Deep sea mining infographic

# Interactive text

Table : Tiered interactive infographic text

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| Top Tier Aspect | Descriptive Text | 1st Tier Aspect | Descriptive Text | Mitigation measures |
| Sound | Deep sea mining (DSM) and associated vessel operations will generate sound in two locations; sound from the MSV and associated support vessels, and sound from the seabed equipment. The deep sea environment has recorded ambient sound levels of typically less than 50dB in the 10 to 45 kHz range (Bashir et al., 2012). Deep diving whales and deep sea fish species are the organisms most likely to be affected by sound produced by DSM operations | * Behavioural changes
 | At levels insufficient to cause direct injuries to animals, the sound levels may cause behavioural disturbances. Behavioural effects may result in animals being displaced from preferred foraging or breeding grounds to potentially less optimal areas, experiencing increased competition or greater energy costs associated with finding food. The effect may be a reduction in the individual's long-term fitness and survival.Cetaceans: In marine mammals, behavioural reactions that may occur include:* Orientation or attraction to a sound source,
* Increased alertness,
* Modification of characteristics of their own sounds, cessation of feeding or social interaction,
* Alteration of movement / diving behaviour,
* Temporary or permanent habitat abandonment and
* In severe cases, panic, flight or stranding.

Fish: In fish, typical behavioural responses to underwater sound include a startle response (Pearson et al. 1992; McCauley et al. 2000) or a change in the vertical distribution of individuals (Slotte et al., 2004). | Potential mitigation measures * Conducting noise modelling to ascertain the distance of impacted by the noise;
* Turning off all seabed equipment when not in use;
* Incorporating acoustic dampening systems into seabed equipment during the design phase; and
* Efficient planning of both mining operations and vessel movements to reduce the amount of noise generated during operations.

However, it is anticipated that the vessel noise from the MSV and associated support vessels will be similar to the noise produced by existing commercial shipping traffic in the area.However, it should be stressed that there is a lack of detailed knowledge on how deep sea fauna will react to increased underwater acoustic levels |
| * Auditory masking
 | If the frequency of anthropogenic sound overlaps with the frequencies used by marine mammals, this may reduce the animal’s ability to detect important sounds for navigation, communication and prey detection (Weilgart, 2007). This is termed acoustic masking, which may occur anywhere within an organism’s auditory range (Wright et al., 2007; Richardson et al., 1995). Masking of cetacean vocalisations will result in increasing information ambiguity and, in extreme circumstances, may culminate in cetaceans being unable to orientate themselves, communicate for reproduction or hunt / evade predation in the marine environment (Wright et al., 2007).The hearing thresholds of marine mammals vary between species. Hearing sensitivity is based on both the frequency range of marine mammals and their threshold of hearing (i.e., the level of sound at which they perceive sound).. |
| * Temporary Threshold Shift (TTS)
* Permanent Threshold Shift (PTS).
 | High exposure levels from underwater sound sources can cause hearing impairment. This can take the form of a temporary loss in hearing sensitivity, known as a Temporary Threshold Shift (TTS), or a permanent loss of hearing sensitivity known as a Permanent Threshold Shift (PTS).Cetaceans: The possibility of cetaceans being exposed to sound levels is dependent on the source level and the number of cetaceans in the project area.Fish: Sound produced by the acoustic energy source could lead to possible eye damage and internal injuries. Other potential impacts include the transient stunning of fish species. |
| Onshore impacts | Various types of solid and liquid wastes will be generated by vessels during DSM operations. Certain waste types will need to be stored on-board the vessels until they return to port and disposed of via a suitable waste management facility. | * Waste management
 | Waste may be either hazardous or non-hazardous waste, and will require appropriate processing and disposal. The effects of disposal of controlled (non-hazardous wastes) associated with onshore disposal are dependent on the nature of the site or processUtilising onshore resources for waste disposal may have the following impacts:* The disposal of hazardous waste at a landfill site may introduce limitations on future land use due to contamination issues
* There is the potential for land, water and air contamination from the various chemicals and materials disposed of.
 | Potential mitigation measures The use of landfill for disposal of mining wastes is undesirable and, where possible, steps should be taken to reduce, recycle and reuse waste generated during a DSM project.* To mitigate this, a DSM operator should establish a Waste Management Plan (WMP) for the proposed drilling operations that encompasses the MSV, support vessels and onshore operations. The WMP will cover the storage, transport and treatment of waste generated on the project. The plan would also contain a hierarchy that considers the prevention, reduction, reuse, recovery, recycling, removal and disposal of waste.
* All hazardous wastes shall be sent to a company registered with the licence holder government for treatment and disposal, hence posing a minimal risk of impacting the environment.
* Incineration of waste permitted under the MARPOL (Annex V) will be conducted on board of the MSV as per MARPOL requirements. However this excludes the incineration of any hazardous waste or heavy metals).
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| Routine marine discharges | The MSV and associated vessels will generate waste streams such as sanitary waste, drainage water from the MSV and support vessels, food waste, process water with sediment (i.e. dewatering discharges), ballast water and other effluents. Some of these streams may be discharged to sea, if permitted by national and international legislation.  | * Sanitary waste
* Drainage / deck water
* Dewatering fluid
* Food waste
* Ballast water
 | Sanitary wastes include all black (sewage) and grey (showers and washing facilities) water. As well as human waste, grey and black water will contain detergents and cleaning agents from toilets and showers.  | Potential mitigation measures * Discharges should be in line with the appropriate requirements of the MARPOL convention. For sanitary waste, this is Annex IV. Annex IV specifies that black water (sewage) will be passed through a macerator (<25 millimetres) and a dedicated onboard sewage treatment plant prior to discharge to the sea.

Grey water will be processed through the same sewage treatment plant before being discharged in line with MARPOL requirements. |
| Drainage water is expected to be generated by the MSV (i.e. non mining related operations) and support vessels. This water may contain trace amounts of chemicals, oils, lubricants and sediments, resulting from small leaks or spills washed out from the open deck areas.  | Potential mitigation measures * Onboard the MSV, drainage and deck water runoff from clean and potentially contaminated areas is directed to on-board holding tanks. From here the water is passed through an processing plant, if appropriate. Overboard discharge from any water treatment system will be monitored for chemical content. Sensors in the deck drains should be set to divert the waste stream back into storage tanks for further treatment if the chemical concentrations exceed pre-set limits.
* All decks should be bunded to minimise the likelihood of any untreated chemicals or leaks entering the marine environment;
* Good housekeeping standards will be maintained on the MSV (and all support vessels) to minimise the presence of any chemicals in discharged drainage or deck water.
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| Food waste may be discharged from the MSV and support vessels into the marine environment.  | Potential mitigation measures * Food waste from the galley will be passed through a macerator (<25 millimetres) prior to discharge overboard outside the 12 nautical miles zone, as required by MARPOL Convention. The disposal of any other garbage at sea is prohibited by legislation.
* Good housekeeping standards and instituting a recycling policy on-board will assist to minimise the volume of waste generated during the project
* The pre-project assessment may consider if the use of a high temperature incinerator would be a viable option instead of discharging the waste. However any incinerator will have to comply with any technical requirements in MARPOL Annex V.
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| The discharge of dewatering fluids associated with the consolidation of recovered material may lead to the following impacts:1. Increased suspended sediment concentration. This could lead to the mortality and reduction in biodiversity of the zoo- and phytoplankton communities in the photic zone. Any re-suspended contaminants could bio-accumulate throughout the food chain and affect higher trophic order organisms.
2. Reduced ambient light levels due to suspended sediment: This may have a number of impacts such as:-
	1. A reduction in primary production: This would be an additional stressor and lead to a reduction in the ability of the ecosystem to tolerate change.
	2. Effects on pelagic fish (mortality and behaviour): The lower light levels may restrict visibility, leading to variations in predator-prey relationships.
	3. Effects on the behaviour of marine mammals and turtles.
 | Potential mitigation measures * Undertake dispersion modelling to ascertain the extent of any sediment plume.
* Conduct dewatering fluid discharge during hours of darkness to minimise impact on the photic zone.
* Release dewatering fluid at depth (i.e. below the photic zone)
* Undertake periodic discharges rather than continuous discharges, in order to give sediments sufficient time to disperse.
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| The intake and discharge of ballast water will be required during project operations. The MSV and support vessels will also require regular ballasting and de-ballasting due to their constant supply of materials, personnel and equipment to and from the MSV.  | Potential mitigation measures Mitigation measures primarily include following the International convention for the control and management of ships’ ballast water and sediments, 2004 (BWM 2004). Specifically Regulation D-2 (Ballast Water Performance Standard) which states that vessels are permitted to: * + Discharge less than 10 viable organisms per cubic metre ≥50 micrometres in minimum dimension; and
	+ Discharge less than 10 viable organisms per millilitre varying in size between 10 and 50 micrometres in minimum dimension

This can include bacteria and other microbes, small invertebrates and the eggs, cysts and larvae of various species. The majority of marine species have life cycles that include a planktonic stage or stages, so even if adults are unlikely to be taken on in ballast water, they may be transferred during their planktonic stage. |
| Socio-economic / Cultural | DSM may have an impact on socio-economic and cultural receptors. As deep sea mining will typically occur a substantial distance from the coastline, there is unlikely to be any impacts on artisanal fisheries or other associated economic activities, with the possible exception of offshore commercial fisheries | * Interactions with commercial fisheries
 | Interference with commercial fishing vessels may occur, and the mining operations may cause temporary, limited disruption and displacement of some commercial fishing operations (if there are any operating within the region), which could lead to a decrease in catch.  | Potential mitigation measures * Project operators should ensure that there is frequent and regular liaison between project vessels and the relevant port and fishing authorities. This includes providing items such as vessel schedules, details of any exclusion zones and project vessel details.
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| * Identification of historic wreck sites
 | There is a possibility that during either pre-project surveys or project operations, shipwrecks or other archaeological / cultural sites may be recorded in the dataset.Shipwrecks are typically protected from disturbance by either national or international law (e.g. UNESCO Convention on the Protection of the Underwater Cultural Heritage ). Military wrecks, remain under the jurisdiction and protection of the government that lost the ship or aircraft. | Potential mitigation measures * DSM operators should consider conducting a pre-project geophysical survey in order to identify any potential wreck sites.
* The DSM operator shall notify the relevant authorities in the event of any wreck being discovered, either during the project planning stage or during operations.
* Should any culturally sensitive sites be observed on the data, the mining area should be adjusted so as to minimise any potential impacts.
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| * Possible presence of UXO
 | If the wreck is a military vehicle, then there is the potential for unexploded ordinance (UXO) to be present. UXO may be detected as magnetic anomalies during any pre-mining surveys. UXO management requires specialist expertise to manage the hazard safely. There is a substantial risk to life, environment and equipment if UXO is improperly handled. | Potential mitigation measures * If UXO is suspected in the area (either as the result of wreck detection, or as the result of background research) then a specialist survey contractor should be engaged to investigate the area prior to project commencement..
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| * Beneficial results
 | The installation of subsea structures (and long-term surface vessel moorings if appropriate) may attract additional fish species to the area. The fishing exclusion zone will limit the level of commercial fishing in the area allowing populations to recover.Mineral processing plants onshore may lead to increased levels of local employment . Infrastructure supporting the offshore and onshore operations may attract additional investments.  | Potential enhancement measures * Encourage and publicise opportunities for local involvement with shore operations
* Provide a clear CSR policy to manage expectations and to provide information on what the company is doing
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| Physical presence (surface) | The MSV and support vessels may present a navigation obstacle to other sea users. This may include international shipping vessels, commercial fishing vessels and marine activity associated with the offshore oil and gas industry.  | * Interaction with commercial fisheries
 | Interference with commercial fishing vessels may occur, and the mining operations may cause temporary, limited disruption and displacement of some commercial fishing operations (if there are any operating within the region).  | Potential mitigation measures * In areas where there is either a heavy commercial fishing presence, or where mining and commercial fishery interests overlap, the project proponent should consider the appointment of a Fisheries Liaison Officer (FLO). The FLO would be responsible for providing information to local fishermen groups and organisations.
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| * Hazard to navigation
 | The MSV will be constrained in its ability to manoeuvre and other sea users will need to accommodate the MSV in their passage plans. Risks may include: * Vessel collisions or damage to project assets; and
* Vessel collisions or damage leading to a release of stored mineral ores or chemicals.
 | Potential mitigation measures In order to ensure the safety of project personnel and other marine users, the following mitigation measures should be considered:* Establishing an exclusion zone around the MSV to prohibit unauthorised vessels from approaching;
* All vessels associated with the project should meet national and international regulations for shipping including the appropriate signals and lights as defined by the International Maritime Organisation (IMO) and Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs);
* Communication equipment (e.g. VHF radio) should be used to contact approaching vessels; and
* A dedicated guard vessel may be required in some areas
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| Riser And Lifting System (RALS) | In order to transport the mined ore from the seabed to the surface, the operations may utilise a set of riser and fall pipes in the water column. Riser pipes are used to transport the recovered material to the surface, and fall pipes used to discharge excess material (sediment and water) to the seafloor. | * Thermal discharges
 | Thermal discharge impacts: There are two issues relating to thermal impacts as detailed below:* Discharge of ocean bottom water at the surface as part of the dewatering process: As material is transferred up the riser pipe, it will be transported suspended in ocean bottom water. Ocean bottom water is typically dense, cold and nutrient rich. This may lead to an increased a risk of algal blooms resulting from the sudden increase in nutrient levels in offshore surface waters, which are typically nutrient limited (Chen, 2007).
* Discharge of processed water at the seabed: Fall pipes may be used to discharge dewatering fluid near the seabed. The discharged water will transport heat, dissolved materials, and waters containing dissolved oxygen to the near-seabed environment. The discharge water will alter the seabed environmental conditions leading to either a shift in ecosystem composition and / or a potential increase in benthic biomass in the vicinity of the fall pipes.
 | Potential mitigation measures* Reduce the volume of ocean bottom water discharged at the surface as far as reasonably practicable.
* Where possible, return of dewatering fluid via the RALS to the seabed may be preferable (depending on the nature of the seabed).
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| * Frictional heating
 | As the dredged / mined material is transferred through the pipes, the friction between the lifting (or falling) fluid containing the suspended sediment matter and the riser pipe will generate heat. This may lead to an associated rise in temperature of the surrounding water due to heat transfer * The increased thermal output from the pipes may also lead to increased rates of marine growth colonisation, which will lead to increased biodiversity.
* The increased water temperature in the immediate vicinity of the RALS, and the potential increase in marine growth (food source) may cause pelagic fish species to aggregate near the RALS.
 | Potential mitigation measures* Periodic cleaning / de-fouling of the RALS may be required to ensure that the rate of thermal dissipation remains within design tolerances.
* Water / slurry mix to be optimised so as to reduce friction generated during transit through the RALS.
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| * Sound
 | The movement of rock and particulates travelling up the riser pipe may generate low levels of sound. However due to the design of the pipes, the sound levels emitted are likely to be low. If the lifting pump is installed on the seabed, this is likely to generate a significant level of sound.Further information on acoustic aspects can be found associated with the surface vessels. | Potential mitigation measures* Seabed lifting pump to be deactivated when not in use
* Water / slurry mix to be optimised so as to reduce noise generated by the transit through the RALS.
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| * Physical presence
 | The pipes may act to provide a hard surface for colonisation. This should be considered a positive impact, as it will increase the levels of mid-water larvae and pelagic species. Organisms that colonise the pipes may contribute to the biodiversity in the area as an additional source of nutrients.  | Potential enhancement measures* Marine growth levels should be monitored to ensure that they do not cause the RALS to exceed its design specifications in terms of weight or thermal dissipation.
* Periodic cleaning / de-fouling operations may be required to limit the additional weight on the RALS.
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| * Fish aggregation
 | The riser pipe could act as a fish aggregation device, where several species of fish may congregate to take advantage of the increased water temperature, additional shelter and food from any biological growth on the riser | Potential mitigation measures* Deployment of an additional mid-water fish aggregation device to enhance fish population and provide support during periodic cleaning operations that may reduce the level of food / shelter.

It is not envisaged that the pipes will obstruct the passage of either fish or marine mammals in any meaningful way due to the open water surrounding the RALS |
| * Sediment plume discharge
 | Fall pipes should extend through the water column to the seabed (or to below the thermocline). This will lead to an increase in mid-water suspended sediment levels. As a result there may be variations in naturally occurring nutrient and chemical levels. This can cause the development of features such as mid-water oxygen minimum zones with corresponding impacts on pelagic fish speciesThis will lead to either a mid-water discharge of fluid and sediment, or potential mounding of the sediment on the seabed. This may lead to localised changes in topography and smothering of benthic communities. | Potential mitigation measures* Plume modelling should be conducted to determine the extent of the potential sediment plume based on both mid-water and near-seabed discharge points in order to determine the option that has the minimum environmental impact.
* Discharge volumes should be minimised wherever possible
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| Physical presence (seabed) | Deep sea mining will result in the physical alteration of the seabed, primarily due to direct physical impact through either suction, drilling or excavation of the surficial and underlying sediments. There will also be an impact on the seabed from the tracks used by the seabed systems to move around the DSM area | * Change in topography
 | During mining and excavation activity, the sediments on the seabed will be removed, moved around as a result of seabed operations. This activity will tend to lead to either shallow trenches (from sediment excavation) or a flattened seabed where topographical features have been removed as part of the mining process. The removal of seabed bed-forms may have an impact on the existing hydrodynamic regime in the area. There is also the potential for the deposition of processed material following near-seabed discharge of dewatering fluid or mineral tailings. As a result of the new seabed topography, the seabed currents may lead to additional sediment deposition or scouring. This change in sediment load may place an additional stressor on the benthic communities. | Potential mitigation measures* Limit the depth of sediment excavation.
* Installation of scour remediation / reduction equipment e.g. scour mats to stabilise the sediment in areas of excessive current speed or if there is evidence of ongoing scour.
* Return excess sediment to extraction area.
* Regularly move the RALS discharge point to avoid excessive deposition in a single area.
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| * Removal of hard substrate
 | The removal of manganese nodules or the cobalt rich crusts from the seafloor will deprive the area of a source of hard substrate. This could lead to increased erosion or scouring as there is less protection for softer sediments from seabed currents | Potential mitigation measures* Installation of scour remediation / reduction equipment e.g. scour mats to stabilise the sediment in areas of excessive current speed or if there is evidence of ongoing scour.
* Return excess sediment to extraction area.
* Habitat compensation - install additional hard substrate on the seabed, composed of chemically inert material (e.g. rock placement), to replace the habitat removed during the mining operations.
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| * Increase in temperature
 | The subsea generators will produce heat as a by-product of the electricity generation process leading to changes in the water temperature near the seafloor.  | Potential mitigation measures* Generators to be turned off when not in use.
* If multiple generators are present, load balancing should be used to ensure that only the minimal number of generators required for safe operations are active.
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| Disturbance to water column (includes surface waters, photic zone and water column to the seabed) | Recovered mineral ores may be de-watered on-board the MSV prior to shipment to shore. As a result, the dewatering fluid may be discharged into the water column at the surface (or through a mid-water fall pipe) from the MSV. | * Increase in suspended sediment concentrations (surface waters and photic zone)
 | Increased suspended sediment concentration resulting from the tailings and dewatering discharge from the MSV. This could lead to the mortality and reduction in biodiversity of the zoo- and phytoplankton communities in the surface waters and photic zone. Any re-suspended, naturally occurring heavy metals or associated compounds have the potential to bio-accumulate throughout the food chain and affect higher trophic order organisms. | Potential mitigation measures* Undertake dispersion modelling to ascertain the extent of any sediment plume.
* Discharge during hours of darkness to minimise impacts on photosynthetic plankton.
* Undertake periodic discharges rather than continuous discharges, in order to allow sediment to disperse
 |
| * Reduced ambient light levels in surface waters (photic zone only)
 | Reduced ambient light levels due to suspended sediment: This may have a number of impacts such as:-* + A reduction in primary production: This would be an additional stressor and lead to a reduction in the ability of the ecosystem to tolerate change.
	+ Effects on pelagic fish (mortality and behaviour): The lower light levels may restrict visibility, leading to variations in predator-prey relationships.
	+ Effects on the behaviour of marine mammals and turtles
 | Potential mitigation measures* Undertake 3D dispersion modelling to ascertain the extent of any sediment plume.
* Discharge during hours of darkness to minimise impacts on photosynthetic plankton.
* Undertake periodic discharges rather than continuous discharges, in order to allow sediment to disperse
* Release fluids below the photic zone
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| * Increase in suspended sediment (mid water)
 | Sediment particles associated with dewatering fluid and tailings mineral will naturally sink to the seafloor under the influence of gravity. This may lead to an increase in suspended sediment concentration in the pelagic area of the water column, with corresponding variations in nutrient and naturally occurring chemical levels. This may lead to the development of features such as mid-water oxygen minimum zones with corresponding impacts on pelagic fish species. | Potential mitigation measures* Undertake periodic discharges rather than continuous discharges, in order to allow sediment to disperse
* Reduce the rate of discharge as far as reasonably practicable and as permitted by standard operations. This will act to reduce the amount of sediment being discharged.
* Release fluids below the photic zone
* Optical backscatter / suspended sediment levels in the vicinity of the discharge point should be regularly monitored and checked against established baselines.
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| * Thermal discharge (mid-water)
 | Water discharged mid-water from the RALS may be warmer than the surrounding environment and will contain dissolved oxygen, nutrients and minerals. The discharge water has the potential to influence the pelagic ecosystem due to either potential algal blooms (Chen,2007) or displacement of existing species due to a change in the physical characteristics of the water column in the vicinity of the discharge point. | Potential mitigation measures* Temperature, nutrient content and chemical concentrations of discharge water to be monitored on a regular basis. Concentrations of chemicals/nutrients should be monitored against the established baseline.
* Minimal rate of discharge as permitted by standard operations to reduce the volume of water introduced to the water column.
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| * Increase in suspended sediment (seabed)
 | Sedimentation from the surface (or mid-water) discharge of dewatering fluid may lead to smothering of sessile organisms, and the clogging of suspension feeders.  | Potential mitigation measures* Optical backscatter / suspended sediment levels in the vicinity of the discharge point should be regularly monitored and checked against established baselines.
* Reduce the rate of discharge as far as reasonably practicable and as permitted by standard operations. This will act to reduce the amount of sediment being discharged.
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| Disturbance to benthic communities | DSM will have a physical impact on the seabed. The alteration of the existing physical and chemical equilibria will have an impact on the biological aspects of the seabed, i.e. the benthic fauna. | * Changes to existing community
 | During the mining and excavation process, organisms will be removed from the seabed along with the sediment. Other organisms may be crushed by the movement of the seabed equipment systems. Communities adjacent to the DSM area of operations may be impacted by changes to the level of hydrothermal activity in the area. The seabed habitat will also be changed during the mining process, including the reduction in the availability of hard substrate (in the case of manganese nodules or cobalt rich crusts). The change in habitat (and subsequent recovery) may lead to a shift in ecosystem structure.  | Potential mitigation measures* Incorporating periods of no activity into project planning in the event of any spawning activity (observed or predicted)
* Recovery of benthic samples from the area for macrofaunal analysis to monitor the levels of deep sea biodiversity
* Leaving areas within a Licence Area un-mined to increase the rate of recolonisation and recovery of benthic fauna;
* Excluding areas from mining if they support unique populations of marine life
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| * Changes to ecosystem structure
 | Impacts from DSM operations may lead to variations in the predator-prey relationships, species abundance, ecosystem structures and biodiversity. This can include affecting the productivity of chemosynthetic organisms at the base of any food webs. In addition, motile organisms may move out of the area in search of a more favourable environment. | Potential mitigation measures* Recovery of benthic samples and trawls from the area for macrofaunal and fish species analysis to monitor the levels of deep sea biodiversity and communities.
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| * Release of naturally occurring heavy metals and hydrocarbon compounds
 | Mining equipment and the mining process may lead to the resuspension of naturally occurring, entrained contaminants (e.g. heavy metals or hydrocarbons). This will result in a localised deterioration in water quality, and consequently lead to additional stress on local benthic communities. | Potential mitigation measures* Excluding areas from mining if they support unique populations of marine life
* Conduct routine monitoring of water and sediment quality in the vicinity of the proposed mining sites.
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| * Increase in suspended sediment
 | Sediment disturbance, mobilisation, transport and redistribution will occur in the immediate vicinity of the DSM operations. The increased levels of particulate matter at the seabed may lead to smothering of sessile organisms, and the clogging of suspension feeders.  | Potential mitigation measures* Minimise the duration of excavation operations through efficient project planning to reduce the level of sediment re-suspension.
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| * Removal of hard substrate (community shift)
 | The removal of manganese nodules or the cobalt rich crusts from the seafloor will deprive the area of a source of hard substrate. Numerous organisms, such as cold water corals, require hard substrate in order for juveniles to settle. | Potential mitigation measures* Habitat compensation - install additional hard substrate on the seabed, composed of chemically inert material (e.g. rock placement), to replace the habitat removed during the mining operations.
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| * Sediment compression
 | Subsea mining systems have an operational requirement to be mobile in order to gather sufficient resources. These systems tend to be relatively heavy (approximately 200 tonnes (Nautilus Minerals, 2008)) in order to tolerate the water pressures at the seabed. Therefore the pressure from the subsea mining system tracks on the sediment will lead to a compression of the surficial sediments. This may make recolonization and community recovery by burrowing fauna more difficult. | Potential mitigation measures* Leave areas within a Licence Area un-mined to increase the rate of recolonisation and recovery of benthic fauna;
* Limit the movement of tracked vehicles to pre-planned pathways and routes
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| * Changes to flow rates from vents
 | Mining in the vicinity of hydrothermal vents may lead to alterations in the temperature and flow rate of vent fluids as overlying sediment is moved or re-suspended, or the chimneys are damaged or mined by the seabed vehicles. This may have an impact on the benthic communities as they exist in a delicate state of equilibrium. | Potential mitigation measures* Monitoring stations in the vicinity of hydrothermal vents should be set up. The stations should monitor flow rate, temperature and water quality
* Collection of macrofaunal samples for the ongoing analysis of benthic communities should also be considered.
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| * Increase in ambient light levels in deep sea environment
 | Organisms in the deep sea are adapted to extreme low-light conditions. Over 99% of sunlight is absorbed by the first 200 metres of water, there is zero light below 1,000 metres of water (NOAA, 2015). The use of underwater lights to provide illumination for DSM operations may lead to physiological damage to benthic communities and individuals in the area that are adapted to low light conditions. | Potential mitigation measures* Turn off lights while equipment is idle
* Consider the use of alternative vision systems e.g. Infra-red illuminators and camera systems
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| Unplanned events | All offshore activities carry the an element of risk. Although not every risk can be planned and mitigated, the most likely ones are vessel collisions and the failure of seabed equipment.  | * Vessel collisions
 | There are likely to be a number of vessels involved with DSM operations. Vessel collisions may involve contact between support vessels and the MSV (whether during transit to the site from port, or while installed over the mining area), or between support vessels / MSV and non-project related vessels (e.g. cargo ships or fishing vessels). Collisions can cause the loss of the both vessels fuel inventory (hydrocarbons) which will lead to a deterioration in the marine environment, other impacts may result in injury or damage to:* Personnel;
* Surface assets and equipment;
* Subsea assets (due to the riser being connected to the MSV).

The severity of damage during a vessel collision event will be dependent upon the nature of the impact zone during the collision (e.g. amidships or on the bow). | Potential mitigation measures* A vessel on stand-by at all times and monitor transiting or fishing vessels within the area and to maintain the safety exclusion zone. Early warning radar and communication systems on board the stand-by vessel and MSV will be used to identify and communicate with any approaching vessels.
* Prior to operations commencing, a Notice To Mariners (or similar notification) should be prepared and issued to the government (who has issued the mining permit) and industry bodies with marine interests in the area.
* The vessel to have suitable ship-board emergency response plans covering various eventualities so that the crew know what their roles and responsibilities are in the event of an incident.
* All vessels associated with the project should meet national and international regulations for shipping including the appropriate signals and lights as defined by the International Maritime Organisation (IMO) and Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs);
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| * Seabed equipment failure
 | Seabed equipment may develop leaks which allow the escape of either chemicals or hydrocarbons into the water column. This will primarily be hydraulic oil from the various systems on the seabed, however it may include additional chemicals or leached metals from the equipment. * Subsea systems may develop faults which allow small quantities of hydraulic oil or other chemicals to be released into the marine environment. This would likely lead to a minor and localised deterioration in the seabed water and sediment quality conditions.
* It may be technically or economically unfeasible to recover broken equipment from the seabed. This may lead to an additional financial difficulties for the mining operator. The likely outcomes are either; a withdrawal from the project as the operator cannot afford to continue, or additional expenditure to retrieve the equipment (if technically possible) with potential future project implications.
* The metals and chemicals leached from the system will lead to a degradation in the local environment. This will have a negative effect on benthic communities and their ecosystem as described earlier in the document.
* Mining equipment left in-situ would lead to an increase in hard substrate (positive impact) from the presence of the equipment.
 | Potential mitigation measures* The use of chemicals posing little or no risk (PLONOR) to the marine environment to minimise any impact from potential leaching;
* Regular maintenance and upkeep operations and schedules;
* Emergency response / contingency plans in place prior to DSM operations commencing.
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Source: <Insert Source or notes>

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