density current into the overlying waters depends on the difference in density between the plume and the overlying waters and the ambient current.

This "dynamic plume" process is well known for reducing the amount of fine sediment in dredging plumes (Whiteside et al, 1995; John et al, 2000; Spearman, 2011, de Wit, 2015).

In deep sea environments, current speeds are low: 0.1 m/s is typical near the bed. So the vast majority of released sediment remains as a near bed layer and will deposit onto the bed close to the point of release.

Physical modelling of disposal sediment plumes (Boot, 2000)

Settling velocity of fine sediment in mining plumes

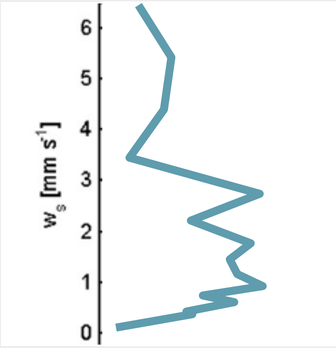
Fine sediment flocculates due to electrostatic forces and biogenic sticky polymers present in the water column

Evidence from measurements of natural background concentrations and dredging induced plumes indicate typical settling velocities of O(1) mm/s

– i.e. one or two orders of magnitude higher than the corresponding speeds for primary fine silt and clay particles.

Where uncertainty exists reliable estimates of the settling velocity can reliably be derived from laboratory experiments for a range of concentrations and relevant turbulence conditions using sea bed samples and video measurement devices.

Some recent mining studies have used the settling velocity of the primary particles rather than flocculated particles and so their predicted plume dispersion is too extensive.



Distribution of floc settling velocities in a mining plume (data reproduced from Smith and Friedrichs, 2011)

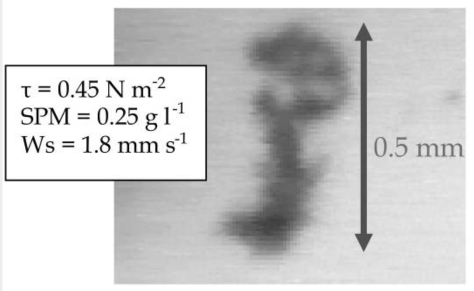


Photo: Manning et al (2011)

Photo: Manning et al (2013)

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Over-conservatism

The complexity of the near-field mixing and flocculation processes present a challenge to the modeller within EIA studies. There is a temptation to simplify these processes through conservative assumptions like:

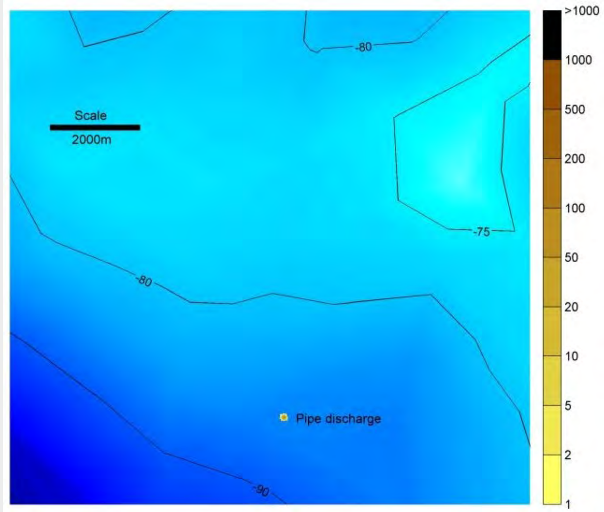
- Assuming all fine sediment released from the pipe discharge is released into the water column;
- Assuming fine sediment settles at the rate of non-flocculated individual particles.

Such simplifications can aid the EIA process if they clarify an already benign result. However, for deep sea mining studies over-conservatism results in the prediction of plume dispersion over long distances which instead contributes to regulator and stakeholder concerns and is counter-productive.

Moreover, concerned stakeholders will naturally worry that any model results presented for EIA are not conservative (even if they are) and so it is much better for all concerned to present “best estimate” rather than “worst case” results.

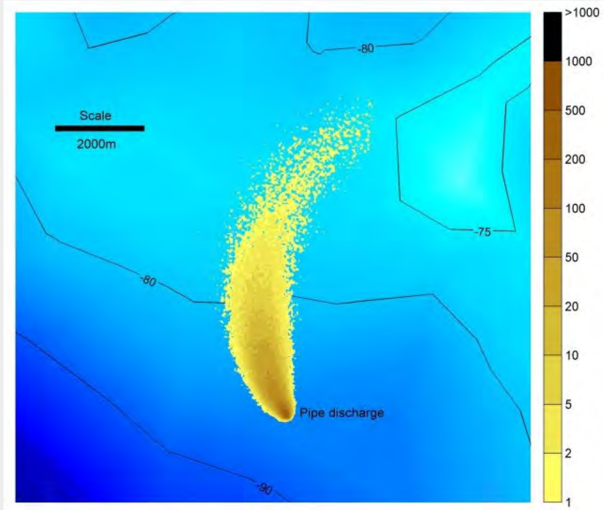
Snapshot of average sediment concentration (mg/l) in bottom 20m water depth, from mining tailings discharge

Modelling *WITH* dynamic plume, plume collapse onto bed, flocculation and turbulent damping



Same snapshot

Modelling *WITHOUT* dynamic plume, plume collapse onto bed, flocculation or turbulent damping



Images: HR Wallingford

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Conclusions

- Learn from other applications
- Anticipate how the consent process will unfold
- Build confidence
- How are you going to validate?
- Anticipate the costs of surveying
- Measure the important things
- Do the modelling properly
- Do good science but don’t confuse science with EIA

MarineE-tech

Marine ferromanganese deposits:

a major resource of E-tech elements

A partnership programme between UK and Brazil totaling £4.5M, involving industry, academic and governance partners.

MarineE-tech: Fe-Mn crusts

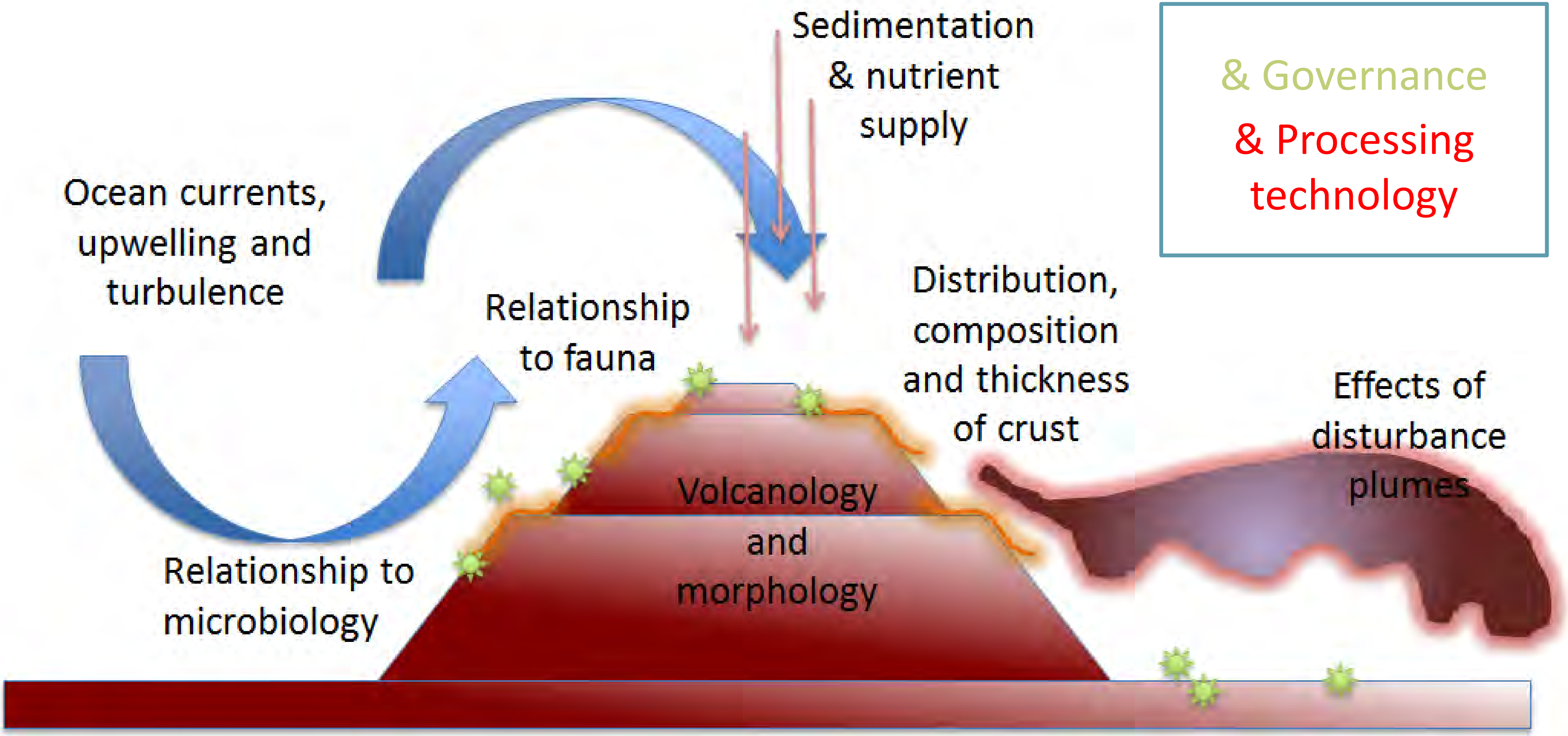
Photo: NOC

*"A sufficient and secure supply of **tellurium** is the single largest barrier the development and production of solar electric collectors."*

- Tellurium is enriched in Fe-Mn crusts

Sample from the Tropic Seamount with a ferro- manganese crust layer (reproduced from Cherkashov and Halbach, 2015).

Marine E-Tech: overview



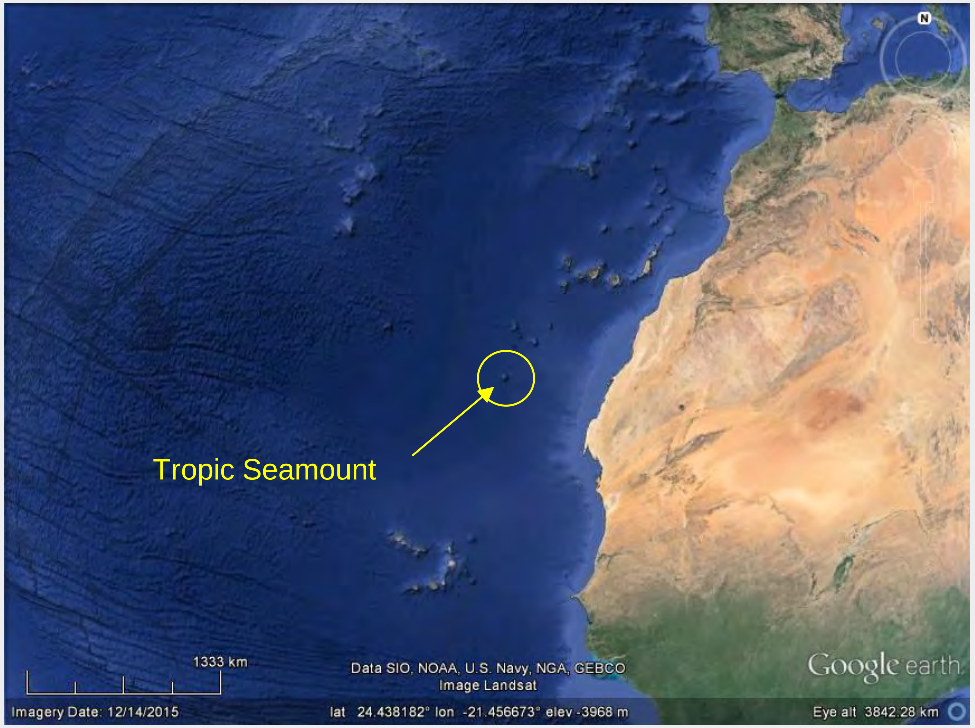
& Governance

& Processing technology

Image: NOC

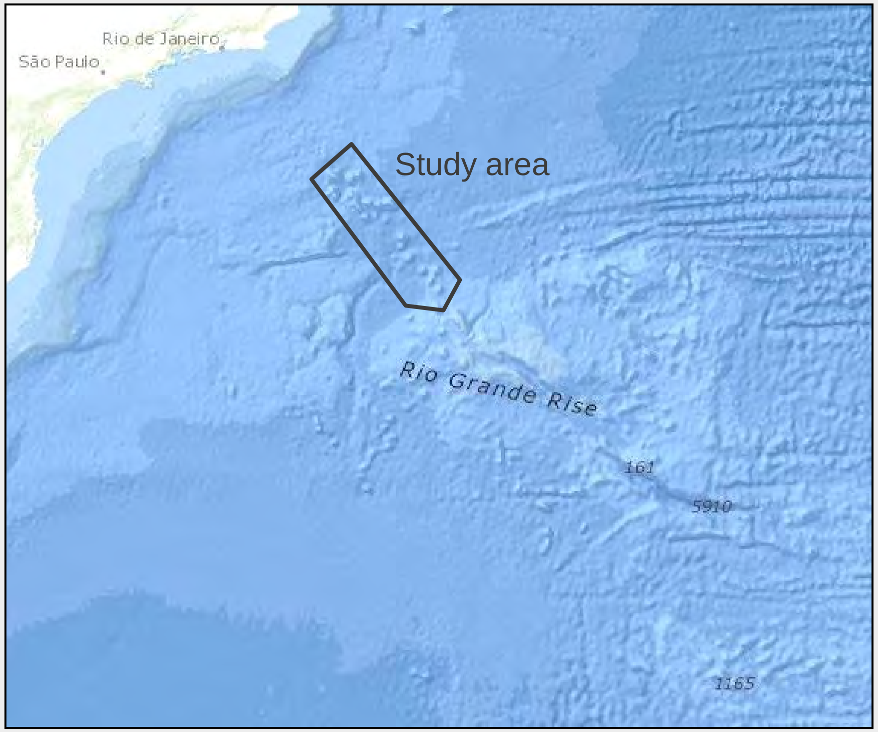
MarineE-tech: Cruises

NE Atlantic



Nov/Dec 2016

SW Atlantic



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http://prj.noc.ac.uk/marine-e-tech/