Review of Seabed Mining in the Northern Territory – Environmental Impacts and Management

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ntepa Northern Territory Environment Protection Authority

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The Northern Territory Environment Protection Authority (NT EPA) provides this review of impacts of seabed mining and the management of this potential industry to the Northern Territory Government (NT Government) in accordance with Government's request and provided terms of reference.

NT EPA's review identifies issues for further consideration by the NT Government; however, the review does not provide a recommendation on the future of seabed mining in the Northern Territory (NT). Ultimately, it is a matter for the NT Government to determine its policy position on seabed exploration and mining in coastal waters of the NT.

The coastal waters of the NT have important environmental and natural resource values. They are highly valued by Territorians for their environmental, cultural and recreational importance and the role they play in natural resource-based industries such as commercial fishing, aquaculture and tourism.

The coastal waters of the NT also potentially contain mineral resources that could be exploited through seabed mining.

In March 2012, the NT Government introduced a moratorium on seabed mining in NT coastal waters. The moratorium was established following community concerns and acknowledges the limited knowledge and information about the environmental impacts of seabed mining and their management.

This report has been prepared by the NT EPA to advise the NT Government on:

- the actual or potential impacts on the environment and other resource industries, and
- the methods for managing the impacts of seabed mining.

Advice on the risks to, and protection of, Aboriginal sacred sites will be provided separately by the Aboriginal Areas Protection Authority (AAPA). Advice from the NT EPA and AAPA will provide a basis for the NT Government to consider the possible future development and sustainability of this industry.

Seabed mining is an evolving industry focused on exploiting aggregate and mineral deposits on and under the seabed. It is considered a relatively new and controversial industry in Australia and other countries.

The likely target resources for seabed mining in the NT include: aggregate sands or gravels, mineral sands containing gold, diamonds and rare earth minerals, offshore salt deposits, and mineral deposits (manganese, phosphate, bauxite) that are extensions of known onshore resources. The techniques available for seabed exploration and mining are continually advancing. Mining methods most likely to be used in coastal waters of the NT involve scraping or excavating the seabed using hydraulic or mechanical dredges, or use of vertical (from anchored platforms) and horizontal drilling (from an onshore base).

The NT EPA's review describes the environmental values associated with the coastal waters of the NT that may be impacted by seabed mining, including biophysical, social and economic values. It identifies that seabed mining has the potential to impact these environmental values and other resource industries of the NT both directly, indirectly and cumulatively. The review describes the range of management measures that, depending on the scale, nature and location of a seabed mining proposal, may be available to seek to manage those impacts that are manageable while noting that the effectiveness of measures on some impacts will remain uncertain and some impacts could remain unacceptable.

The NT EPA's review identifies:

- the wide variability in scale, nature and location of mining activities, with the significance of impacts, and the extent to which they can be effectively managed, strongly related to the scale, nature and location of individual proposals

- limited experience in regulating seabed mining in tropical environments in Australia and the world
- the gaps in knowledge about the marine and coastal environments of the NT required to adequately assess and make decisions about the potential impacts of seabed mining and their management
- the considerably strengthened environment protection framework afforded by the *Environment Protection Act 2019* (EP Act) that provides for the environmental impact assessment and approval of proposals that have the potential to have a significant impact on the environment.

The NT does not have any specific regulation aimed at the environmental impacts of seabed mining. With the introduction of the EP Act, the regulatory environment and decision-making framework for identifying and managing the impacts of proposals in general have substantially improved since 2012 when the moratorium was introduced. Any seabed mining proposal would be considered under this new regulatory framework. This framework ensures the rigorous assessment of environmental impacts by an independent authority, with numerous opportunities for community participation. It ensures that the assessment undertaken by the NT EPA directly and transparently informs approval decisions by the Minister for Environment.

The NT Government's commitment to transferring the environmental regulation of mining from the *Mining Management Act 2001* to the EP Act provides an opportunity to consider whether further reform is required to regulate seabed mining activities.

Notwithstanding the regulatory environment has changed, there are considerable challenges in effectively regulating seabed mining operations. The lack of adequate environmental information is a major barrier. It is possible that manageable impacts from small-scale seabed mining activities in relatively data-rich locations and/or resilient ecosystems could be effectively assessed and regulated. In contrast, seabed mining activities on a large scale, in sensitive environments and/or where data is scarce, will require a very substantial investment by the proponent to provide adequate baseline data, describe potential impacts with sufficient certainty, and develop evidence-based mitigation measures. In some situations, the costs to the proponent to collect the necessary information to support a proposal is likely to be highly prohibitive to the viability of the proposal. As a consequence of high levels of uncertainty and risk, the NT EPA expects that some proposals may be unacceptable and result in a recommendation of early refusal by the Minister for Environment to provide certainty to proponents and government, avoiding unnecessary expenditure and delay.

The NT EPA has made a number of key findings and conclusions on the management of seabed mining in the coastal waters of the NT in its advice to the NT Government.

List of key findings and conclusions

1. Any seabed mining activity in the Northern Territory must occur within an evidence-based, transparent, robust regulatory and policy framework that promotes ecologically sustainable development and establishes clear expectations on industry. This framework should be supported by:

   - the declaration of marine environment protection 'no go' areas for areas with high biodiversity, economic, recreational and/or cultural value
   - adequate baseline knowledge of environmental values
   - documenting the appropriate and acceptable standards for seabed mining practices and environmental management.

   Should seabed mining be considered for the Northern Territory, adequate resourcing would be required to ensure that government, the NT EPA and regulators have the capacity and expertise to deliver policy and technical guidance, rigorous environment impact assessment and regulatory oversight of a new and complex industry.

2. The Northern Territory Government should consider declaring a 'seabed mining' activity trigger under the *Environment Protection Act 2019* for all seabed exploration and mining activities so that referral to the NT EPA is required to determine whether environmental impact assessment is required.

3. Seabed mining activities can be broadly categorised into three classes, based on their potential for significant environmental impact:

   - Manageable impacts – are likely in some relatively data-rich, low-sensitivity locations. Potentially significant impacts may be effectively managed under current environmental impact assessment and regulatory arrangements resulting in acceptable proposals.
   - Uncertain impacts – are likely in some situations, based on either the impact of seabed mining or the condition/quality and knowledge about the receiving environment. Potentially significant impacts may be effectively managed based on the extensive collection of new environmental information and knowledge prior to environmental impact assessment.
   - Unacceptable impacts – are likely in some situations where serious environmental risks and high uncertainty remain and no amount of information or knowledge is likely to adequately address the residual impacts in a reasonable time and at a reasonable cost. The NT EPA considers these proposals are likely to be unacceptable and may trigger a recommendation for early refusal.

4. Currently, the lack of adequate environmental information and knowledge about the existing condition of environmental values and the potential impacts from seabed mining is a major barrier to the robust environmental impact assessment, approval and appropriate conditioning of seabed mining in the Northern Territory.

   There is difficulty in applying known management measures to poorly understood marine environments. This contributes to uncertainty about the effectiveness of management and mitigation measures.

   It will be important to communicate to proponents the considerable information requirements necessary for robust environmental impact assessment, including adequate baseline data that encompasses the substantial natural, temporal and spatial variation in marine and coastal environments.

5. The collection of adequate data at a regional scale required for environmental impact assessment requires coordination between industry, government, research institutes and other stakeholders, rather than a piecemeal approach at the individual project scale.

The establishment of a government managed and resourced central data repository is essential to support environment protection and the assessment and regulation of any proposed seabed mining activities in the Northern Territory. An accessible data repository would enable the most effective use of environmental data collected by industry, research organisations and government agencies and ensure that data is:

- collected to appropriate data standards
- verified and stored securely
- shared amongst all stakeholders.

Over time, this approach would further reduce the barriers to the robust assessment, approval and appropriate conditioning of seabed mining in the Northern Territory.

Any NT seabed mining policy should ensure that data collected for the purposes of understanding the marine environment to support seabed mining must be made available to the broader community.

6. Should seabed mining be approved, relevant approvals would require environmental monitoring that informs regulation of proposal-specific management targets, and develops an evidence-based understanding of environmental impacts to support future impact assessment and regulation of the industry. Baseline data, monitoring data and compliance reporting should be reviewed on a regular basis and be available to the public.

7. The NT EPA considers that the use of adaptive management would not be appropriate for managing the high levels of uncertainty and risk associated with the mitigation of potentially significant environmental impacts from seabed mining proposals. Any use of adaptive management would be limited in its application to clearly defined issues where it can be proven to be effective.

8. The NT EPA considers that environmental offsets cannot currently be readily or easily applied to seabed mining proposals in Northern Territory coastal waters. The collection of pre-impact baseline data does not qualify as an environmental offset.

9. Closure and rehabilitation are important considerations for the assessment, approval and management of seabed mining. In the absence of specific guidance, seabed mine closure and rehabilitation should follow the best practice principles of the International Marine Minerals Society Code for Environmental Management of Marine Mining, the International Council on Mining and Metals for Mine Closure, and the WA Guidelines for Preparing Mine Closure Plans.

   Requirements to achieve environmental protection outcomes must include: extensive baseline information, appropriate financial assurance, progressive rehabilitation wherever possible, agreed rehabilitation objectives, completion criteria and monitoring of rehabilitation success. These requirements should be captured in specific closure and rehabilitation criteria and guidance developed by government with substantial industry and stakeholder input.

   Regulation of seabed mining would need to include the application of a financial assurance framework that adequately protects the interests of government and the community.

   Effective rehabilitation and biological recovery is unlikely to be feasible where seabed mining removes or alters extensive areas of the seafloor, or for seabed mining proposals greater than five years duration.

10. Independent expert groups can provide valuable advice to regulators and industry during the planning, assessment, operational and rehabilitation stages of seabed mining projects, should seabed mining proceed in the Northern Territory beyond a limited number of small-scale operations.

The cost of funding a proposal specific expert advisory group would appropriately lie with the proponent with its scope and membership determined by the regulator in line with the 'user pays' principle.

11. The powers afforded by the *Environment Protection Act 2019* to the Northern Territory Government and the NT EPA (section 6.1) provide a strong framework for community involvement in the environmental impact assessment and approvals process and, ultimately, environment protection.

    Transparent, meaningful community engagement and consultation should commence early in project planning prior to the impact assessment and approvals process, and extend to project implementation and closure.

    Further investigation of learnings from the Northern Territory (Hydraulic Fracturing Inquiry), national (NOPSEMA) and international (NZ and BMAPA) experiences will be valuable to guide the Northern Territory Government's position, implementation and communication pathways.

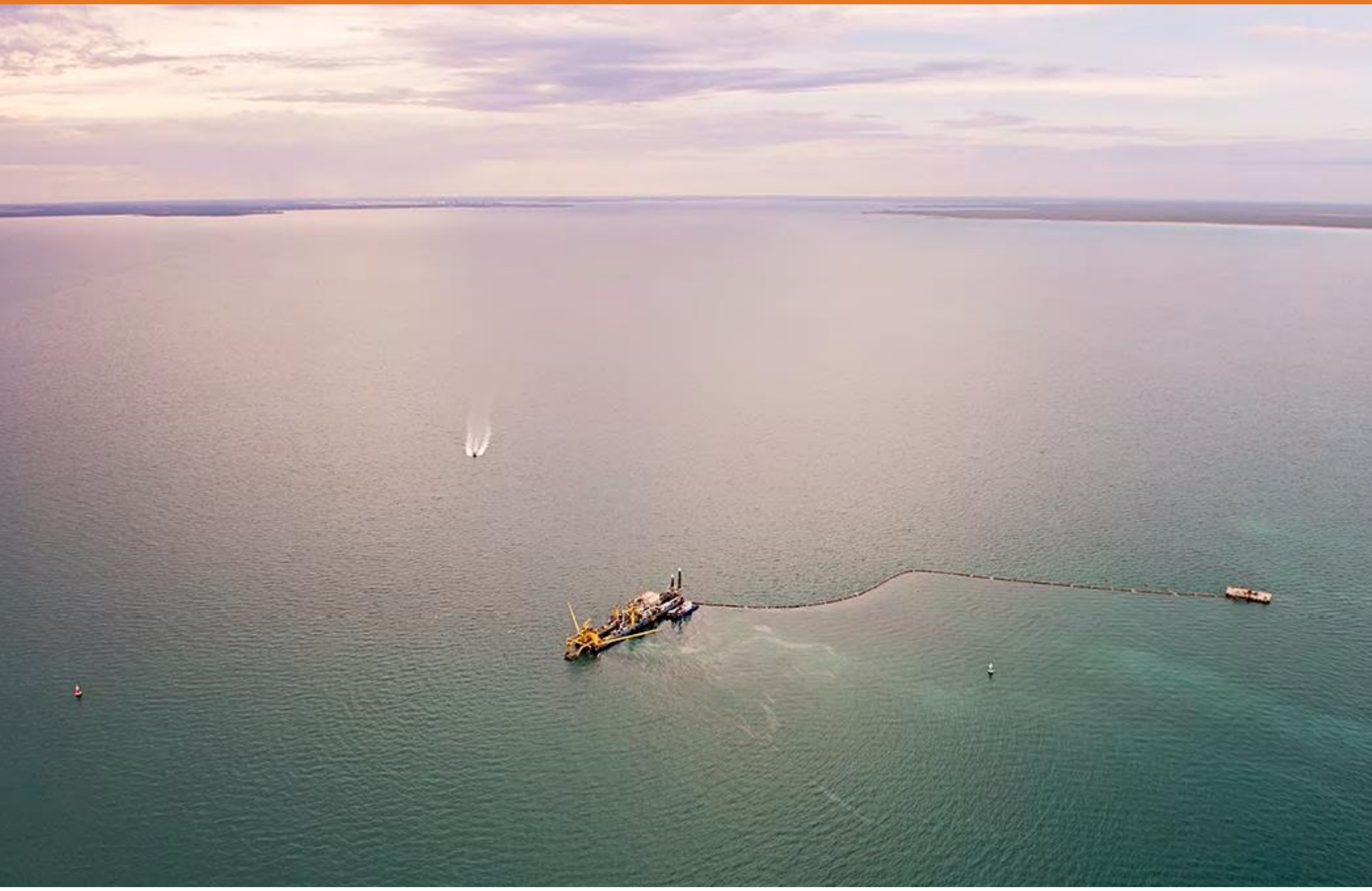


Photo courtesy of Darwin Port

1 Introduction

Seabed mining is an evolving industry focused on exploiting mineral deposits on and under the seabed. Seabed mining activities are diverse and range from established shallow marine mining industries, e.g. extracting gravel or sand for construction, mining of nearshore manganese, phosphate and bauxite deposits, and mineral sands for gems and heavy metals, to exploratory deep seabed mining. In the coastal waters of the Northern Territory (NT coastal waters), the water depth over the continental shelf is generally less than 50 metres. Shallow marine mining is therefore the most likely method of seabed mining that could be pursued in the Northern Territory (NT).

While established international seabed mining has shown economic benefits (Advisian 2017) there is currently limited information about the existing mineral resources and the environmental values of NT coastal waters. This limitation extends to substantial uncertainty about the likely impacts of most seabed mining methods on the environmental values of the NT and on other resource industries, such as commercial fisheries and tourism.

In recognition of these limitations, and in response to community concerns, on 6 March 2012 the Northern Territory Government (NT Government) put in place a Moratorium on exploration and mining in coastal waters of the NT. The Moratorium provided an opportunity for the NT Government to seek advice from the Northern Territory Environment Protection Authority (NT EPA) and other experts on the benefits and impacts associated with seabed mining prior to finalising a policy position on the future of seabed mining in the NT. The Moratorium has been extended twice, and is currently anticipated to expire on 5 March 2021. To date no seabed mining has occurred within NT coastal waters.

1.1 Purpose of the review

The purpose of this review is to respond to a request from the NT Government for a review and advice on the actual and potential environmental impacts arising from seabed mining and the management of these impacts.

The NT EPA has reviewed the potential environmental impacts of seabed mining and the appropriate management of these impacts in accordance with the request of the NT Government in 2012 (Appendix 1). Specifically, as outlined in the Moratorium documentation, the NT EPA review provides advice on:

- *the actual or potential impacts on the environment and other resource industries*
- *methods for managing the impacts of seabed mining.*

The NT EPA has considered further relevant guidance from the Moratorium that:

- *the review of seabed mining will provide a basis for assessment of the possible future development and sustainability of this industry.*

During the establishment of the Moratorium, the then Minister for Natural Resources, Environment and Heritage requested the NT EPA consider the following in preparing its review:

- *identify the appropriate standards for acceptance by the Territory which will adequately address the needs of the community in respect of industry 'best practice', protection of the environment, protection of social and cultural impacts, mitigation strategies and community involvement*

- *permit the development of regulations, guidelines, or both, for the assessment of applications (received but not assessed due to the Moratorium and future applications) to ensure consistency of assessment procedures and appropriate determinations, taking into account the relevant factors*
- *the review will:*
    - *examine practices adopted or applied in seabed mining both internationally and within Australia, and identify which of these are considered as environmentally best practice*
    - *identify the likely impacts of seabed mining on the environment and other resources, including identification of impacts which have occurred as a result of, or in association with, seabed mining*
    - *examine the mitigation strategies that have or could be used to manage the impacts of sea based exploration and seabed mining on the environment and other resources.*

1.2 Scope of the review

The NT EPA has reviewed '*the actual or potential impacts on the environment and other resource industries and methods for managing the impacts of seabed mining*', in the context of the *Environment Protection Act 2019* (EP Act) and relevant NT EPA guidance documents, in particular the NT EPA's environmental factors and objectives (NT EPA 2020a) as they relate to what is known about the environmental values of the NT's coastal waters.

For the purposes of this review, the NT EPA defines seabed mining as the exploration and extraction of sub-sea minerals and extractive minerals for commercial gain (refer section 1.3.1). Case studies are provided to highlight important examples and include examples of deep seabed mining where these are particularly relevant. While the NT EPA review considers individual case studies and examples, this review does not seek to determine the acceptability of any individual proposal, but rather understand the common issues or themes associated with impact assessment and environmental management that are relevant to the NT.

To fulfil the terms of reference, the NT EPA recognises the importance of:

- defining the geographic scope and terms used in this review (section 1.2.1)
- providing an overview of mining and management methods used for seabed mining (section 2.1)
- providing an overview of successes, failures and learnings from previous seabed mining proposals and projects (sections 2.1 and 2.3)
- identifying the values of NT coastal waters and likely impacts on these values (sections 4 and 5).

The NT EPA has engaged experts in marine ecosystems, industry, maritime archaeology, and social and cultural impact assessment to inform this review. The reports provided to the NT EPA by other parties are provided as appendices.

1.2.1 Geographic scope

The Moratorium defines the geographic scope of NT coastal waters as the sub-tidal waters under the NT's jurisdiction from the low water mark (normal baseline at the level of the lowest astronomical tide) seaward to 3 nautical miles (nm) from the straight territorial sea baseline. Coastal waters of the NT are defined under the *Australian Coastal Waters (Northern Territory Powers) Act 1980* as '*any sea that is on the landward side of any part of the territorial sea of Australia*'.

Importantly for the NT, the Moratorium includes large areas of inter-island waters previously unreserved from mining. Of equal importance, the Moratorium excludes intertidal areas, which are essential to the existence of many marine and coastal environmental values.

The NT EPA review includes discussion of impacts on the intertidal waters above the low water mark. These areas provide essential ecological services to maintain the environmental values of NT coastal waters and in doing so form an integral component of this review. Consequently, for the purpose of this report, the term ‘marine’ should be read to apply to subtidal and intertidal areas and ecosystems.

The review does not include any impacts of land-based activities associated with seabed mining, as these are not in the scope of the terms of reference and are analogous to similar activities for land-based mining operations which have relatively well-known impacts and risks, and established mitigation and management measures. The review does not consider seabed mining of intertidal areas for the same reasons, noting that most impacts to intertidal areas and their management will be similar to those described in this review for mining below the low tide mark. Further, the NT EPA recognises the high connectivity between terrestrial environments (e.g. wetlands and waterways), intertidal areas and the marine environments of the NT, and any proposal that spans these environments would require the appropriate information to inform environmental impact assessment and approval processes before being considered environmentally acceptable.

The spatial scope of this review is shown in Figure 1.

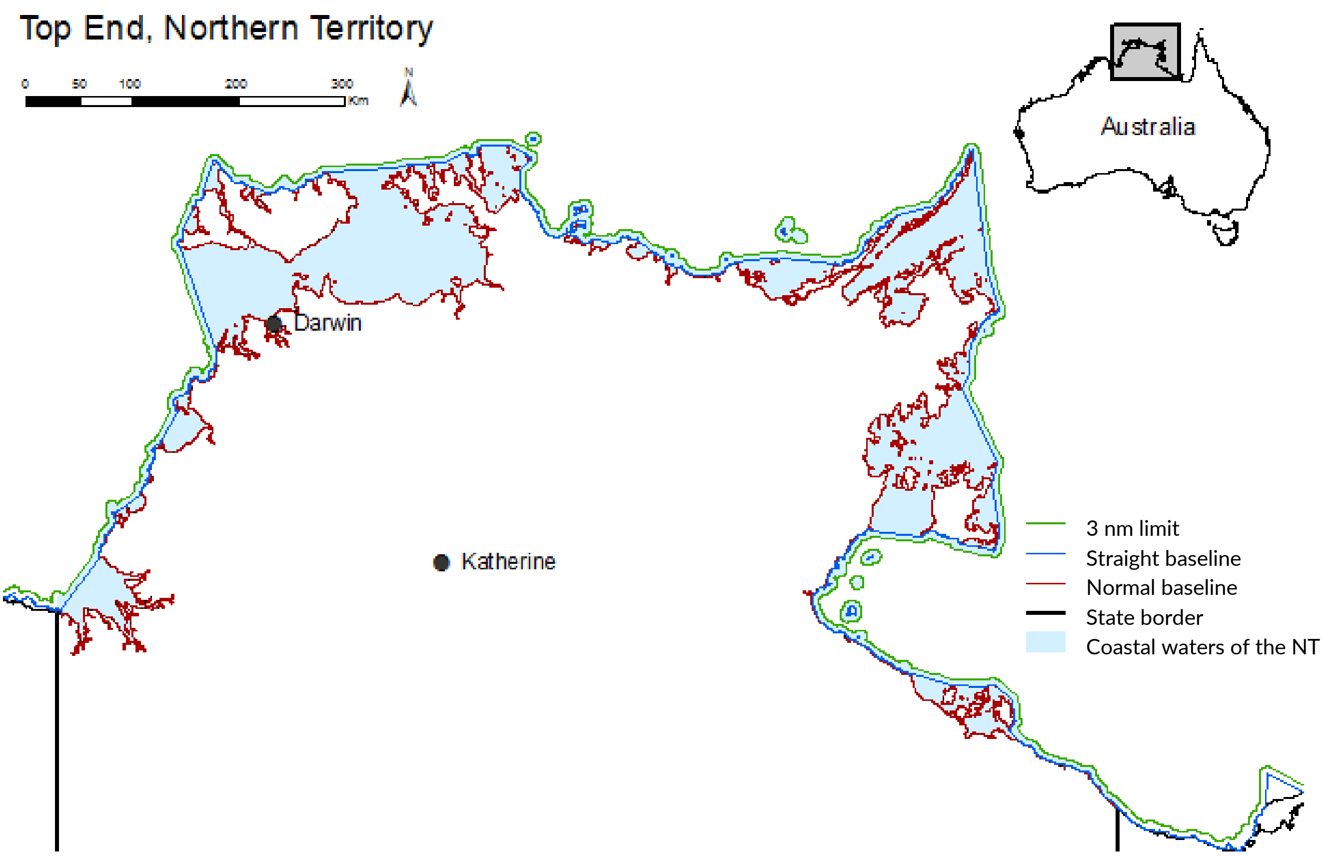


Figure 1: Spatial scope of seabed mining Moratorium in coastal waters of the NT

Case Study 1: Establishing boundaries: mining applications and protected areas in the coastal waters of the Northern Territory

An increased interest in exploiting mineral resources in the marine environment led the NT Government to establish a reservation from occupancy of some coastal waters under the NT Government's *Mineral Titles Act 2010* (MT Act) in 2005. The reservation protected the belt of coastal waters between the straight Territorial Sea baseline and 3 nm limit. The inter-island and bay areas between the NT coastline (normal baseline) and reserved area (straight baseline to 3 nm) remained unreserved, resulting in 26 title applications for exploration and extraction being submitted for these areas.

Consistent with the grant of title, activity commenced in 2012 to undertake exploration along the seabed near Groote Eylandt. These actions caused considerable concern to the Aboriginal people on Groote Eylandt, and subsequently led to combined action by the Anindilyakwa and Northern land councils to protect the sea country and to halt the seabed exploration.

While the intertidal zone between the land and NT coastal waters is recognised as land and protected under the *Aboriginal Land Rights (Northern Territory) Act 1976*, the sea country beyond the intertidal zone (below the low water mark) is not. However, Aboriginal people have strong cultural ties which extend out to sea through Songlines and Dreamings and bind the people to ancestral paths shared between clans. The ancestral paths also bind Aboriginal people to the sea, its resources and the responsibility to care for them (Munday 2017).

As a result, in acknowledgment of the limited information available on environmental impacts and management methods associated with seabed mining, the NT Government established a Moratorium on exploration and seabed mining in 2012. The Moratorium protects all coastal waters from the low tide mark to the 3 nm limit and is to continue until a review on seabed mining in the NT coastal waters is completed.

The mineral titles in the Groote region were bought back by the Territory Government and in 2014 the area declared a reservation from occupancy under the MT Act. In 2016 the Anindilyakwa Indigenous Protected Area was expanded to include 7000 km^2 of the marine environment surrounding the Groote archipelago.

At present NT coastal waters contain two declared general reservations from mining, seven mineral exploration and six mining authorisation applications, two NT Government managed marine parks, and six Indigenous Protected Areas that incorporate coastal and, in some cases, marine environments.

There are six Australian Government managed marine parks in Commonwealth waters adjacent to NT coastal waters, and one Australian Government (Kakadu National Park) and 13 NT Government managed terrestrial parks and reserves that extend to the landward boundary of coastal waters (Figure 3, section 3).

1.3 Definitions

1.3.1 Seabed mining

The definitions of seabed mining generally vary based on the types of minerals being mined, how they are mined and the depth or geographic location at which mining is undertaken (EPA 2012).

This NT EPA review defines seabed mining as the exploration and extraction of sub-sea minerals and extractive minerals for commercial gain. Seabed mining does not include capital or maintenance dredging on any scale, nor beach nourishment, and excludes offshore oil and gas recovery. Seabed mining does not include mining in the intertidal zone, as considered by EPA (2012), but potential impacts from seabed mining on the intertidal zone and their management are recognised as an important component of this review.

1.3.2 Dredging

Dredging is a technique commonly used to extract and move seabed material. An important question that is often asked is, '*why is seabed mining different from large scale dredging?*' Indeed some seabed mining activities may be much smaller than some dredging activities, and in some cases dredging activities may result in the extraction of seabed material. The key differences are around the purpose and location of activities, the frequency and duration of activities, and expectations and feasibility of rehabilitation, irrespective of the magnitude of proposed activities.

Dredging is generally conducted to maintain navigable shipping channels, ports and material offloading facilities for the oil and gas industry where the seabed needs to remain in a disturbed state with no expectation of rehabilitation of the immediate area. The dredged material is deposited to other sub-sea locations (NRETAS 2011), used for beach nourishment (in all Australian States, but not the NT, Cooke *et al.* 2012) or extracted for terrestrial construction purposes (Moreton Bay Sand Extraction – WBM Oceanics Australia 2002 and Queensland Government 2005).

Seabed mining involves the extraction of seabed material for commercial purposes and has an expectation of closure planning and rehabilitation, just as for terrestrial mining. The ability to rehabilitate the seabed though, has inherent difficulties that are introduced in section 2.1.4 and discussed throughout this review.

Nonetheless, dredging of channels in coastal waters may be subject to the same restrictions and management requirements as seabed mining projects.

1.3.3 Ecologically sustainable development

The principles of ecologically sustainable development (ESD) are key to recent reforms of NT environmental legislation and underpin all decision-making under the EP Act. The principles of ESD are defined in the EP Act as:

- Decision-making principle
- Precautionary principle
- Principle of evidence-based decision-making
- Principle of intergenerational and intragenerational equity
- Principle of sustainable use
- Principle of conservation of biological diversity and ecological integrity
- Principle of improved valuation, pricing and incentive mechanisms.

Importantly, the precautionary principle, as defined in the EP Act, provides for circumstances where there are threats of serious or irreversible environmental damage. If there are threats of serious or irreversible environmental damage, then the lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. Further to this the precautionary principle requires decisions to be guided by a careful evaluation to avoid serious or irreversible damage to the environment wherever practicable and a risk-based assessment of the consequences or alternative options.

1.3.4 Environment

Environment is defined in section 6 of the EP Act as, '*all aspects of the surrounding of humans including physical, biological, economic, cultural and social aspects.*'

1.3.5 Significant impact

Significant impact is defined in section 11 of the EP Act as '*an impact of major* consequence *having regard to:*

- *the context and intensity of the impact*
- *the sensitivity, value and quality of the environment impacted on and the duration, magnitude and geographic extent of the impact.*'

Potential for significant impact may be quite different for each proposed activity, as a result of the interactions between the impacting action (context and intensity) the nature of the impact (duration, magnitude and extent) and the receiving environment (quality, value, sensitivity and resilience).

The NT EPA provides further direction on how to determine significant impact in its referral guidance (NT EPA 2020c).

1.3.6 Environmental values

Environmental values are aspects of the environment that are important or serve an important function. Some values are recognised through legislation such as threatened species, sacred sites, national parks and Beneficial Use Declarations. Other values such as coral reefs provide beneficial uses to ecological and human communities alike. Indicative environmental values are identified in NT EPA's Environmental factors and objectives guidance (NT EPA 2020a).

1.3.7 Alternative terminology

Recent advancements associated with the dredging and seabed mining industries have led to new terminology. A key example is the term '*sub-sea mining*', which may be more appropriate than seabed mining as it considers impacts on the water column and sediments both on and below the seabed itself.

The glossary in section 8 provides further clarification of terms used in the review.

Photo courtesy of Yirralka Rangers

2 Seabed mining techniques and experiences

Seabed mining is an evolving industry focused on exploiting mineral deposits on and under the seabed. Seabed mining deposits and activities are diverse and range from established shallow marine mining industries to exploratory deep seabed mining. Shallow marine industries are based on a range of dredging techniques for aggregate extraction of mud, sand, clay, shell and gravel for construction purposes; and mining of nearshore deposits of phosphates, manganese and mineral sands for gems and heavy minerals. Deep sea mining is considered the potential to mine concentrated mineral deposits deeper than 500 m and includes target resources of polymetallic sulphides, manganese nodules and cobalt-rich crusts using remote operated mining vehicles.

The growing demand for construction materials and increasing metal prices, combined with advances in mining technologies, have contributed to a recent global push for mining in the marine environment (Paar 2008, OECD 2012, Global Ocean Commission 2013, Kaikkonen *et al.* 2018).

To date, seabed mining is largely based on shallow-water mining using elaborations of dredging technology. Management of the industry is largely focused on improving the knowledge base required to achieve better environmental outcomes. Many seabed mining proposals have not progressed to implementation due to the recognised poor state of knowledge of the affected environment and uncertainty around impacts from seabed mining (Miller *et al.* 2018, ECORYS 2014).

Most seabed mining activities are currently located within the coastal and territorial waters of nation states and are subject to state and/or national laws. Prospective mineral deposits in deeper waters may be located in the Exclusive Economic Zones of nation states and subject to national laws, or occur in international waters regulated by the International Seabed Authority (ISA). The ISA has granted 28 contracts for deep sea exploration and a number of countries are investing in reducing uncertainty through improving the state of knowledge of environmental (including socio-economic) values, impacts and impact management (ISA 2018, Miller *et al.* 2018, ECORYS 2014).

2.1 Seabed mining techniques

A range of techniques and equipment may be used to exploit seabed materials. This section describes the techniques commonly applied for key phases of mining from exploration and discovery to rehabilitation and closure.

2.1.1 Exploration

Prospecting and exploration are undertaken using a broad range of techniques and equipment developed to investigate the seabed for both resources and surrounding environmental features (ISA 2015). Exploration techniques and equipment range from low impact remote sensing surveys (using airborne and vessel-towed instruments) for initial definition of resources, to progressively more intrusive seismic surveys and drill and core sampling as exploration programs progress and the quantity and grade of resources are defined. Extensive two and three dimensional seismic surveys have been conducted in Australian waters for many years. Although marine seismic surveys do not directly disturb the seabed, the impacts of acoustic emissions on megafauna, marine fishes and benthic and pelagic invertebrates remain uncertain and contested (NOPSEMA 2018b).

In Australia a listed company is required to use the Joint Ore Reserves Committee (JORC) code when making public statements on exploration results (JORC 2012). The process of defining the quantity and grade of resources from an inferred status through to indicated, probable, measured and proved status requires incrementally more information obtained from more intensive survey techniques.

2.1.2 Extraction

Extraction from the seabed may be categorised into four main mining methods (shown in Figure 2): scraping from the surface; excavating from a pit; drilling into the deposit then fluidising and pumping it; or tunnelling beneath the surface (ISA 2015). Collection of nodules by automated underwater vehicles (AUVs) could be considered under the scraping method based on impact pathway.

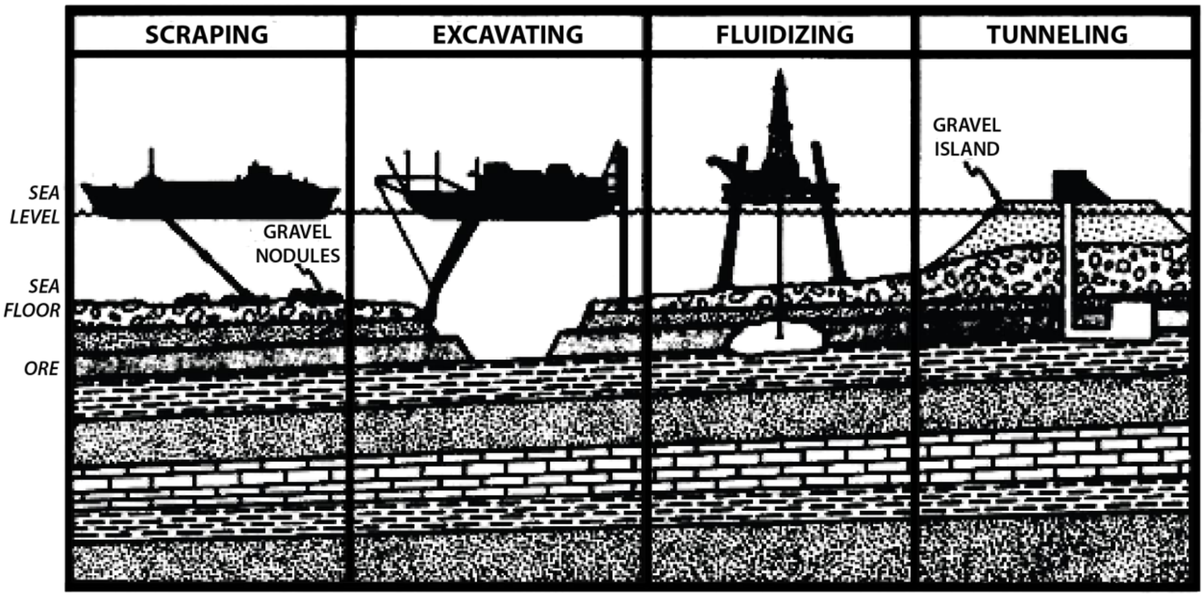


Figure 2: Four broad extraction methods for seabed mining. Sourced from ISA (2018)

The mining technique and equipment used to extract minerals will depend on:

- the form, composition, grade and quantity of the target resource
- the geotechnical characteristics, depth and topography of the seabed to be mined
- the method and location of tailings (waste) disposal
- environmental characteristics of the mining and disposal areas
- agreed environmental commitments and conditions for mining
- the scale and schedule of the project.

Mineral deposits in the relatively shallow waters of the NT are suited to mining through extraction by scraping or excavating using dredging technology. It is important to note that while capital and maintenance dredging may use similar techniques and machinery to extractive dredging for mining, impacts are likely to be different due to the duration, magnitude and geographic extent of operations.

Extraction by dredging can occur while a vessel is static or moving (trailing). Static dredge mining by an anchored vessel is suited to localised seabed deposits. Longer term static mining can result in deep local dredge depressions or pits. Trailing dredge mining is suited to deposits that occur in extensive sheets on the seabed. The drag-head is towed slowly across the seabed, resulting in a series of furrows where surface layers have been removed.

Dredging techniques can be broadly grouped into two types based on the mechanism of extraction: hydraulic dredges use the erosive quality of water flow to move material from the seabed; and mechanical dredges use teeth or cutting edges to extract material from more cohesive substrates. Transport of the dredged material to the surface can also be conducted through hydraulic or mechanical means, irrespective of the initial extraction method. Mechanical transport methods are more suited to deep sea mining operations and so are not discussed further in this review.

The three main types of hydraulic dredges are stationary suction dredges, trailing suction hopper dredges (TSHD) and cutter suction dredges. These dredges usually work most effectively in loose, unconsolidated silts, sands, gravels and soft clays. Mechanical dredges use similar methods to onshore excavation and include bucket-ladder dredges, backhoe dredges and grab dredges. Mechanical and cutter suction dredges are suitable for removing hard-packed, cohesive seabed material or debris and can operate in confined areas.

When seabed material is transported via hydraulic methods it is pumped as a slurry containing substantial amounts of seawater to a hopper within the vessel or an adjacent hopper barge. The heavy seabed material in the slurry will preferentially settle in the bottom of the hopper while lighter and finer sediment particles tend to remain in suspension. When the hopper fills with slurry, the water component containing fine sediment begins to overflow to the surrounding water, creating turbid suspended sediment plumes. This continues until the hopper is full of the mined seabed material. The particles in the turbid plume will ultimately settle to the seafloor. Although turbid plumes can travel tens of kilometres from the source, the highest rates of sediment deposition are much closer to overflow point (typically less than 2 km; Fisher *et al.* 2015).

Hydraulic TSHD is considered best practice by the UK aggregate marine mining industry (case study 7), and is now used for shell sand mining in WA (case study 2), and proposed for phosphate mining off the Namibian coast (NMP 2012, case study 6).

Technological advancements to more productively explore and exploit seabed materials have resulted in the design and use of crawler dredges and water injection dredges. Crawlers are a self-propelled, tracked vehicle located on the seabed that pump seawater to fluidise seabed sediments. Water injection dredging uses large volumes of water injected at low pressure into the sediment using pumps with a series of nozzles on a horizontal jet bar. Fluidised seabed sediment is retained or removed to access the target deposit below.

Crawlers have been purpose-built for diamond mining in Namibia. The seabed sediments are scraped to 12 m below the sea floor and then extracted to the surface through flexible slurry pipes. Crawler technology is proposed for the extraction of iron sands to 11 m below the seafloor in New Zealand (case study 4).

The technique of fluidisation by drilling from either the nearby coastline, or from an offshore rig, may be used to exploit offshore salt deposits in NT coastal waters.

2.1.3 Processing and transport

The processing of mined material is highly project-specific and dependent on the quantity and quality of the target mineral and surrounding seabed material, as well as meteorological and oceanographic (metocean) conditions of the area. Mineral separation may be undertaken offshore or onshore through physical and/or chemical processes.

In general, offshore processing is limited by economic viability and depends on the mined material and the scale of the operation. High grade mineral deposits requiring minimal processing may be processed offshore. Methods of offshore processing include screening and dewatering, gravity separation, clay washing and magnetic separation of mineral sands (Advisian 2017). Phosphate mined from the seabed is likely to be processed offshore with tailings and seawater used in processing being discharged to the seabed or water column above the seabed.

Offshore chemical processing of seabed minerals is less likely due to the increased containment requirements and environmental contamination risks inherent on a constantly moving vessel. Availability of fresh water is also likely to be a major obstacle for offshore chemical separation and would likely require on-board desalination.

Tailings may comprise fine and/or coarse sediments and are typically returned directly to the mined seabed, or deposited in designated tailings sites remote from the mining operations. All discharges, such as chemicals, process water, suspended solids, brine from desalination, freshwater and heat, represent potential pressures with impact pathways to environmental values.

Transport of mined seabed materials is generally by vessel or purpose-built barges. Mined materials may also be transported onshore via a slurry pipeline. Export of final products would typically be by large vessels loaded at ports or trans-shipment from barges at sea.

2.1.4 Remediation and rehabilitation

The purpose of remediation and rehabilitation is to restore, to the extent practicable, the environmental values of an area following the conclusion of mining. Traditionally the focus of restoration is on physical and biological characteristics of the environment, but the importance of considering socio-economic aspects of closure planning, particularly on local communities, is identified in Western Australian guidelines for mine closure and the sustainable development principles defined by the International Council on Mining and Metals (Unger 2015).

Techniques may vary depending on the mining methods used, the location of the mined area and the desired future use of that area, but active rehabilitation of the seabed in terms of both the substrate (habitat) and associated biological communities is not usually feasible and rehabilitation generally relies on natural recovery (Advisian 2017, Newell and Woodcock 2013). The rate and extent of recovery of physical characteristics and biological communities of the seabed post-mining will depend on the type of material that has been extracted, the magnitude of seabed features lost or created, water depth and the hydrodynamics of the affected system (Steele *et al.* 2010 in Advisian 2017).

In areas of direct disturbance where the seabed character has been substantially modified (e.g. changed from soft substrate to hard substrate), remediation and rehabilitation to the natural state are not practicably possible and some impacts are likely to be permanent. Indirect impacts typically diminish with distance from the active mining area and, where impacts are minor and the substrate is not significantly altered, recovery can occur rapidly once the pressure has ceased. The minimisation of residual impact from seabed mining is further described through mitigation measures presented in section 5 and consideration of closure and rehabilitation in section 6.6.

2.1.5 Baseline and ongoing environmental monitoring

All stages of seabed mining rely on data acquisition to build knowledge and an understanding of the environment and therefore the potential for impacts from development.

Baseline data is often collected during prospecting and exploration activities using technologies identified in section 2.1.1 above. Rapid advances in new technologies (e.g. drones, robotics, artificial intelligence and genomics) is likely to reduce time and expense of obtaining baseline data in the future.

2.2 Seabed mining internationally

Extraction of minerals from the seabed has been undertaken internationally since 1954, commencing with exploration for diamonds in Africa (Gurney *et al.* 1992). Since then, commercial scale mining operations have been established to depths up to 400 m. Examples of established seabed mining industries are provided by Rona (2008) and include:

- diamond exploration and mining up to 150 m deep in Namibia and South Africa
- gravel and sand extraction in Europe and Japan

- gold mining and underwater drill and blast mining of barite off the Alaskan coast
- extension of underground coal mining under the seabed at Cape Breton Islands, Canada
- sulphur mining off the Gulf of Mexico
- tin mining in Thailand and Indonesia (TIMAH 2013).

The global seabed mining industry is now focusing on deep sea exploration and extraction technologies, particularly to exploit rare earth minerals required for renewable energy and hybrid vehicle technology. These minerals often occur in enriched forms in the deeper waters of continental shelf areas and the deep sea at depths of 1500 m to 4500 m (Miller *et al.* 2018, Global Ocean Commission 2013). The target deep sea mineral deposits occur in a broad variety of geological forms including unconsolidated sands and gravels (e.g. iron sands placer deposits), polymetallic manganese nodules, massive sulphide deposits and consolidated cobalt rich crusts (World Ocean Review 2014). Deep sea mining remains in the exploratory phase with no commercial exploitation of minerals up to 2020 (ISA 2018, Ocean Foundation 2018).

Recent proposals in shallow marine waters to mine phosphate from marine sediments (180 m to 300 m, Namibia and South Africa) and deeper nodules (400 m, New Zealand) have not progressed to the mining phase due to strong opposition from social, environmental and scientific sectors as well as other resource industries potentially affected by mining (NZ EPA 2015a, 2015b, CER 2016, Benkenstein 2014, Case studies 3 and 6).

2.3 Seabed mining in Australia

Seabed mining in Australia is currently limited to extraction of aggregate material for the construction industry (Evans *et al.* 2016). The industry shares impacts and management actions with capital and maintenance dredging activities, which has led to claims by some sectors that no seabed mining industry exists in Australia. Despite these similarities, major dredging activities differ from extractive mining operations in the purpose, location, and around expectations of rehabilitation outcomes. Dredging is usually associated with a collection of localised dredging campaigns in areas that are to remain cleared.

As a coastal nation, Australia has significant experience with large-scale capital and maintenance dredging projects (Styan and Hanley 2011, Moreton Bay Sand Extraction Study). In the case of dredging in Moreton Bay, Queensland, this has included retention of extractive material for construction and land reclamation (WBM Oceanics Australia 2002). Styan and Hanley (2011) consider the large-scale dredging for port development associated with natural gas production in Western Australia (WA) and describe the monitoring programmes, reflective of dredging activity, as amongst the largest in this country. Over a period of 13 years the Western Australia Environment Protection Authority (WA EPA) and WA Government have assessed and approved, respectively, over 200 million cubic metres of dredging for multiple projects in the Pilbara.

Dredging of shell sand for quicklime and cement production in WA since the early 1970s represents the only other long-term extractive project in Australia (WA EPA 2017, case study 2). Other extractive operations include mining for iron ore using seawalls at Cockatoo and Koolan islands in WA, and ongoing exploration for tin in Ringarooma Bay, Tasmania (TNT Mines 2012, Ocean Mining Ag 1969). Translocation of dredged material for beach replenishment at various locations along the Australian coast, involves dredged material generally remaining within the same connected ecosystem rather than being extracted and removed from the ecosystem.

There is potential for seabed mining in Australian waters, within its continental shelf and 200 nautical mile economic exclusion zone, to extract minerals from extensions of onshore mineralisation such as coal, iron ore and manganese (GA 2018), placer deposits containing gold, heavy minerals and gems (GA 2018) or aggregate deposits comprising sand, coral or gravel.

Marine mineral deposits with documented or speculated potential for seabed mining in Australia include:

- alluvial gold and unproven heavy minerals (rutile and zircon), NSW
- coal in New South Wales and Gippsland Basin off the coast of Victoria
- scheelite (tungsten) at King Island, Tasmania
- alluvial iron, Pilbara region of WA
- diamonds in WA, Queensland and the NT (Joseph Bonaparte Gulf and Gulf of Carpentaria)
- tin and tantalum in Bynoe Harbour, NT
- phosphate, bauxite (aluminium) and manganese at various locations along the north east coast of the NT
- manganese near Groote Eylandt, NT
- aggregate deposits throughout coastal and territorial waters of Australia.

The scale of seabed exploration and mining activities varies and examples are provided for some proposed and existing international and Australian operations (Table 1). The capital and maintenance dredging undertaken in Darwin Harbour is included to enable comparison of scale.

Case study 2: Long term dredging for sand and gravel: changes to acceptability and improved methods, knowledge and management approaches, Western Australia

Since 1972, Cockburn Cement Ltd (CCL) has dredged shell sand from the seabed at Owen Anchorage, WA, for production of cement and quicklime. Following a controversial and complex history of operations and approvals for the CCL activities, long term dredging approval was awarded in 2000 based on a 'very substantial base of new knowledge' provided by the proponent as acknowledged by the WA EPA. Stage 1 approval allowed extraction of 19.9 Mt from 2002 to 2010 and Stage 2 approval to remove 60 Mt of shell sand over 20 years. Changes to management measures, informed by extensive research programs enabled environmental acceptability and continued operation of the project.

Shell sand is currently dredged using a trailer suction dredge, stored in the dredge hopper and transported to a jetty adjacent to an onshore wash plant at Woodman Point. Sand is released into the sea next to the jetty, reclaimed from the seabed and pumped to the wash plant where it is screened and washed to remove salt and silt. The used wash water containing fines material is discharged to the sea under the jetty. Sand is then pumped as a slurry to the cement and quicklime manufacturing plant. This method of extraction reduces the amount of sedimentation experienced at the extraction site and limits disturbance to previously impacted areas.

Seagrass habitats and hydrodynamic changes to the wave climate of Owen Anchorage and Cockburn Sound are the key environmental issues associated with the project. Extensive and targeted research, modelling and monitoring programs have provided the knowledge base to facilitate the environmental management, regulation and acceptability of the long-term dredging project. The CCL dredging project is supported by the Dredging Environmental Management Plan; Seagrass Research and Rehabilitation Plan; Wave Climate Measurement and Modelling Plan; Shoreline Monitoring Plan; Banks and Shoreline Protection Management Programme; and surveys of commercial and recreational fisheries activity (BMT Oceanica 2014). Ongoing mapping of marine habitats is conducted with annual, high resolution, aerial photography and five yearly ground truthing.

The WA EPA developed environmental monitoring standard operating procedures (WA EPA 2005) and environmental quality criteria (WA EPA 2017) to support the Cockburn Sound Management Council and State Environment Policies of 2005 and 2015.

This case study, based on long term data acquisition, highlights the importance of strategic, integrated research and monitoring programs required to assess and enable the environmental acceptability of proposals.

Table 1: Examples of proposed and operational seabed mining activities internationally and in Australia

Location	Project	Area of extent *(hectares, ha)*	Amount of extraction *(Million tonnes, Mt)*	Life of mine *(years)*
UK – total[1]	British Marine Aggregate Producers Association (BMAPA)	In 2016, 8750 ha was dredged from total workable area of 45 200 ha and total licenced area of 93 400 ha. In 2011 a total of 18 344 hours of dredging activity were recorded by electronic monitoring systems, equivalent to approximately 55 000 km of dredge track.	16 to 24 Mt per year	>20
NZ – TTRL[2]	Iron sands Proposal currently at NZ Court of Appeal	6576 ha (sediments mined to average excavation depth of 5 m, and up to 11 m depth in places)	50 Mt per year seabed material (= 5 Mt ore)	35
NZ – CRP[3]	Phosphorite nodules Proposal refused 2015	• 3000 ha mined per year over total area 82 000 ha in first five years • 45 000 ha mined over 15 years and whole proposal to mine 105 000 ha from a total area of 520 700 ha • (initially proposed from total 1 019 200 ha but reduced in assessment process)	More than 1.5 Mt per year	Initial = 5 Total = 35
Namibia[4]	Phosphorite sediments	300 ha per year (sediments mined to 3m)	Less than 5.5 Mt per year sediment equivalent to 3 Mt rock phosphate	20
Aust. - WA[5]	Cockburn cement Commenced early 1970s	Cockburn Cement has been in operation under the authority of a *'State Agreement Act' Cement Works (Cockburn Cement Limited) Agreement Act 1971* which pre-dates the EP Act. This act gives the company rights to mine for 40 years with the option of a 10 year extension to early 2020s.		50
Aust. – WA[5]	Cockburn cement Stage 1 – shell sand Commenced 2002	• widen existing shipping channel to 350 m • completing a second shipping channel 350 m • 52 ha and 19 ha blocks	Total = 19.9 Mt	8
Aust. – WA[5]	Cockburn cement Stage 2 – shell sand Commenced 2010	< 365 ha in area and located > 750 m from reefs and islands	Total = 60 Mt	20
Aust. – Qld[6]	Moreton Bay sand dredging	~ 4000 ha	0.711 Mt permitted per year (5 companies, 15 leases) Port of Brisbane = 23 Mt Brisbane airport expansion = 29 Mt Sunshine coast airport expansion = 1.7 Mt	na
Aust. – Tas[7]	Exploration for tin Ringarooma Bay	Total marine tenements of ~ 35 000 ha. Less than half this area has been explored with indication of resource over ~2000 ha	Inferred 194 Mm^3 Indicated 16 Mm^3 (= 0.03 Mt to 0.05 Mt tin, zircon, rutile, ilmenite)	na

Location	Project	Area of extent *(hectares, ha)*	Amount of extraction *(Million tonnes, Mt)*	Life of mine *(years)*
Aust. – NT[8]	Capital dredging Darwin Harbour, Inpex	~ 375 ha	Total = 25 Mt	2

[1] https://bmapa.org/issues/area_dredged.php accessed October 2018
[2] NZ EPA (2017) Decision report – granted TTRL
[3] NZ EPA (2015a,b) Decision report – refused CRP
[4] Benkenstein (2014)
[5] BMT Oceanica (2014)
[6] WBM Oceanics Australia (2002) MBSES Stage 1, and Queensland Government (2005) MBSES stage 2
[7] TNT Mines Ltd (2012)
[8] NRETAS (2011) Assessment report 65 – Ichthys gas field development project, Blaydin Point

Photo courtesy of Darwin Port

3 Seabed mining – the Northern Territory context

This section outlines the key jurisdictional and regulatory considerations that are relevant to seabed mining in NT coastal waters and identifies possible seabed mining targets.

3.1 Ownership of minerals, land and waters

All minerals and extractive minerals located in the NT and its coastal waters, except those that are ‘prescribed substances’ under the *Atomic Energy Act 1953* (Cth) (e.g. uranium and thorium), belong to the NT.

The spatial extent of coastal waters of the NT is from the low water mark (normal baseline) to three nautical miles seaward from the territorial sea baseline (straight baseline) which generally follows the coast, but in places encloses bays and gulfs, and wraps around islands. Tenure of NT coastal waters includes general mining reservation, mining exploration and authorisation applications, Indigenous Protected Areas (IPAs, which in some cases extend over the sea), and marine parks and reserves (Figure 3).

The scope of the NT EPA review on seabed mining excludes consideration of activities above the low water mark; however, it is noted that some components of any larger seabed mining proposal (e.g. ports, shipping channels and pipelines) are likely to extend above the low water mark, including the intertidal area, to the coast (see section 1.2.1).

Tenure is an important consideration when evaluating current and future regulatory requirements for seabed mining, specifically with regard to the complexities around securing approvals for activities on Aboriginal land.

While it is generally acknowledged that Aboriginal custodianship and connection with the seas extends into and beyond NT coastal waters, the *Australian Aboriginal Land Rights (Northern Territory) Act 1976* and *Native Title Act 1993*, and the *Northern Territory Aboriginal Land Act 1991*, define Aboriginal land to extend only to the low water mark, excluding coastal waters and beyond. The implications for engagement with Aboriginal landowners and custodians, and obtaining access and approvals for mining, have improved under the EP Act as described in section 3.3.3 and Appendices 3 and 5.

3.2 Potential for seabed mining in the Northern Territory

Based on existing knowledge of the geological environment of NT coastal waters, there is unproven potential for shallow seabed mining to target:

- mineral sands (containing gold, diamonds and rare earths minerals)
- aggregate sands or gravels
- offshore salt deposits under the seabed
- mineral deposits (manganese, phosphate, bauxite) that are extensions of known onshore resources.

Exploration is required to identify possible resources, and subsequently more intensive investigation to prove up the resource and determine whether extraction can be economically viable.

In NT coastal waters the continental shelf depth is generally less than 50 m deep and seabed mining would likely be shallow marine mining, largely based on existing dredging technology. The mining techniques likely to be applied to seabed mining in the NT are hydraulic dredging of sands and gravels, and potentially of placer deposits for diamonds; and mechanical dredge extraction of seabed extensions of onshore deposits such as manganese and bauxite.

Mineral-containing sands have been identified in NT coastal waters near Wadeye, Cape Scott, Melville and Cobourg Peninsula and Gulf of Carpentaria (Ahmad and Munson 2013a, 2013b).

Diamonds have been identified in offshore alluvial mineral sands originating from several rivers in WA, and in the Limmen Bight and McArthur Rivers in the NT. However, these are currently not considered to occur in commercially viable quantities.

Coastal sands, claystone and gravels (devoid of heavy metals) are potential sources of basic raw materials to support the building industry. Currently all basic raw materials for the construction of housing, infrastructure and roadworks are provided by land-based extractive operations in the NT.

Salt domes have been identified in coastal waters of the NT near Wadeye (Minemakers Australia Pty Ltd 2010).

The geology below the seabed also provides potential sources of mineralisation which may be targeted for seabed mining, particularly manganese, phosphate and bauxite occurring in northern and eastern NT coastal waters.

The scale (duration of mining, volume of material extracted, geographic extent) of any seabed mining project in NT coastal waters would depend on the resource, method of extraction, processing requirements and location (Table 1 and section 2).

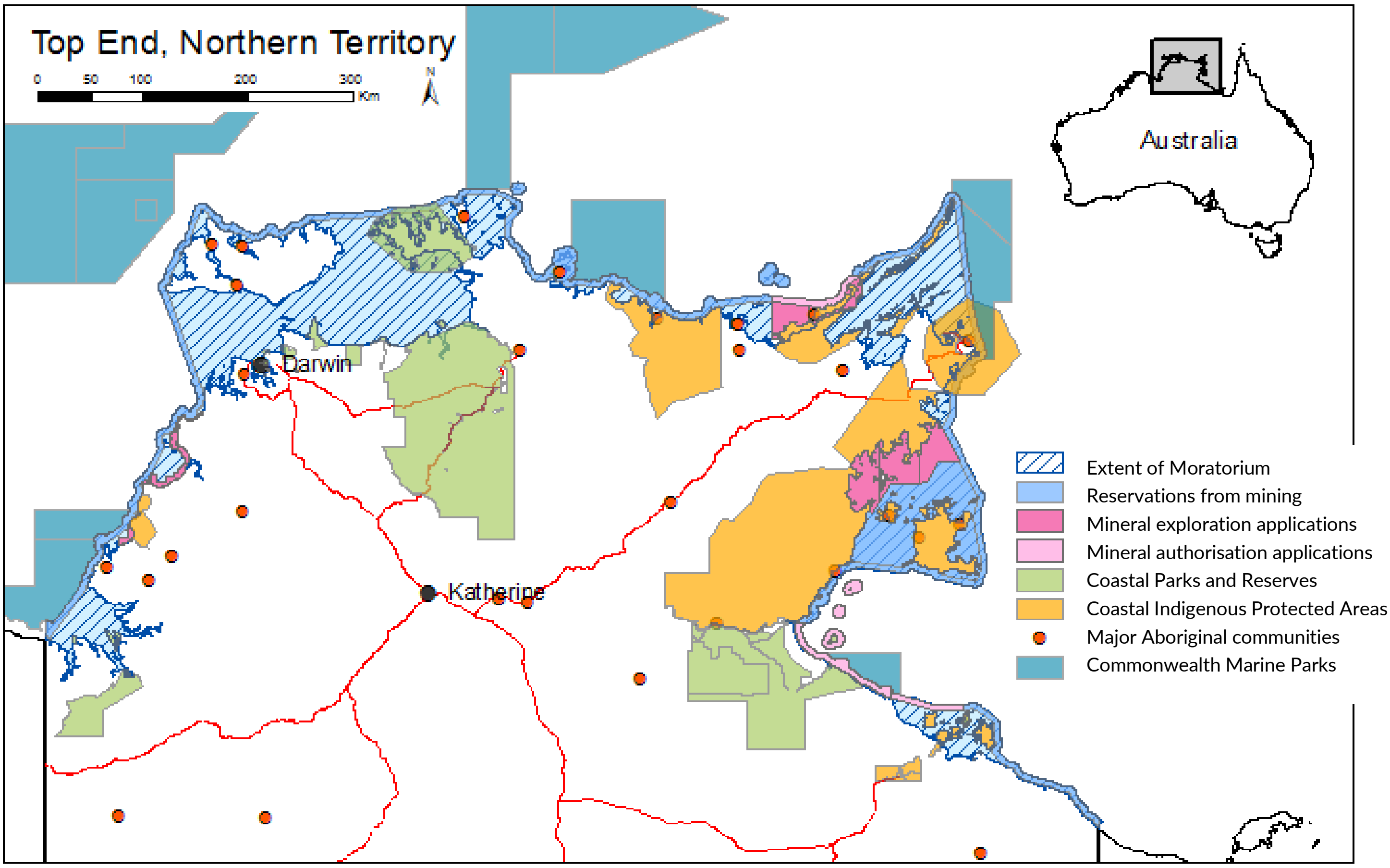


Figure 3: Tenure within and adjacent to the coastal waters of the NT

3.3 Existing regulatory environment

The NT does not currently have any legislation aimed specifically at managing seabed mining rights and activities within its jurisdiction. If seabed mining were to be undertaken currently, it would be managed under existing legislation for mining activities conducted on land. This legislation supports granting of mineral titles, environmental assessment and operational management of mining activities in the NT. The key Acts are summarised here, with further details and discussion of legal issues and complexities relating more specifically to regulation of seabed mining provided in Appendix 3.

3.3.1 *Mineral Titles Act 2010*

The regulation of mining of minerals within the NT primarily occurs under the *Mineral Titles Act 2010* (MT Act) and the *Mining Management Act 2001* (MM Act). The MT Act establishes the framework for granting and regulating mineral titles that confer rights to conduct exploration for, and extraction and processing of, minerals and extractive minerals. The MT Act also provides a system for reserving land from exploration or extraction of minerals and extractive minerals. A reservation over an area can prevent or limit applications for mineral titles or prevent or limit certain activities in relation to certain minerals. In most cases, the rights and authorised activities under a mineral title or consent cannot lawfully be exercised unless the operator has obtained an authorisation to carry out the relevant 'mining activities' on the 'mining site' under the MM Act.

There are a number of types of mineral titles and consents that can be obtained under the MT Act. Although the MT Act applies to both land and waters, it contains certain assumptions that are specific to land based mining. Consequently, the types of titles and consents available under this Act may not be well suited to the requirements for seabed mining.

3.3.2 *Mining Management Act 2001*

The MM Act applies to '*all mining sites and mining activities in the Territory'* excluding fossicking, certain extraction of fill for infrastructure purposes, and dredging activities to manage the Port of Darwin. The MM Act is principally intended to provide for: authorisation and management of 'mining activities', provision of benefits to affected communities, a security and levy for rehabilitation of mining sites, and the protection of the environment. The MM Act prohibits an operator from carrying out mining activities on a mining site without an authorisation. An authorisation is accompanied by a mining management plan (MMP) that must be approved, regularly reviewed, and complied with by the operator.

The mining management plan is intended to detail the relevant mining interests, mining activities, organisation structure for operations, management systems, environmental management plans, closure plans and other details. Conditions appropriate for the relevant mining activities and the period of an authorisation may be determined by the relevant Minister, and matters that can be the subject of a condition in an authorisation, include the outcomes of an environmental assessment of mining activities undertaken under the EP Act.

The object of environmental protection is repeated throughout the MM Act and includes the provision for the relevant Minister and Chief Executive Officer to have regard to the desirability of protecting the environment and the outcomes of any assessment under the EP Act. However, the principles of ecologically sustainable development are not explicitly incorporated into decision-making under the MM Act.

3.3.3 *Environment Protection Act 2019*

The NT is currently reforming its environmental regulatory system. Completion of the first stage of these reforms is marked by the commencement of new environmental impact assessment legislation. The EP Act establishes a contemporary environmental impact assessment and environmental approval system for the NT, comparable – and arguably better in some respects, to other Australian jurisdictions with environmental impact assessment specific legislation. The EP Act and Environment Protection Regulations 2020

(EP Regulations) replace the *Environmental Assessment Act 1982* and Environmental Assessment Administrative Procedures 1984.

The EP Act provides a new environmental impact assessment and environmental approval system for the NT to protect against unacceptable impact on the environment resulting from development, now or in the future. The EP Act provides for the development of environmental impact assessment procedures and guidance which satisfies in part the Minister's request in the NT EPA terms of reference (see section 1.2).

The new system includes strengthened requirements for early community consultation by proponents, recognising that meaningful engagement by proponents with the community and stakeholders is fundamental to conducting an open, transparent and robust environmental impact assessment. The importance of community involvement, includes a focus on Aboriginal people and communities, and is expressly recognised in the objects of the EP Act (NT EPA 2020b).

Proposed development that has the potential for significant environmental impact must be assessed by the NT EPA and must have an environmental approval granted by the Minister for Environment (the Minister) before it can proceed in the NT. The Minister's whole-of-government approval will usually contain legally-binding approval conditions recommended by the NT EPA.

Environmental impact assessment by the NT EPA

The EP Act determines that if a development has the potential for significant impact on the environment, it is to be planned, assessed and carried out taking into account:

- the principles of ecologically sustainable development
- the environmental decision-making hierarchy
- the waste management hierarchy
- ecosystem-based management
- the impacts of a changing climate.

The EP Act puts in place a new tiered assessment system based on the potentially significant impacts and risks associated with the proposed development. The four levels of environmental impact assessment are assessment by referral, supplementary environmental report, environmental impact statement and inquiry.

The EP Act establishes clear referral pathways based on the potential for a significant impact on the environment and provides for declared referral triggers, which can be locality-based (e.g. sensitive environments) or activity-based (e.g. seabed mining). An activity-based referral trigger would require all such proposals be referred to the NT EPA for a decision as to whether environmental impact assessment is necessary.

The EP Act also provides for the declaration of environmental objectives which have the purpose of guiding proponents and decision makers in their judgement of 'significant impact'. The NT EPA's factors and objectives (NT EPA 2018b, 2020a) represent an example of what may be declared as environmental objectives under the EP Act.

Through the statutory process of environmental impact assessment, the NT EPA examines the information provided by the proponent in environmental impact assessment documents (such as the referral, or an environmental impact statement) to understand the significance of the predicted environmental impacts. It also takes into account comments made by stakeholders about the proposed action. The NT EPA then considers the likely efficacy of proposed measures to avoid, manage and mitigate predicted impacts during this process so it can make a judgement about the environmental acceptability of the proposed action. The NT EPA will issue public Statements of Reasons for its statutory decisions.

The NT EPA then prepares an assessment report which captures all the information above. This public assessment report is provided by the NT EPA to the Minister with advice on whether to grant, or refuse to grant, an environmental approval. The NT EPA's assessment report will also contain a draft environmental approval or a statement of unacceptable impact for the Minister's consideration and decision.

Environmental approval by the Minister

The environmental approval has the purpose of managing potentially significant environmental impacts of a proposed action. Conditions placed on an environmental approval can apply to all stages of a proposed action ensuring that impact avoidance, management and mitigation informs a proposed action from its planning to its closure. Conditions can apply to financial requirements, offset requirements, and management of environmental, health, social and cultural impacts. It is an offence to not comply with an environmental approval and its conditions.

If a proponent cannot demonstrate the ability to implement the proposed action without significant residual impact on the environment, the NT EPA can recommend to the Minister for Environment that an environmental approval is refused.

The NT EPA is also able to recommend to the Minister for Environment that an 'early refusal' be issued if, after its assessment of a referral, the NT EPA concludes that the proposed action will have an unacceptable impact on the environment.

Additional environmental protection/ further environmental protection measures

The EP Act provides a range of other tools to support the objective of environment protection. These include:

- Financial provisions, for example environment protection bonds, to ensure there are the resources available to respond if there is an environmental incident or requirement for site remediation.
- Environmental audit provisions which require a documented evaluation of an action and its environmental impact, with the purpose of improving operations and environmental outcomes.
- A range of enforcement tools, like environment protection notices, to allow Environmental Officers appointed under the EP Act to respond appropriately to ensure compliance with an environmental approval. Environmental offences are appropriately scaled to provide a proportionate response to breaches of the legislation.
- The declaration of temporary or permanent protected areas to provide additional protection of areas with particularly high environmental value. Protected areas provide certainty to the community and proponents about the types of activities that are allowed (or not allowed) in those areas.
- The declaration of prohibited activities may be used to give certainty to the community that certain types of activities will not be authorised in the NT based on their potential for significant environmental impact or risk.

3.3.4 Environment Protection and Biodiversity Conservation Act 1999 (Cth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides for the protection and management of nationally and internationally important flora, fauna, ecological communities and heritage places, identified in the EPBC Act and known as matters of national environmental significance (MNES). Matters relevant to seabed mining include:

- nationally threatened species and ecological communities
- migratory species listed under the EPBC Act (species protected under international agreements)
- Commonwealth marine areas.

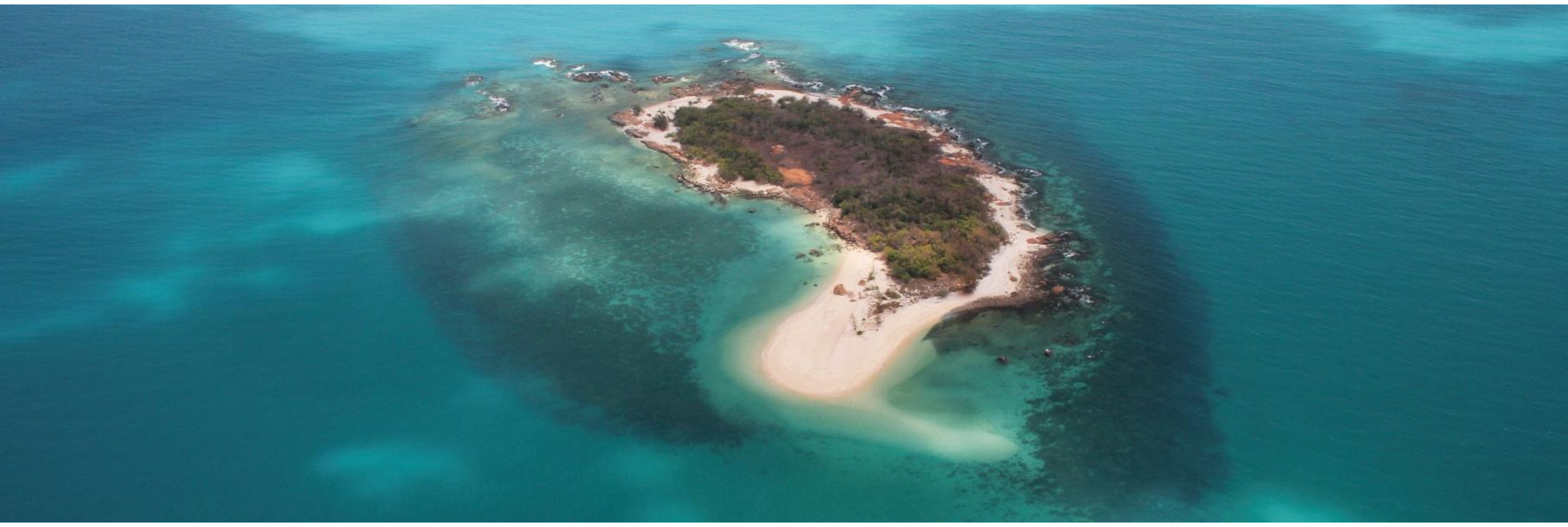
Proponents are required to refer a proposed action to the Australian Government Department of Agriculture, Water and Environment (DAWE) for consideration of MNES, under the EPBC Act, if it determines there is a potential for significant impact to an MNES. The NT Government or NT EPA may also refer a proposal to DAWE if the proposal will, or is likely to, have a significant impact on the relevant MNES. A delegate for the Australian Government Minister of the Environment will then determine whether environmental impact assessment, and an environmental approval, is required for the proposed activity.

To facilitate assessment processes, at various times, the NT and Australian governments have entered into assessment bilateral agreements and accredited process arrangements which enable the NT to undertake environmental assessments on behalf of the Australian Government. Separate approval under the EPBC Act is required following assessment and approval under the EP Act.

3.3.5 Other legislation

Seabed mining activities may require consent or authorisation under a number of other pieces of NT legislation, including but not limited to the: *Territory Parks and Wildlife Conservation Act 1976, Marine Act 1981*, *Fisheries Act 1988*, *Northern Territory Aboriginal Sacred Sites Act 1989*, *Water Act 1992*, *Waste Management and Pollution Control Act 1998* and *Heritage Act 2011* (Appendix 3).

Appendix 3 provides an overview of legislation with broader relevance to maritime aspects and context for regulatory approaches for consideration, including but not limited to the: United Nations Convention on the Law of the Sea 1982 (UNCLOS 1982), Intergovernmental Agreement on the Environment (IGAE 1992), *Offshore Minerals Act 1994* (Cth), *Marine Pollution Act 1999*, *Environment Protection (Sea Dumping) Act 1981* (Cth), *Underwater Cultural Heritage Act 2018* (Cth – replacing the *Historic Shipwrecks Act 1976*) and the *Marine Safety (Domestic Commercial Vessel) National Law Act 2012* (Cth).



4 Values of the Northern Territory marine environment

The coastal waters of the NT have an area of approximately 72 000 km^2, representing 17.5% of Australia's coastal waters. The NT coastline extends for 10 953 km and includes 887 islands, with Melville Island, Groote Eylandt and Bathurst Island three of the five largest islands of Australia (after Tasmania). Aboriginal lands currently comprise 78% of the coastline, with a further 12% subject to outstanding claims; and extend to the low water mark, including the intertidal zone and overlying waters. Most of the NT coastal waters are remote from major settlements and much of the coastline is sparsely populated.

The largely pristine waters of the NT marine and coastal environment support flora, fauna and coastal processes that provide Territorians with an exceptional natural heritage and recreational lifestyle, with tens of thousands of years of rich cultural heritage. Coastal waters of the NT are highly valued by Territorians for active and passive recreational pursuits, their rich cultural heritage, provision of ecosystem services and for the important economic value of natural resource-based industries such as commercial fishing, aquaculture and tourism.

This section provides an overview of current knowledge of the environmental values of the NT's marine and coastal environment, as well as a profile of existing resource industries. Further information is available in the supporting reports (Appendices 4 to 7). The state of knowledge of these values is presented in the context of confidence in determining the potential impact of seabed mining and appropriate mitigation of any impact. The values are set out in sections mirroring the environmental factors framework used by the NT EPA in assessing the impacts of development proposals (NT EPA 2020a, see also section 6.2).

4.1 Coastal processes

Coastal processes shape the physical environment of the coast and adjacent marine environment and are important in determining and maintaining the ecological character of the region. Ecological character includes the location and viability of key habitats (e.g. turtle or seabird nesting beaches, reefs, mangrove forests and seagrass beds), and critical life-cycle processes (e.g. coral or fish spawning and recruitment).

The NT's marine and coastal areas remain some of the world's most intact environments, encompassing several seas and major estuaries and supporting a range of regional and local economies and livelihoods (Smit *et al.* 2018, Munday 2017). The Timor Sea borders the west coast and is adjacent to three substantial inlets in the NT coastline – the Joseph Bonaparte Gulf, Beagle Gulf and the Van Diemen Gulf. The Arafura Sea borders the north coast, including the Tiwi Islands in the west, Van Diemen's Gulf and many important island groups of eastern Arnhem Land. The Gulf of Carpentaria borders the east coast and is characterised by shallow waters with fringing reefs and seagrass meadows. The Victoria, Daly, McArthur and Roper rivers are very important for freshwater and nutrient inputs, driving the productivity and life histories of many marine species (Burford *et al.* 2009).

The NT's coastal waters are largely characterised by the shallow flat continental shelf, generally to 50 m deep. The marine environment of the NT more broadly reaches depths of up to 200 m and includes scattered troughs, shoals and banks across the Timor and Arafura seas and the remains of two large basins – the Joseph Bonaparte Gulf and the Gulf of Carpentaria (Rochester *et al.* 2007). The topography of the seafloor is important as it influences the characteristics of tides, currents and waves and affects the physical and chemical properties of the water. Examples of features of the NT seabed include a series of extensive sandbars, generated by the strong outflows of sediment-laden water from large rivers in the Joseph Bonaparte Gulf (Woodside 2004); significant freshwater inflows into coastal waters during the wet season from large catchments; and the complex bathymetry surrounding eastern Arnhem Land and Groote Eylandt where water depths of up to 40 m are reached close to shore.

The interaction between the tropical monsoon climate and the extensive shallow coastal shelf results in distinctive and dynamic cycles of coastal processes at a range of temporal scales. Substantial natural environmental variability exists between the wet and dry season states of water column mixing, turbidity, productivity, salinity, waves and wind-driven surface currents. In particular, there is higher turbidity in the wet season due to predominantly onshore winds and river outflows following monsoon rainfall.

Tidal currents are also a significant force in the NT and influence the movement of water, sediments and biota and operate on fortnightly and semidiurnal cycles (Figure 4). Generally higher current speeds and an associated increase in turbidity occurs during spring tides compared to neap tides, and during flood and ebb tides compared to the slack water at the change of tides.

The tidal range varies dramatically within NT coastal waters, with a spring tidal range of over 8 m in the west to only 2 m to 4 m in the east (Figure 4). The combined effects of wind and tide cause naturally high turbidity in the Joseph Bonaparte Gulf. The shape of estuaries such as Bynoe and Darwin Harbours and Van Diemen Gulf result in variations to tidal currents within these systems. Water circulation in the Gulf of Carpentaria is dominated by a clockwise residual tidal current which, combined with seasonal variation in the wind regime, drive a more complex pattern of currents. These currents influence biological connectivity resulting in unique systems with very different biological diversity in the eastern and western sides of the gulf.

Coastal habitats comprise a mixture of rocky cliffs, sandy beaches, broad intertidal mangrove forests and salt flats, becoming more complex where large rivers enter the sea. Low tides expose extensive mudflats and rocky reef flats.

Coastal and marine processes, such as primary productivity, nutrient cycling, connectivity, carbon storage and climate regulation, are essential for healthy ecosystems. Ecosystems in turn provide a range of services that are of fundamental importance to human health and wellbeing. Crossman *et al.* (2018) identify ecosystem services as a bridge between healthy and functioning ecosystems and the social and economic benefit derived from ecosystems.

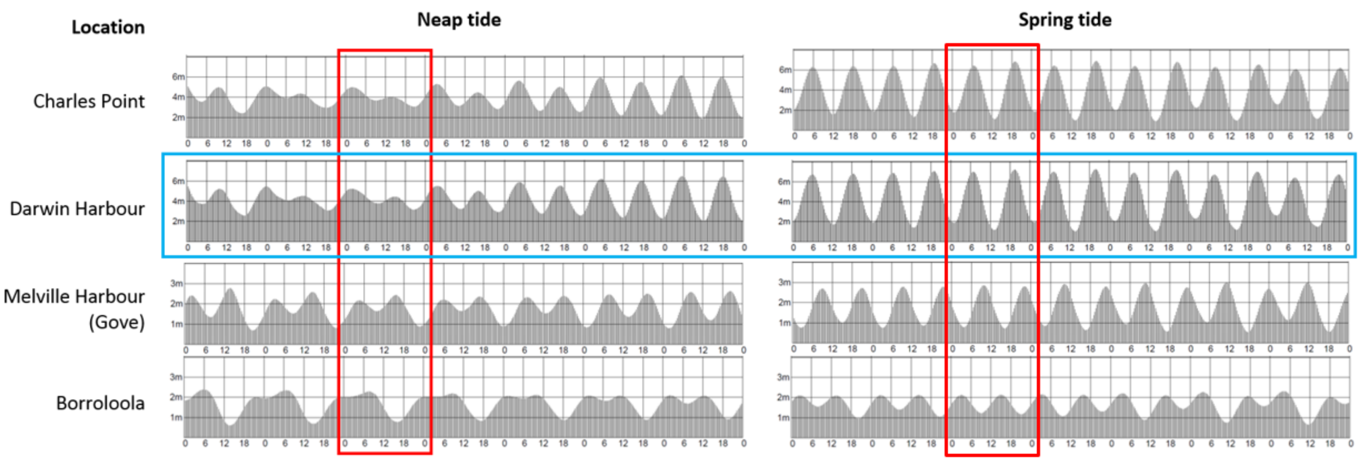


Figure 4: Tidal cycles showing the variation across for four locations, spanning central to eastern NT. Modified from BOM (2019)

4.2 Marine environmental quality

Good marine environmental quality is necessary for healthy marine ecosystems. In turn, healthy marine ecosystems provide the essential ecosystem service of regional and global climate regulation.

Climate regulation by marine ecosystems is achieved through a number of processes including capturing carbon and reducing greenhouse gases (and global warming); acting as a source of aerosols which reflect sunlight (reducing global temperature) and affect cloud formation; evapotranspiration which enhances cloud formation and rainfall; and surface reflection and illumination which regulate temperature and radiative forcing (the difference between climate the amount of insolation absorbed by the earth and the energy radiated back to space) (Smit *et al.* 2018, WAMSI 2020).

Water quality of the NT's coastal waters shows strong seasonal variation, with greater variability experienced in the wet season. Knowledge of this natural variability and changes within the water column is important in order to determine how changes of marine environmental quality are related to potential impacts from development proposals. For example, DEWHA (2007) identified a coastal boundary layer which traps sediment and nutrients from monsoonal rainfall events resulting in a turbid, eutrophic and highly productive layer extending to depths of 30 m. Despite this mixing, DEWHA (2007) noted that primary production is limited to surface waters due to turbidity.

Mobilisation of heavy metals (e.g. ilmenite, leucoxene, zircon, gold and rutile) and gems (diamonds) from weathering processes onshore, results in mineral sands on the seabed that extend as a continuation of major river systems. Nutrient and sediment outflows from rivers also become trapped in the coastal environment and support high primary productivity (Smit *et al.* 2018). Primary productivity supports entire marine ecosystems and coastal areas near rivers may therefore represent areas of competing high environmental value and a rich source of seabed mineral deposits.

4.3 Marine ecosystems

4.3.1 Benthic communities and habitats

The biological values of NT coastal waters have been recognised for their national and international significance and include extensive coastal benthic communities and habitats (e.g. coral reefs, seagrass beds, mangrove communities); island chains; soft sediment basins and complex processes that drive these systems (Smit *et al.* 2018).

Benthic communities provide food, habitat and shelter, critical to the survival of a range of marine life. They can be considered cornerstone communities upon which entire marine ecosystems and associated environmental values and resource industries depend. The most important benthic communities in NT coastal waters are arguably the primary producers, including microphytobenthos (microalgae and cyanobacteria in the surface layer of sediments), macro algal and coral reefs, and seagrass communities. These communities generally require sufficient sunlight to survive and grow.

The NT is recognised for diverse assemblages of hard corals despite highly turbid waters. These corals are thought to withstand the effects of sedimentation due to high tidal movements which periodically remove the sediment from the surface of the corals (Smit *et al.* 2018). Reef ecosystems are biologically diverse and economically important in providing ecosystem services through fisheries, coastal protection, building materials, new biochemical compounds, and tourism (Moberg and Folke 1999 in Smit *et al.* 2018).

In deeper, calmer or more turbid waters where there is insufficient sunlight to support these primary producers, filter-feeding communities can dominate, forming large 'gardens' made up primarily of sponges and soft corals, which provide habitat for a range of recreationally and commercially important finfish and invertebrates such as pearl oyster. Soft substrate communities, dominated by worms and other fauna that live in the sediment, can be found from the intertidal to offshore waters. Soft substrate communities support migratory seabirds in intertidal areas, and in NT coastal waters provide an important food source for many species higher in the food chain.

Seagrasses in the Gulf of Carpentaria are important as nursery habitat for juveniles of four species of prawns that are commercially important to the Northern Prawn Fishery (Poiner *et al.* 1987 in Smit *et al.* 2018).

Mangroves are an exceptionally important intertidal habitat in the NT, particularly in sheltered bays and the Gulf of Carpentaria, with 42% of Australia's mangrove communities occurring in the NT (Smit el at. 2018). Mangroves provide multiple essential services (e.g. nursery habitat for commercial fisheries, coastal stabilisation and storm surge protection, carbon storage) for the sustainability of a range of environmental values as well as resource industries in NT coastal waters.

4.3.2 Marine flora and fauna

The rich marine fauna of NT coastal waters is also recognised for its national and international significance (Smit *et al.* 2018).

While the identity and distribution of marine vertebrate fauna is relatively well understood, the long-term trends for these populations, and the environmental processes that determine these, are generally not. The marine invertebrate fauna is more poorly known, with many species undiscovered and many recognised taxa that are not yet scientifically named. The distribution of benthic communities and habitats, which are important for marine fauna, is particularly poorly known (Smit *et al.* 2018).

The fauna of the NT coastal waters includes:

- over 150 threatened, migratory and/or marine species listed under NT and/or Australian legislation (e.g. humpback whale, false killer whale, coastal dolphins, sea snakes, shorebirds, pipefish)
- iconic fauna of high cultural and/or social value (e.g. barramundi, dugong, marine turtles, saltwater crocodile, white-bellied sea-eagle)
- species of commercial importance (e.g. finfish, prawns, trepang, pearl oysters)
- over 1600 vertebrate species (e.g. shorebirds, waterbirds, mammals, reptiles, bony fish, sharks and rays)
- over 12 500 species of sessile and mobile invertebrates (e.g. jellyfish, sponges, corals, tube worms, nudibranchs, squid, clams, sea stars, crabs).

Many of the physical factors that influence species diversity are the result of sea level rise over the last 18 000 years. While the sea level has been relatively stable for the past six to seven thousand years, the physical environment and the habitats it supports are still adapting to this change, which has important implications for present day flora and fauna species diversity (DEWHA 2007 and Russell *et al.* 2008 in Smit *et al.* 2018).

4.4 Communities, economy, culture and heritage

The values of communities, economy and culture are recognised by the National Marine Science Committee of Australia to deliver on the National Marine Science Plan (NMSP) (Moltmann and Hodgson-Johnston 2017). With a key focus on the blue economy, the full integration of socio-economics, innovative approaches and indigenous engagement (with emphasis on northern Australia) were identified as necessary components for the success of the NMSP.

The NT EPA's review includes consideration of the community, economic and Aboriginal cultural values of the coastal and marine environments of the NT. Munday (2017) presents and discusses the social and cultural values of the NT in Appendix 5. The Fisheries Research and Development Corporation presents the economic and social contributions from the Australian fisheries and aquaculture industry (FRDC 2019). Crossman *et al.* (2018) describe the economic values of the NT coastal and marine environments with particular consideration to acknowledging and quantifying the value of ecosystem services. Cosmos (2017) provide a strategy for managing underwater cultural heritage values (Appendix 6).

Community, economic, cultural and heritage values are intrinsically linked with each other and the environment; this is especially true in regard to the NT coastal waters. Munday (2017) describes the coastal areas of the NT as '*characterised by their remoteness, clean waters, natural scenery and conservation zones popular with tourism and recreational fishing. The waters, pristine beaches, camping sites and parks are integral to what Territorians feel is a unique lifestyle. Communities along this coastline have limited experience of industrial activities. Many have demonstrated antipathy to large-scale resource extraction*.'

Culture and heritage values of NT coastal waters comprise those of Aboriginal and non-Aboriginal historic origin. Cultural values may be represented by site types that are listed on statutory heritage databases as well as those with the potential to exist, but not yet discovered and/or formally documented. Site types include: submerged Aboriginal cultural landscapes; Aboriginal and Macassan archaeological sites; Aboriginal and Macassan shipwrecks; recent historic shipwrecks including those from severe tropical cyclones (1896 and Cyclone Tracy) and World War II; aircraft wrecks; maritime infrastructure; unexploded ordinance; military discard; sea-dumped material; abandoned pearl farms; scuttled vessels including those forming artificial reefs; and other discard (Cosmos 2017, Appendix 6).

Communities of the NT value the coastline and NT coastal waters for important recreational activities (fishing, diving, sailing, beach activities, bushwalking and relaxation), aesthetic and educational activities (natural and cultural history through parks, reserves and historic sites), human safety (storm protection and climate regulation) and cultural connections.

The economic value of NT coastal waters has been quantified by Crossman *et al.* (2018) as currently supporting over 6000 jobs and directly contributing $1 billion (4%) to the NT economy. This value is built upon established resource industries such as commercial fisheries and aquaculture ($174 million per year) and pearl cultivation ($48 million per year). The Fisheries Research and Development Corporation reports that in 2017-18, the NT's fishing, aquaculture and associated processing industries contributed $71 million to household income and employed 941 full time equivalent jobs in the NT (FRDC 2019).

Social and cultural values contribute directly to the NT economy as well as providing non-market based economic welfare values (Beaver *et al.* 2017a and 2017b, Crossman *et al.* 2018). For example, recreational fishing ($76 million per year) and tourism ($691 million per year) contribute directly to the NT economy. Aesthetic, amenity and education values are estimated to contribute up to $40.3 million per year, and Aboriginal cultural values are estimated to contribute up to $412 million per year to the NT economy (Crossman *et al.* 2018). It is acknowledged that economic estimates of cultural and ecological values may not reflect the true value that Aboriginal and non-Aboriginal Territorians place on coastal and marine environments. Even so, placing a monetary value on them may help stakeholders and policy-makers to communicate and appreciate the value of cultural and ecological resources in terms that are well understood (Crossman *et al.* 2018).

The marine environment provides ecosystem services which deliver social and economic benefits that are largely dependent on ecosystems remaining healthy and functional (Crossman *et al.* 2018, Beaver *et al.* 2017b, Costanza *et al.* 2014). Ecosystem services may be grouped as:

- provision services (e.g. primary industry)
- regulating services (e.g. carbon storage and storm protection)
- cultural services (e.g. tourism, recreation and cultural values)
- habitat services (which serve to maintain biodiversity).

Beaver *et al.* (2017b) determined that unaccounted for environmental services of the coastal and marine environment are worth more than $420 million per year to the NT. Beaver *et al.* (2017b) also estimated the value of undefined healthy ecosystem initiatives at more than $34 million per year, based on choice modelling of the community's willingness to pay for environmental outcomes.

Photo courtesy of Anindilyakwa Land Council

5 Potential impacts and management of pressures

Seabed mining has the potential to impact both directly, indirectly and cumulatively on environmental values and other resource industries of the NT. This review considers the potential impacts of seabed mining through identifying the pressures and impact pathways, as well as the mitigation and management measures that may reduce the pressures and the resultant impact to an acceptable level. Cumulative impacts may also arise from the compounding effects over time of a single seabed mining operation, from multiple operations, or from interactions with other activities within the same area. Some examples of current best practice management nationally or internationally are identified, which may inform the development of guidelines and/or codes of practice for future seabed mining activity in the NT.

Smit *et al.* (2018) provide a valuable overview of the pressures and resultant impacts (direct, indirect and cumulative) on environmental values and ecosystem processes, building on the impact pathways described by Advisian (2017). The types of pressures that may be associated with seabed mining and the potential direct and indirect impacts on key environmental values are summarised in Table 2 and discussed further in the following sections.

Table 2: Summary of pressures and potential impacts (prior to any mitigation) from seabed mining on marine and coastal environmental values of the NT. Modified from Smit *et al.* (2018)

Actual and potential pressures (Direct impact / Indirect impact)	Marine fauna					Marine habitats				Marine ecosystem processes			
	Birds	Marine reptiles	Marine mammals	Fish	Invertebrates	Mangroves	Submerged aquatic vegetation	Reefs	Soft substrates	Primary productivity and nutrient cycling	Hydrology and oceanic currents	Connectivity	Climate regulation
Removal of seabed	Indirect	Indirect	Indirect	Indirect	Indirect	Direct	Direct	Direct	Direct	Indirect	Indirect	Indirect	Indirect
Entrainment and collisions	Direct	Direct	Direct	Direct	Direct								
Underwater blasting, noise and vibration	Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect							Indirect	
Turbidity	Indirect	Indirect	Indirect	Direct/Indirect	Direct/Indirect		Direct/Indirect	Direct/Indirect	Indirect	Direct/Indirect			
Sedimentation	Indirect	Indirect	Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Indirect	
Organic enrichment	Indirect	Indirect	Indirect	Indirect	Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect			
Release of contaminants	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect		Indirect	
Light emissions	Indirect	Indirect	Indirect	Indirect	Indirect								
Air emissions						Direct	Direct	Direct	Direct	Direct			Indirect
Chemical and hydrocarbon spills	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect	Direct/Indirect		Indirect	
Marine pest introductions	Indirect	Indirect	Indirect	Indirect	Direct		Direct	Direct	Indirect	Indirect	Indirect	Indirect	

It is important to recognise that the high degree of connectivity in marine systems via the water column compounds the complexity of the marine environment and therefore the management of pressures to reduce any impacts of mining. This connectivity means that many pressures and impacts are shared, or partly shared, across the environmental factors described in section 4 and Table 2.

A fundamental requirement for predicting and assessing environmental impacts and developing appropriate mitigation measures is an adequate knowledge base, both of environmental values, the processes supporting them and the interaction with pressures arising from development activities. In the context of seabed mining this includes having an adequate understanding of:

- Seabed mining practices – all activities associated with the proposed development and the potential risks and pressures on the environment that may be associated with each activity.
- The environment – key aspects of the natural environment including the physical and chemical properties of the seabed and the water column, benthic and pelagic communities, and the key ecological processes that control the physical environment and sustain the associated biological communities. It is likely to be important to also understand how these vary spatially and temporally (over a range of time scales including inter-annual, seasonal and by day/night and neap/spring tidal cycles) and the influence of extreme weather events (e.g. cyclones and sea water temperature rise).
- Pressure-response relationships – how biological groups respond to each type of mining related pressure and their sensitivity or resilience to those pressures.
- Impact and recovery pathways – how affected components of the environment are affected and can recover from disturbance or loss, the conditions needed to allow recovery and the time scales for the recovery to occur.
- Mitigation and management options – how pressures can be reduced to address undesirable or unacceptable impacts or risks.

The complex and connected nature of marine values and processes is difficult to measure and describe (Smit *et al.* 2018, Evans *et al.* 2017) and it is even more difficult to predict the impacts of various disturbances on marine values and processes. The knowledge required to address uncertainty around prediction of impacts may be delivered through baseline assessment and modelling (prior to assessment, e.g. DENR 2018a) and comprehensive environmental monitoring with appropriate management triggers during operation.

The following sections provide examples of the pressures, impacts, and mitigation and management measures likely to arise from seabed mining, with examples of environmental best practice currently applied to the seabed mining industry. Further detail of impacts and impact management is provided in Appendix 2 and Appendices 4 and 5.

5.1 Coastal processes

Impacts from seabed mining on coastal processes are likely to occur beyond the immediate area of mining and affect a range of marine environmental values, ecological processes and man-made infrastructure (Smit *et al.* 2018, Advisian 2017, WA EPA 2016a, Grech *et al.* 2013).

The most important impact on coastal processes results from alteration of the seabed through direct removal, generally equivalent to the disturbance associated with terrestrial strip mining. Changes in the bathymetry (topography) of the seabed, through erosion or accretion, can lead to changes in wave and tidal patterns which shape the coast and hence the associated environmental values. Bathymetric changes and alteration of sediment characteristics can occur during each stage of seabed mining, but the major changes would be associated with extraction and processing (particularly tailings disposal). The extent and irreversibility of impacts will depend on the size, type and duration of seabed mining operations as well as the physical processes of the existing environment and the recovery potential of local biota. Depending on the scale, nature and location of the activity, there may be serious or irreversible damage to habitat, particularly from direct disturbance of the mining footprint on the seabed. The difficulties of remediation and rehabilitation in seabed mining are discussed further in section 6.6.

Highly dynamic systems, like the tropical NT coastal waters, experience high levels of natural disturbance which means that the local biota are generally adapted to natural disturbance events and have a relatively high resilience and recovery potential (Penney *et al.* 2008). This natural resilience may mean the severity of some seabed mining impacts is reduced over the shorter term. However, if the timing, frequency or duration of pressures arising from seabed mining is significantly different from, or interacts synergistically with, natural disturbance cycles then the inherent resilience threshold of the environment may be exceeded, leading to significant impacts on even relatively resilient biota.

Sedimentation may also occur through hydraulic dredging and transport methods which slurry the sediment by adding large amounts of process water causing turbid plumes carrying sediments in suspension. The sediments eventually fall out of suspension and, over time, these activities may change the original structure of sediments and also associated biota.

Smit *et al.* (2018) illustrate how large-scale seabed mining activities can impact a number of important coastal processes including primary productivity, hydrology, connectivity and climate regulation (Figure 5).

Impacts on coastal processes and environmental values are summarised by the WA EPA (2016a) factor guidance which reinforces the importance of baseline information to quantify potential impacts from changed bathymetry and coastal processes before mitigation and management measures can be defined.

Mitigation and Management

Impacts and therefore appropriate management measures will vary depending on the area, size and duration of the seabed mining activity and the values and sensitivity of the local environment.

The NT EPA recognises the need to have a very good understanding of values and coastal processes (derived from metocean, bathymetric and other data) for sediment transport and fate, and ecosystem response modelling of sediment plume impacts.

The British Government and the British Marine Aggregate Producers Association (BMAPA) provides guidance on good practice management for mitigation of sedimentation, including management of changes in sediment characteristics through locational controls on processing techniques such as limiting on-site separation of material (BMAPA and The Crown Estate 2017).

Adequate baseline information, incorporating seasonal variation, is essential for accurate predictions of changes to coastal processes and impacts on environmental values, and developing appropriate mitigation and management. Long term, high quality and on-going monitoring information collected by Cockburn Cement Ltd continues to inform management of off-site impacts of their mining operations (e.g. Wave Climate Measurement and Modelling Plan, Shoreline Monitoring Plan, and Banks and Shoreline Protection Management Programme) (WA EPA 2005).

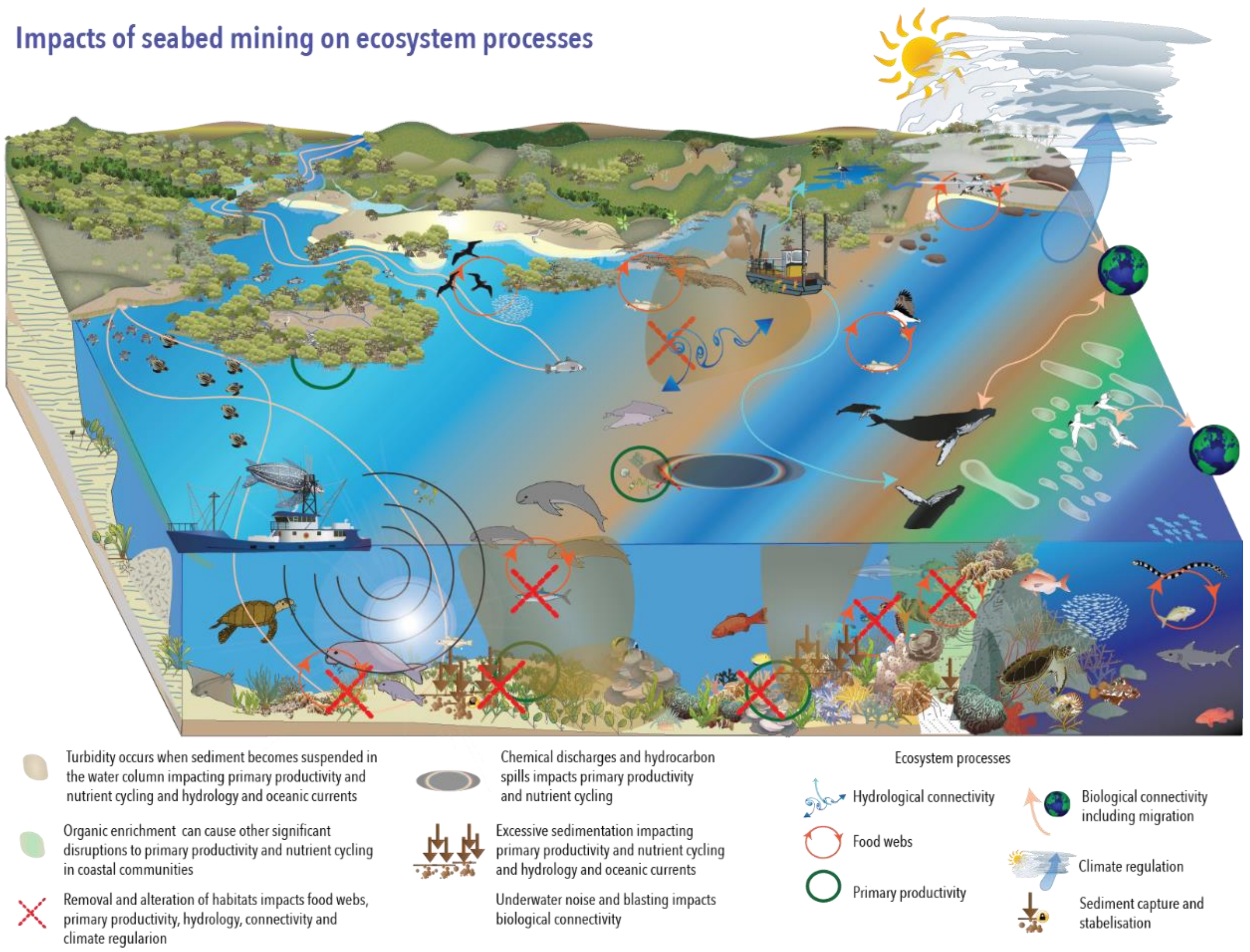


Figure 5: Potential impacts of seabed mining on marine and coastal processes in the NT. Sourced from Smit *et al.* (2018)

5.2 Marine environmental quality

The most significant pressures on marine environmental quality from seabed mining are associated with increases in turbidity and sediment deposition as a result of extraction and tailings disposal. The main source of suspended sediment is the overflow from hoppers on dredges or barges. These pressures have the potential to shade and smother sensitive benthic communities and habitats and in doing so alter primary productivity and nutrient cycling, which in turn will affect survival and foraging ability for many different marine flora and fauna (Smit *et al.* 2018).

Pressures and impacts from returning tailings to the seabed also may include changes in water quality, increased turbidity, reduced light penetration, altered biogeochemical cycles (nutrients or toxicants), oxygen depletion, altered pH levels and benthic sedimentation over quite large areas (WA EPA 2016b, Stoddart and Anstee 2005). Impacts of releasing sediments to the water column via overflow may include reduced water clarity and light availability at the seabed, sometimes at distances of tens of kilometres from the discharge point, and increased rates of sediment deposition at distances of up to a few kilometres from the discharge point (Fisher *et al.* 2015).

As an example, the potential cumulative effects of discharging coarse sediments from diamond mining in Namibia were found to be more significant than combined discharge of fine sediment from vessel and land-based discharges which resulted in a detectable, but minor, cumulative effect (Taljaard *et al.* 2006).

Sedimentation may also occur through hydraulic dredging and transport methods which slurry the sediment by adding large amounts of process water causing turbid plumes carrying sediments in suspension. The sediments eventually fall out of suspension and, over time, these activities may change the original structure of sediments and also associated biota.

Mitigation and Management

Hydrodynamic plume and sedimentation modelling based on appropriate parameters and survey effort are key to mitigating and managing activities to reduce impacts from seabed mining on marine environmental quality (Sun *et al.* 2020, Grogan 2020). This modelling predicts the movement of sediments generated by mining activity and its deposition on the seafloor, providing an indication of the location and extent of impact from sedimentation to inform site specific management strategies. Only by using the most robust modelling approach and model inputs can hydrodynamic modelling be used to accurately predict mining impacts, and as a valuable tool for environmental management purposes.

Management of turbidity and sedimentation may be achieved by restricting discharges in high value areas to reduce sediment plumes and mitigate the cumulative impact on marine ecosystems, particularly benthic communities and habitats.

Planned commencement of overflow can be used for TSHDs operating near isolated sensitive receptors such as a coral reef with little additional financial cost. The dredge track is planned, with knowledge of tidal currents, so that the hopper does not fill and overflow until it is down-current of the sensitive receptor. 'Green valves', which discharge sediment-laden overflow below the keel and closer to the seabed can reduce the vertical and horizontal extent of plumes. Hoppers can be designed to maximise the retention of fine material in the hopper hence reducing sediment load and turbidity of the overflow. Shrouds on cutter heads can be used to minimise turbidity generation at the cutter head of cutter suction dredges. Kemps and Masini (2017) identify the key sources of turbidity generation associated with trailing suction hopper and cutter suction dredges and provide estimates of associated release rates.

Activity windows can be applied to reduce cumulative impacts from seabed mining and natural disturbance events. For example, impacts from sedimentation may be reduced by timing discharges to when turbidity levels are naturally higher (such as during the wet season). The application of activity windows requires appropriate baseline knowledge of natural disturbance tolerance limits of the environmental value in question, to ensure that these are not exceeded.

Sediment transport modelling is necessary to predict rates of sedimentation and areas of potential impacts from turbidity (zones of low, moderate to high impacts), in order to guide mitigation and management measures. This requires a sound understanding of sediment production and spill rates, so that appropriate source terms can be input to sediment transport models. All environmental modelling requires adequate site-specific baseline information to enable calibration and validation of models.

Tailings may be returned to the seabed at the time of mining or removed to an alternate site to avoid or reduce impact on sensitive receptors. The primary management considerations for tailings disposal are the disposal method and characteristics of the receiving environment. Best practice disposal activities are those that are conducted as close to the seabed as possible to avoid separation of sediments; where tailings and receiving sediments are most similar; and incrementally over time to avoid smothering of seabed flora and fauna (NRETAS 2011, Smith and Rule 2011, Advisian 2017). On-site retention of uncontaminated tailings is preferred as it reduces the changes in bathymetry and retains seabed substrate for recolonisation by at least some of the taxa that were present pre-mining. It also prevents the need for a disposal site hence reducing the overall footprint of the mine.

The WA EPA (2016g) provides further technical guidance to design fit-for-purpose modelling and monitoring to spatially define, assess and manage potential impacts on marine environmental quality.

5.3 Marine ecosystems

5.3.1 Benthic communities and habitats

Impacts on benthic communities and habitats may be direct, with often substantial and irreversible damage to habitat and communities, or indirect through shading or smothering from sedimentation. These indirect impacts may be reversible once the pressure is removed (WA EPA 2016c) or lead to the loss of habitat for primary producers such as corals and seagrasses (Styan and Hanley 2013) resulting in loss of biodiversity.

If deposition rates of sediments exceed the natural clearance rates of benthic plants or animals such as corals, these organisms may suffer chronic or acute stress leading to mortality (Jones *et al.* 2017). Sediment covering surfaces can also interfere with natural recruitment processes by reducing settlement and survival of some biota. Benthic communities can also be highly biodiverse with significant changes in species composition occurring over relatively small spatial scales. Seabed mining of a moderate to large area of extent could therefore lead to important loss of biodiversity.

The greatest impediment to the prediction and successful management of most impacts on benthic communities and habitats arises from uncertainty associated with the limited state of knowledge of these values. Information about distribution and local importance as foraging or breeding habitats, resilience and sensitivity to mining related-pressures and pathways and potential for recovery are limited. Baseline surveys of proposed and alternative sites for mining and tailings disposal are essential to provide the site-specific information required to understand and assess the potential impacts from seabed mining. Long-term monitoring programs must include reference sites that are not exposed to mining-related pressures in order to understand and account for natural variability and responses to extreme events.

Mitigation and Management

Best practice methods to reduce the uncertainty described above include sufficient strategic baseline monitoring of the physical and biological environment over multiple seasons (typically from two to five years) to describe and quantify the natural variation in environmental drivers and key biological values (Grech *et al.* 2013). The Western Australian Marine Science Institution's (WAMSI) Dredging Science Node has developed and implemented a science plan designed to fill the large gaps in understanding of how dredging activities impact on the marine environment, with six of the nine themes devoted to understanding thresholds, response indicators and ecosystem processes of benthic communities and habitats. This program has identified pressure thresholds (no effect, effect and impact threshold) for a number of dredging-related parameters (including intensity, frequency and duration elements) for representative species from the key functional groups that occur in tropical marine ecosystems (i.e. corals, seagrass and sponges). Most of the taxa studied have a geographic range that includes NT coastal waters.

Activity windows can be applied to avoid periods of sensitive lifecycle stages for biota (benthic communities, marine flora and fauna) that have been identified as sensitive receptors. The application of activity windows requires appropriate baseline knowledge of natural disturbance tolerance limits of the environmental value in question (see section 4.2).

The key pressures on benthic communities and habitats associated with seabed mining are described under coastal processes (section 5.1). The pressure-response pathways occur primarily through changes in marine environmental quality through mechanisms such as shading by turbid plumes, sediment deposition from plumes and tailings disposal operations and physical changes in sediment grain sizes. Some management measures that have been successfully used to reduce the pressures associated with turbidity generating activities and tailings disposal are discussed under marine environmental quality (section 5.2).

5.3.2 Marine flora and fauna

There are a number of pressures that may impact on marine flora and fauna directly and indirectly (see Table 2). It is likely that the dominant impact pathway is indirect, resulting from the high connectivity of the marine environment and associated with impacts on coastal processes and marine environmental quality. The indirect impacts on flora and fauna arise from impacts discussed in previous sections and so this section focuses specifically on direct impacts on fauna. The WA EPA (2016d) also provides guidance on potential impacts and information requirements to address marine fauna.

Clearing of seabed sediments for extraction, or to access mineral deposits underlying them, will cause the loss of slow-moving fauna living in and on these substrates. Mobile fauna may also be impacted directly through entrainment and collisions, light and noise emissions and introductions of marine pests.

Significant impacts on threatened species and the marine environment in Commonwealth marine areas are defined by Australian Government guidance (DOE 2013). Significant impacts on threatened species, and iconic and commercial species alike, include but are not limited to long-term decrease on population size; fragmenting an existing population into two or more populations; adversely affecting habitat critical to the survival of a species; disrupting the breeding cycle of a population; introducing invasive species or disease causing decline to threatened species; and modifying, destroying, removing, isolating or decreasing the availability or quality of habitat to the extent that the species is likely to decline (Smit *et al.* 2018).

Mitigation and Management

Best practice management of pressures such as entrainment, collisions, underwater noise and vibration involve technological and procedural mitigation measures. For example, turtle exclusion devices have been successfully used near marine turtle breeding beaches to significantly reduce entrainment in dredging equipment; trained observers are used to help to prevent collisions with vessels and impacts from blasting; and soft start-up pile-driving procedures are used to reduce impact on cetaceans and other fauna by alerting them to impending noise and percussion and allowing them time to vacate the area.

5.4 Communities, culture and heritage

Aboriginal people make up a large proportion of the NT population and are recognised custodians of much of the coastal environment of the NT so it is fundamental that impacts on Aboriginal people are considered. Most of the prospective area for seabed mining represents Aboriginal land and seas. For Aboriginal people, the land and seas are as one and are not an unexplored nor vacant source of untapped wealth. Aboriginal people are likely to have both practical concerns regarding physical disturbance and culturally based fears for country in the face of seabed mining.

The Moratorium on seabed exploration and mining in NT coastal waters was established following concerns raised by Aboriginal custodians of sea country around Groote Eylandt (case study 1). Similar concerns regarding social and cultural impact of seabed mining and other resource extraction are well documented from examples in Canada, New Zealand and elsewhere in northern Australia (Munday 2017, KASM 2013). The social, economic, cultural and heritage values held by non-Aboriginal people are also considered through these examples. The WA EPA (2016e) describes issues, potential impacts and information requirements to address impacts on social surroundings from development proposals; these are relevant to seabed mining.

Impacts from seabed mining on community, economy, cultural and heritage values may be beneficial or detrimental (Munday 2017, Cosmos 2017, Crossman *et al.* 2018) and may arise from development of both offshore and onshore activities. Social impacts resulting from offshore activities may affect the values, lifestyles and livelihoods of multiple communities, and include socio-environmental (changes to landscapes, the seabed, biodiversity, pollution), psychosocial (anxieties and fears), economic (displacement of other commercial and traditional economies, or conversely more jobs and local services) and socio-economic (recreational and provision of ecosystem services) values. Onshore activities may create both positive and negative impacts, either separately or in parallel. Positive impacts could include local jobs and improved services, such as the construction of project-related facilities. Actions may have both positive and negative impacts to communities including the influx of workforces, use of social infrastructure and changes to landscapes and lifestyles. The benefits of seabed mining could be enhanced if associated with onshore activities that generate jobs and income, but this may also lead to additional environmental impacts that would need to be managed.

Case study 3: Community, economy and cultural concerns, Chatham Rise, New Zealand

The Exclusive Economic Zone (EEZ) of New Zealand (NZ) supports seabed mineralisations that are of interest for commercial extraction. Two seabed mining proposals to mine the EEZ of NZ have faced considerable opposition despite substantial financial investment from the proponents.

The NZ *Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012* (EEZ Act) is specifically aimed at regulating activities 12 to 200 nautical miles (nm) from the coast of New Zealand, including its satellite islands. Its purpose is to promote the sustainable management of the natural resources in this area. The EEZ Act restricts activities that are likely to have an adverse effect on the water column, seabed or subsoil and establishes an approvals regime through categorising activities depending on the potential environmental risks involved. Discretionary activities under the EEZ Act require marine consent from the NZ Environmental Protection Authority (NZ EPA).

Chatham Rock Phosphate Ltd (CRP) applied to extract phosphorite nodules from the seabed of the Chatham Rise, in New Zealand's Exclusive Economic Zone (EEZ). Chatham Rise is 243 nm offshore, between Christchurch and the Chatham Islands. CRP proposed to mine the top 50 cm layer of seabed, returning tailings immediately adjacent and effectively over the mining tracks, at water depths of 250 to 450 metres. In 2014, CRP applied for a 35 year marine consent separated into three phases. Consent was refused in 2014 and CRP intends to resubmit.

While the most significant impacts of the CRP proposal were identified as the direct physical removal and mortality of the benthic biota over an extensive area (85 000 ha) and the deposition of returned sediment to the seabed in and surrounding the mined area, the proposal also attracted considerable concerns from community, economy and cultural sectors.

The proposed seabed mining was almost entirely within the Mid Chatham Rise Benthic Protection Area, which also supports important customary and commercial fishing. The uncertainty about impacts of the proposal raised concerns from customary fisheries, ecotourism and other vessels using the area. The Decision-making Committee (DMC) appointed by the NZ EPA acknowledged these concerns but found that impacts on social and cultural interests were unlikely to arise to the extent submitted and were not determinative of the application. However, the economic impact on existing industries, primarily the fishing industry, were not represented sufficiently by the economic forecast provided by CRP, contributing to the DMC's refusal decision based on uncertainty regarding economic effects.

The application was considered before the 2015 Dumping and Discharge Regulations ruled out the use of adaptive management responses to discharges; however it was determined that these impacts could not be mitigated by any adaptive management regime that might reasonably be imposed. Uncertainty around the existing state of the receiving environment and adverse effects on the environment and existing interests, combined with the application of world first extraction methods and equipment at depth, contributed to the refusal of CRP's proposal.

The DMC considered whether a three-stage adaptive management approach would be practicable, incorporating a pre-mining research stage to collect further data to validate habitat predictions, a trial mining stage to validate the sediment plume model, and full mining only if the objectives of the first two stages were met. However, CRP did not support such an approach due to the upfront investment required in undertaking a trial stage without certainty about full mining.

5.4.1 Social and cultural engagement

Management of social and cultural impacts are discussed in detail by Munday (2017, Appendix 5), based on recent approaches in Australia, New Zealand and Canada. Key elements of managing social impacts from seabed mining in the NT include:

- ensuring 'early and meaningful engagement' well before the formal impact assessment process (NT EPA 2020b, Canadian model in Munday 2017)
- application of free, prior and informed consent, noting the statutory responsibility of land councils in the NT to ensure that Aboriginal people have provided free, prior and informed consent to development on their land and seas
- a qualitative approach to social impact assessment
- providing approaches that respect Aboriginal rights and connections to their land and seas through informed engagement
- tailoring approaches to consider impacts on Aboriginal people and cultures (e.g. First Nations controlled impact assessment review boards in Canada's Northern Territories, Maori advisory committee in New Zealand, Aboriginal Social Impact Assessments in Australia)
- making better use of social impact assessment as a planning tool rather than a regulatory tool with a focus on compliance and mitigation
- focusing on distributive justice, rather than communities accruing some benefits from mining but bearing the environmental and social burdens
- focusing more on monitoring and management of, rather than just identifying, social and cultural impacts for life of the project, including post operation
- considering cumulative impacts of development with community input influencing the type, scale and pace of development in regions
- preparing peer-reviewed social impact management plans (SIMP) using suitably qualified experts.

The NT EPA's Stakeholder engagement guidance (NT EPA 2020b), identifies that Proponents who commence the stakeholder engagement process early, with a strategic long-term view, are more likely to achieve overall positive outcomes for their proposal. Effective stakeholder engagement involves interactions between identified groups of people to build relationships, gain mutual respect, make better decisions and assist proponents in obtaining and maintaining a social licence to operate (NT EPA 2020b).

The EP Act recognises the role that Aboriginal people have as stewards of their country and the importance of participation by Aboriginal people and communities in environmental decision-making processes. Further, the EP Act directs a proponent to its general duties relating to consulting with communities, documenting knowledge and addressing Aboriginal values and rights.

The connection between Aboriginal people and the sea is strong in the NT. This connection with sea country is recognised through the proactive engagement by Aboriginal communities in land and sea management through the establishment of Indigenous Protected Areas and Joint Management of NT Parks, many of which have significant marine and coastal habitats (see Table 3, section 3). The Indigenous Protected Areas form part of the National Reserve System and Caring for Our Country strategy, with management plans that identify commitment to internationally recognised IUCN land management standards (Dudley *et al.* 2013). Jointly managed coastal parks are supported by the Parks and Wildlife Commission of the NT, the Northern Land Council and government endorsed management plans.

Seabed mining is recognised as a significant threat in the following management plans:

- Laynhapuy Indigenous Protected Area Management Plan – 'Seabed exploration and mining is a significant concern … One of the more significant potential threats to sea country is from seabed explorations and mining. There are currently a number of undersea mineral exploration licences covering sea country in and adjacent to the Laynhapuy IPA.'(Laynhapuy Homelands Aboriginal Corporation and Australian Government 2017)

- Anindilyakwa Indigenous Protected Area Plan of Management – 'In addition to the environmental impacts, Anindilyakwa traditional owners believe that seabed mining would destroy sacred sites and songlines that are central to Anindilyakwa culture and identity.' (Anindilyakwa Land Council 2016)

- Limmen Bight Marine Park Plan of Management – 'The Northern Territory Government is committed to no seabed mining in the Limmen Bight Marine Park. Appropriate ongoing protection for the Marine Park will be set in place by gazetting the Park as Special Reserved Land under the Minerals Titles Act 2010 and Reserved Blocks under the Petroleum Act 1984, Geothermal Energy Act 2009 and Petroleum (Submerged Lands) Act 1981.' (Parks and Wildlife Commission of the NT 2019).

5.4.2 Social licence

Social licence to operate, govern and regulate are important for the acceptance and success of natural resource industries (Wilkinson and King 2016). A social licence to operate represents a measure of community's perception and acceptance of an organisation's contribution to the community and how it operates, beyond the minimal legal requirements, with respect to the protection of values important to the community. Government also needs a social licence to regulate by providing a robust and transparent regulatory system that the community can trust to bring non-compliant operators to account and ensure the environment is protected.

The consequence of a strong social conscience for the marine environment combined with community concerns about the uncertainty surrounding seabed mining is a real and common obstacle to the establishment of this industry worldwide. The community's opposition to proposed seabed mining of iron sands in New Zealand, even after an assessment decision that impacts were acceptable, based on extensive baseline information and consultation, highlights the fine balance between informed environmental impact assessment and earning a social licence to operate (case study 4). The Australian Marine Conservation Society (2014) provides a snapshot of environmental concerns for the Top End in the context of seabed mining.

The NT EPA believes it is the responsibility of the proponent to develop and maintain a social licence to operate. The importance of industry, government and the NT EPA delivering on their respective social licence obligations is also recognised. These obligations include the requirements to conduct timely, transparent, ongoing and meaningful communication and engagement, and to make sound, evidence-based decisions.

Case study 4: Seeking approval: a complex and difficult process, Taranaki Bight, New Zealand

Trans-Tasman Resources Ltd (TTRL) applied for a marine consent in 2013 for a proposal to extract iron ore from iron sands over a 20 year period. Mining of the seabed is proposed at depths of 20 to 42 metres and approximately 12 to 20 nautical miles (nm) offshore in the South Taranaki Bight. The seabed is proposed to be mined to depths up to 11 m below the seafloor (TTRL 2013).

Marine consent was refused in 2014 and the NZ EPA identified that the operation of the project had the potential to result in the following potential impacts:

- sediment plumes from mining and discharge of tailings resulting in increased turbidity and reduction in primary productivity
- loss of benthic habitat and food resources, displacement, noise and risk of collision and entanglement impacts on marine megafauna, including threatened species
- biofouling and accidental introduction of non-native marine species
- inadequate baseline and modelling data resulting in levels of uncertainty about the potential impacts on the marine environment too high to allow an assessment (NZ EPA 2014).

Following refusal by the NZ EPA's decision-making committee (DMC), TTRL appealed and then abandoned its appeal, during 2014.

TTRL commissioned further environmental assessments (TTRL 2016a) and resubmitted in 2016 (TTRL 2016b, NZ EPA 2015c). During 2015 additions to the EEZ Act, under the *Exclusive Economic Zone and Continental Shelf (Environmental Effects) Amendment Act 2013*, came into effect which prohibits the application of adaptive management to marine discharge consents. As such, adaptive management was excluded from the TTRL application due to the inherent connection between marine discharge consents and other consents (Environment Foundation 2018).

TTRL was granted consents for marine (mining) and for marine discharges in 2017, following consideration of extensive information, consultation and a majority decision by the DMC (NZ EPA 2017).The approvals instigated 12 industry and conservation appellants to lodge an appeal before the High Court of NZ under section 105 of the EEZ Act. The hearing was held in April 2018.

The appeal was upheld by the High Court in August 2018, quashing the DMC decision. The decision to uphold the appeal was based on points of law rather than social opposition or scientific facts and expert opinion. Specifically the decision was based on the incorrect and narrow interpretation of the concept of adaptive management applied by the NZ EPA's DMC in granting the Marine Discharge Consent.

In response all parties appealed aspects of this decision and a Court of Appeal Hearing was held in September 2019. In April 2020 the Court of Appeal upheld the High Court's decision, but on different grounds. The court of Appeal also dismissed the industry and conservation application to decline TTRL's approval for marine and marine discharge consents.

In its decision statement, the Court of Appeal recognised that the NZ EPA could grant an application for a marine discharge consent subject to a wide range of conditions. The NZ EPA is obliged and permitted to incorporate an adaptive management approach into a **marine consent** (EEZ Act s 61(3)); however, the NZ EPA is expressly prohibited from imposing conditions that together amount or contribute to an adaptive management approach to a **marine discharge consent** (EEZ Act s 87F(4)). The High Court decision (NZHC 2018) supported the argument that the conditions imposed by the DMC constituted or contributed to an adaptive management approach. The Court of Appeal (NZCA 2020) found that conditions imposed by the DMC did not amount to an adaptive management approach, but instead were reflective of a more fundamental problem; specifically that the DMC did not have sufficient information before it to grant the consent. The EEZ Act requires that decisions must favour caution and environmental protection (EEZ Act s.87E) where the information available is uncertain or inadequate.

There are now implications of new case law on various aspects as they relate to seabed mining. Two key aspects relate to: the interaction between the *Resource Management Act 1991* and the EEZ Act where activities have effects across the land and sea; and secondly on the implementation of the international law restrictions on pollution. Under the EEZ Act, seabed mining discharges are considered harmful substances, and therefore pollution under international law.

TTRL's application was referred back to the NZ EPA for a decision based on the findings of the two judicial reviews; however, TTRL subsequently lodged a notice of appeal to the Supreme Court. As at the date of this review, the Supreme Court has not heard the appeal.

5.4.3 Cultural and historic heritage

Seabed mining, disposal of tailings and infrastructure that affects the seabed may impact underwater cultural and historic heritage values. The potential impacts and measures to avoid or protect sacred sites are addressed by the AAPA in its review. Underwater cultural and historic heritage values may be compromised through damage by mechanical, chemical or biological processes at the site, or by destruction of context if heritage items are relocated from a site (Cosmos 2017).

Mechanical damage occurs when the physical integrity of the site is affected through direct mining activities as well as changed seabed topography. Chemical damage relates primarily to the corrosion of the metal components of a site through increased electrochemical activity resulting from changes in pH level, salinity, light levels (heat) and water movement. Biological damage occurs where organic materials of the site, such as wreck timbers, come into contact with biological organisms (marine borers, bacteria or vegetation) through increased exposure due to erosion of sediment. In some cases biological coverage over iron objects has a beneficial effect for long term survival of the site.

Direct, indirect and cumulative impacts from seabed mining on heritage sites include, but are not limited to, physical removal of seabed, relocation of dredged material (e.g. tailings disposal and rehabilitation activities), installation of temporary or permanent infrastructure, disturbance of seabed from vessel movements, accidental discard to the seabed of industrial waste, sediment erosion and accretion, and alteration of hydrodynamics.

Management

Key management actions should be detailed for environmental impact assessment, to ensure implementation of appropriate mitigation and management measures prior to disturbance, during mining, and throughout rehabilitation. Information required at the assessment stage is summarised by Cosmos (2017) as:

- record of archaeological heritage without disturbance through desktop assessment, high resolution remote geophysical data, diving, photographs and video
- likely project-specific restricted works and/or exclusion zones
- excavation and salvage strategies for relocation or conservation of significant heritage items
- ongoing monitoring plan for heritage items during operations concurrent with multi-beam surveys of mining progress and rehabilitation monitoring – results could trigger a visual inspection (e.g. diver or ROV) for more detail
- post mining monitoring plan to determine status of impacts on cultural heritage values

- management measures for unexpected discovery of cultural heritage values.

Management of any impact from seabed mining is contingent on identifying and assessing the potential and actual presence of cultural heritage. It is important to note that while the survey techniques used for geophysical surveys are similar to those for resource identification, the parameters and interpretation of results require the input of a suitably qualified maritime archaeologist to ensure that cultural heritage items are not overlooked (case study 5).

Cosmos (2017, Appendix 6) provide further details through case studies of managing impacts on underwater cultural heritage during dredging projects conducted in Darwin Harbour, Australia, Hong Kong and England.

Case study 5: Engagement of suitably qualified experts to inform environmental assessment and acceptability of development proposals, Northern Territory

Engagement of suitably qualified and accredited experts in the relevant field is essential for good environmental impact assessment. The example provided in this case study focuses on cultural heritage values. However, the principle applies to all fields of investigation and highlights the requirement to engage professional experts within the scope of their expertise.

Two surveys were conducted to determine the impact of a large-scale dredging project on cultural heritage values. Each delivered quite different recommendations. The surveys were undertaken to address the potential for dredging to impact on significant but not yet located maritime heritage within the project footprint in Darwin Harbour. Following concerns arising from a draft environmental impact statement, the proponent commissioned two reports which considered the underwater cultural heritage of Darwin Harbour.

One investigation was conducted by maritime archaeologists and the other by marine environmental scientists. The conclusions of each report differ with one providing recommendations for further work and the other stating no further work is necessary.

The main sources contributing to this difference were an underestimation of the number (9 versus 39 wrecks) and type (low profile timber wrecks) of unlocated wrecks, and therefore the parameters and interpretation of the remote sensed data required to locate these wrecks.

The NT Government reviewed both reports, supporting the better-informed recommendations made by the maritime archaeologists operating within the scope of their expertise.

5.5 Economy and other resource industries

Coastal and territorial waters are recognised as a national asset providing enormous economic and environmental wealth to Australians (NMSC 2016). While seabed mining may have positive benefits for the NT economy, it may also have some potential negative impacts through effects on other resource industries. Negative impacts may result from establishment of exclusion zones; increased shipping and associated risks; and altering and degradation of environments and ecosystems which support existing and future resource industries. Impacts on other resource industries are considered, in part, through management of impacts on social and cultural values. Socio-economic benefits should be assessed against potentially adverse economic and environmental impacts and risks to enable decision-makers to make informed decisions.

Economic impact management should also be based on a comprehensive cost benefit analysis using agreed models and considering ecosystem services, existing and future resource industries, and supported by a robust and well-defined regulatory framework (BMAPA and The Crown Estate 2017, NMSC 2015, OECD 2012, Costanza *et al.* 1997). While outside the scope of this review, the NT EPA recognises the value of such a cost benefit analysis for decision making. Key to reducing conflict between competing industries, is the establishment of mutually agreed exclusion zones (for mining) and reserved areas (where mining is not permitted); and activity windows to mitigate cumulative effects and interaction between multiple industries and natural environmental variation.

Other resource industries with established interests in NT coastal waters include: commercial fisheries (which includes mud crab and finfish, the Northern Prawn Fishery operating in adjacent Commonwealth waters, and aquaculture); tourism (based on recreational fishing, enjoyment and use of coastal and marine parks and reserves, cruise ship visitation and other recreational activities such as sailing and diving); export industries (e.g. mineral and live export); the petroleum industry (with tenure, exploration and infrastructure in NT coastal waters); the biodiversity industry (bioprospecting) and emerging industries such as the blue carbon economy (based on carbon stored in coastal and marine ecosystems).

Impacts specific to these resource industries are provided below with acknowledgement that management of many of these impacts is required through well-defined regulatory frameworks established by government as described above.

5.5.1 Commercial fisheries

The potential conflict, impacts and proposed management measures regarding seabed mining and fishing industries are documented globally (Penney *et al.* 2008, D'Arcy 2013, FRDC 2010). Potential conflicts may be resolved through codes of practice to manage direct impacts from shared use of marine areas (IMMS 2011, BMAPA *et al.* 2015).

However, uncertainty remains with regard to indirect impacts on fish communities and cumulative impacts from all marine industries on the sustainability of natural fisheries (Penney *et al.* 2008, Wenger *et al.* 2018, case study 6). As a consequence of this uncertainty, many guidelines for managing impacts from seabed mining provide no clear standards and trigger values to manage or protect coastal fish communities and fisheries, despite acknowledging that such standards should exist (Wenger *et al.* 2018).

Potential impacts of seabed mining and dredging operations on fish communities include shifts in species composition; loss of species; bioaccumulation of contaminants and associated deformities; increased rates of disease; and decreases in fish catch per unit effort at sediment disposal sites (Wenger *et al.* 2018).

Of greatest concern to NT fishing industries is the loss of access to fishing grounds through either exclusion provisions or due to the degradation or modification of the marine environment leading to an area that is commercially unviable (NTSFC 2020). Potential impacts on coastal processes and benthic communities and habitats underpin recruitment of commercial fisheries which are crucial to the sustainable management of fished species (Penney *et al.* 2008, Wenger *et al.* 2018). Wenger *et al.* (2018) developed suspended sediment concentration thresholds for fish and identified activity windows (applied through seasonal restrictions) to protect fish and therefore fishing industries. This research has relevance to the management of impacts on other commercial species.

Case study 6: Potential conflict with other resource industries: new seabed mining industry leads to moratorium, Namibia

Seabed mining for diamonds off the south-west coast of Namibia began in the early 1960s. Mining initially occurred in shallow waters less than 35m using divers and suction pump equipment mounted on boats or tractors on the beach (Gurney *et al.* 1991). Advances in technology have allowed more productive mining to occur in deeper waters between 70 m and 140 m. Today, mining occurs in waters 20 to 40 kilometres offshore using purpose-built vessels which deploy either a suction crawler to scrape seabed sediments, or vertical drilling of rocky and uneven seabeds. Some processing occurs on board and diamond-containing crushed sediments are kept locked on board then flown to shore weekly via helicopter transport.

In 1991, De Beers Marine, the major diamond miner in the region, commissioned an environmental impact assessment of its seabed mining operations in southern Namibia. The team of independent scientists involved in the assessment concluded that offshore mining operations did not have a significant effect on the environment in comparison to the dynamics of the natural system, but acknowledged localised negative impacts on seabed communities from mining and the discharge of tailings.

In 2011 the Namibian Government issued a 20 year mining licence to Namibian Marine Phosphate (NMP, which is 85% Australian owned) for the exploitation of phosphate deposits in water depth of 180 to 300 metres, located 40 to 60 kilometres off the Namibian coastline. NMP produced an environmental impact assessment and environmental management plan (EMP) to comply with its mining licence, addressing sea-based and land-based components separately. The environmental impact assessment and EMP identified potential impacts, mitigation and management measures as well as commitments to promote environmental acceptability of the proposal.

The project attracted considerable opposition from local and international environment groups including the Namibian fishing industry (Benkenstein 2014) with concerns that the environmental impact assessment did not adequately reflect the environmental risks associated with the proposal. Primary environmental concerns included the release of hydrogen sulfide and reduced phosphorous compounds in the sediment, contributing to toxic, low oxygen levels in the water; the potential for heavy metals released from seabed sediments to enter the food chain and affect fisheries; and the release of toxic elements from land-based processing (Benkenstein 2014).

In 2013 the Namibian Government established a Moratorium on seabed mining of phosphates which was lifted in late 2016. To date mining has not commenced.

Other countries where there are applications to mine offshore phosphate deposits similarly face strong opposition from environmental organisations and fishing industries. These include South Africa, where prospecting rights were granted, but which were deemed uneconomical due to low phosphate prices and have not progressed to exploration; Mexico, which denied an environmental licence in 2016; and New Zealand, which rejected phosphate mining in 2015 (Case study 3).

5.5.2 Tourism

Tourism NT is seeking to strengthen the emotional connection between place and people by better integrating Aboriginal culture and natural adventures. Ecotourism on National Parks and pastoral lands could be impacted by proposed seabed mining. For example, there exists an overlap between the Limmen Bight Marine Park and Mineral Authority applications which cannot be resolved during the period of the Moratorium. These Mineral Authority applications also border the Lorella Springs Wilderness Park, an established ecotourism venture with increasing local, national and international visitation. The recently gazetted Limmen Bight Marine Park Plan of Management, prepared with Marra Traditional Owners, documents the NT Government's commitment to prohibiting seabed mining in the park (PWCNT 2019).

Recreational fishing contributes greatly to the tourism economy of the NT as shown in section 4.4 of this review. Recreational fishing supports substantial retail and service sectors as well as providing cultural, social, health and wellbeing benefits that could be negatively impacted if important fishing areas or fish stocks were compromised through seabed mining.

A decision to allow seabed mining in NT coastal waters may have significant impacts on the tourism industry both directly through impacts on environmental values and indirectly on communities through social conscience decisions made by some tourists (Smyth 2020). Similar concerns have been shared with development of uranium mining in Kakadu National Park since the 1960s (Wellings 2002). However, seabed mining has the potential to impact on multiple locations with less visibility to the general population.

Although transparency with regard to the assessment and management of seabed mining may ameliorate some negative impacts associated with social conscience, it is unlikely that transparency measures alone would be sufficient (KTECH 2020).

5.5.3 Petroleum and export industries

Seabed mining may affect petroleum and export industries through shared use of marine areas and port facilities and increased use of shipping channels.

Good communication is key to positive management of shared use areas as identified by BMAPA guidance (BMAPA *et al.* 2015). Management measures to avoid collisions and damage to subsea infrastructure through clear proximity protocols are also described by BMAPA guidance (BMAPA 2016).

5.5.4 Bioprospecting

Bioprospecting refers to the systematic search for compounds derived from natural resources including plants, microorganisms and animals that can be further developed for commercialisation and overall benefit to society. Clarke and Walsh (2014) identify mineralising marine organisms as providing new directions for bone tissue engineering, particularly in the supply of biomimetic templates that may enhance bone formation, indicating potential for future interest in marine bioprospecting.

Previous bioprospecting projects in the NT for plants and marine organisms have provided important research funding during low impact prospecting ventures. Seabed mining is unlikely to impact on this highly selective industry.

5.5.5 Blue carbon

'*Blue carbon'* is the carbon stored in coastal and marine ecosystems. There is growing interest in these systems to contribute to a carbon abatement industry similar to, and possibly much larger than, that in terrestrial woodlands in the Top End of the NT. Carbon abatement projects in NT terrestrial woodlands generate significant environmental, social, cultural and economic benefits (DENR 2018b). To date, interest in blue carbon largely focuses on carbon in coastal ecosystems – mangroves, tidal marshes and seagrasses – which sequester and store large quantities of carbon in both the plants and the sediment below.

Crossman *et al.* (2018) valued the annual sequestration of blue carbon in the NT to be worth up to $468M; while the total stock of carbon in the marine environment is valued in the order of $23.9 billion to $198.5 billion. The bulk of carbon stocks occurs in mangroves, which store on average three to four times more carbon than tropical terrestrial forests (Donato *et al.* 2011, Ahmed and Glaser (2016) in Crossman *et al.* 2018). The NT contains almost half of all mangrove forests in Australia (Smit *et al.* 2018).

Clearing of mangroves therefore results in a negative impact on long-term carbon storage potential, with carbon emissions from the loss of one hectare of mangroves equivalent to the loss of 10 to 40 hectares of native terrestrial forest (McLeod *et al.* (2011) in Crossman *et al.* 2018). Seabed mining may potentially impact mangroves and other coastal ecosystems indirectly through impacts on coastal process, and directly where port construction and other activity in the intertidal zone is required.

5.6 Cumulative impacts

While the concept of accumulation of impacts on environmental values is generally understood, a single definition of cumulative impact and how to measure and assess cumulative impacts is complex and difficult to apply. The WA EPA (2014) provides strategic advice for the assessment of cumulative environmental impacts. While this advice is targeted at the terrestrial environment, the concepts are relevant to the marine environment. The importance of cumulative impacts for environment protection is recognised in NT legislation. Section 10 of the EP Act defines impact as 'an impact [that] may be a cumulative impact and may occur over time'.

Cumulative impacts can occur from the collective pressures of related or independent activities and can arise from direct and indirect impacts (e.g. NMP 2012, case study 6, Namibia). Cumulative impacts may also be considered as the combined environmental impact resulting from past, present and reasonably foreseeable future actions (Dalmer 2012). In the context of seabed mining cumulative impacts can arise from a single seabed mining project with a number of interacting impact pathways, or multiple seabed mining projects within the same region, or other resource industries in an interactive combination with seabed mining. Despite the source of impact, the complexity of multiple pressures may be such that some effects are greater and more difficult to predict than the summation of individual impacts (Advisian 2017).

Isolating an individual cause of a measurable impact is often difficult due to the multitude and complexity of pressures affecting the marine environment at any one time. It follows that understanding and predicting how these pressures will interact and what cumulative impacts may occur is even more difficult (Evans *et al.* 2017). This may be made more complex by large natural variation in environmental processes, particularly extreme weather events.

To account for this complexity the WA EPA guidance on benthic communities and habitats describes assessment of cumulative impact which specifically *includes* all anthropogenic impacts but explicitly *excludes* the impact of natural events in any considerations (WA EPA 2016h). To address the complexity of assessing cumulative impacts on seagrass and coral ecosystems of the Great Barrier Reef, Queensland, Anthony *et al.* (2013) have developed a cumulative impacts and structured decision-making (CISDM) framework. The CISDM framework uses a qualitative modelling approach to understand and predict cumulative impacts and so enable managers to identify precautionary spatial and temporal boundaries for the assessment of development proposals.

Researchers from the WAMSI Dredging Science Node provide a Bayesian risk-based modelling framework which describes the cumulative impacts of dredging on seagrass ecosystems through estimates of the individual impact of a pressure on a system's resilience (Wu *et al.* 2017). The authors have validated their work using three different populations and species of seagrass in Queensland and WA.

Another approach to managing cumulative impacts on seagrass communities in Queensland is provided by Grech *et al.* (2011). In this case qualitative measures of vulnerability were combined with geospatial data to determine high risk areas where management intervention would be best targeted. The coastal and marine environments of the NT do not have the same level and variety of pressures as the Great Barrier Reef; however, this approach has merit in attempting to identify, with relatively low investment in data collection across broad spatial scales, sites most suited for industry development and environmental protection in order to minimise cumulative impacts.

The amount and complexity of information required to assess impacts of seabed mining, including cumulative impacts, is discussed further in section 6.

6 Management approaches to seabed mining

This section presents the NT EPA's views and advice on the potential for impact and the management of impacts from seabed mining, based on the information and experiences provided in this review. In particular, this section focuses on environment protection and management approaches as they relate to seabed mining in the NT. The NT EPA presents key findings and conclusions, to assist the NT Government's decision-making on the future of the Moratorium and a seabed mining industry in the NT.

While the NT EPA review is necessarily broad and considers the large range of potential seabed mining activities and environmental values, it also recognises that significant impact is strongly related to the scale, nature and location of individual seabed mining proposals. The significance of actual and potential impacts, and the extent to which they can be managed to meet environmental objectives and outcomes influences the environmental acceptability of any proposals to mine the seabed.

The NT EPA considers that there may be circumstances where seabed mining can be environmentally acceptable, provided that proposals are relatively small in size, supported by adequate information, comprehensive consultation and engagement, transparent assessment and a clear, robust framework for environmental regulation and compliance to ensure environmental acceptability.

There are other scenarios where the scale, nature and location of seabed mining would likely result in proposals with such high levels of uncertainty or residual environmental impact that they are environmentally unacceptable. In some cases the information requirements to enable robust assessment may result in proposals that are not financially viable.

As identified in this review, the most significant potential impacts from seabed mining on the environment are on: coastal processes and marine environmental quality; marine ecosystems, including benthic communities and habitat; and community, economic and cultural values.

This section discusses the following key requirements associated with managing the potential impacts of seabed mining in the NT:

- Ensuring there is a robust regulatory and policy/technical guidance framework that provides for informed environmental impact assessment and approval decisions and promotes ecologically sustainable development (section 6.1).
- Providing certainty for proponents to avoid unnecessary expenditure and delay through clear expectations about referral and information requirements and 'no go' areas (sections 6.1 and 6.2).
- Applying best practice assessment and regulatory tools to proposals which may be considered environmentally acceptable (sections 6.1 to 6.7).
- Addressing information gaps and mechanisms to develop strategic environmental and baseline data collection and management in a central repository (section 6.2).
- Addressing the importance of social impact on developing and maintaining a social licence by industry to operate and by government to regulate (sections 6.1 and 6.8).

The NT EPA provides its advice on the management of impacts from seabed mining as key findings and conclusions **in bold** throughout section 6 based on its review and its expertise and experience in environmental impact assessment and environmental regulation in the NT.

6.1 Regulatory environment

6.1.1 Current regulatory provisions

The MM Act authorises mining activities in the NT on land and at sea and manages operational aspects of mining activities and environmental impacts not considered significant, but which unmanaged would represent unacceptable environmental impact. The MM Act has largely been developed and applied to terrestrial mining, with limited extension to riverine dredging operations, and no application to seabed mining.

The NT EPA is aware that environmental reforms are proposed by the NT Government, which include potential changes to environmental regulation of different types of land use developments, including mining activities. The proposal to transfer the environmental regulation of mining from the MM Act to the EP Act should consider how regulation could be strengthened in its application to seabed mining.

Any seabed mining activity in the NT would need to occur within a transparent and robust regulatory and policy framework. It is the NT EPA's view that this framework now exists for the management of significant environmental impacts in the NT with the promulgation of the EP Act and EP Regulations. The EP Act and EP Regulations take into account major reviews into environmental regulation commissioned by the NT Government (EPA 2010, Hawke 2015, NT EPA 2017b) and represent substantial environmental regulatory reforms for the NT since the Moratorium was imposed in 2012.

The NT EPA acknowledges that these, and ongoing, environmental reforms will contribute to increased industry certainty; greater accountability for industry and the regulator, more efficient and transparent decision-making; and improved environmental performance and outcomes. The reforms represent a major advance in environmental regulation and provide the NT Government and the NT EPA with substantially improved powers in undertaking environmental assessment and protection of the natural resources of the NT, including those in coastal waters.

Specifically, the EP Act contains the following provisions that could be applied to the regulation of seabed mining in the NT:

- powers to establish protected environmental ('no go') areas
- powers to prohibit certain activities
- the ability to identify clear referral triggers for environmental impact assessment (locality and activity-based triggers)
- a requirement for the Minister for Environment to grant or refuse a whole-of-government environmental approvals at the completion of the environmental impact assessment process
- powers to undertake appropriate compliance and enforcement activities to ensure compliance with any approval conditions and the objectives of the Act is achieved.

The EP Regulations provide an improved regulatory and approvals framework, supporting NT EPA environmental impact assessment decisions through:

- a tiered assessment system based on potential significance of impact
- increased community participation, including by Aboriginal communities.

The lands and seas of the NT contain areas of environmental significance which can be declared temporary or permanent environment protection areas by the Minister under the EP Act. The Minister's declaration may prohibit or limit the development that can occur in these areas. The EP Act also provides for an activity type to be prohibited, and so allows the NT Government to establish no-go zones or define when a specific activity type, such as seabed mining, would not be permissible in the NT. The Northern Prawn Fishery has similar no-go zones based on a set of spatial, temporal and permanent closures to protect key ecological communities and support improved productivity and economic return from the fishery (AFMA 2019). According to Cuvelier *et al.* (2018), from an ecological point of view, the designation of set-aside areas as refuges is of utmost importance as it appears to be the most comprehensive and precautionary approach, both for well-known and lesser studied areas.

Environment protection is facilitated through environmental impact assessment (see section 6.3 of this Review). The EP Act and EP Regulations provide for robust and systematic environmental impact assessment and environmental approvals, supported by clear decision-making criteria. Of particular note is the application of the principles of ecologically sustainable development throughout the environmental impact assessment process and as the basis of all decisions (DENR 2020b).

Transparency of decision-making is improved through community participation opportunities and published statements of reasons by decision makers, at all key stages of the environmental impact assessment process (see section 3.3.3 and the flowchart at DENR 2020c). The EP Act is clear on the purpose of environmental impact assessment and sets out expectations of how industry is to engage with the process.

All proposals that undergo environmental impact assessment under the EP Act will require an environmental approval before they can proceed. The approval is issued by the Minister for Environment, informed by the NT EPA's assessment and recommendations. An environmental approval can incorporate conditions relating to the management of impacts, financial provisions and any environmental offset requirements. The EP Act provides compliance and enforcement provisions to oversee the regulation of an environmental approval.

The Minister may refuse to grant an environmental approval at the completion of the environmental impact assessment process based on advice for the NT EPA. However, the NT EPA recognises that early engagement between proponents and the NT EPA would identify, upfront, any potential 'fatal flaws' or unacceptable impacts that may prove insurmountable. Such a transparent process does not deny a proponent procedural fairness, but clearly places the burden of proof with the proponent who may wish to avoid unnecessary expenditure and delay by withdrawing or re-designing the proposal.

6.1.2 Next steps

The NT EPA recognises the value of recent and ongoing environmental reforms by the NT Government. The EP Act provides a comprehensive statutory basis for environmental impact assessment and approve/not approve decisions for seabed mining activities. Similar, and specific, reforms to mining legislation would strengthen the ability of the NT Government to manage impacts on the values of NT coastal waters from seabed mining.

Transparency of decision-making for mining, including seabed mining, would be increased through publicly available monitoring information and environmental reports as well as decision documentation. Enhancing community access to information relating to seabed mining Mineral Titles, both active and proposed, would facilitate best practice and inclusive engagement (see Case Study 7) and could be achieved through providing a coastal waters layer to the Spatial Territory Resource Information Kit for Exploration (DITT 2020). Another key improvement would be to ensure that the financial assurance framework is able to overcome the challenges of rehabilitating the seabed and associated security costings (see section 6.6).

A clear policy position on seabed mining would provide certainty to industry, investors and the community on the NT Government's expectations. Development of such a policy should consider the findings of this review and the advice of the AAPA. The policy should identify through spatial planning any limitations to seabed mining, including protected areas based on high biophysical, social, cultural and economic values.

Protected areas would need to be established based on clear criteria, informed by adequate baseline information and stakeholder engagement. The EP Act and MM Act provide statutory mechanisms for establishing protected areas, although some stakeholders have expressed concerns about the capacity of government to unwind such protections (2020 submissions by AFANT, EDO, KTEHC, Lorella Springs, NTSFC). The delineation of protected areas would need to consider the potential for impacts to occur some distance from mining activity due to the connectivity of the marine environment. As with Indigenous Protected Areas and National Parks (see section 5.4.1), declared protected areas should be supported by regional environmental management plans to ensure that environmental protection outcomes are communicated to all stakeholders.

Even the staged establishment of a new seabed mining industry would require a substantial amount of preliminary work to be undertaken by the NT Government, industry and the proponent. For example, environment protection ('no go') areas, and appropriate standards for seabed mining should be developed as a series of seabed mining policy statements and technical guidance prior to granting any exploration or mining licences in NT coastal waters.

Policy statements should:

- establish expectations and criteria around declarations of environmental protection areas
- set expectations on the level of information required to support environmental impact assessment and approvals
- recognise existing policies and practices in place for other resource industries and sectors, including Aboriginal land and sea management practices, and addressing consistency and/or conflict as necessary.

Fit for purpose technical guidance and standards should define the appropriate and acceptable standards for seabed mining techniques, baseline survey requirements, mandatory and preferred management and mitigation measures and monitoring protocols, and should be made enforceable through approvals. Examples include, but are not limited to:

- acceptable data collection standards
- acceptable operation, management and reporting standards
- marine protected areas and how they relate to mining activities
- information requirements for environment impact assessment of seabed mining, including baseline environmental information
- seabed mining closure and rehabilitation criteria and guidance.

The NT EPA relies on the expertise held within the NT Government agencies to inform environmental impact assessment and its advice to the Minister for Environment. Seabed mining would be a new and complex activity for environmental impact assessment and regulation in the NT, and is an activity that has challenged other environmental regulators in Australia and internationally. Robust assessment and regulation of the industry would need to be supported by adequate resourcing and availability of the required expertise and capacity.

Key finding and Conclusion 1

Any seabed mining activity in the Northern Territory must occur within an evidence-based, transparent, robust regulatory and policy framework that promotes ecologically sustainable development and establishes clear expectations on industry. This framework should be supported by:

- **the declaration of marine environment protection 'no go' areas for areas with high biodiversity, economic, recreational and/or cultural value**
- **adequate baseline knowledge of environmental values**
- **documenting the appropriate and acceptable standards for seabed mining practices and environmental management.**

Should seabed mining be considered for the NT, adequate resourcing would be required to ensure that government, the NT EPA and regulators have the capacity and expertise to deliver policy and technical guidance, rigorous environment impact assessment and regulatory oversight of a new and complex industry.

6.1.3 Best practice management and regulation

A strong policy and regulatory framework is critical to achieving 'best practice' industry standards and 'best practice' environmental protection. The NT EPA considers three different approaches to establishing robust policy and regulatory frameworks in the marine environment. The limitations and learnings from these examples provide valuable insight on elements that may be relevant to the NT context. The limitations and learnings gained from these examples highlight the complexity of regulation of the marine environment and depth of knowledge required, as relevant to developing appropriate standards, guidance and regulations for seabed mining in the NT.

Australia's management of the offshore petroleum industry through the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) provides insights into the management of activities impacting on the marine environment beyond coastal waters. While NOPSEMA has strengthened environmental management of offshore petroleum industry through rigorous assessment processes (NOPSEMA 2016, 2018), the Australian Government's operational review of NOPSEMA identified key areas of improvement to assist the petroleum industry (DIIS 2015). Specifically, the review identified the lack of guidance available to industry about communicating the importance of 'nature and scale' within the risk-based assessment process, particularly about what was considered to be as low as reasonably practicable (ALARP) for management of environmental impacts. Improved guidance would serve to avoid confusion, delays to approvals and increased project expenses for some offshore petroleum projects.

The NT Government has built upon the NOPSEMA experience and developed a code of practice for onshore petroleum projects, clearly defining its expectations around ALARP for environmental impact management. Further to this the NT Government has improved transparency in decision-making and regulation of environmental impact management through public reporting of onshore petroleum activities under the Petroleum (Environment) Regulations 2016, and non-petroleum development under the EP Act and EP Regulations. These improvements represent best practice methods to be considered for all types of impacts and industries.

The United Kingdom has developed a comprehensive policy framework to govern offshore aggregate mining (case study 7). The UK Marine Policy Statement provides a structured framework for management and regulation of seabed mining at regional and national levels. The framework provides for consistent management of environmental values, resources and impacts associated with mining marine aggregates in consideration of other established industries. The UK policy has evolved in response to concerns about the potential impacts of a long standing industry. In contrast, the NT Government has the opportunity to ensure that the right regulatory and policy framework is in place prior to any consideration of seabed exploration or mining activity.

New Zealand's ongoing experiences with seabed mining also provides insights into the successes, limitations and learnings arising from two quite different seabed mining proposals (case studies 2 and 3). Decision-making for activities in New Zealand waters is regulated by the *Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012* (EEZ Act). Distribution of decision-making among different marine management regimes provides clear separation of roles and builds a stronger public sector focus on EEZ activities. The existing statutory regime has successfully provided environmental oversight of restricted activities in the EEZ within the tight timeframes adopted by the EEZ Act (NZ EPA pers comm. 2020).

However, recent challenges to seabed mining in the High Court of New Zealand (NZHC 2018) and the Court of Appeal (NZCA 2020) identify limitations of the EEZ Act and have led to slowly evolving case law about application and interpretation of the EEZ Act (case study 4). The NZ EPA (pers comm. 2020) acknowledges a shortage of New Zealand-based expertise to assist decision-makers on technical matters including modelling, and that much of that expertise is offshore. The NZ EPA recognises key roles for decision-making such that procedural and administrative decisions are best managed by officials, and decisions of merit and public significance are best made by appropriately competent decision-makers.

The NT EPA acknowledges that further discussion is required about the uncertainty associated with the impacts of seabed mining on the marine environment and the role of decision makers in ensuring that impacts of seabed mining are understood before approving proposals (subject to conditions) to ensure the objectives of environmental legislation are achieved. Further best practice advice is provided in Grogan (2017) through a review of successful aspects of environmental legislative processes for the effective implementation of environmental legislation for extractive industries.

Case study 7: Best practice achieved through a robust policy and regulatory framework, United Kingdom

The United Kingdom (UK) has a well-established seabed mining industry that extracts sand and gravel for construction, coast defence, beach replenishment projects and export.

A strong policy and regulatory framework is critical to best practice. The UK has an established national framework (Marine Policy Statement) for planning and decision-making on matters affecting the marine environment with the aim of achieving sustainable development. The national framework contains several major policies specific to seabed mining designed to guide the development of regional Marine Plans. Marine plans set out priorities and direction for future development and provide for the adjustment of proposals during planning and environmental assessment prior to commencement of dredging.

Further, the British Marine Aggregate Producers Association (BMAPA), as the representative trade body for this industry, works closely with The Crown Estate (government) to develop and implement good practices to mitigate and manage the effects of its operations. In April 2017, BMAPA and The Crown Estate published Good Practice Guidance for extraction by dredging of aggregates from England's seabed (BMAPA 2017). This guidance incorporates progressive changes to the dredging industry resulting from a large number of environmental studies and identifies best practice for industry and environmental protection.

The industry now operates within clearly defined licensing, operational, and management frameworks which aim to:

- ensure the long term sustainable management of the available resources
- maximise the extraction of available resources and minimise waste in individual dredging areas
- minimise the footprint of the activity on the seabed
- minimise the adverse environmental impacts of the extraction process
- mitigate the effects of aggregate dredging on other users of the seabed.

Seabed mining is undertaken by suction hopper dredges which are considered the best practice method for aggregate extraction. Screening of sediments on board to retain coarser or finer sediments is possible but often avoided due to increased financial constraints and environmental impacts as outlined in BMAPA and The Crown Estate (2017).

To aid in transparency the BMAPA provides annual summary statistics on dredging area and volume estimates. Data are obtained through electronic monitoring systems (EMS) fitted to all vessels dredging on production licenses and are automatically uploaded to both The Crown Estate and the industry regulator monthly. These data have been recorded since 1998 and summary statistics are publically available on BMAPA's website.

Understanding of the nature and extent of impacts from seabed mining has improved significantly, due to the large number of environmental studies undertaken, making it possible to minimise these impacts more effectively. The framework underpinning best practice operations and environmental protection is provided by BMAPA and The Crown Estate (2017) and described through the good practice principles. Good practice principles are considered through environmental impact assessment, surveys and monitoring, mitigation and management, liaison and communication, and reporting and transparency.

The UK experience highlights that best practice is achieved through investing in and developing an extensive and relevant knowledge base.

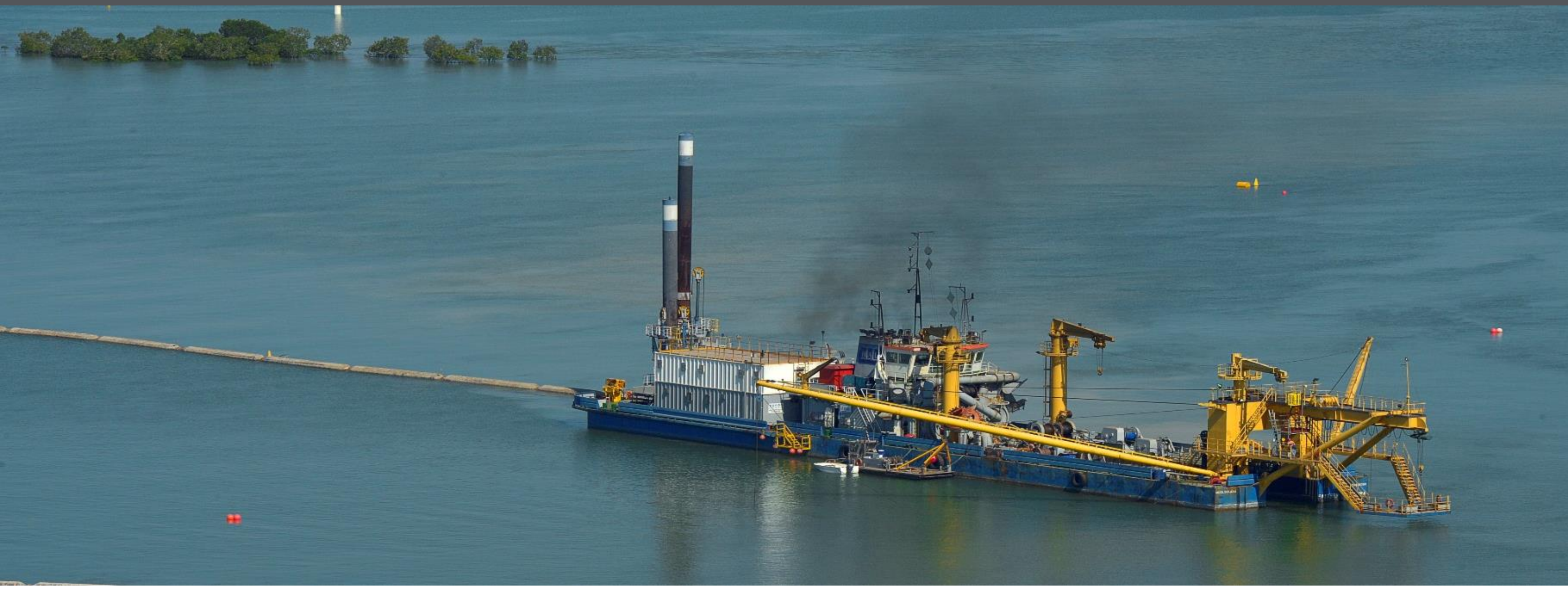


Photo courtesy of Darwin Port

6.2 Environmental impact assessment

Environmental impact assessment is a key function of the NT EPA and allows for the assessment of potentially significant environmental impacts of proposed developments on environmental values of the NT. Assessment is conducted in accordance with the EP Act and EP Regulations to:

- protect the environment of the NT
- promote ecologically sustainable development so that the wellbeing of the people of the NT is maintained or improved without adverse impact on the environment
- recognise the role of environmental impact assessment and environmental approval in promoting the protection and management of the environment
- provide for broad community involvement during the process of environmental impact assessment and environmental approval
- recognise the role that Aboriginal people have as stewards of their country as conferred under their traditions and recognised in law, and the importance of participation by Aboriginal people and communities in environmental decision-making processes.

The environmental impact assessment process provides government, proponents and public stakeholders with the information needed to consider and make decisions on matters that could significantly affect the environment.

The NT EPA applies the environmental impact assessment process to predict the impacts of development on important environmental values, including social, economic, cultural and heritage aspects, to enable judgements to be made about the acceptability of proposed development. This substantially enhances the likelihood of improved environmental outcomes while maximising the positive benefits of development.

The environmental impact assessment process promotes early consideration of potential environmental impacts and risks, together with appropriate mitigation and management measures, in the planning and design of new development proposals. Planning of all development must be in accordance with the principles of ecologically sustainable development, as defined by the EP Act, to avoid unnecessary and unacceptable harm to the environment.

Alternative approaches and technologies should be identified and considered when planning and assessing a proposed action, ensuring the least environmentally damaging approach to the development of the proposed action. Coupled with this, the environmental impact assessment process allows opportunities to be identified (and assessed) for a proposed action to enhance, restore or rehabilitate a site, further reducing the potential for significant environmental impact.

The initial notification of a proposed action that may have a significant impact on the environment to the NT EPA is known as a referral. The purpose of a referral is to provide essential information required for the NT EPA to determine whether assessment under the EP Act is necessary (DENR 2020b, NT EPA 2020c). The information required in a referral includes details of the:

- proposed development
- environmental values of the impacted environment
- likely impacts from the proposed development
- mitigation and management measures of impacts arising from the proposal.

A referral that does not provide adequate information may not be accepted. An accepted referral is placed on public exhibition and circulated to government authorities for expert advisory comment.

The NT EPA decides whether a referral requires assessment based on the potential for significant impacts from the proposal. If the NT EPA determines that environmental assessment is required under the EP Act, it will select one of the four assessment levels needed to undertake the examination of the proposed development (see section 3.3.3). The NT EPA will publish its decision with a supporting statement of reasons.

The NT EPA considers that all proposals for seabed mining activities are likely to require referral to the NT EPA to determine whether environmental impact assessment and an environmental approval under the EP Act are required. To provide certainty and ensure appropriate consideration of proposals under the EP Act, seabed mining could be declared an activity-based referral trigger under the EP Act.

Key finding and Conclusion 2

The Northern Territory Government should consider declaring a 'seabed mining' activity trigger under the *Environment Protection Act 2019* for all seabed exploration and mining activities so that referral to the NT EPA is required to determine whether environmental impact assessment is required.

6.2.1 Significant impact

The environmental impact assessment process provides for a comprehensive examination of individual proposed actions or strategic proposals that may cause significant environmental impact. The definition of environment used in the EP Act is '*all aspects of the surroundings of humans including physical, biological, economic, cultural and social aspects*'. A new and important inclusion in the EP Act is the clear definition of significant impact as, '*an impact of major consequence having regard to the context and intensity of the impact, and the sensitivity, value and quality of the environment impacted on and the duration, magnitude and geographic extent of the impact*'.

The EP Act provides for environmental assessment of significant impacts to take into account:

- the principles of ecologically sustainable development
- the environmental decision-making hierarchy
- the waste management hierarchy
- ecosystem-based management
- the cumulative impacts of a prosed action or strategic proposal
- the impacts of a changing climate.

The NT EPA considers that in the context of seabed mining the significance of any environmental impact is likely to relate to the scale, nature and location of seabed mining, taking into account the duration, magnitude and geographic extent of proposed actions, and the sensitivity, value and quality of the receiving environment. It is important to note that the sensitivity of the environment may be locality based and that values include social, economic, cultural and heritage aspects.

For the purpose of communicating the outcome of individual proposals, the NT EPA considers it useful to categorise seabed mining activities into three broad indicative classes. These classes reflect the potential for significant impact from individual proposals and, for explanatory purposes, are termed: manageable impact, uncertain impact and likely unacceptable impact (Table 3). The level of uncertainty, and consequently the information requirements for robust assessment and management, increases significantly across these classes. For the purposes of this review, the indicative general classes assist in communicating the likely assessment outcomes of different proposals, noting that the assessment, management and regulation of actual impacts from individual proposals is described in section 6.2.2 through defining zones of influence. Further guidance would be necessary if these classes were to be applied to any seabed mining policy outside the scope of this review.

The interplay between both the scale of mining and characteristics of the receiving environment is important to define the significance of impact. For example what might be considered a manageable impact, but located in a sensitive or high value area is likely to have a similar, or even greater impact, than a larger proposal in a less sensitive, lower value area. In some cases, even a small-scale proposal located in a high value area could represent an unacceptable outcome (Table 3 final row).

Proposals with manageable impacts are considered those which are limited in scale and proposed for locations that are relatively data-rich and/or with demonstrated low sensitive values and/or high resilience. These proposals are likely to be amenable to robust environmental impact assessment and approval with conditioning that provides an adequate level of certainty that potentially significant impacts can be managed within acceptable limits. The NT EPA anticipates such proposals would be similar to capital dredging undertaken to date in Darwin Harbour (Table 1), noting that the NT EPA has concerns that the cumulative impacts of multiple dredging activities has not yet been adequately considered.

For proposals where some uncertainty exists, it is feasible that impacts may be managed to the point that they are acceptable. Proponents should be aware that there may be very substantial information and knowledge requirements to demonstrate this, and would likely require collection of substantial new baseline information for three to five years (see Tables 3 and 4 in Appendix 4). New baseline information and further information obtained through comprehensive environmental monitoring and management programs (see section 6.3) would be required to establish confidence that the environment will be protected.

Finally, the potential impacts and uncertainty associated with those proposals that are so large, or located in highly sensitive environments are such that the NT EPA considers it unlikely that these proposals could demonstrate that they can be managed and mitigated without unacceptable environmental impact. Unacceptable proposals are those with such high residual environmental impact and/or such high levels of residual uncertainty and/or little confidence in the success of proposed mitigation measures, that no amount of information could make them environmentally acceptable.

Table 3: Potential outcomes for proposed seabed mining activities – a qualitative categorisation based on environmental characteristics, scale of mining and information requirements

Environment *1.value* **2.sensitivity** 3.resilience	Scale of mining (duration, magnitude and geographic extent)	Information and knowledge requirements	Certainty about impact and management[1]	Likely outcome
moderate to low **low** high	small	low – data rich locations	moderate	Manageable
moderate to low **low** high	small to medium	medium – environmental and proposal information	moderate	Manageable
moderate to low **low** high	large	large – environmental and/or proposal information	moderate	Manageable
moderate to low **moderate** low	small	large – environmental and/or proposal information	moderate	Manageable
moderate to low **moderate** moderate	medium to large	very large – long term baseline monitoring	moderate to low	Uncertain
moderate to low **moderate** low	medium (e.g. long term/ moderate/ small)	extensive baseline and ongoing	moderate to low	Uncertain
high **moderate** low	large	extensive baseline and ongoing	low	Unacceptable
high **high** low	small, medium or large	very large	low	Unacceptable

[1] after application of the mitigation hierarchy

An example of a proposal originally considered manageable, but which introduced uncertainty through an increase in the scale of mining and sensitivity of the environment, is that of a long term sand shell dredging project in WA (section 2.3, case study 2). The scale of operations is moderate (long term, moderate volume and small area), but conducted in a sensitive area (highly visible location, close to seagrass communities, important fish nursery and other users). In operation since the 1970s, the continuation of operations was contested in the Supreme Court, leading to the establishment of the Cockburn Sound Management Council and the State Environmental (Cockburn Sound) Policies 2005 and 2015 (WA EPA 2005, CSMC 2005, WA Government 2015). In 2000 the proposal was awarded approvals based on substantial changes to management measures, informed by extensive research programs. The improved management and information base sufficiently improved understanding of impacts and their management to enable environmental acceptability and continued operation. The 2015 policy provides an improved management framework, reporting mechanisms and updated supporting documents based on the information gained from ongoing research programs. The project remains controversial.

Key finding and Conclusion 3

Seabed mining activities can be broadly categorised into three classes, based on their potential for significant environmental impact:

- **Manageable impacts – are likely in some relatively data-rich, low-sensitivity locations. Potentially significant impacts may be effectively managed under current environmental impact assessment and regulatory arrangements resulting in acceptable proposals.**
- **Uncertain impacts – are likely in some situations, based on either the impact of seabed mining or the condition/quality and knowledge about the receiving environment. Potentially significant impacts may be effectively managed based on the extensive collection of new environmental information and knowledge prior to environmental impact assessment.**
- **Unacceptable impacts – are likely in some situations where serious environmental risks and high uncertainty remain and no amount of information or knowledge is likely to adequately address the residual impacts in a reasonable time and at a reasonable cost. The NT EPA considers these proposals are likely to be unacceptable and may trigger a recommendation for early refusal.**

6.2.2 Information and knowledge requirements for assessment

The importance of information and knowledge to inform the understanding of the environment and potential impacts on it and how they can be effectively avoided and mitigated is discussed above. The availability of local and regional information to inform impact assessment and approval decisions, as well as ongoing compliance monitoring, is a major limitation to seabed mining activity in the NT.

The NT EPA's environmental factors and objectives framework (NT EPA 2018b; 2020a) provides a systematic approach to organise environmental information for the purpose of environmental impact assessment, establishes clear benchmarks based on values, applies to all proposals considered and simplifies consistency across environmental impact assessment and reporting.

Of key relevance to the assessment of seabed mining proposals are the factors: Marine ecosystems; Marine environmental quality; Coastal processes; Communities and economy; and Culture and heritage (see sections 4 and 5). Other factors may be relevant if the proposal has a land-based component. The NT EPA is developing technical guidance for each of these factors to support the environmental impact assessment process. Further to this, the NT EPA considers it appropriate that a fit for purpose guidance document for environmental impact assessment of seabed mining be developed through government and industry collaboration, in line with the best practice example from the United Kingdom (case study 7).

The inherent ecological and physical links between the NT EPA's marine environmental factors necessitates a holistic approach to assessing the environmental impacts of proposed development. A holistic approach has regard to connections and interactions between all values of the marine environment. The greater connectivity within the marine environment, compared with the terrestrial environment, combined with the lack of visibility of underwater values and generally lower levels of understanding of how marine ecosystems function, leads to more complex assessment requirements. It follows that the minimum level of information required to enable environmental impact assessment is likely to be much higher than previously accepted for terrestrial assessments.

The sensitivity and values of much of the NT's marine environment are poorly documented, studied or understood (see section 4). Also, the scientific understanding around the numerous potential pathways for both direct and indirect impacts on the range of marine values is limited for the NT.

In contrast, there are established information bases for large-scale dredging projects in tropical environments on the east and west coast (AIMS, GBMP, WAMSI, refer to section 6.3). While this information base and the policies and systems that lead to the data acquisition, management and accessibility are valuable, much of the information itself cannot be applied to manage the marine environment of the NT. The fundamental difference between the marine environments, and therefore the relevance of existing information, is a result of the seafloor characteristics. The NT's coastal waters extend across an expansive, shallow continental shelf extending far offshore and are not influenced by the oceanic currents of the east and west coast.

The NT EPA has described the values, potential impacts and management measures for protection of the NT marine environment from the effects of seabed mining in sections 4 and 5, providing an indication of the information and knowledge required. This review has shown that impacts from seabed mining will extend well beyond the activity footprint due to connectivity of the marine environment. Clear communication of the extent of potential impacts is essential for the assessment, management and regulation of environmental impacts and is best presented in spatial form.

The spatial representation of impacts from seabed mining can best be achieved through defining zones of influence as shown in WA EPA guidance (WA EPA 2016f). The geographic extent of impacts in the marine environment, is clearly shown as three zones of increasing impact in Figure 6. The duration and magnitude of impacts combine to define the three zones of impact where the:

- Zone of high impact – shows the area where impacts are so severe that benthic communities will not recover within five years of ceasing post mining activity.
- Zone of moderate impact – shows the geographic extent of measurable impacts, including mortality, where full recovery of benthic communities can occur within five years of the pressures from the activity ceasing.
- Zone of influence – represents the least impact, where there are measurable pressures from the activity (e.g. elevated turbidity), but no measurable effect on the environmental value (e.g. impacts are within the natural tolerance levels that benthic communities can cope with).

The main advantages of defining the scale of impacts in this way are that the visual representation by maps can clearly communicate environmental information for impact assessment, compliance monitoring and consideration of cumulative impacts. This spatial approach has been further developed by the WAMSI Dredging Science Node to specifically define, describe and predict environmental impacts from marine dredging proposals/activity.

Defining zones of influence relies on appropriate habitat characterisation, hydrodynamic plume and sedimentation modelling. There has been significant progress in the dredging and seabed mining industry in relation to the robustness of plume models, habitat characterisation and development of site specific trigger values for sedimentation rates and plumes. CSIRO has developed guidance on best practice dredge plume modelling (Sun *et al.* 2020) which shows that increased confidence in predictions and management is possible when modelling is based on appropriate measurements and survey effort.

However, the limitations on the information available for environmental impact assessment also affects the level of confidence in both the prediction of impacts and in the success of proposed mitigation. Given the current knowledge base, the level of confidence is likely to be low for most seabed mining proposals due to the limited information available to support temporal predictions and modelling efforts. The NT EPA recognises this limitation cannot be overcome through the established information bases for large-scale dredging in tropical and temperate environments elsewhere in Australia. The inherent difficulty associated with applying known management measures to a poorly known environment is such that management of impacts from seabed mining remain poorly understood in the NT marine environment. Where scientific knowledge is lacking and there are risks of serious or irreversible environmental harm, the precautionary principle is likely to apply.

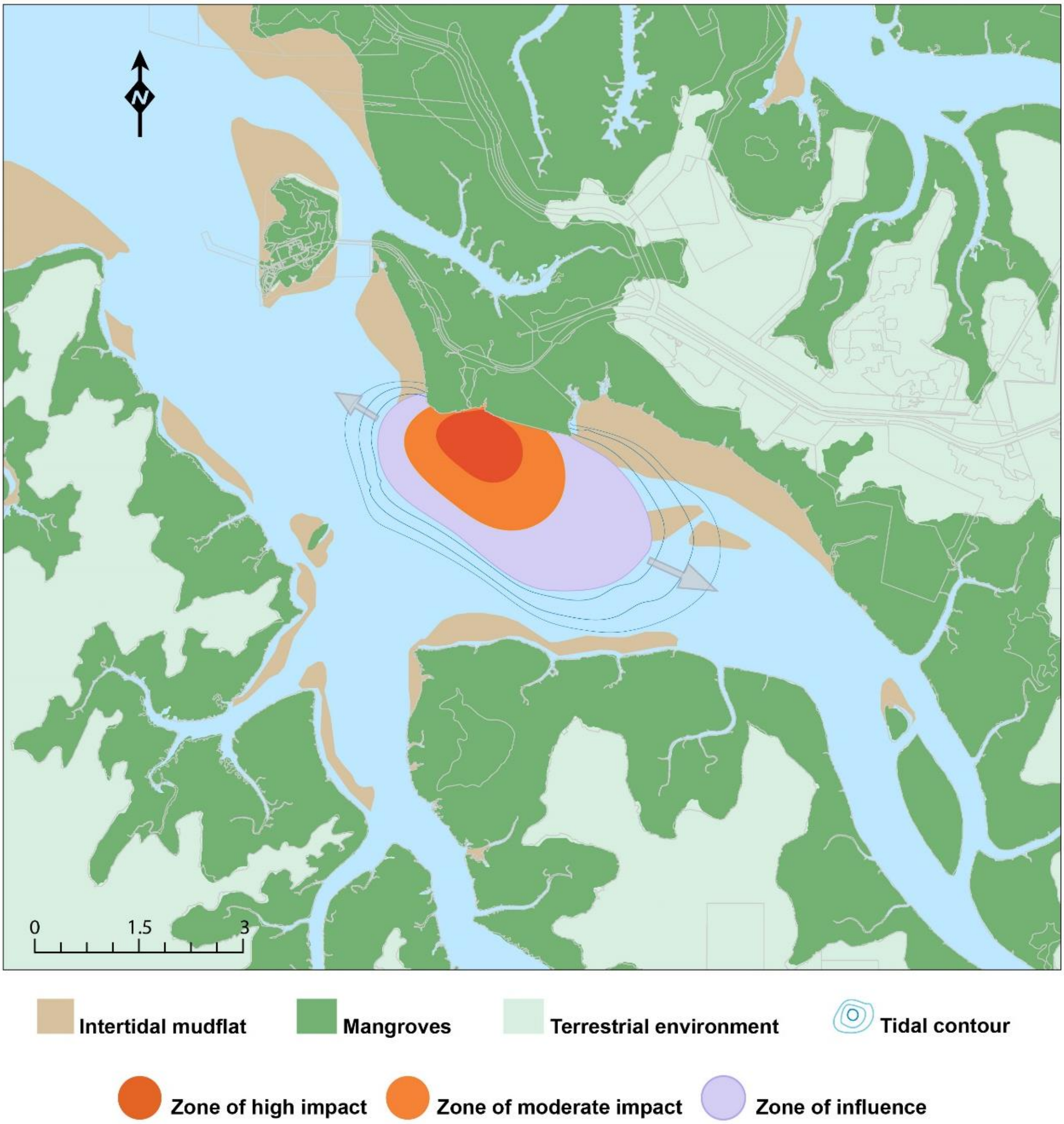


Figure 6: Schematic showing the zones of influence and the geographic extent of dredging related impacts. Image provided by the Aquatic Health Unit, DEPWS (2020)

Key finding and Conclusion 4

Currently, the lack of adequate environmental information and knowledge about the existing condition of environmental values and the potential impacts from seabed mining is a major barrier to the robust environmental impact assessment, approval and appropriate conditioning of seabed mining in the Northern Territory.

There is difficulty in applying known management measures to poorly understood marine environments. This contributes to uncertainty about the effectiveness of management and mitigation measures.

It will be important to communicate to proponents the considerable information requirements necessary for robust environmental impact assessment, including adequate baseline data that encompasses the substantial natural, temporal and spatial variation in marine and coastal environments.

6.2.3 Addressing information and knowledge gaps

This review has emphasised that a key barrier to assessment and management of the potential impacts from seabed mining is the sparse information on environmental values of the NT's marine environment. Information and knowledge about the ecological and physical processes surrounding these values, and influencing direct and indirect impacts is also limited.

A key area for improvement in information gathering and environmental assessment lies in asking better questions, based on past data and making data more freely available (Styan and Hanley 2013). The importance of asking the right questions is reflected by the Northern Territory Marine Science End User Needs Analysis commissioned by the Australian Institute of Marine Science (AIMS) and Charles Darwin University (Australian Venture Consultants 2018 in collaboration with the North Australian Indigenous Land and Sea Management Alliance (NAILSMA)). That analysis recognises the value of innovative approaches including the importance of drawing on traditional and non-traditional knowledge. It also contains a collection of information and stakeholder requirements for marine research in the NT and provides an indication of the extent of marine research required for the protection of marine ecosystems and the services they provide to the community and economy of the NT.

The NT EPA considers that the complex information requirements necessary to manage seabed mining, community expectations, and meet best practice environmental protection outcomes call for a government coordinated and managed program. A collaborative approach to data collection and information management, involving industry, government and research agencies would, over time, address information and knowledge data gaps and reduce uncertainty around effective mitigation of impacts.

The value of collaborative approaches to improve knowledge and therefore protection of the marine environment through improved management outcomes is well recognised (Sun *et al.* 2020). The National Marine Science Committee describes the need for a fully integrated approach to data collection and analysis into decision-making (Moltmann and Hodgson-Johnston 2017). It also describes innovative approaches to diverse, non-traditional science and new technological solutions to support the National Marine Science Plan.

There are a number of examples of successful collaborative approaches between governments and industry to address complex or large-scale marine development, including: the Dredging Science Node of the Western Australian Marine Science Institution (WAMSI 2020, case study 8), the Great Barrier Reef Marine Park Authority (Grech *et al.* 2013), the African Benguela Current Large Marine Ecosystem Programme (Penney *et al.* 2008), and the British Marine Aggregate Producers Association (BMAPA 2018, case study 7).

Understanding the nature and extent of impacts from shallow seabed mining is incrementally improving. Information gaps have been traditionally addressed through environmental studies commissioned by industry to inform environmental impact assessment. Many of these studies are; however, conducted in isolation by industry and the information generated is not readily available. More recently, government led strategic research programs or collaborative partnerships with industry have provided crucial information to inform dredging impact management. Rapid advances in new technologies is likely to reduce time and expense of obtaining baseline data in the future.

Industry generally has the greater financial capacity to fund large environmental studies as they are the primary beneficiary; while government generally has the responsibility to identify the relevant critical information gaps and requirements; and research institutions generally have the expertise to design and undertake the applied science to address them.

The establishment of the Dredging Science Node of WAMSI in 2011 is an example of a coordinated research initiative to enhance capacity within government and the private sector to predict and manage the environmental impacts of dredging (case study 8). Since 2010, environmental monitoring data is required to be publicly available in WA (Jones and Twomey 2019). Additionally, for proposals in the WA assessment process, marine and terrestrial survey data provided to the WA EPA are now publicly accessible via the Index for biodiversity surveys for assessment (IBSA) and the Index for marine surveys for assessment (IMSA). These data require a coordinated data management framework in order to contribute to improved knowledge about values and impact management in the future.

The Scientific Inquiry into Hydraulic Fracturing in the NT (the Inquiry, 2018) comprehensively considered environmental risks from a developing industry, and emphasised the need for adequate environmental, social and cultural baseline information prior to environmental approvals. The Inquiry also stressed the need for data and information collected by industry, researchers and government to be shared to:

- ensure its most effective use
- be made transparent and readily available to the public to build community confidence and social licence.

The Inquiry recommended that a ‘strategic regional environmental and baseline assessment’ (SREBA) was required to obtain adequate baseline data for planning, environmental impact assessment and robust monitoring. The Inquiry recognised that these studies were likely to take three to five years to complete and be cost recovered from industry.

The NT EPA recognises that the key differences associated with applying a SREBA approach to seabed mining include: the capacity for an emerging industry to fund a SREBA; the substantially smaller information base that exists for the marine environment; and the limitations of drawing on existing information from elsewhere in tropical Australia, including modelling. The NT EPA recognises the learnings from New Zealand, which identify a shortage of expertise to assist decision-makers on technical matters including modelling in the marine environment, may apply to the NT. However, the NT EPA considers that the SREBA concept may be appropriately applied to seabed mining activities and that the Inquiry findings and recommendations relating to the consolidation and availability of all relevant data and information are also informative.

Recognising similar concerns with data availability, the WA EPA formed a working group to investigate ways in which digital technologies could be used to streamline the capture, supply and interpretation of data in the environmental impact assessment process through the Digitally Transforming Environmental Assessment project (WABSI 2019). This project builds on the work conducted by WAMSI and the Western Australian Biodiversity Science Institute (WABSI) to enhance access, aggregation, interpretation and management of biodiversity information collected in WA. The value of this initiative is more than just data sharing. It provides the framework to manage information to streamline project-specific environmental impact assessment while laying the foundations for longer-term development of cumulative impact assessment methodologies and decision-making to support complex environmental assessments, including strategic assessments.

Improved systems of data sharing and management, as identified by Jones and Twomey (2019) and WABSI (2019), are key to addressing information gaps and will lead to improved decision-making by the NT EPA and the NT Government. Currently, NT Government agencies, such as the Department of Environment, Parks and Water Security, collect and manage data that is available to the community and industry. This data provides information on terrestrial and marine environments and includes the SREBA information identified by the Hydraulic Fracturing Inquiry. The development of a centralised data repository addressing information gaps, where industry and other organisations are required to make data they collect available to others would build the knowledge base and inform a collective understanding of the marine environment.

The NT EPA acknowledges that the government, research institutes, industry and individual proponents would be collectively responsible for establishing the resources, data and expertise that would contribute to the NT EPA's ability to effectively assess what would be, by nature, very complex environmental impact assessments of seabed mining.

Substantial resourcing would be required to establish a government managed data management program. Clear data collection and reporting guidelines are necessary to ensure data is standardised and of maximum use. For example, lessons can be learned from the ISA's failure to implement standards for the collection and management of appropriate data, resulting in considerable effort required to develop guidance for standardised data. Managing initial and ongoing requirements for complex and robust information requires the establishment of data management systems comprising a data repository for baseline, monitoring and environmental impact data. Over time this resource will reduce barriers to assessment approval and conditioning of seabed mining.

Key finding and Conclusion 5

The collection of adequate data at a regional scale required for environmental impact assessment requires coordination between industry, government, research institutes and other stakeholders, rather than a piecemeal approach at the individual project scale.

The establishment of a government managed and resourced central data repository is essential to support environment protection and the assessment and regulation of any proposed seabed mining activities in the Northern Territory. An accessible data repository would enable the most effective use of environmental data collected by industry, research organisations and government agencies and ensure that data is:

- **collected to appropriate data standards**
- **verified and stored securely**
- **shared amongst all stakeholders.**

Over time, this approach would further reduce the barriers to the robust assessment, approval and appropriate conditioning of seabed mining in the NT.

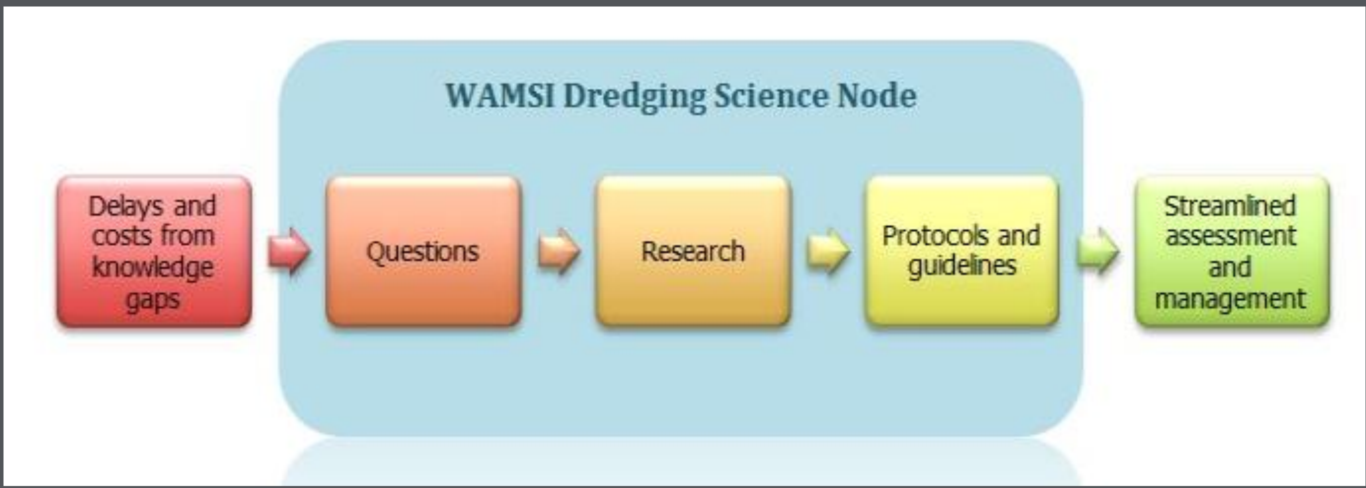
Any NT seabed mining policy should ensure that data collected for the purposes of understanding the marine environment to support seabed mining must be made available to the broader community.

Case study 8: Collaborative approaches: enhancing capacity of industry, government and research to inform management of impacts on the marine environment - WAMSI

The establishment of the Dredging Science Node (DSN) of the Western Australia Marine Science Institution (WAMSI) in 2011 represents a coordinated research initiative to enhance capacity within government and the private sector to predict and manage the environmental impacts of dredging in WA. The collaboration between industry, research and government not only allows the scale of research required to be delivered, but also ensures a strong focus on delivering good environmental outcomes. Of particular note is the focus of the DSN to develop and deliver standardised protocols and guidance for impact prediction, monitoring and management through a combination of reviews and research based on field studies, laboratory experimentation and scientific relationship testing, and to consolidate, synthesise and make accessible data across multiple disciplines. The DSN is designed to provide specific information to assist proponents apply the WA EPA guidance for the assessment of dredging proposals (WA EPA 2016f). The DSN is led jointly by a science node leader responsible for ensuring the science is world class, and a policy node leader responsible for translating the science into fit for-purpose guidelines for environmental impact assessment.

WAMSI is supported by 81 scientists from 10 research organisations, is funded equally by three industry leaders and WAMSI joint venture partners (total $19 million), and has access to extensive confidential data from industry organisations. Industry partners shared hundreds of millions of dollars' worth of environmental monitoring data which is managed through WAMSI. The Industry partners, government agencies, environmental consultants and the researchers are all represented on a Dredging Science Advisory Committee (DSAC), chaired by the WA EPA Chairman. The DSAC is charged with broad oversight, and to facilitate dissemination and uptake within their organisations and sectors. The research findings are publicly available at https://www.wamsi.org.au/dredging-science-node

WAMSI also manages additional data records spanning 12 years of research covering the Kimberley marine environment, Ningaloo, climate change, fisheries, marine ecosystems and oceanography. Data consolidation, synthesis and access has been identified among the top priorities for marine science in WAMSI's Blueprint for Marine Science 2050. WAMSI data are available via the WA State Government Open Data portal, and the Australian Ocean Data Network (AODN).



Summary of the valuable services provided through strategic collaboration to achieve the common goal of streamlined environmental assessment and management, image sourced from WAMSI 2020.

6.3 Environmental monitoring

Environmental monitoring can deliver long term data which may reduce the uncertainty surrounding marine environmental values, ecosystem functions and processes, the pressures on these values and the potential environmental impacts from seabed mining. Environmental monitoring begins prior to approval with collection of baseline information and predictive modelling data essential for environmental impact assessment. Environmental monitoring programs inform pre-, during and post-mining activities and are also essential for compliance and incident management.

In the NT context, the limited information available on marine and coastal environmental values and the uncertainty about impacts of seabed mining on them would likely be addressed through substantial long-term monitoring programs (e.g. baseline, modelling, compliance and post-closure monitoring programs). However, it should be noted that the natural variability of environmental parameters in some regions of the NT can be very high, which will further confound the capacity for obtaining adequate baseline data. The extensive information and data collected by monitoring programs are necessary to provide confidence in predictions and demonstrate that impacts do not exceed the authorised thresholds and extent. All environmental monitoring in coastal waters of the NT will require extensive baseline data, standardised methods and would need to incorporate both compliance and evidenced based, scientific learning approaches.

Compliance monitoring, an essential regulatory tool during and post mining, typically focuses on detecting biological responses (e.g. ensuring no mortality of a particular species) and physical states of marine environmental quality (e.g. turbidity), outside of the area where impacts are authorised by approvals. Uncertainty about the scope of environmental impact often leads proponents to determine threshold triggers based on a conservative approach, or incorporating worst case scenarios to define the extent of impact and provide confidence that they can comply with any authorisations based on these predictions. The use of high trigger values may overestimate the extent or severity of impact which results in monitoring programs not detecting impact. Conversely, the use of low trigger values may result in frequent exceedances and non-compliance issues. Although information from compliance monitoring is necessary to demonstrate and audit compliance, it does little to improve knowledge and predictive capacity for management of future proposals. Predictive capacity would be improved if compliance monitoring is conducted in the zone of impact.

Evidence based learning about impacts through smarter compliance monitoring programs can inform improved management measures, future assessment of similar proposals and improved environmental outcomes. The example from an extensive environmental monitoring program for capital and maintenance dredging in the Pilbara, WA, show how this can be achieved. Styan and Hanley (2013) provide examples of massive resource investment in environmental monitoring to compensate for uncertainty surrounding impact prediction. Importantly, they describe the 'Predictive Links' research component of the environmental monitoring which allowed the time necessary to examine and explore the monitoring data on a range of scales, leading to insights that describe the impacts from dredging. The monitoring went beyond compliance and included sites where impacts were likely and incorporated monitoring of both pressure and response – not just response. From the data it was possible to establish predictive links between actual dredging pressures and biological responses to learn more about impacts from dredging. This shift of monitoring effort, and associated expenditure from strict compliance, can generate better information, improve confidence for proponents and regulators and facilitate increased understanding of environmental impacts over time at little to no extra cost. Strategic environmental monitoring, as value adding to compliance monitoring, underpins the WA EPA's guidance on the environmental impact assessment of marine dredging proposals (WA EPA 2016f).

The NT EPA supports these findings and encourages proponents and regulators to ensure monitoring effort focuses on dual purpose monitoring used to demonstrate compliance and management targets are met, as well as environmental monitoring to understand impacts (see Figure 7). This requires monitoring of both pressure and response, simultaneously, where impacts are possible and likely to provide data on the response of local biota to actual pressures in their natural environmental setting.

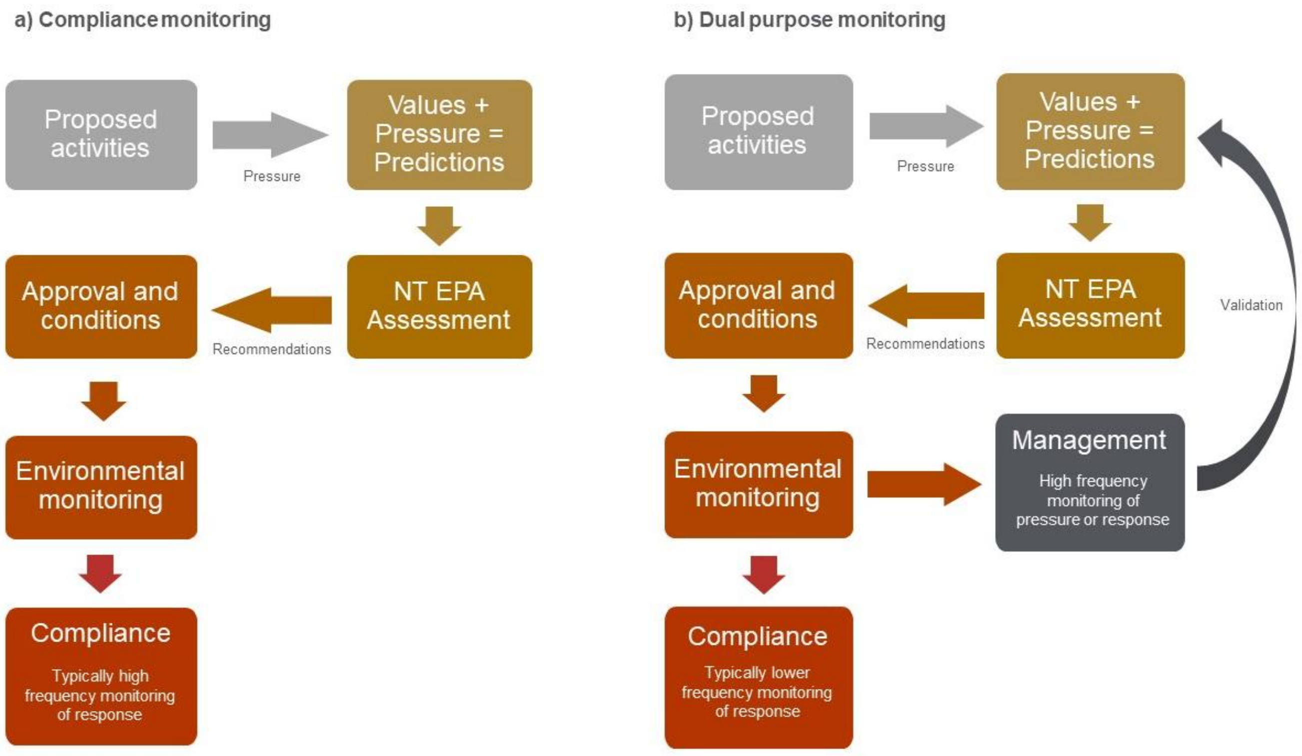


Figure 7: Schematic showing the best practice approach of dual purpose environmental monitoring. Modified from Masini (2018)

Environmental monitoring is expected to lead to improvements in management and compliance measures through improved understanding from strategic, evidence based information and improved confidence in outcomes. This process is considered good management and does not require the upfront framework of an adaptive management system to occur.

Monitoring programs designed to understand impacts in addition to compliance monitoring have broader benefits informing impact assessment and management. Such monitoring programs can be used to develop, calibrate, validate and improve predictive relationships, improve confidence about the response of local biota to actual pressures and minimise unnecessary management conditions and/or impacts associated with seabed mining. Improved confidence in environmental outcomes balances predictive confidence based on existing information and imposed confidence from comprehensive monitoring and management actions. When the predictive confidence (existing information) is high, the level of imposed confidence (monitoring and management required) is reduced. Conversely, in the face of high predictive uncertainty (from limited existing information), a higher level of monitoring and management effort is required to counter the uncertainty and gain the necessary confidence to determine that impacts would be acceptable (see Figure 8).

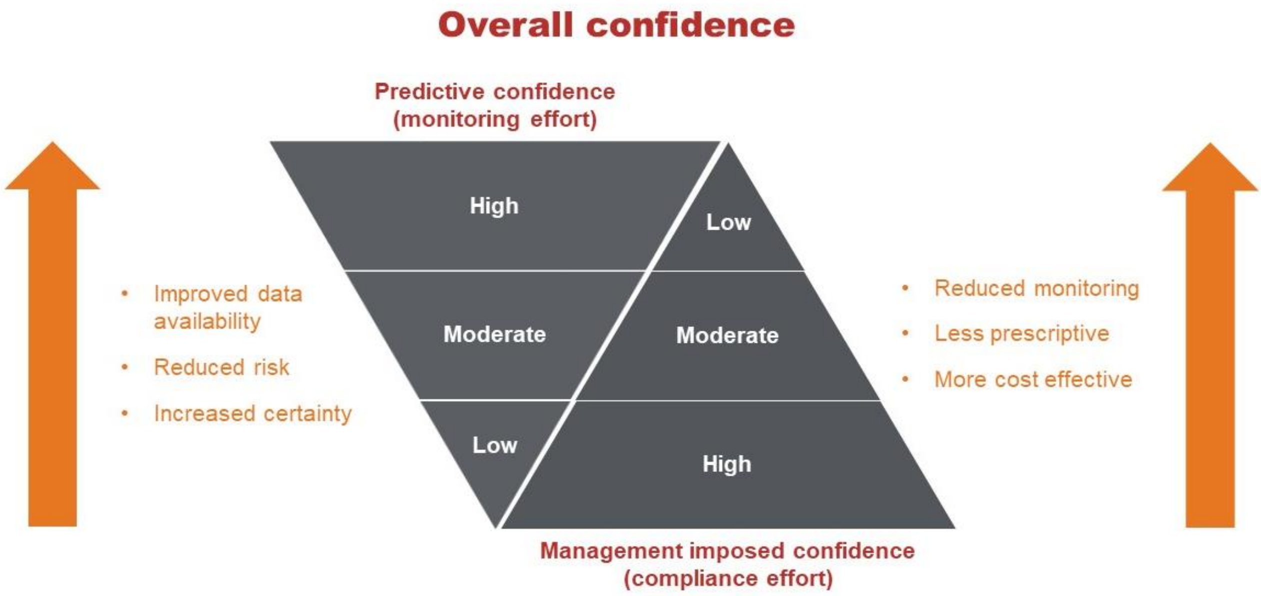


Figure 8: Conceptual model of the relationship between the predictive and imposed confidence as informed by environmental monitoring. Modified from Masini (2018)

Finally the NT EPA recognises the value of public reporting of monitoring data. Accountability of industry and government can be enhanced through open reporting of activities as is mandated for the onshore gas industry in the NT. In the United Kingdom, reporting is conducted by seabed mining vessels using on board, real time data loggers with the amount of seabed material mined uploaded monthly to public records. Regular review of data collection, analysis and reporting methods would enable the dual purpose of compliance auditing and ensuring that monitoring and management actions are achieving desired environmental protection outcomes.

Key finding and Conclusion 6

Should seabed mining be approved, relevant approvals should require environmental monitoring that informs regulation of proposal-specific management targets, and develops an evidence-based understanding of environmental impacts to support future impact assessment and regulation of the industry. Baseline data, monitoring data and compliance reporting should be reviewed on a regular basis and be available to the public.

6.4 Adaptive management

Adaptive management is often promoted as an approach to address uncertainty about management outcomes in the face of environmental impact. Adaptive management is an upfront approach with a systematic process for the iterative improvement of management practices by learning from the outcomes of past and current practices. If applied rigorously, adaptive management may be an effective approach to reducing risk and consequences where there is uncertainty about management outcomes.

In practice there is a tendency to misinterpret adaptive management as adapting management practices through standard environmental management practices (see section 6.4) or worse, loosely interpret adaptive management as a '*trial and error*' management process.

The NT EPA has published guidance on adaptive management that describes the structured and rigorous process of adaptive management, and defines the conditions required for an adaptive management approach to be considered (NT EPA 2018a).

Adaptive management cannot compensate for a lack of baseline information required for good environmental impact assessment, inadequate modelling or undefined trigger values (NZ Government 2016, NZCA 2020). Successful adaptive management also requires a clearly defined system for making adjustments that is enforceable by law. For example, adaptive management has been incorporated into the consent procedure for long term aggregate dredging in the UK (Newell and Woodcock 2013). However, the difficulty with regulating adaptive management is illustrated in case study 4 where adaptive management was not consistently applied across multiple legislation regulating seabed mining in New Zealand, leading to successful legal appeals against an approval decision.

The NT EPA has concerns that the effective application of adaptive management in an environmental impact assessment and approval context is yet to be proven in the NT. The NT EPA expects that adaptive management in the context of seabed mining would only be considered in exceptional cases. In particular there must be a high level of certainty that the NT EPA's environmental objectives are able to be met. Based on the information provided in this review, the NT EPA considers that all the pre-conditions required for effective application of adaptive management are unlikely to be met in the case of seabed mining activities in NT coastal waters.

Key finding and Conclusion 7

The NT EPA considers that the use of adaptive management would be highly problematic in managing the high levels of uncertainty and risk associated with the mitigation of potentially significant environmental impacts from seabed mining proposals. Any effective use of adaptive management would be limited in its application to clearly defined issues.

6.5 Environmental offsets

Environmental offsets are a measure designed to compensate for the residual impact of an activity on the environment and avoid net environmental loss. Offsets are applied as a last resort in the mitigation hierarchy, following the identification of measures to avoid and mitigate impacts. Offsets cannot be used to make 'acceptable' an activity assessed as having unacceptable residual impacts (DENR 2020a).

The NT Government has developed a Northern Territory Offsets Framework (DENR 2020a) which comprises a number of related but separate guidance documents and aims to provide transparent and consistent principles for use in the development and design of both compulsory and voluntary environmental offsets. The Offsets Framework considers a '*Territory-specific target-based offsets model*' (DENR and DCM 2020b) to facilitate a strategic and holistic approach to address the most serious environmental threats or broad elements of habitat or biodiversity which are most threatened, values or amenable to recovery. The NT EPA recognises the value of this approach to offsets for seabed mining.

The NT Offsets Principles (DENR and DCM 2020a) focus on the NT context and provide for two offsets policies, one for greenhouse gas emissions and a second for biodiversity offsets. The principles identify three key characteristics, which are of particular importance to the consideration of offsets for seabed mining.

These characteristics are; relatively intact land(sea)scapes that require broad-scale management rather than 'locking-up' an offset area, the absence of ecosystem metrics used in offset calculations and problematic land tenure regimes that make securing land for conventional offsets complex. The NT Offsets Principles also acknowledges a lack of information required to inform the development and design of appropriate offsets (DENR and DCM 2020a).

The challenges of applying offsets to seabed mining are greater again than those of applying offsets to terrestrial activities. Shumway *et al.* (2018) examined research into the international application of marine biodiversity offsets and found complicating key characteristics consistent with those identified by the NT Government in designing offsetting approaches for the NT. Shumway *et al.* (2018) identified two important differences between marine and terrestrial offsets based on their review of national, regional and state policies from 77 countries. The main differences between terrestrial and marine offsets were found to be:

- biophysical differences, including: greater connectivity within the marine environment and therefore containment of impacts; lower likelihood of rehabilitation success; and limited and low resolution of information
- social or governance differences, including lack of private ownership and 'leakage' of impacts outside the activity area, particularly into protected areas.

Addressing information gaps is an obvious priority to improve the development, design and success of environmental offsets. Funding baseline marine inventory and research, or other environmental management measures are, at times, proposed as an offset mechanism for development activities to manage predictive uncertainties. The NT EPA notes, that in some situations, environmental offsets have been valuable in funding collaborative partnerships that deliver environment protection outcomes through enhanced understanding of ecosystem response to dredging pressures (e.g. WAMSI in case study 8). However, the NT EPA considers that environmental offsets are not a substitute for adequate baseline information. Further to this, while the NT EPA considers that 'indirect' offsets that fund research to address uncertainty about environmental values and outcomes cannot be used to secure environmental approvals, there may be circumstances, e.g. WAMSI case study 8, where research can lead to more cost-effective environmental regulation of a known activity. However, over time, the development of improved data sharing and management systems may lead to reduced uncertainty, and therefore an increase in value and therefore, acceptability of research offsets.

This view was echoed by the NZ EPA's Decision Making Committee (DMC) in providing its decision to refuse consent for the marine mining application to mine Phosphate nodules of the Chatham Rise (case study 3). The DMC noted that the proposed environmental package including the Environmental Compensation Trust Fund, Chatham Islands Trust Fund and funding an Environmental Reference Group, were indirect offset measures rather than mitigation measures or direct offsets (NZ EPA 2015a).

Key finding and Conclusion 8

The NT EPA considers that environmental offsets cannot currently be readily or easily applied to seabed mining proposals in NT coastal waters. The collection of pre-impact baseline data does not qualify as an environmental offset.

6.6 Closure and rehabilitation

Closure and rehabilitation are important aspects of mining management, and this applies equally to seabed mining as to terrestrial mining activities. Important considerations for the assessment and approval of exploration and mining activities are whether, following completion of mining, the impacted area can be made stable, safe and non-polluting, and whether any damage to environmental values is reversible. However, the NT EPA acknowledges that closure and rehabilitation of the marine environment is complex and that expectations about outcomes, and therefore approvals, do not readily align with those established for terrestrial environments.

The NT EPA recognises the particular issues and challenges for closure and rehabilitation of mining in the marine environment are due to

- impacts that are not visible from the surface
- high connectivity of the marine environment leading to 'leakage' of potentially significant impacts on multiple environmental values both on and off-site
- limited baseline information about marine ecosystems and processes upon which to base closure criteria
- low certainty about the type and success of environmental rehabilitation required.

In some circumstances, changes to the seabed would occur through natural marine processes over short to long timeframes. However, where the seafloor is removed over extensive areas, or in sensitive areas, rehabilitation and complete biological recovery is likely to be impossible and impacts will be irreversible (section 5).

The NT EPA considers that the extensive capital and maintenance dredging projects previously conducted in the NT (CCNT 1992, NRETAS 2011, NT EPA 2013) and WA (Hanley 2011, WA EPA 2006, 2013) are fundamentally different from seabed mining based on expectations around closure and rehabilitation. Notably, rehabilitation is generally not required for dredging activity as its primary purpose is to maintain open ports and shipping channels.

Rehabilitation success in the marine environment relies on upfront identification of effective mitigation and management actions of the mining activity, well before closure and implementation of rehabilitation actions. Cuvelier *et al.* (2018) provide a detailed list and discussion of actions to support a combined mitigation and rehabilitation approach to deep sea mine closure; the authors recognise that these actions may be applied to other marine ecosystems. Fundamental to this combined approach is the availability of baseline information about marine ecosystems and processes, a clear understanding of the type of mining activity proposed and the associated impacts. Cuvelier *et al.* (2018) note that mitigation and rehabilitation actions often featured comparable positive and negative effects on marine ecosystems, compounding the difficulty of rehabilitation.

Rehabilitation outcomes may be improved by a staged approach to mining incorporating, both mitigation and rehabilitation measures during seabed mining operations, through spatial and temporal management of impacts. The NT EPA considers that such a 'protective' mining approach, based on appropriate baseline information and ongoing risk assessment, would improve rehabilitation outcomes upon closure. This is likely to be particularly important for seabed mining operations where active rehabilitation is unlikely to be practicable or possible. Such methods would facilitate natural rehabilitation such that impacts would be reversed with limited management and are suited where there is a high likelihood of natural recovery. Protective mining methods require upfront information at the planning and operational stages of any mining activities to avoid or mitigate impacts to as low as reasonably practicable.

The NT EPA recognises the importance of clear closure and rehabilitation requirements early in the planning and assessment process. As with terrestrial mining, any seabed mining proposal would require a mine closure plan that includes progressive rehabilitation, leading to self-sustaining ecosystems, and supported by regular robust monitoring to determine rehabilitation success. However, the requirement for upfront detailed information on the marine environment and processes, necessary to inform closure and rehabilitation is paramount due to the likelihood of irreversible change from seabed mining activities.

Further limitations exist around information and knowledge with implications for the application of financial assurance to complete rehabilitation, and conduct post-closure monitoring in accordance with environmental approvals. The MM Act and EP Act both provide for environment protection bonds. Under the MM Act these bonds (securities under that Act) are calculated with reference to the level of disturbance likely to be caused by the mining activity. The quantum of the bond is the amount that would be required to rehabilitate the disturbance at the site.

There is a significant challenge in trying to determine expected closure outcomes and calculate a bond based on level of disturbance within the marine environment. Further work would be required to establish a financial assurance framework for seabed mining that adequately addresses and provides a mechanism to redress the environmental impacts while protecting the interest of government and the community.

General closure and rehabilitation guidance is provided through the Code for Environmental Management of Marine Mining (IMMS, 2011). Best practice mine closure and mine closure planning are also provided for terrestrial environments through the International Council on Mining and Metals guidance on Integrated Mine Closure (ICMM 2019) and Western Australia Department of Mines and Petroleum and Environment Protection Authority guideline for preparing mine closure plans (DMP and EPA, 2015). The NT EPA acknowledges that currently there is no specific guidance on what would be acceptable closure criteria for seabed mining. The NT EPA considers that, in line with IMMS (2011), any industry code of practice should include closure and rehabilitation. Given the novel nature of seabed mining in Australia, the NT EPA considers that a collaborative approach to developing specific closure and rehabilitation criteria and guidance, with substantial industry input and involvement, should be undertaken prior to commencement of a seabed mining industry in the NT.

Key finding and Conclusion 9

Closure and rehabilitation are important considerations for the assessment, approval and management of seabed mining. In the absence of specific guidance, seabed mine closure and rehabilitation should follow the best practice principles of the International Marine Minerals Society Code for Environmental Management of Marine Mining, the International Council on Mining and Metals for Mine Closure, and the WA Guidelines for Preparing Mine Closure Plans.

Requirements to achieve environmental protection outcomes must include: extensive baseline information, appropriate financial assurance, progressive rehabilitation wherever possible, agreed rehabilitation objectives, completion criteria and monitoring of rehabilitation success. These requirements should be captured in specific closure and rehabilitation criteria and guidance developed by government with substantial industry and stakeholder input.

Regulation of seabed mining would need to include the application of a financial assurance framework that adequately protects the interests of government and the community.

Effective rehabilitation and biological recovery is unlikely to be feasible where seabed mining removes or alters extensive areas of the seafloor or for seabed mining proposals greater than five years duration.

6.7 Independent expert advice

Independent expert advisory groups, also known as panels of experts, scientific advisory groups, technical advisory groups, or technical advisory and consultative committees can be an important component of regulating development projects, particularly where there are multiple, complex risks to the environment (e.g. Brodie 2014, Ports Australia 2014, McCook *et al.* 2015).

The NT EPA frequently requires independent oversight by technical experts to promote compliance of impact management activities. For projects that are particularly large or complex and the potential for significant impact is high, the NT EPA recommends the establishment of independent expert advisory panels to address uncertainty about environmental management outcomes (NT EPA 2017a, 2017c, 2018c). Independent experts working to clear terms of reference and within a clear regulatory framework can develop draft policy and technical documents, provide transparent oversight and reporting to advise government and inform regulatory decisions, as well as build community confidence.

Should seabed mining develop in the NT, particularly beyond the scale of a limited number of small-scale projects, the establishment of independent expert advisory groups may be appropriate. The appointment of independent expert advisory groups would assist in making regulatory decisions based on the best available scientific and technical advice and are independent of the proponent. The terms of reference for an independent expert advisory group should be established by the regulator, and set out the terms for: roles and responsibilities; membership; scope; timeframe for commencement; and reporting obligations. The structure of the group and its terms of reference would be reviewed by the relevant Ministers and be based on advice from the NT EPA. For matters of national environmental significance, the Federal Minister for Environment would also be consulted as necessary.

Membership of independent expert advisory groups should comprise suitably qualified and well-respected experts with experience in the science and technology of the relevant ecosystems, processes, impacts and management measures. In the context of NT coastal waters, membership should also include appropriate Aboriginal representation. Sufficient experts should be available, and it may be appropriate to draw from a pool of experts similar to the DMC of the NZ EPA. Independent expert advisory groups should be appropriately resourced and supported to ensure:

- effective protocols are established for the retention of members and documentation of group knowledge
- communication between members is transparent, accountable and inclusive
- publication of collective member opinion and advice
- periodic independent review of group decisions, procedures and performance.

Key finding and Conclusion 10

Independent expert groups can provide valuable advice to regulators and industry during the planning, assessment, operational and rehabilitation stages of seabed mining projects, should seabed mining proceed in the Northern Territory beyond a limited number of small-scale operations.

The cost of funding a proposal specific expert advisory group would appropriately lie with the proponent with its scope and membership determined by the regulator in line with the 'user pays' principle.

6.8 Community concerns

Community concerns about seabed mining in NT coastal waters are ongoing, strong and shared across Australia by individuals and organisations. Concerns focus on the protection of the full range of environmental values of the shallow marine environment. For example, the recent 'Seabed mining threatens Top End treasures' report from the Keep Top End Coasts Healthy collaboration expresses the view that seabed mining would have 'an unacceptable impact on the Top End's unique coastal waters, culture and fishing lifestyle' (Smyth 2020). In a major study of community perceptions about seabed mining in Australia, CSIRO found that 'the majority of the participants were reluctant to see development of seafloor mining in Australia, primarily because of concerns about the industry's potential environmental impact' (Mason *et al.* 2010). That community concern is not new and has stopped coral mining in Moreton Bay (Hogan and Ritchie undated) and supported the NSW Government's rejection of offshore sand mining (State of NSW 2016).

The environmental values of the NT include the strong connection that Aboriginal and non-Aboriginal Territorians, as well as other Australians have with the marine environment. The NT EPA has described the environmental values of the NT (section 4) as the basis for its review into actual and potential impacts from seabed mining and the management of the associated pressures (section 5).

Community concerns exist, in part, from the high levels of uncertainty about actual and potential environmental, economic, social and cultural impacts associated with seabed mining; the availability of effective tools to manage impacts; and the difficulty of detecting and regulating adverse outcomes or impacts in an environment that is not visible.

The NT EPA's review on seabed mining points to examples of established and emerging seabed mining industries and the importance of informed communication with all relevant stakeholders. The review highlights the importance of appropriate information to promote informed and ongoing communication and engagement outside the environmental impact assessment process (section 5.5) and enable evidence-based decisions through robust environmental impact assessment (section 6.2). Munday (2017, Appendix 5) shows that community concerns are best addressed through early and effective consultation, and that this should be achieved through the impact assessment process. The NT EPA recognises that early community engagement and consultation conducted with a strategic long-term view is more likely to achieve positive outcomes (NT EPA 2020b). However, the NT EPA notes that early engagement does not guarantee community acceptance of any given proposal.

The EP Act expressly recognises the importance of community involvement in the environmental impact assessment process and provides for a number of opportunities for public review of environmental impact assessment documentation. The NT EPA provides specific guidance on preparing a public submission at these public review opportunities (NT EPA 2020d). The NT EPA does not consider that these opportunities mitigate or negate the need for proponents to undertake effective and timely engagement with stakeholders prior to, and throughout project development as outlined in its 'Stakeholder engagement and consultation' guidance (NT EPA 2020b).

Opposition to seabed mining in the NT community and elsewhere remains despite the process of environment impact assessments prepared by proponents and approved by governments (KTEHC 2020). This view reflects the sentiment that environmental impact assessment and environmental approvals are just one part of the decision-making process.

The complexities associated with managing community involvement is highlighted by the New Zealand experience where ongoing questions remain about policy settings around public involvement, especially in the case of notification of non-notified consents and evaluation of risk. These questions extend to the role of iwi/Maori in decision-making, recognising their strong voice in respect of marine resources, yet unclear decision-making obligations under existing treaties. The New Zealand Court of Appeal decision released April 2020 (NZCA 2020) clarified these limitations; however, the implications of this decision are ongoing. The EP Act recognises the role that Aboriginal people have as stewards of their country and the importance of participation by Aboriginal people and communities in informing environmental decision-making processes.

In addition to addressing community concerns through timely, transparent, ongoing and meaningful communication and engagement, the NT EPA recognises the value of social and cultural impact assessment as a policy framework to achieve consistent and appropriate consultation.

Key finding and Conclusion 11

The powers afforded by the *Environment Protection Act 2019* to the Northern Territory Government and the NT EPA (section 6.1) provide a strong framework for community involvement in the environmental impact assessment and approvals process and, ultimately, environment protection.

Transparent, meaningful community engagement and consultation should commence early in project planning prior to the impact assessment and approvals process, and extend to project implementation and closure.

Further investigation of learnings from the Northern Territory (Hydraulic Fracturing Inquiry), national (NOPSEMA) and international (NZ and BMAPA) experiences will be valuable to guide the Northern Territory Government's position, implementation and communication pathways.

7 Conclusion

The NT EPA has conducted its review of *'the actual or potential impacts on the environment and other resource industries and methods for managing the impacts of seabed mining'*, in accordance with the request of the NT Government in 2012. Further, the NT EPA provides information and examples necessary to describe the current state of knowledge about the NT's environmental values, including natural resources, likely to be impacted by seabed mining.

The NT EPA review concludes that current knowledge gaps result in uncertainty about the condition of the existing environment, the extent, duration and magnitude of impacts from seabed mining, the ability of industry to manage impacts, and for the environment to recover from impacts.

The significance of impacts from seabed mining, and the extent to which they can be effectively managed, is strongly related to the scale, nature and location of individual seabed mining proposals. The NT EPA considers that there may be circumstances where seabed mining can be environmentally acceptable, provided that proposals are supported by adequate environmental and impact assessment information, comprehensive consultation and engagement, transparent assessment and a clear, robust framework for environmental regulation and compliance to ensure environmental acceptability. There are other scenarios where the scale, nature and location of seabed mining would likely result in proposals with such high levels of uncertainty or residual environmental impact that they are environmentally unacceptable. In such cases, where the information requirements are so extensive and the uncertainty so great, an early decision of unacceptable impact may be appropriate. Further, these proposals may not be financially viable, which is a matter for the proponent to consider.

Where uncertainty exists about environmental values, impacts or management associated with large-scale mining projects, extensive data is required. This data provides information about existing environmental conditions and the extent of potential impacts, including cumulative impacts from multiple stresses or multiple mining projects. The NT EPA considers that this information base does not exist yet in the NT, and must be obtained by strategic, collaborative and long-term baseline data collection, to the extent necessary, for robust assessment of environmental impacts.

The NT EPA considers that, depending on the scale, nature, location of a particular proposal, and where there is an appropriate level of confidence in the information base, best practice management of the impacts from seabed mining could be assessed, and that significant impacts could be managed under the EP Act and EP Regulations. Proposed reforms of the environmental regulation of mining provide an opportunity to consider whether further changes are required to effectively regulate seabed mining. However, irrespective of the level of scientific confidence in the information base or assessment process, or the introduction of seabed mining specific regulation, there is no guarantee that a particular proposal (or the industry) would ever be acceptable to communities of the NT.

Potential environmental regulatory reforms to the MM Act and EP Act should consider how the legislation could be strengthened to ensure relevant and appropriate application to seabed mining. Consideration should be given to specific amendments designed to address marine mining operations.

The NT EPA provides its advice to Government through this review and its key findings and conclusions which identify the next steps required before seabed mining could be considered acceptable and successful in the coastal waters of the NT.

The NT EPA reiterates the importance of having clear policy and guidance to clarify expectations and provide certainty to industry, regulators and the community. The NT EPA is mindful of the significant resourcing implications necessary to achieve a sufficiently robust information base, as noted in this review, to enable an adequate assessment of the potential impacts from seabed mining.

8 Abbreviations and glossary

Abbreviations

AAPA	Aboriginal Areas Protection Authority
ALARP	As low as reasonably practicable
AMZ	Australian Maritime Zone - which comprises Territorial Seas and the Exclusive Economic Zone (EEZ)
ANZECC	Australian and New Zealand Environment and Conservation Council
BMAPA	British Marine Aggregate Producers Association
CRP	Chatham Rock Phosphate
DAWE	Australian Government Department of Agriculture, Water and the Environment (previously DOEE and DOE)
DENR	NT Department of Environment and Natural Resources
DIIS	Australian Government Department of Industry, Innovation and Science
DMC	Decision making committee
DPIR	NT Department of Primary Industry and Resources
draft EIS	Draft Environmental Impact Statement
EEZ	Economic Exclusion Zone, which is the area beyond and adjacent to the Territorial Sea extending to a 200 nm limit from the territorial sea baseline (see Coastal Waters, AMZ and Territorial Sea), and which falls under Australian Government jurisdiction
EIS	Environmental impact statement
EP Act	*Environment Protection Act 2019*
EP Regulations	Environment Protection Regulations 2020
EPA or former EPA	the former Environment Protection Authority established under section 4 of the *Environment Protection Authority Act (repealed)*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
HFI	Hydraulic Fracturing Inquiry (the Inquiry)
ICES	International Council for the Exploration of the Sea
ICMM	International Council on Mining and Metals
ISA	International Seabed Authority
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
JORC	Joint Ore Reserves Committee
KASM	Kiwis against seabed mining
Ma	million years ago
MA	Mining authorisation to enable exploration or mining in areas under reservation

MBSES	Moreton Bay sand extraction study
MM Act	*Mining Management Act 2001*
MNES	Matters of national environmental significance under the EPBC Act
MT Act	*Mineral Titles Act 2010*
NMP	Namibian Marine Phosphate Ltd
NMSC	National Marine Science Committee
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NT	the Northern Territory of Australia including the coastal waters
NT EPA	Northern Territory Environment Protection Authority
NRETAS	Previous NT Department of Natural Resources, Environment, the Arts and Sport
NZ	New Zealand
NZ EPA	New Zealand Environmental Protection Authority
pH	a figure expressing the acidity or alkalinity of a solution, where 7 is neutral, lower values are more acidic, and higher values more alkaline
RMC	Rick Morton Consulting Pty Ltd
ROV	remotely operated vehicle
SAIIA	South African Institute of International Affairs
SIMP	Social Impact Management Plan
SREBA	strategic regional environmental and baseline assessment
TPWC Act	*Territory Parks and Wildlife Conservation Act 1976*
TTRL	Trans-Tasman Resources Limited
UNCLOS	United Nations Convention on the Law of the Sea, 1982
WAMSI	Western Australian Marine Science Institution

Glossary

alluvial	deposit of clay, silt, and sand left by flowing floodwater in a river valley, delta or seabed
biota	biological organisms comprising flora, fauna and algae
coastal waters	coastal waters (3 nm limit) is the belt of water adjacent to the Australian coast (from the low water mark), extending to a 3nm limit from the territorial sea baseline. These waters fall under State and Territory jurisdiction (see territorial sea baseline)
dredge	vessel with various modifications designed to excavate, process, transport and/or dispose of underwater sediments
dredging	method of removal and disposal of underwater sediments from one location to another. The term dredging is generally applied to capital and maintenance works and this review makes the distinction between the

	method and purpose of dredging. Dredging refers to the movement of sediments while seabed mining using dredges refers to the extraction of sediments (see seabed mining)
ecologically sustainable development	development that improves the total quality of human life, both now and in the future, in a way that: maintains the ecological processes on which all life depends, and recognises the need for development to be equitable between current and future generations (EP Act, s4)
environment	all aspects of the surroundings of humans including physical, biological, economic, cultural and social aspects (EP Act, s6)
environmental value	physical, biological, economic, cultural and social elements of the environment
environmental offset	a measure designed to compensate for the residual impact of an action on the environment (EP Act, s4)
government authority	advisory agency or statutory authority (EP Act, s4)
habitat	the natural environment comprising a particular physical structure and composition that supports individual organisms and/or biological communities (e.g. beaches, coral reefs, seagrass beds, mangrove communities)
high quality data	data that comprises core information, collected using clearly articulated sample design, standardised survey and modelling methods and incorporating sufficient seasonal variation (2 to 5 years pre-disturbance)
irreversible	lacking a capacity to return or recover to a state resembling that prior to being impacted within a time frame of 5 years or less (see reversible)
marine	subtidal and intertidal areas and ecosystems
metocean	abbreviation of meteorology and (physical) oceanography often used in offshore and coastal engineering
mitigation hierarchy	the order of applying mitigation and management measures to avoid, minimise, restore and/or offset
precautionary principle	where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
project	an approved and regulated action (e.g. once a proposal has been assessed and approved it becomes a project)
proposal	the proposed action undergoing environmental impact assessment, often referred to by industry as a project
proponent	the company or person undertaking the proposed action
resource industries	industries which rely on healthy ecosystems to provide natural resources of economic value. Resource industries considered in this review are; commercial and recreational fishing, aquaculture, tourism, export, petroleum, bioprospecting and blue carbon
reversible	a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of 5 years or less (see irreversible)
scale	of a seabed mining proposal is determined by duration, magnitude and geographic extent of the mining

seabed	is the geological layers and free sediments of the earth beneath the sea (also referred to as seafloor)
seabed mining	the commercial recovery of minerals and extractive minerals on the surface of, or below the seabed, including exploration and mining activities. Oil or gas recovery and dredging for port development and maintenance are NOT considered to be seabed mining.
sensitivity	of the environment is determined by the location, values and resilience of the receiving environment
significant impact	Significant impact as defined in the EP Act is, an impact of major consequence having regard to: • the context and intensity of the impact • the sensitivity, value and quality of the environment impacted on and the duration, magnitude and geographic extent of the impact.
sub-sea minerals	minerals and extractive minerals from the surface of, or below the seabed
sub-sea mining	preferred term for seabed mining. May be emerging as the preferred term nationally, as it includes consideration of the water column and sediments both on and below the seabed itself
territorial sea	territorial sea (12 nm limit) is the belt of water between the coastal waters and the EEZ, extending to a 12nm limit from the territorial sea baseline, and falls under Australian Government jurisdiction (see coastal waters, AMZ and EEZ)
territorial sea baseline	the line from which the seaward limits of Australia’s Maritime Zones are measured. The territorial sea baseline may vary depending on the shape of the coastline and two types are considered in the NT for the purpose of this review - the Normal baseline (low water line along the coast corresponding to the Lowest Astronomical Tide) and Straight baseline (incorporates straight lines across bays or between islands close to the coast). See Figure 1

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