Identifying and mitigating potential impacts of seabed mining on whale, dolphins and other marine megafauna

David Paton PhD[1] and Simon Childerhouse PhD[2]

Blue Planet Marine

[1]Canberra, Australia; [2]Nelson, New Zealand

www.blueplanetmarine.com

February 2015

BLUE PLANET MARINE

THE 3RD ANNUAL DEEP SEA MINING SUMMIT 2015

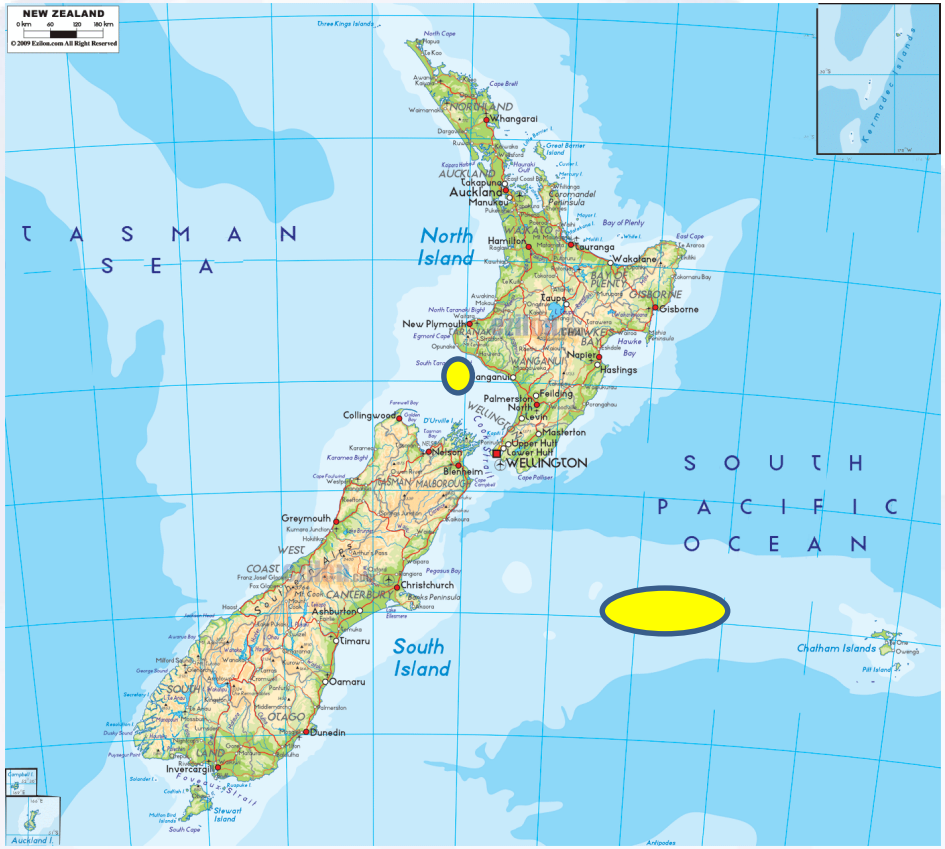
Deep Sea Mining and Environmental Impacts

- There is potential for environmental impacts associated with deep sea mining
- It is a relatively new technology with considerable uncertainty regarding the potential for environmental impacts
- In most mining locations, the biological environments are often poorly understood by comparison to terrestrial environments
- The potential for environmental impacts have also attracted considerable attention from NGOs, IGOs and other stakeholders
- There are currently no recognised international best practice guidelines for minimising or mitigating environmental impacts
- Regulators, therefore, often apply the precautionary approach

New Zealand Case Studies

Blue Planet Marine has recently been involved in providing technical marine environmental advice associated with two sea bed mining projects in New Zealand:

- Trans-Tasman Resources proposal to mine iron sand off the coast of South Taranaki Bight
- Chatham Rock Phosphate proposal to mine phosphate from the Chatham Rise



What are Marine Megafauna?

- Marine Megafauna includes:
  - Marine mammals
    - whales, dolphins, dugong, manatee and pinnipeds
  - Other taxa
    - large marine species such as sharks, rays, turtles and other charismatic marine fauna
- Often attract significant attention from Regulators and other stakeholders

Photo Dave Paton

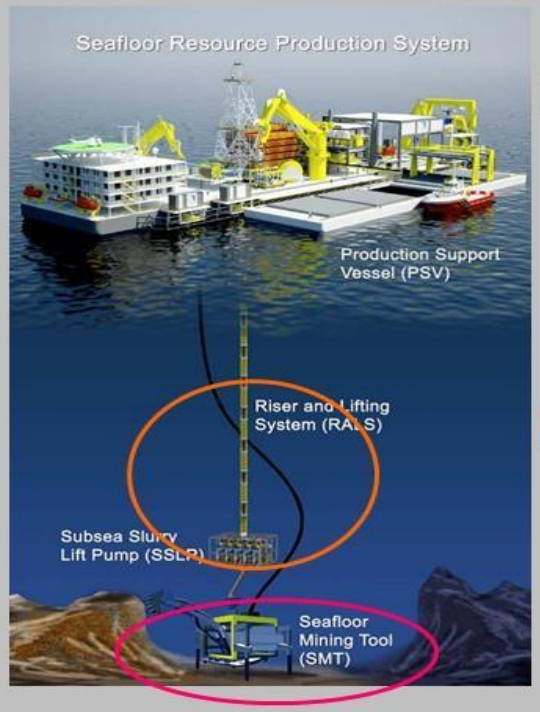
Potential effects on Marine Megafauna

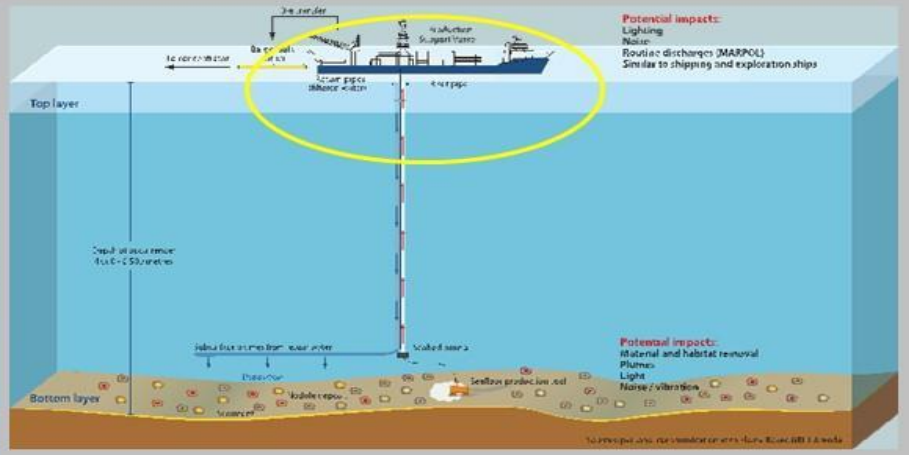
CAVEAT: Potential effects will vary considerably in their nature and extent across these groups subject to a range of factors:

- Their usage of the area (e.g. breeding, feeding, migrating)
- Importance of the mining area (e.g. are marine megafauna able to undertake those activities elsewhere or not?)
- Sensitivity (e.g. can they tolerate increased sedimentation, noise, or switch prey and/or areas)
- Threat status (e.g. endangered vs. non-threatened)
- The exact nature and extent of the operation and effect (e.g. sedimentation highly localised; operational noise only a little above ambient)

Potential Environmental Effects

Deep-sea mining impacts





Effects are 3 dimensional

Surface: ships, barges, lights

Midwater: riser pipes, discharges

Seafloor: mining tools, sediment

Source Clark et al. 2014

Potential Environmental Effects - general

Seafloor:

- Physical destruction
- Entrainment of megafauna in dredge equipment
- Sediment smothering
- Toxic effects from sedimentation
- Loss and/or alteration of habitat
- Noise (i.e. from benthic operations such as pumps, sonar on crawler units)
- Light pollution

Potential Environmental Effects - General

Water column:

- Sediment plume can lead to ecological effects and reduced foraging success for visual predators
- Displacement and/or mortality of species (e.g. fish)
- Seabed toxins released and can accumulate in food webs
  - Potential physiological and/or reproductive impacts
- Oxygen depletion
- Noise (i.e. from riser and discharge pipes)
- Entanglement risk (e.g. anchor lines, riser and discharge pipes & lines)

Potential Environmental Effects - General

At the surface:

- Vessel traffic
  - potential ship strike
  - Noise (i.e. from vessels, mining machinery, pumps)
  - Displacement from area around mining operation
- Lighting effects on seabirds and turtle hatchlings

Photo Dave Paton

Photo Ros Butt

Potential Environmental Effects relevant to Marine Megafauna

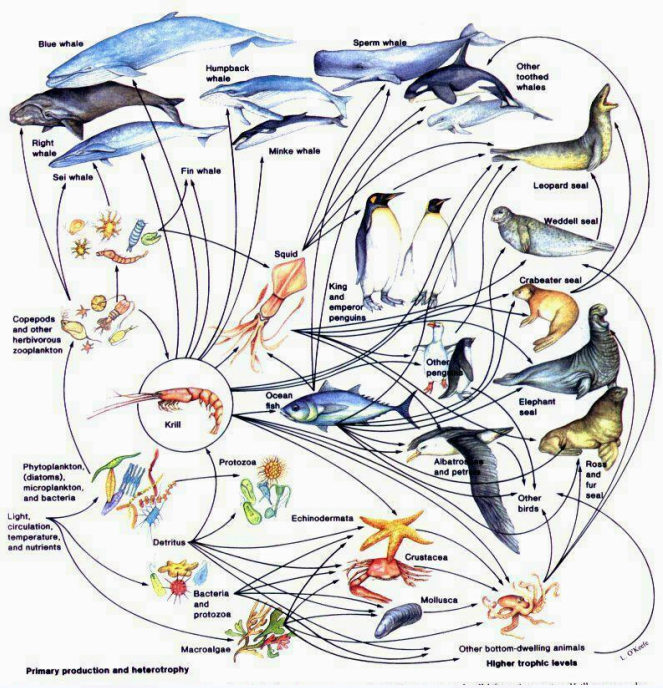
- Ecological effects
  - Due to displacement and/or mortality of prey
  - May lead to changes in food webs
- Noise
  - From riser and discharge pipes, crawlers, processing and support vessels, pumps, sonar
  - May lead to displacement of prey and/or megafauna
  - Temporary or Permanent hearing threshold shifts
  - Effects on communication, navigation and prey finding

Potential Environmental Effects relevant to Marine Megafauna

- Entrainment
- Entanglement risk
  - Anchor lines, riser and discharge pipe and/or lines
- Ship strike
  - Increased vessel traffic in the area can increase the risk of injury or mortality to marine megafauna
- Physiological effects
  - Seabed toxins can be released and may accumulate in food webs including biomagnifying in higher order predators such as megafauna

Potential Ecological Effects

- Covers a wide array of possible effects
- Generally due to:
  - Direct modification/destruction of sea floor habitat from actual mining activity
  - Sediment plume in water column
  - Deposition onto the sea floor
- Ecological effects
  - Displacement and/or mortality of megafauna prey
  - May lead to changes in food webs and can be indirect
    - Effecting parts of web that flow onto megafauna prey



Potential Ecological Effects

- In general, poorly understood and theoretical
  - Few examples of a comprehensive evaluation of effects on food webs
  - Few locations will have sufficient data to reliably estimate any potential effects
  - Most rely on generalised ecological theory
- Almost no examples of actual ecological effects from deep sea mining other than direct habitat destruction
- Risk varies considerably by operational configuration, composition and extent of sediment plume and local biodiversity
  - Generally estimated as low to medium risk

Potential Ecological Effects - Mitigation

- Primary mitigation is to minimise area of mining
- Secondary, to ensure the sensitive placement of mining area to exclude or minimise areas of high biodiversity and/or productivity
- These options are not always possible depending on the location of the commercial resource being mined
- Minimising the sediment plume through ensuring discharge pipes are as close to the sea floor as possible
  - Ensuring as much sediment is discharged back onto the actual area mined and into low current areas
- Understanding the chemical composition of discharge and minimising uptake from areas with high toxic loadings

Potential Entrainment Effects

- Possible in dredge heads, crawlers and suction pumps
- Impacts on an individual is potentially significant (i.e. mortality)
- Will be highly dependent on the exact operational configuration, habitat, water depth and megafauna species in the area
- Based on most operational configurations, estimated at being a low to moderate risk
- May be more relevant when highly endangered or threatened populations overlap with mining operations and the injury or loss of a single individual has significant population level implications

Potential Entrainment Effects - Mitigation

- Only engage dredge head and pumps when in or just before contact with sea floor
- Marine fauna displacement mechanisms:
  - Ticklers
  - Water jets
  - Acoustic detergents
- Camera on dredge heads and crawler units
- Mitigation zones applied and operation reduced in power or shut down when megafauna detected within the zones
- May have to consider seasonal closures for migratory species if entrainment is a major impact
- Training of personnel on safety issues and appropriate handling of injured marine megafauna

Potential Entanglement Effects

- Possible in operational gear
  - Anchor lines, riser and discharge pipes and/or lines
- Will be highly dependent on the exact operational configuration and megafauna species in the area
- Based on most operational configurations, estimated at being a negligible to low risk
- May be more relevant when highly endangered or threatened populations overlap with mining operations and the injury or loss of a single individual has significant population level implications

Photo Seaworld

Potential Entanglement Effects - Mitigation

- Operational configuration designed with a view to minimising entanglement risk as well as meeting engineering requirements
- Ensuring best practice in maintaining equipment to a high standard
- Ensuring lines are kept as tight as possible to minimise slack that can lead to entanglement
- When deploying or moving gear (e.g. pipes, anchors), ideally maintain visual and/or acoustic monitoring for megafauna and undertake when megafauna absent
- Dis-entanglement protocols in place if it does occur

Potential Ship Strike Effects

- Increased vessel traffic in the area can increase the risk of injury or mortality to marine megafauna
- Some species, may be attracted to the area (e.g. bow riding dolphins) leading to potentially increased interactions
- Will be highly dependent on the exact operation (e.g. number and type of vessel/s) and megafauna species in the area
  - Species such as turtles, dugongs, right whales may be especially vulnerable
- Risk generally considered to be low
  - Negligible for mining vessel itself due to slow speed
  - Increased risk for fast crew transport vessels

Potential Ship Strike Effects - Mitigation

- No single mitigation option will work for all species, in all places for all types of operations
- Understanding what species are in the area and how they behave can be used
  - Communicated to vessel masters and crews through environmental inductions
- In areas of known high densities or of increased sensitivity (e.g. breeding)
  - Vessel routing can be moved
  - Vessel speed restriction
- Visual lookout maintained on fast vessels with appropriate protocols for when megafauna detected

Potential Physiological Effects

- Seabed toxins can be released and may accumulate in food webs including biomagnifying in higher order predators such as megafauna
- Potential effects can include increased mortality and/or reduced reproductive performance
- Is a direct function of the elements in the discharge and the sensitivity of megafauna in the area of the discharge/plume
  - Concerns around release of elements such as radioactive compounds
- Poorly understood in most instances
- Generally considered as a low to medium risk depending on the composition of the discharge

Potential Physiological Effects - Mitigation

- Very similar to that as described for ecological effects
- Minimising the sediment plume through ensuring discharge pipes are as close to the sea floor as possible
  - Ensuring as much sediment is discharged back onto the actual area mined and into low current areas
- Understanding the chemical composition of discharge and minimising uptake from areas with high toxic loadings
- Potential for increased processing of discharge to remove undesirable elements may be possible but is generally technically and financially challenging

Potential Noise Effects

- Noise from mining operations is generated throughout the water column including from sources such as:
  - Surface - processing vessel, support vessels
  - Water column - riser and discharge pipes, pumps
  - Sea floor – mining units
- Magnitude and nature of noise varies but it is primarily a function of the operational configuration
- Major noise sources include:
  - Pumps for moving material to and from the processing vessel
  - Machinery associated with processing vessel and processing equipment
  - Surface vessel traffic
  - Mining units – pumps, sonar, extraction tools

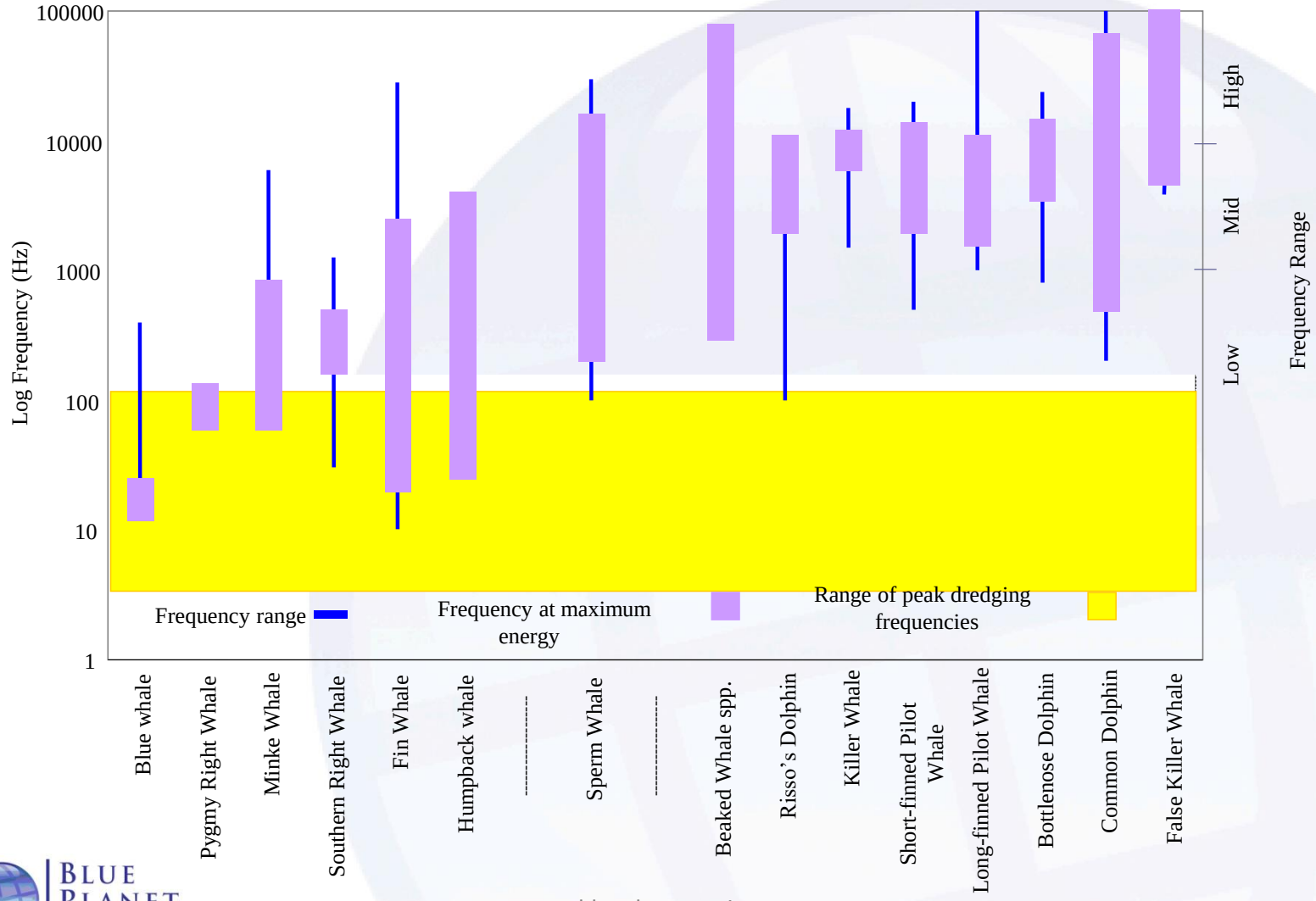
Potential Noise Effects

- Sound propagates extremely well in water so operational noise can travel considerable distances from the source, especially low frequency sound
- Sea bed mining can produce noise across a broad range of frequencies
  - Generally dominant frequencies below 1 kHz
- Estimated noise level in the order of ~188db re 1 µPa at 1m
  - Varies considerably depending on operational configuration
- Noise level will be influenced by equipment used and substrate type
  - Sand generates less noise than gravel and courser materials

Potential Noise Effects

- Sound in air (e.g. above the surface) poses little risk to megafauna
- Sensitivity to noise varies significantly between species, sexes, behavioural state and even temporally
  - Different frequencies will affect species differently
- Potential effects may include:
  - Displacement of prey and/or megafauna
  - Temporary or Permanent hearing threshold shifts
  - Alteration of behaviour
  - Effects on communication, navigation and prey finding
- Risk assessed as low to medium

Cetacean Vocalisation Range



Potential Noise Effects - Mitigation

- Best form of mitigation starts with the design and engineering of operational gear giving due consideration to noise minimisation
- Primary form of mitigation is designing equipment with lowest possible power and highest levels of sound proofing, dampening, and/or isolation from vibration
- Isolation of machinery and pumps (e.g. baffles, machinery mounts) to minimise vibrations into the water column
- Maintenance of equipment to a high standard ensures running at quietest possible levels
- Location of major machinery on the processing vessel is preferred over location in the water column as sound transmission is reduced

Potential Noise Effects - Mitigation

- Sonar is regularly used to assess mining operations and for navigation
  - Should be lowest possible power and used as infrequently as possible
  - Sonar source should be closest to target as practical (e.g. located close to sea floor rather than on processing vessel)
- Depending on the exact magnitude of the noise generated best practice mitigation could be considered:
  - Soft-start of equipment
  - Visual and/or acoustic monitoring prior to start up and potentially also during operations
  - Mitigation zones applied and operation reduced in power or shut down when megafauna detected within the zones
- Support vessel speed reduced in the vicinity of operations

Current status of TTR and CRP Projects

- Trans-Tasman Resources had their project proposal rejected by NZ Environmental Protection Authority in June 2014 which cited uncertainty over the project's environmental impact as their main concern.

- Chatham Rock Phosphate is expecting a determination by NZ Environmental Protection Authority on their proposal in early February 2015.

Knowledge Gaps

- Understanding of the real impacts of deep sea mining
- Understanding of the effectiveness of proposed mitigation strategies
- In most mining locations, the biological environments are often poorly understood by comparison to terrestrial environments
- Spatial and seasonal distribution and abundance of marine megafauna
  - Especially offshore in deep water environments
- Knowledge of locations that are important for core biological functions, such as marine mammal breeding, feeding and resting areas, and migration routes
- Potential impacts of deep sea mining operation, including:
  - effects of sound on behaviour (including communication, foraging, migration, reproduction and predator avoidance),
  - auditory factors that affect behaviour (including perception, sensitivity, and auditory masking),
  - the biological significance (population-level effects) of these changes including long-term cumulative effects