WP8.3 – STRATEGIC REPORT ON OFFSHORE MINING AND FISHERIES

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1 Introduction

Concept description: Offshore Mining operations involve the excavation, transport and on-board handling of mined ore. With the transport, deep water containing dissolved nutrients like phosphates, nitrates, silicates, iron and silts are transported up towards the surface: an artificial upwelling. This effect can potentially create favourable ecosystems for fish. Nutrients are often a limiting factor for the primary production and thereby zooplankton and fish (Kirke, 2003, Maruyama et al., 2004, White et al., 2010, Zhang et al., 2016). The artificial upwelling can be managed passively or actively. In a passive approach, the upwardly transported deep waters (discharge waters) are to be mixed thoroughly but are not additionally managed. The surrounding waters will be enriched with the deep water nutrients and the surface system can potentially increase its primary productivity and the depending consumer network. For an active approach, combinations should be sought in which the nutrient flow is actively used for enhancing primary production and associated biomass growth by stock enhancement especially on the zooplankton level and eventually juvenile fish (Figure 1). The resulting higher densities of fish stocks can be managed and harvested sustainably. One can also consider active stock enhancement by adding (local) algae, zooplankton. The concept will be multiple use of space; no shared platforms.

Basin suitability: There are limited prospects for seabed mining in all of the MARIBE basins. Near the Azores (Atlantic ridge) and Mediterranean some SMS deposits are found, some potentially commercially exploitable crusts can be found near seamounts near Madeira, the Canary and Azores islands, and one sample from the western Mediterranean Sea[1]. Offshore mining should be considered as European enterprises operating on a global scale to provide a global market. The lessons learned from non-MARIBE basins are most likely applicable to MARIBE basins (with site specific adjustments).

Existing Projects or Proposals in this area: The actual innovation of using the discharge waters of offshore mining for enhancement of primary production as such has not been applied yet. It is in its conceptual state. The principle of artificial upwelling or adding nutrients otherwise is a topic of interest and has been studied by several authors[2]. Concrete projects for upwelling are e.g.: the Ocean Productivity Perturbation EXperiment (OPPEX-I), a field experiment (White et al., 2010); the activities at Kochi artificial upwelling laboratory in Japan on the utilization of deep seawater resources[3]; the envisioned SANSAQUA Project in Haiti[4].

Technical details: Fisheries will be operated with existing techniques for pelagic fisheries. Offshore mining will use common (foreseen) technologies, possibly with adaptation to make sure nutrients are available for local ecosystem (sufficient mixing of the return tailings in the surface waters; entrapping and retaining silt when necessary). The ecological aspects need to be studied, especially when thinking of active stock enhancement.

Ecological details: The treatment of discharge waters of offshore seabed mining operations is still under debate. This discharge water will most likely contain different and additional nutrients, some fine material (thought to be up to around 8 µ in size, on the small side as compared to e.g. Dutch nearshore silts (up to 63 µ, Rozemeijer, 2012) and maybe elevated metal concentrations. It will be different in temperature and possibly salinity. Roughly three discharge scenarios can be thought off (SPC, 2013, Ortega, 2014):

i) Near bottom: the approach is the return the water to its origin. This can lead to e.g. sedimentation on an anticipated sensitive benthos community and potential impact by the slight water alteration due to the treatment. This method prevents any impact on phytoplankton and primary production.

ii) On the surface. This can either stimulate phytoplankton by nutrient addition (the preferred impact) or reduction of phytoplankton due to the associated silts and light impairment. Detailed studies (e.g.

[1] (Marques & Scott, 2011, Boschen et al., 2013, Muiños et al., 2013, Conceição et al., 2014, Rozemeijer et al., 2016.)

[2] See Kirke, 2003 and Zhang et al., 2016 for reviews on upwelling; Williamson et al., 2012 for nutrient addition.

[3] http://www.clubdesargonautes.org/otec/vol/vol6-4-1.htm

[4] http://www.energinat.com/future_upwelling.shtml

measuring and modelling) can generate the necessary information. Also the long term, far field impacts need to be understood.

iii) In the midwaters, below the photic zone. This is supposed to be at sufficient distance from the bottom. Here impacts seem to be of a localised nature whereas the potentially affected communities and species have a global distribution. This approach also reduces potential benefits. The potential impacts and benefits should be investigated in order to tune the innovation of artificial upwelling, offshore seabed mining and fisheries to a sustainably balanced approach.

Socio-economic: This innovation can create a new source of employment for the fishing industry, which is currently in decline. It could potentially provide large revenues if the concept is as successful as expected. It could facilitate licensing procedures for offshore mining if a major environmental impact concern appears a positive impact rather than a threat.

Key concerns: It is a new method of operation, not yet proven. Offshore mining is still a major environmental concern due to a lack of data and knowledge (Rozemeijer et al., 2016). Decision-makers and stakeholders need to be convinced. Moreover, the technique of artificial upwelling is innovative. The products of both sectors (ores and fish) can readily be distributed. With active management with stock enhancement, offshore fishing can be concentrated in one area around upwelling, and its environmental impact can therefore be minimised, possibly contained and optimistically mitigated. In addition, the nutrients can enhance productivity on a larger and longer scale (far field).

A B

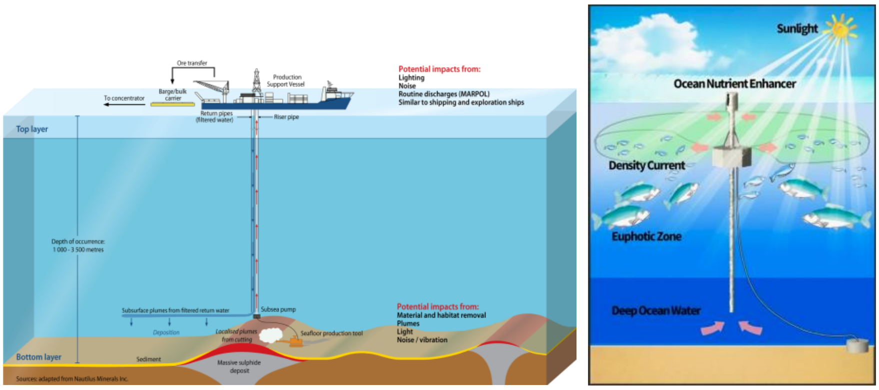

Figure 1 A: Offshore mining in which the return water is released below the photic zone to prevent impact on primary production (courtesy of SPC, 2013). B: an example of artificial upwelling in order to enhance biomass production (from Zhang et al., 2016).

2 Products

Description of products/services: The potential products of offshore and nearshore mining are metal ores of different origins (nodules, crusts, SMS deposits, riverine deposits), phosphorites and phosphates sands, gas hydrates and diamonds. The products of fisheries are fish. One can also imagine constructions (on associated service platforms for offshore operating ships) on which seaweeds are grown, although that is more applicable to nearshore permanent upwelling systems.

Current and near term planned: No initiatives are known yet. In the coming period potential investors will be approached.

3 Market Analysis

Sizing: The nearshore market for phosphorites is ready to take off through three initiatives potentially representing ~10% of the world market (Rozemeijer et al., 2016). The impact on fisheries is anticipated to be small although still under societal debate.

Development drivers: At the moment, phosphorites (phosphates), riverine ore sands and diamonds appear as commercially viable ores. These are in production or on the verge of being in production (Phosphorites). They can also occur at depths below -100 where upwelling can be interesting (although the upwelling is preferably below the photic zone of -200m). A major driver could be the environmental concerns that currently block promising initiatives of phosphorite mining. One of the innovative aspects is the paradigm shift from return waters being an adverse impact to being an economic asset. This could help attaining the necessary support from decision-makers and stakeholders.

In the scientific field of artificial Upwelling (pumping deep waters to use it for cooling facilities and/or using the nutrients for biomass culture) the technological development focuses on efficient water transport from the deep to the surface. The focus is to developed pumps that are using renewable energy sources like wave energy. In addition the need is to develop pumps that can sustain the long term wearing under oceanic conditions.

4 Customers

Since the innovation needs further development, there are currently no actual customers. However, some dredging companies have shown their interest. All operators and investors are the primary consumers of the technique. The products (ores and fish) are regular products with a worldwide, well-developed market. The application of artificial upwelling is in the interest of developers. Both ocean based and land based variants and facilities are under investigation (see section **Existing Projects or Proposals in this area**).

5 Competition

In this section three competitors are compared with the offshore seabed mining fisheries combination: Offshore Artificial Upwelling; Onshore Artificial Upwelling (with the harvesting installations onshore) and regular fisheries. In Table 1 these competitors are relatively rated against the offshore seabed mining fisheries combination. On a scale from 1-10 a 6 represents the two initiatives being equally competitive. In the column Key Differentiators the key features are discussed in which the competitor differentiates itself either positively or negatively from the offshore seabed mining fisheries combination. These key features are rated based on most competitiveness in techniques and they are rated in overall application and use.

The second column is added because in terms of techniques the competitors will be outcompeting the combination due to the dedication to the product. However, is it a competition? The conversion of discharge waters into a form of appreciated artificial upwelling is an addition to an ongoing offshore seabed mining (presumably with small investments as compared to an offshore mining operation). Using this pumped up deep sea water for fertilising surface waters can function actively and passively converting negative impact of offshore mining into a positive impact. In this sense it is a form of mitigation of the activity and therefore an enabler of offshore mining (in an licensing procedure). An advantage is that the installations are integral parts of the dredger reducing vulnerability as compared to a dedicated offshore artificial upwelling installation. In addition stock enhancement can be stimulated using the dredger and its associated vessels and logistics.

The competition is the dedicated applications of artificial upwelling and fisheries. They all have the advantages of the dedicated approach. Design and choice for artificial upwelling can be optimised for the preferred locations, water layers (e.g. desired ratios of nutrients, White et al., 2010) and to maximize the potential biomass production.

For fisheries as a single sector the harvesting is optimised. However stocks are declining worldwide due to overfishing. Therefore employment and GVA are declining as well. The new combination of OFC can be cost saving because of reduced use of diesel due to fishing being concentrated in one location. Motherships could be located in areas, possibly service hubs, which would assist in cost reduction. In addition more cost efficient fishing methods could be developed for this new one zone fishing concept.

Table 1 Description and rating of competitors. In the rating the competitor is valued against the combination of Offshore mining with fisheries (valuation of the competitor) in techniques and in absolute use. The figure 6 is interpreted as being equally competitive. A higher mark than 6 indicates the competitor is better and vice versa. OFC stands for Offshore Fisheries Combination

Competitors	Key differentiators	Rating against competitors (1-10) 10 is most competitive/desirable based on techniques	Rating against competitors (1-10) 10 is most competitive/desirable

			based on overall application and use
Offshore Artificial Upwelling	**Positive**: Specifically designed Larger volumes with larger impact Selected optimised sites Selected optimised water layer (for the desired nutrients) Energy use expected to be from sustainable source (wave solar, gravity) **Negative** Can demand extra mixing facilities due to the larger volume that the OFC can integrate in their on-board technique Active stock enhancement will need extra vessels and manpower Vulnerability of the offshore installation	8	6
Onshore Artificial Upwelling	**Positive**: Specifically designed Larger volumes with larger impact Selected optimised sites Selected optimised water layer (for the desired nutrients) Energy use expected to be from sustainable source (wave, solar, gravity) Exploitation potential higher due to the land based harvesting (products like cooling, shallow water or land based culturing **Negative**: Potentially adverse impacts due to importing substantial foreign water masses in vulnerable coastal areas Large transport costs; More cost efficient fishing methods could be developed for this new one zone fishing concept.	10	1
Fisheries	**Positive**: Proven technology with sufficient yield Optimised sites **Negative**: Large impact on the ecosystem No restoration of the historical damage Energy costs	10	4

6 Revenue

The innovation itself of offshore mining and fisheries is in its earliest stages (TRL1). Therefore there are no revenue estimates yet. The GVA is hard to evaluate since the extra production of fish biomass and species is hard to estimate. Given its potential boost on biomasses over large distances and time if the nutrients are retained in the upper-layer, it could mean a prolonged boost for biomass production for the ocean upper layers as a whole and all fisheries. The nutrients would extend beyond the concessions of the offshore mining.

7 Strategic Roadmap

The Strategic Roadmap plan demonstrates a timeline of how the combination could progress through the Technology Readiness Levels (TRL) based on its current status.

Current TRL and IRL of combination: The value chain of offshore mining is between TRL 1 to 5: the essential vertical transport is at TRL5, and the surface processing at TRL 1-3 (Rozemeijer et al., 2016). The conversion of the release of tailings in deep or mid water to surface release of tailings seems a conversion to regular practice where tailings are released at the surface (Rozemeijer, 2012). Only the mixing of the deep sea waters with surface waters would require a new development. Major questions arise concerning biomass production and ecology on local, regional to large scale and associated timespans (short to long term). Active stock enhancement starting with algae or zooplankton is a real innovation.

Government policy requirements: a major issue is the juridical and social acceptance (Rozemeijer et a., 2016). This is the first hindrance to overcome. Given the social and scientific uncertainties that could take a prolonged unpredictable period it would be best to find support for one pilot using any momentum generated by other Artificial Upwelling projects.

Projected TRL and IRL by 2020: In five years' time the adaptation of the vertical rising and surface handling to tailor to the needs (mixing) is expected be from TRL1 to TRL3 (proof of concept). The ecological needs and impacts are anticipated to take a longer time span given that ecological variability needs to be taken into account.

Research and development requirements: Ecological impacts on local, regional to large scale and associated timespans (short to long term).

Investment requirements: A first approach would use the classical surface return tailings of a conventional dredger. The ecological research will require a large investment. A desktop study is necessary at the beginning. The investments in research are anticipated to be small when compared to the total investment in gear and operational costs (Rozemeijer et al., 2016).

Table 2 Strategic Roadmap for the ecological aspects. TRL: Technological Readiness Level IRL: Investment Readiness Level

2016	2017	2018	2019	2020
→	→	→	→	→
TRL 2/3				**TRL 2/3**
First experiments in the field				proof of concept
Hypotheses level: investors need to be intrigued				Hypotheses level
IRL 1				**IRL 2**

8 Conclusion

The combination of offshore mining (its artificial upwelling) and fisheries is very innovative. It could provide large GVA, if the concept is as successful as its potential implies. The negative image of seabed mining might be improved if it proves to be of benefit to fisheries and the depleting fish stocks. It can then contribute to the fisheries sector, generate new revenues for fishing companies. Investors need to be sought to develop the concept.

9 References/appendix

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