

Harmful Marine Extractives:

Understanding the
risks & impacts of
financing non-renewable
extractive industries

Dredging & Marine Aggregate Extraction

Acknowledgements

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List of abbreviations and acronyms

CDA	Central Dredging Association
CO₂	Carbon dioxide
CH₄	Methane
DPSIR	Driver, pressure, state, impact and response
EEZ	Exclusive Economic Zone
GAIN	Global Aggregates Information Network
GHG	Greenhouse gas
H&M	Hull and machinery [insurance]
IADC	International Association of Dredging Companies
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organisation
IFI	International Finance Institution
IPCC	Intergovernmental Panel on Climate Change
IRP	International Resource Panel
IUCN	International Union for Conservation of Nature
MSP	Marine spatial planning
NbS	nature-based solution
OECD	Organisation for Economic Co-operation and Development
P&I	Protection and indemnity [insurance]
UNEP	United Nations Environment Programme
UNEP FI	United Nations Environment Programme Finance Initiative
UNEP-GEAS	UNEP Global Environmental Alert Service

Executive summary

The ocean covers the majority of earth's surface, holding 97 per cent of all our water and 80 per cent of all life forms. Major ocean sectors such as fisheries, ports & shipping, marine renewable energy and coastal infrastructure, collectively contribute to a “blue” economy.

According to estimates prepared by the Organisation for Economic Co-operation and Development (OECD), ocean-related sectors contributed approximately USD 1.5trn of global gross value-added in 2010, a figure that is projected to increase to USD 3trn by 2030, with some ocean industries set to grow faster than the global economy.

However, ocean health is under increasing stress, faced with the triple crises of climate change, nature loss, and pollution—leaving the industries, businesses and livelihoods that rely on the ocean exposed to serious risks. While many existing ocean-linked sectors have the potential to contribute positively to a sustainable blue economy, this is not true for all sectors. The extraction of non-renewable marine resources such as oil & gas and seabed mineral deposits in particular poses a significant risk to the ocean and cannot be considered sustainable.

Recognizing that a significant amount of investment and financing continues to be directed towards the exploitation of non-renewable marine mineral resources, UNEP FI has prepared a series of sector-specific briefing papers¹ to explore their social and environmental impacts, with particular reference to the development, operation and closure of each of these sectors, the risks to financial institutions of continued association with these activities, and managing the transition to more sustainable alternatives.

This briefing discusses the potential risks associated with dredging and the extraction of marine aggregates, and how financial institutions should engage with and respond to this sector.

Key takeaways

- It is widely recognized that dredging and the extraction of marine aggregate material is highly damaging to seabed habitats. The resulting substantive (and often permanent) alteration to hydrodynamic and ecosystem processes leads to removal of associated species and broader risks of physical/mechanical stress to marine organisms.
- Despite this, dredging and marine aggregate extraction also underpin a number of sectors that can be recognized as contributing elements to the sustainable blue

¹ The sectors addressed are: (i) offshore oil & gas; (ii) dredging and marine aggregates extraction; and (iii) deep-sea mining.

economy (e.g. shipping, ports, and marine renewable energy). Thus, any investment into those sectors needs to recognize the additional impacts and risks associated with dredging and marine aggregate extraction.

- A significant proportion of dredging and aggregate extraction activity is related to broader capital construction and infrastructure projects. As a result, the material risks to financial institutions and investors specifically from dredging and aggregate extraction, may not be readily apparent because the supply of these resources is often taken for granted without considering the supply chain operations.
- The impacts arising from dredging activities may present a number of risks to financial institutions, particularly where the impacts of the dredging activity are not fully contained within the dredge site, or where dredged material is disposed of at sea.
- Reputational and regulatory risks may manifest themselves in cases where dredging and disposal of dredged material impacts other marine users or where dredging impacts areas of high conservation value.
- Where dredging and aggregate extraction leads to unintended changes to seabed and coastal geomorphological processes, these may exacerbate existing risks to coastal economy and ecosystems creating future liabilities for contractors and investors.
- Despite ongoing needs for dredging and the supply of sand and gravel, options exist for the financial sector to influence and support a transition to more responsible practices and the deployment of dredging capacity towards low-carbon and green coastal infrastructure.
- Financiers and insurers are encouraged to seek out opportunities to partner with relevant organizations to help reduce negative social and environmental impacts from dredging. Several areas may be considered, which represent strong business opportunities for financiers:
 - Focus on green infrastructure and the active development of nature-based infrastructure solutions;
 - Emphasize the importance of marine spatial planning (MSP) and multi-stakeholder decision-making on siting of developments that require dredging in order to minimize harm;
 - Invest in alternatives to aggregate materials for concrete;
 - Promote changes to design and construction methods that reduce the need for marine dredging and sand and gravel;
 - Recognize the important role financial institutions can play in ensuring responsible sourcing in the aggregates supply chain;
 - Reduce the environmental footprint of dredging and application of best practice management to reduce the overall environmental footprint of dredging and aggregate extraction activities.
- Understanding how and where dredging and aggregate extraction sits within a broader project supply chain presents financiers with an opportunity to influence positive change, thereby reducing risks and increasing returns by supporting important infrastructures in their journey towards sustainability.

Introduction

Context

The ocean is a vital driver of planetary systems and a source of economic activity, livelihoods and food security. The Intergovernmental Panel on Climate Change (IPCC)'s 2019 special report on the ocean and cryosphere in a changing climate states: “In addition to their role within the climate system, such as the uptake and redistribution of natural and anthropogenic carbon dioxide (CO₂) and heat, as well as ecosystem support, services provided to people by the ocean and/or cryosphere include food and water supply, renewable energy, and benefits for health and well-being, cultural values, tourism, trade, and transport” (IPCC 2019 pp 15). This dependence on the ocean as a major source of resources and services is projected to continue growing as human populations increase, which by 2050 is projected to reach nine billion.

At the same time, the health of the global ocean is under threat from human activity, with increasing pollution, overfishing, invasive species, physical damage to ocean habitats, unsustainable coastal development and climate change all contributing to the loss of biodiversity and ecosystem services, and to the decline in the environmental health of the ocean. Finance for a sustainable ocean remains limited, with SDG 14 (Life Below Water) receiving the least official development assistance (ODA) of all the SDGs in 2017 (Pincet, Okabe and Pawelczyk 2019). Nevertheless, awareness of the key services and provisions provided by the ocean is increasing, as well as the recognition that continued ocean health decline inhibits prosperity (Laffoley *et al.* 2019).

The sustainable blue economy is an approach put forward by the international community to take into account the health of the ocean as it strives to balance the three dimensions of sustainable development: economic, social and environmental. It is an economy based on circularity, collaboration, resilience, opportunity and interdependence. Its growth is driven by investments that reduce carbon emissions and pollution, enhance energy efficiency, harness the power of natural capital and the benefits that these ecosystems provide, alongside halting the loss of biodiversity.

With appropriate planning, governance and decision-making that involves the broad range of relevant stakeholders, many existing ocean sectors have the potential to contribute positively to a sustainable blue economy. However, this is not the case for all sectors. The extraction of non-renewable marine resources—particularly: (i) offshore oil & gas, (ii) dredging and marine sand & gravel (aggregates) extraction, and (iii) the potential future development of deep-seabed mining—and the inherent impacts of these sectors on environment and society pose a significant risk to the ocean and therefore cannot be considered sustainable.

Given the critical importance of the ocean as a driver of socioeconomic development, it is becoming increasingly important that future investment in those ocean sectors that present the greatest social and environmental risks is replaced by investment in sectors of the blue economy that are rapidly transitioning towards sustainable pathways. In this regard, banks, insurers and investors have a key role to play in financing the transition to a sustainable blue economy, helping to rebuild ocean prosperity and restore biodiversity. Through their lending, underwriting and investment activities, as well as their client relationships, financial institutions have a major impact on ocean health and hold the power to accelerate and mainstream the sustainable transition of ocean-linked industries.

With a significant amount of existing financing still largely directed towards the unsustainable extraction of non-renewable marine mineral resources, UNEP FI considers it important to provide financial institutions with science-based and decision-useful information to support those financial institutions wishing to transition away from, or avoid any involvement in non-renewable, marine extractive activities. Given the substantial differences within the three broad sector categories listed (oil & gas, dredging, and deep sea mining), UNEP FI has prepared a series of sector-specific briefing papers to explore their social and environmental impacts, with particular reference to the development, operation and closure of each of these sectors, the risks to financial institutions of continued association with these activities, and managing the transition to more sustainable alternatives.

About this briefing paper

Purpose and scope

These briefing papers are intended as a practical, working resource for financial institutions to assess their potential exposure to social and environmental risk factors associated with investing in non-renewable marine extractive industries and recommend actions based on indicators of the social and environmental pressures in each sector. They summarize the key relationships between pressures and their associated impacts following a modified Driver-Pressure-State-Impact-Response (DPSIR) framework, building on this understanding to highlight how and why these pressures are material to financial institutions and the types of risk they represent.

The approach taken for these briefing papers is based on:

- How financial institutions should view these sectors, particularly in terms of managing and accelerating the transition away from unsustainable economic activity;
- The avoidance of new financing for the sectors;
- Challenging the existing finance approaches (where these exist) for some of the above activities to minimize harm and mitigate their impact as far as possible; and
- The search for sustainable alternatives and divestment from these activities.

Notwithstanding the need to transition away from and seek alternatives to highly damaging marine extractive activities, in order to secure the long-term health of coastal and ocean ecosystems, dredging and marine aggregates extraction also underpin a number of sectors that can be recognized as contributing elements to the sustainable blue economy (e.g. shipping, ports, and marine renewable energy). Thus, any investment into those sectors needs to recognize the additional impacts and risks associated with dredging and marine aggregate extraction. This briefing paper discusses the impacts and potential risks associated with the removal of marine sediments and aggregates, and how financial institutions should engage with and respond to the dredging/aggregates sector.

Intended audience

The primary audience for this briefing paper is financial institutions (banks, insurers and investors) with exposure to harmful and non-renewable marine extractive industries and those seeking to support the transition away from unsustainable activity towards

a sustainable blue economy. The briefing paper aims to provide an initial framework for this broad variety of institutions to consider how sustainability impacts and risks specific to harmful and non-renewable marine extractives manifest within their own portfolios, as well as the potential business risks arising from financing such activities. Given the breadth of this subject matter and the relevance of sustainability considerations to a broad array of stakeholders, this information may also be valuable to the public sector, intergovernmental organizations, academia, civil society, commerce and industry.

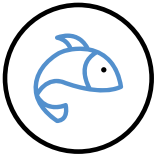
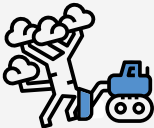
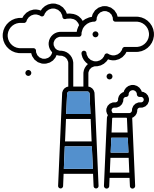
Approach

The information and recommendations in this paper were developed using a bottom-up approach grounded in extensive literature review and expert interviews. Based on this and the latest available science, the drivers of impact in the sector were determined, the pressures exerted by the sector were identified, and these pressures were linked to categories of social and environmental impact. This approach is consistent with the DPSIR² framework developed by L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) in 2004. On the basis of these pressures and impacts, risks and how these are material to financial institutions are articulated.

Table 1 outlines the meaning of the environmental and social impacts discussed in this briefing paper, and provides examples of where they may materialize.

2 DPSIR (Driver, Pressure, State, Impact, Response) is a framework to systematically approach impacts and describe the relationship between human activity and impact. It allows for a more precise assessment and understanding of how actions and activities affect the environment. It is based on a model originally developed by the Dutch National Institute of Public Health and Environment and later adopted by the European Environment Agency (EEA) (IFREMER 2004).

Table 1: Table of impact definitions

Environmental impacts	Description	Examples
 Loss or reduction in marine biodiversity including loss of endangered, threatened and protected species	Loss or reduction of populations of a given species, or of a species as a whole, due to human impact. This includes endangered, threatened and protected (ETP) species as defined by the IUCN Red List of Threatened Species and protections under applicable jurisdictions.	This may result from the impacts of noise or other disturbance that causes individuals to change their behaviour or may result from impacts to the habitats that support these organisms.
 Loss of ecosystem resilience and provision of ecosystem services	Loss or reduction in the ability of an ecosystem to provide specific benefits. These benefits, termed ecosystem services, include provisioning services such as oxygen production and carbon sequestration, as well as regulating services for the climate.	The introduction of pollutants (including suspended sediment) may exacerbate existing impacts and impact key services such as primary production.
 Loss or degradation of coastal and marine habitats	Changes to the physical environment on which life depends.	This may result from physical damage to the seabed as a result of dredging or mineral extraction.
 Reduction in animal welfare	The consequences of human activity on the health of individual animals, both wild and farmed. It complements the impact on biodiversity, which looks at impacts on groups of animals and species. These impacts are closely linked and often appear together.	Reduction in animal welfare includes sources of stress for many organisms—including noise pollution from vessels and construction activity.
 Increased GHG concentrations	The role of greenhouse gas (GHG) emissions in contributing to climate change. While human activity affects the climate in many ways, as well as the capacity to offer resilience or adapt to climate change, this impact covers the output of GHG emissions into the atmosphere itself, raising concentrations that result in a changed climate.	This results from a broad range of human activity, including emissions from vessels and offshore mineral extraction activity (including flaring and venting of gas from offshore installations).

 Changes to marine biological, chemical and geological cycles	The consequences of changes to biogeochemistry—the natural processes within the ocean that play a role in regulating the planet, such as the water, carbon and nitrogen cycles. While dependent on water chemistry, marine life also plays a role in these cycles. As such this is closely linked to loss of ecosystem services—though the consequences differ, focusing specifically on these global chemical regulation processes.	This may result, for example, from removal of specific mineral layers from the seabed or from the release of contaminants such as heavy metals to the water column.
Social impacts	Description	Examples
 Violation of human rights including rights of indigenous communities	The violation of any human right, including the rights of indigenous communities, in the process of development or financing of a given sector. This includes both specific and clear examples of human rights violations as well as more systemic human rights violations such as the impact of inequality of opportunities between social groups and genders.	This may result, for example, from the exclusion of local communities from sites of specific cultural significance due to the occupation of the site for mineral processing purposes.
 Reduction or loss of access to sustainable and inclusive livelihoods	The consequences of development on an individual or community's ability to attain and maintain livelihoods.	This impact may cover the consequences of pollution preventing a community's ability to harvest living marine resources upon which their livelihoods depend, or the construction of mineral processing infrastructure physically preventing coastal communities' access to the marine environment.
 Increased likelihood of injury, disease or loss of life	The consequence of an activity on the short- and long-term physical health of an individual or community as a result of development.	This may include the risks of injury or fatalities associated with high-risk offshore extractive industries as well as the impacts of increased levels of atmospheric pollution on coastal communities and workers.

 Economic damage and loss of productivity	While all these impacts ultimately lead to some form of economic damage and loss of productivity, this impact specifically examines the direct, proximate consequences of a given pressure on the economic output and productivity of an individual or an enterprise.	This may include economic damages and losses because of a loss of livelihoods or a reduction in attractiveness of a coastal community due pollution or the development of new infrastructure.
 Inequality of opportunities on the basis of age, sex, disability, race, ethnicity, origin, religion or economic or other status	Closely linked to the impact of human rights violations, this impact looks more specifically at those instances where the development of a sector reinforces or establishes inequality of opportunities within and between communities and between individuals.	This may include gender imbalances in corporations across blue economy sectors, or racial discrimination in employment. This may also include unequal distribution of costs or benefits associated with a development.
 Perceived degradation in cultural value of the environment	The degradation of cultural value perceived by communities because of development or operation of a sector of the blue economy. This is distinct from the economic implications of the impact, and covers changes to the non-monetary value of an environment for local stakeholders.	This may include, as an example, the destruction of coastal sites of cultural or historical significance to make way for coastal development of mineral processing facilities.

Pressures and impacts were mapped against current and potential risks to financial institutions, with the materiality of these risks assessed. These risks cover five broad categories, as highlighted in Table 2.

Table 2: Table of risk descriptions

Risk	Description	Example
Physical	The risk to physical assets, often related to the impacts of climate change	Liabilities arising as a result of damage to sites of marine cultural heritage.
Operational	The risk of interruption of ongoing activities, including supply chain operations, logistics and other disruption of business operations	Loss of licence to operate or changes in project requirements due to environmental concerns.
Market	The risk of changes to the market served by a sector or development, including shifts in demand or supply	Major environmental incidents may result in significant financial liabilities for the operator/company to remedy the damage.
Regulatory	The risk of changes in the regulatory environment affecting the sector in question, including changes in how it may be taxed or subsidized	Policy/regulatory reforms as a result of increasing opposition to extractive industries. Risks of financial penalties for poor environmental performance.
Reputational	The risk of change in public perception, manifesting as public campaigns, boycotts or purchasing decisions	Negative press coverage associated with the loss of biodiversity or marine habitats associated with extractive activities. Economic losses experienced by other marine users resulting in local opposition.

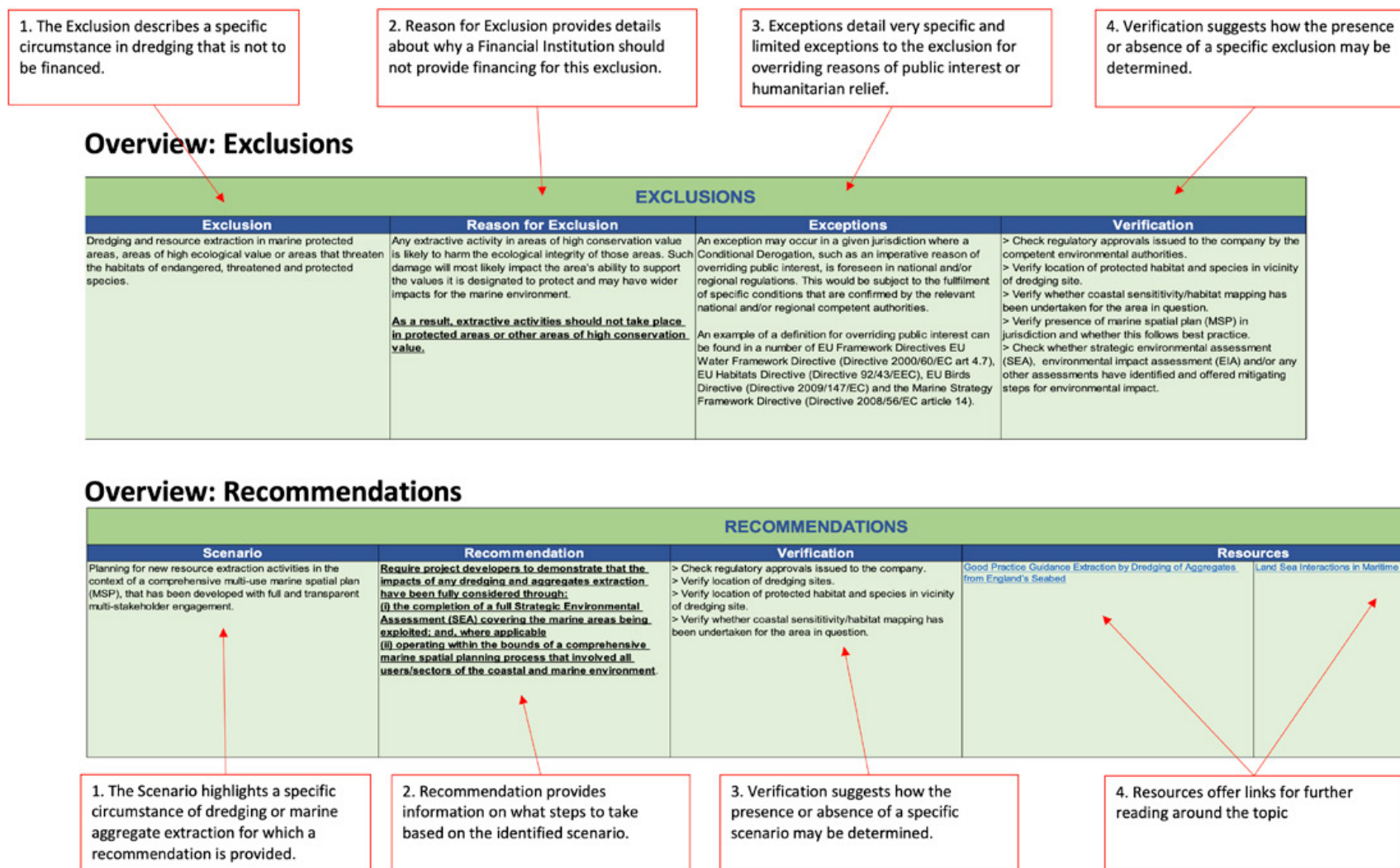
The summary of key pressures, impacts and risks forms the basis of this briefing paper, and inform the recommendations and exclusions for financial institutions.

Sector-specific recommendations and exclusions

It should be noted that the process of dredging and marine aggregate extraction are inherently harmful to the marine environment. In light of this, these activities are not considered as part of the sustainable blue economy. However dredging, specifically capital and maintenance dredging, underpins a number of economic sectors that are central to the sustainable blue economy - notably ports, maritime transportation and marine renewable energy.

For this reason, UNEP FI has developed the **Recommendations and Exclusions Annex** (Figure I) for the briefing paper that describes key social and environmental concerns associated with dredging, what activities to **exclude** from financing by default, and what **recommendations** can be made to financial institutions to minimize harm from dredging and, wherever possible, identify and finance alternatives to this harmful activity.

Figure I: Recommendations and exclusions annex explained



Sector overview

For the purposes of this briefing paper, marine dredging refers to the removal or transport of sediments, rocks and debris from the seabed, either in near-shore (estuarine and coastal) or in offshore (shelf) waters. Broadly speaking dredging serves two purposes:

1. **Recovery of material:** Most commonly sand and gravel (hereafter referred to as “marine aggregates”) and other non-aggregate mineral resources. Where material is dredged to recover materials of economic value, this can be regarded as a form of seabed mining; and
2. **Deepening water:** If the natural depths in an area are increased for the first time the activity is known as “capital” dredging, often associated with port developments. Conversely, where there is an ongoing requirement to ensure minimum clearance for both navigation and berth operations, “maintenance” dredging is undertaken to remove accumulated sediment.

These two purposes are not mutually exclusive, since capital (and in some cases maintenance) dredging may generate material that has other beneficial uses similar to aggregates.

Dredging

Capital dredging

Coastal development and infrastructure projects (including port developments) often require the removal and redistribution of large amounts of previously undisturbed sediment to increase water depths or create land. This is referred to as “capital” dredging and may require the removal of deep layers of either soft (silt and mud) or hard (mudstones or rock) sediment. Capital dredging is often associated with port developments, including the construction of new harbours, ports, basins, canals and waterways.

In tropical regions, a specific concern that requires consideration is the dredging of coral reefs to accommodate new tourism developments (e.g. Cayman Islands, Maldives). Coral reef systems are under significant threat from the impacts of climate change and other pressures such as pollution and destructive fishing methods. Dredging of coral reefs increases their vulnerability to other threats thereby risking the livelihoods that depend on the valuable services such ecosystems provide (UNEP and PIANC 2010).

Maintenance dredging

Deepening below pre-existing seabed levels can result in sediment becoming trapped in the deepened area, as a result of continuous transport of mobile sediment from the broader estuarine catchment/basin. The siltation then has to be removed to maintain the required depth. This type of dredging is known as “maintenance” dredging. In some situations, maintenance dredging may be required only once every few years. In others, it may be a continuous operation throughout the year. Maintenance dredging is a necessity for almost every navigable waterway and port in the world.

Marine aggregate extraction

Marine aggregates are non-metallic sediment deposits, consisting of sands, gravels, and shells/shell debris, formed as a result of sedimentary and hydrodynamic processes. Their extraction takes place globally in tidal channels, deltas, inlets, continental shelves, and coastal beaches (Baker *et al.* 2016), normally in water depths of less than 50m (International Council for the Exploration of the Sea [ICES] 2016).

Mineral aggregates (sand, gravel, and crushed rock) have been used historically for global economic development. They are used in land reclamation, for major infrastructure projects and as a raw construction material, including to manufacture concrete. Aggregates are estimated to be the fastest-growing material group extracted over the twentieth and twenty-first centuries and are currently the most-extracted and consumed material group worldwide (UNEP 2019a).

The global demand for construction aggregates

According to the Global Aggregates Information Network (GAIN), aggregate mining is projected to increase significantly, with global demand reaching 60 billion tonnes per annum by 2030. This is mainly a result of rapid economic growth in Asia, Africa and Latin America. The manufacture of concrete—a key end use of construction aggregates—requires cement, and demand for cement in China alone has increased exponentially by 540 per cent in 20 years (International Resources Panel [IRP] 2019), while use in the rest of the world increased by 60 per cent.³

Until recently, sand and gravel were primarily extracted in land quarries and riverbeds in many parts of the world. However, while the extraction of marine aggregates is an established practice in many countries (particularly in Europe), a shift to marine and coastal aggregates mining has occurred elsewhere, as a result of declining inland resources and the increase in demands to reclaim land to support major infrastructure projects or expand coastal urban areas (UNEP Global Environmental Alert Service [UNEP-GEAS] 2014; UNEP 2019a). Some sands (e.g. most desert sands) are also unsuitable for concrete and land reclaiming, as the wind erosion process forms round grains that do not bind as well as sands formed by wave action (UNEP 2019a). In many countries, the extraction of marine aggregates for uses other than coastal infrastructure and protection works is prohibited (UNEP 2022).

According to the International Council for the Exploration of the Sea (ICES) (2016), there are three main uses for marine aggregates, namely:

- i. construction, mainly for making concrete;
- ii. land reclamation, infilling of docks, road base, and other ground works; and
- iii. coastal protection in both recharge and coastal feeding (e.g. beach nourishment).

3 For each tonne of cement consumed in concrete, the building industry needs about six to seven times more tonnes of sand and gravel.

In addition, small quantities of marine sand and gravel are used in agriculture to improve soil structure and as cover for subsea pipelines. Marine sand and gravel are also being used to construct concrete gravity-base foundations used for offshore wind turbines.

The increase in replenishing beach sediment for tourism in many parts of the world (for example the Middle East, South East Asia and the Caribbean) and more importantly as a resource to support coastal protection strategies in the context of anticipated sea level rise as a consequence of climate change has fed demand for marine sand. There is a clear and deep linkage here with the Diving Deep guidance for financial institutions developed by UNEP FI, notably the chapter on coastal resilience: infrastructure and nature-based solutions (UNEP FI 2022). This chapter and its associated recommendations for financial institutions explores sustainability considerations for finance for coastal resilience as well as some of the trade-offs and co-benefits associated with human-built (grey) versus nature-based (green) infrastructure solutions.

Global extraction of sand

Despite the absence of precise global statistics, UNEP reports that between 40 and 50 billion tonnes of aggregate (from both marine and land sources) are extracted globally each year, accounting for up to 85 per cent of the weight of minerals mined annually (UNEP 2019b). Up to 30 billion tonnes of this is used by the construction industry to produce concrete and asphalt (UNEP-GEAS 2014). This demand, coupled with lax regulations and enforcement in some countries, has created a significant global black market for sand (in particular) characterized by illegal extraction and trading and even violence against local people engaged in anti-extractive activism (Bisht 2021).

The impacts of increased marine aggregate extraction fuelled by this growth in demand, exacerbate many of the other threats facing global marine ecosystems. As a result, there is a need to identify and secure alternative supplies of material to satisfy global demand and to ensure that those marine aggregate resources that are exploited are done so as responsibly as possible.

The Nature of Marine Aggregate Deposits

Most aggregates are landed ashore for processing/use on land. An exception to this is the direct application of sand from offshore sources for land reclamation, to temporarily refill eroded beaches or to create new beaches.

The Nature of Marine Aggregate Deposits

On a human timescale, sand and gravel deposits can be considered **inactive** or **active**. Inactive deposits are static and lie outside of the influences of the present-day sedimentary regime. In contrast, where sand and gravel deposits are subject to modern erosional and depositional processes, they can be considered active and dynamic.

Some environments where active movement occurs are more dynamic (e.g. estuaries, rivers, deltas, deserts, and beaches), while others represent lower energy regimes (e.g. the offshore marine environment). Source: UNEP (2022).

In addition, a significant proportion of material derived from capital and maintenance dredging (fine sands, silts, and clays) may also either be used directly as engineering fill material (e.g. in reclamation) or in the construction of coastal structures, the creation of bunds, beach replenishment etc. This depends to a large extent on the environmental suitability, its mechanical properties and whether an appropriate project is available to accept the material.

Where there is no alternative use for the dredged material, as is the case with a lot of port maintenance dredging spoil, the material may be transported for disposal offshore in designated marine disposal sites. According to the UN Atlas of the Oceans, 80–90 per cent of the material dumped at sea results from dredging and currently amounts to hundreds of millions of tonnes a year. Of the total material dredged, probably two-thirds is associated with operations to keep harbours, rivers and other waterways from silting up (UN 2022), and is generally released from discharge pipes, barges or hoppers. Open-water sites can be either dispersive or non-dispersive (retentive) depending on whether the sediment is transported out of the site or remains within the designated boundaries. Generally, only clean or mildly contaminated sediments are disposed of in this way, although the disposal of highly contaminated material does occur (CDA 2021).

International Regulation for Dumping of Waste at Sea

The dumping of all waste at sea is internationally regulated under the International Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (known as the London Convention). A number of regional legal instruments, such as The Convention for the Protection of the Marine Environment of the North-East Atlantic ['OSPAR Convention']; and The Convention for the Protection of the Mediterranean Sea Against Pollution [Barcelona Convention], also address the disposal of waste at sea and establish legal requirements for the effective management and monitoring of the environmental impacts of at-sea disposal.

Parties to these instruments are required to assess applications for ocean disposal of dredged material based on both the 'precautionary principle' and the 'polluter pays principle' and to control ocean disposal via permits and permit conditions.

Key environmental and social impacts and dependencies

Dredging is a four-stage process:

- i. **loosening** the material;
- ii. **extraction**—bringing the material to the surface;
- iii. **transportation**; and
- iv. **utilization/disposal**.

With certain types of marine aggregate extracted for construction, some form of primary processing might also take place on the dredging vessel/dredger before transportation.

While impacts to the environment occur at each stage, by far the biggest impacts are associated with extraction, which may last for a few days or weeks (in the case of maintenance dredging) or for several decades (in the case of aggregate dredging).

In developed economies, the permitting and monitoring processes for controlling dredging and aggregate extraction may be easily controlled since most of these activities fall within a state's territorial waters/EEZ, and as such may be subject to the environmental regulatory framework of the applicable host country (Fauna & Flora International [FFI] 2020). This may not be the case in developing economies, most of which do not have robust permitting and monitoring systems to manage the extraction of marine aggregates. Combined with a lack of regulation, this often leads to informal and unregulated extraction.

Extraction impacts

The best-documented impacts associated with dredging and aggregate extraction concern aggregate-extraction in European waters (ICES 2016). The nature and scale of potential impacts from marine aggregate dredging in temperate waters are, therefore, well described and broadly comprise:

- direct or “primary” impacts caused by the direct disturbance of the dredge head on the seabed; and
- indirect or “secondary” impacts that occur beyond the boundary of the dredge site as a consequence of the suspended sediment generated through the extraction process.

However, it should be noted that the environmental impacts in some other regions (e.g. tropical waters) need further research, in particular with regards to marine ecosystems that are significantly different from those in temperate waters. Figure III...

Direct impacts

The main direct impacts caused by dredging and marine aggregate extraction are due to the passage of the dredge over the seabed resulting in the direct disturbance and removal of habitats in rivers, deltas and coastal areas, and associated benthic organisms within the active dredge zone (Todd *et al.* 2015). The resulting substantive alteration to hydrodynamic and ecosystem processes leads to removal of associated species and broader risks of physical/mechanical stress to marine organisms (Manap and Voulvoulis 2015). This will be true for both aggregate and non-aggregates sediment dredging.

The extent of these biological, physical and hydrodynamic impacts, and the ability for areas to recover following disturbance, varies considerably and is subject to many factors, including:

- the physical characteristics of the seabed material,
- the intensity of the dredging activity,
- the “resting” period between dredges, and
- the status of surrounding habitats and the biodiversity they support.

However, broadly speaking, aggregate dredging can be expected to result in a major suppression of species diversity, population density and biomass of invertebrates that live in seabed deposits that have been dredged (Newell 2013).

In cases where dredging results in a permanent change to the sediment composition (i.e. of substrate characteristics surrounding the dredging site) any recovery may alter the nature and diversity of benthic communities and their composition (e.g. decline of individual density, species abundances or biomass) (OSPAR Commission 2004).

A recent study published in the journal *Nature* (Sala *et al.* 2021) has also suggested that significant amounts of stored carbon can be released from the seabed sediment into the water, as a result of seabed disturbance (in the case of the *Nature* study, by bottom trawling). In the current context of global climate change, the implications for seabed mining contributing to carbon emissions is a cause for concern.

Physical impacts from marine aggregate extraction can also arise cumulatively with other seabed activities, such as offshore wind turbine construction, cable or pipeline laying, or fish trawling.

Indirect impacts

Secondary impacts are mainly generated by local resuspension of sediments and increase of turbidity from the dispersing plume, and from the deposition of material mobilized by the dredging process (Newell 2013). Sediment plumes can also be generated during the initial screening and dewatering process on the dredge barge/vessel. Over time these plumes can extend many kilometres from the dredging operations,

depending on the quantities and grain-size composition of the dredged material and local hydrodynamic conditions (Wenger *et al.* 2017). The plumes may include toxic metals and result in effects on marine organisms downstream of the plume and consequential effects on the food chain including birds, fish and marine mammals.

Where dredged material is contaminated (as is often the case with the removal of soft fine during maintenance dredging in port areas) the potential toxicity associated with the release and redistribution of contaminants (such as heavy metals, petroleum hydrocarbons and organo-pesticides) may be a particular cause for concern, particularly where those toxins may directly impact economically valuable marine living resources (e.g. shellfish beds).

In addition, indirect and long-range impacts on the physical environment can potentially result from:

- i. changes in wave transformation processes due to the altered seabed bathymetry;
- ii. reduced shelter afforded to adjacent shorelines by dredged banks and bars;
- iii. drawdown of sediment from the shoreface or seabed to infill dredged areas;
- iv. changes in tidal currents; and
- v. alteration of regional sediment transport pathways and the supply of sediment to adjacent sandbanks or beaches (Cooper and Brew, 2013).

Moreover, extraction from active aggregate deposits resulting in changing rates of mineral transport (e.g. in rivers or in coastal and nearshore marine zones) could lead to erosion threatening communities and livelihoods—not just at the point where extraction is occurring, but also downstream in the affected system (UNEP 2022). Where these impacts are not correctly modelled and anticipated, significant downstream coastal impacts may occur—including increased coastal erosion and inundation—threatening the integrity of coastal infrastructure and coastal communities. Extraction from active aggregate deposits therefore requires careful assessment, mitigation, and management.

A range of additional and significant impacts may be caused by underwater noise, light and physical disturbance to marine organisms, particularly to those that are higher in the food web such as fish, marine mammals and birds. More broadly, impacts associated with aggregate extraction may have negative impacts on adjacent coastal communities and those communities that rely upon marine resources. For a comprehensive overview of the full range of impacts associated with aggregate extraction see the report published by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP 2019).

The impacts associated with aggregate extraction (primarily sand) has recently been recognized during the 2021 IUCN World Conservation Congress, which adopted Motion 033 calling on all state members to ensure *inter alia* that the management and regulation of sand extraction activities is carried out in a sustainable way.⁴

4 iucncongress2020.org/motion/033.

There is also a broader equity dimension as to “who” benefits from sand mining, and who doesn’t—e.g. sand being dredged for beach replenishment of private resorts at the expense of ecosystem health on which local communities rely for subsistence, livelihoods and coastal protection.

Transportation impacts

In addition to the normal environmental impacts that are associated with maritime transport (as reported in *Turning the Tide*) such as atmospheric emission, underwater noise, physical disturbance and marine pollution, screening and dewatering of cargo may take place on the barge/hopper or even during the transport phase.

Screening is first performed to remove debris and sometimes separate the dredge material based on particle size for an anticipated end use or subsequent treatment. Sediment and debris removed from barges after mechanical dredging or sediment slurries pumped from hydraulic dredging can be processed through mechanical screens to separate materials by particle size.

Dewatering to remove excess water, which usually occurs after screening, is typically performed on the barge to reduce the volume of material to be handled ashore. The most common and lowest cost method is to place dredged material into the barge hopper and allow gravity to separate the sediment particles. After settling, the overlying water (supernatant) can be removed by slowly draining over an outlet weir or the cargo can be drained through the bottom of the hopper.

Both of these processes add to the potential release of sediment plumes to the marine environment.

Impacts associated with utilization and disposal

Most aggregate and non-aggregate minerals are landed ashore for use onshore. However, non-aggregate dredging material may either be used directly as engineering fill (e.g. in reclamation) or, as is the case in most maintenance dredging spoil, transported for disposal offshore in designated marine disposal sites. This can happen when the material is not suitable for utilization or no alternative beneficial uses can be identified. An exception to this is the use of sand from offshore sources to restore eroded beaches (nourishment) or to create new beaches.

Handling and utilization

Other than screening for particle size, aggregates require very minimal processing. Ready-mixed concrete and concrete products are the main uses of marine aggregates, and many wharves in Europe and North America now incorporate manufacturing facilities.

At-sea disposal

Dredge spoil—although sometimes used for local land reclamation or deposited on land—is most often deposited at sea.

One of the main concerns over dumping is the generation of sediment plumes from the dumped material. This can lead to increased levels of turbidity, which may also affect organisms that are light-dependent, smother organisms and interfere with respiration and feeding mechanisms. Of greater concern is the potential mobilization of contaminants such as heavy metals and TBT (tributyl tin)⁵ into the water column. This can lead to increased availability of contaminants to the food chain. Dumping sediments on the seabed may also smother and crush organisms living on the seafloor and may cause changes in benthic habitats and biological communities (OSPAR Commission 2021).⁶

Social impacts of sand mining

In addition to the broad range of environmental impacts associated with dredging and marine aggregate extraction, there is growing evidence of the social impacts associated with the illegal trade in sand. Sand mining and its associated activities serves as a source of livelihoods for entire communities, but it can also trigger conflicts and violation of human rights. Although many countries have laws to regulate the extraction of sand and other aggregates, in many cases these are enforced poorly or not at all.

In some countries, the mining of sand from beaches and coastal areas presents an important source of income for local communities. This can place them at risk of unscrupulous operators resulting in human rights abuses (such as violence against those opposing sand mining, displacement of local communities from areas rich in sand and poor/unsafe employment practices) as well as environmental damage that threaten the livelihoods of local people (UNEP 2019a). For example, the practice of sand mining has spelt disaster for fishing communities in Cambodia. For more than a decade, sand mining in Cambodia has contributed to the collective poverty of fishing communities as well as displacement (Hubler and Pothen 2021; Lowe 2018).

5 TBT is a banned biocide capable of causing severe harm to the marine environment.

6 ospar.org/work-areas/eiha/dredging-dumping

Table 3: Pressure and impacts of the dredging and aggregate extraction sectors

Pressures	Impacts	Explanation
Seabed disturbance and disruption of habitat		The removal of seabed material results in the direct loss of benthic habitats. The discharge of sediments during dredging and product screening/processing may also cause changes to adjacent benthic habitats through increased sedimentation, smothering and changes to the sediment structure.
		Disturbance to seabed habitats will result in the direct loss of organisms on those habitats. This habitat damage may result in long-term loss of biodiversity from the dredge area and ongoing dredging activities will make it difficult for natural processes to support recovery of dredged areas.
		Physical disturbance to habitats, increased turbidity and changes to ecosystem structure may all result in less resilient ecosystems.
		The removal of aggregates, particularly from near-shore environments, may lead to changes to coastal sedimentation processes resulting in increased rates of coastal erosion, scouring, inundation and threats to the integrity of coastal infrastructure and assets.
Disruption to wildlife		Noise generated during dredging and shipping activities can result in changes in the behaviour of some animals (particularly marine mammals and seabirds), with some organisms entirely avoiding an area that may be critical to their life cycle (e.g. a feeding ground). Physical damage to hearing and disruption to communications may also result from high levels of noise.
		Vessel movements within and to/from dredging sites can result in collisions with marine life, notably large fish, turtles and marine mammals.

Pollution and water contamination		Discharge of pollutants, particularly those containing nutrients, can encourage the proliferation of some species at the expense of others resulting in less species diversity and a less healthy ecosystem. This may directly impact productivity and impact marine food chains.
		These changes may also lead to changes in the fundamental structure of some habitats, e.g. through the proliferation of macro-algae. Spills of fuel oil, diesel or hydraulic oil can impact wildlife (such as sea birds and marine mammals) through direct oiling and ingestion. These impacts can lead to high levels of mortality to wildlife which could impact species of high conservation value (i.e., those considered endangered or vulnerable). Oil spills can lead to smothering and toxicity of coastal ecosystems, particularly low-energy ecosystems such as mangroves and wetlands, causing damage to vegetation and long-term changes in habitat structure. Depending on the level of pollution, recovery from this type of damage may take many months or even years.
		The mobilization of sediments from polluted areas (e.g. port basins) and the discharge of sediment from placer mineral mining operations may result in the discharge of high levels of pollutants to the marine environment. This may directly impact productivity and impact marine food chains.
		Oil spills may significantly impact marine living resources (e.g. fisheries) making them unavailable for exploitation. Similarly, oil pollution may impact other economic sectors of the blue economy such as tourism beaches and infrastructure.
		The discharge of contaminants to water (particularly relating to sewage) is generally culturally unacceptable and may impact coastal communities' ability to utilize coastal resources. This includes the transfer of pathogens to the marine environment, which may cause sickness or render shellfish unsafe to eat.
Air pollution		Aqueous CO ₂ emissions, owing to increased carbon metabolism in the sediment in the first year after dredging. Reduced sequestration of carbon by photosynthetic organisms such as seagrasses when impact by dredging works.
		The discharge of air pollutants to the atmosphere emissions from dredging vessels may contribute to changes in the chemical composition of the sea and the health of all marine life. Pollutants that alter marine biochemistry include CO ₂ , SO _x , NO _x , untreated ballast water and fuel residue.
		All ships burn fuel to generate power. GHG emissions from fuel combustion contributes to global warming and acidification, resulting in storm surges, sea level rise, and coastline erosion. Dredging works can also affect GHG through the impact on coastal vegetation and marine photosynthetic organisms such as seagrasses.

Use conflicts		Dredging can cause conflict with other marine users. The allocation of areas for dredging, and the dredging activity itself, can result in large offshore areas being unavailable for other productive uses (e.g. trawling).
		Temporary loss of access to marine areas may directly impact other users' ability to carry out their own economic activities effectively resulting in lower economic returns than normal. Damage to habitats and the resulting losses of biodiversity in those areas reduce their ability to support other productive sectors.
Social and economic conditions		Coastal dredging and the potential changes to coastal processes may permanently damage or destroy sites of cultural significance (e.g. historic shipwrecks, military war graves and palaeo-landscapes). Illegal sand mining has resulted in violence against local communities in some parts of the world.

Relationship to sectors of the blue economy

In addition to the impacts outlined above, dredging and aggregate extraction activities may have negative effects on blue economy sectors if they are not regulated or managed effectively, including:

Fishing: physical disturbance and damage to the benthic environment that destroys key fishing grounds and habitats—particularly those that support spawning activity or nursery areas for key species. Increased sedimentation may impact areas beyond the area of dredging activity resulting in smothering of seabed resources, trophic changes and avoidance of certain areas by mobile species. The disposal of contaminated dredge material may also adversely impact offshore fishing grounds.

Shipping: While much dredging is related to maintaining shipping routes, dredging activity may cause temporary displacement for shipping.

Tourism: May cause short-term loss of amenity due to increased turbidity of water. Longer term impacts may include loss of beach sediment, erosion and damage to coastal infrastructure and loss of critical habitats that support marine tourism (e.g. coral reefs).

Coastal infrastructure: Aggregate extraction (particularly sand) can either contribute to coastal infrastructure (as in the case of beach replenishment or use of sand motors (UNEP FI 2022) or present a risk to infrastructure where downstream impacts such as erosion and inundation result from offshore sand extraction.

Energy: May conflict with and bring benefit to energy development. It brings benefit by seabed intervention for offshore energy facilities and might impact through multi-use conflicts for the same maritime space.

Outlining materiality

A significant proportion of dredging activity is related to broader capital construction and infrastructure projects. As a result, the material risks to financial institutions and investors associated with the direct and indirect impacts of dredging may not be readily apparent, because the availability and supply of these marine resources are often assumed to be available.

In the case of dredging for the purpose of deepening water (for ports and port approaches) the precise location, timing and nature of the dredging are, more often than not, dictated by the operational/safety requirements of the port in question and are, therefore, largely beyond the control of financial institutions. Dredging for the purpose of extracting marine aggregates may be more discretionary, since there may be alternative locations where dredging can take place and the timing of dredging can be planned to minimize disruption and environmental impacts. That said, aggregate extraction is primarily dictated by the geographic distribution of the resource. Furthermore, in some parts of the world, where marine spatial planning arrangements are well developed, regulatory and marine planning constraints may dictate that aggregates may only be removed from specific locations on the basis of social and environmental considerations.

The impacts arising from dredging activities may, therefore, present a number of risks to financial institutions, particularly where the indirect impacts of the dredging activity are not fully contained within the dredge site, or where dredged material (particularly highly contaminated sediment) is disposed of at sea. Reputational and regulatory risks may manifest themselves in cases where dredging and disposal of dredged material impacts either other marine users (e.g. fishing and shellfish culture), coastal communities (coastal erosion) or where dredging impacts areas of high conservation value. Similarly, in instances where extraction of aggregates leads to unintended changes to seabed and coastal geomorphological processes, these may exacerbate existing risks to coastal infrastructure and coastal communities and create future liabilities for contractors and investors alike as well as creating significant potential liabilities for insurers. With the expectation that coastal areas are at increased risk due to rising sea levels associated with climate change, there is little question that sand in coastal areas will play an increasingly greater role in determining the amount of damage from floods and erosion (Leal Filho *et al.* 2021).

Many of these impacts can be reduced or managed with planning, modelling and the application of robust environmental performance standards. Financiers must require accountability from port operators, developers and construction companies to ensure regulatory compliance and, especially, social and environmental best practices—including measures to ensure the responsible sourcing of the mineral resources required—to

minimize risks while delivering projects. A recent study undertaken by UNEP proposes 10 recommendations and associated actions that can be taken at different levels to make the extraction of aggregates more sustainable (UNEP 2022).

The nature of dredging, and its nexus with broader infrastructure and capital works activities, suggest that comprehensive due diligence of the entire supply chain is a prerequisite for financial institutions investing in, or otherwise supporting, construction works that require dredging, reclamation or the use of mineral aggregates either for coastal development purposes (e.g. replenishing of eroded beaches for coastal defence purposes), or as a core ingredient for concrete. This could be supported by requiring major projects to provide detailed construction material resource and supply plans to detail what volumes of construction materials will be required to deliver the project and where they will be sourced from—which can be subject to external audit. In this context, financial institutions are encouraged to examine the recommendations for coastal resilience: infrastructure and nature-based solutions in UNEP FI's *Diving Deep* guidance (UNEP FI 2022) for further support on this topic.

Financiers must require accountability from developers, port companies and dredging companies, to ensure regulatory compliance and, especially, social and environmental best practices are adhered to throughout the supply chains they employ. This must increasingly include a focus on identifying and testing alternative materials (such as recycled construction materials) as a way to reduce the overall pressure on marine resources.

The impacts above create a number of material risks to financial institutions, notably in the realm of reputational and regulatory risks as well as operational risks. Table 4 builds on the information set out in the previous section and summarizes these risks.

Table 4: Overview of dredging and aggregate extraction risks and materiality

Pres-sures	Impacts	Risks	Explanation
Seabed distur-bance and disruption of habitat	   	Reputational	Dredging in or near areas of high conservation value or critical habitats, such as coral reefs and coastal wetlands, may become a significant source of civil society campaigning and public pressure. Reputational risk from civil society action concerning ecosystem damage may lead to loss of social licence to operate.
		Regulatory	Poor environmental controls and/or damage to marine habitats and biodiversity loss increase the risk of additional regulatory controls being imposed as well as legal liability for the costs of damaged ecosystem services and use conflict with other industries (e.g. fishing, tourism).
		Operational	Concerns about the potential damage to key habitats and resources may lead to demands for project design to be changed, resulting in impacts to project schedules and budgets.
		Physical	Significant liabilities may arise as a result of damage to coastal assets and infrastructure—including increased flooding—that result from changes to seabed morphology and sediment movement from dredging. Dredging may also directly impact and damage sites of marine cultural heritage (e.g. historical ship wrecks).
Disruption to wildlife	 	Reputational	Loss of biodiversity and habitat damage are some of the most likely issues for sustained campaigning from civil society around dredging and aggregate extraction. Conservation of marine mammals is a highly emotive issue for the public and public pressure regarding their welfare may increase in future.
		Regulatory	Negative impacts on endangered, threatened and protected species could result in policy reforms or regulations and forced shutdown of operations in the worst cases.
		Operational	Concerns over the location and timing of dredging operations where those may impact key life cycle stages (e.g. feeding and breeding) may result in regulators requiring modifications to the spatial and temporal management arrangements for dredging operations.

Pollution and water contamination		Reputational	High levels of sedimentation, especially where this is associated with pollutants, may result in opposition from local communities, particularly where coastal communities are prevented from using specific resources or amenity areas. Spills of oil, sewage and other types of pollution, discharged from dredging vessels, may directly impact the amenity value of marine areas and prevent local communities from using them for social and recreational purposes. Concerns over the offshore disposal of dredge material may also result in significant opposition from civil society.
		Operational	Unacceptable levels of pollution (e.g. uncontained sediment plumes) may result in temporary stoppages of work by environmental regulators until a solution is found.
		Regulatory	Uncontrolled pollution may result in adoption of more stringent regulations making it harder to gain consent for future dredging.
		Physical	Dredging in some areas may expose historical unexploded ordnance, which at best may stop work or at worst result in physical damage.
		Market	Contamination of fishery resources as a result of contaminant mobilization may result in harvesting bans affecting the livelihoods of local fisherfolk. In some jurisdictions, claims for compensation for economic losses may be allowable against third parties including investors.
Air pollution		Regulatory	Risk of financial penalties for violations of local pollution regulations.

Use conflicts		Reputational	Any economic impacts suffered by other marine users may be directly attributed to the dredging sector, which may result in local protests. Physical damage to subsea structures (such as pipelines and cables) caused by dredging. Physical changes to coastline and coastal amenity areas and infrastructure as a result of changes in sediment processes that could impact other marine users.
		Regulatory	In the context of marine spatial planning, regulatory risk exists where development conflicts with designations of protected habitats and vulnerable species, though instances in which these designations shift after significant investment has already been made (as opposed to during the mapping or auctioning phases of development) do not appear to be likely.
Social and economic conditions		Market	Given the high levels of criminal activity associated with coastal sand mining, there is a risk of actual or perceived corruption associated with aggregate extraction (in particular) as well as the risks of corruption associated with high value placer deposits (such as diamonds).
		Reputational	Potentially significant reputational risks associated with the direct and indirect negative social impacts associated with the loss of access to marine areas for other marine users as well as the potential socioeconomic impacts and loss of livelihoods associated with sand mining.
		Operational	Protests from other marine users may result in work stoppages. If protests are of high enough profile, regulators may require fundamental changes to project design and implementation thereby impacting project schedules and budgets.

Exclusions and recommendations for responsible financing

Based on the impacts and their materiality outlined above, the attached Recommendations and Exclusions Annex for financing the transition of the dredging sector to a more sustainable future is proposed. The Annex identifies unsustainable and harmful activities that should be **excluded** for any type of financing. For those activities that are not explicitly excluded, the Annex offers **recommendations** setting out how financing can be used to achieve more responsible dredging practices that result in an overall reduction in the damaging impacts associated with dredging and aggregates extraction.

Using finance to reduce the harmful impacts of dredging

Financial institutions need to understand the impacts to the environment and the risks arising from dredging and aggregate extraction, and to work with project developers to identify, manage and mitigate them. Integrating environmental factors into financial decision-making will direct capital more effectively towards sustainable activities and away from the “business as usual” trajectory (WWF 2021).

In addition to making existing dredging activity as low-impact as possible, for example through leveraging marine spatial planning to identify where harm to the marine environment can be minimized, there are opportunities for the financial sector to influence and support a transition to more sustainable practices and the deployment of dredging capacity towards low carbon and green coastal infrastructure. Moreover, redirecting sustainable finance to look for alternatives will be key if the significant impacts associated with dredging activities are to be addressed. Unlocking these opportunities requires innovation and risk financing to support sustainability approaches that are effective and scalable.

Several areas of such may be considered, which represent strong business opportunities for financiers:

Focus on green infrastructure

Dredging is often a necessary component of coastal infrastructure development, which has traditionally followed a development pathway of human-engineered solutions. Coastal infrastructure is the collection of works at coastlines, estuaries, rivers and canals, and in port areas. Although traditionally these types of development have focused primarily on engineered solutions, *Hijdra et al. (2021)* argue that for most coastal infrastructure needs, “hybrid” or “green” project variants, which support sustainable development goals beyond legal requirements, can be developed that look after both socioeconomic and environmental values (e.g. examples of nature-based solutions for coastal infrastructure and resilience [UNEP FI 2022]). In this regard, the vital role of nature-based solutions (NbS) as critical infrastructure along coastlines is increasingly being recognized. The value and application of NbS should form part of a holistic assessment of coastal infrastructure needs that critically assesses whether and to what extent dredging may be required, and its potential impacts on the ecosystem services that form the basis of these nature-based solutions. NbS can bring additional co-benefits for biodiversity and livelihoods that make them attractive alternatives to grey infrastructure approaches (UNEP FI 2022).

Nature-based solutions

Nature-based solutions (NbS) are defined by the International Union for the Conservation of Nature (IUCN) as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits”. (International Union for the Conservation of Nature 2016).

NbS can serve a critical infrastructure function along coastlines. Coastal ecosystems such as mangroves, coral reefs and sand dunes can protect inland communities and development against sea-level rise and natural hazards such as tropical cyclones. Similarly, engineered solutions that incorporate natural elements can provide greater resilience and adaptability for infrastructure solutions. Further, NbS can provide a broad range of social and environmental co-benefits, including ecosystem services such as carbon sequestration, food production and recreational opportunities. In turn, these can support coastal livelihoods that may increase their financial attractiveness (UNEP FI 2022).

For these reasons, there is significant and growing support for NbS by both public and private sectors, with substantive commitments being made to invest in their protection and rehabilitation. See for example the range of commitments coming out of the 26th Meeting of the Conference of Parties to the Paris Agreement (COP 26).

Invest in alternatives to aggregate materials for construction

Demand for dredged materials may be significantly reduced by applying the principles of the circular economy that promote recycling and reuse of materials,. A number of multi-national cement manufacturers have active research programmes in this field. Further investment in research and development is needed to identify sustainable alternatives for aggregates as a building material (such as alternatives to conventional concrete). Finding suitable alternatives should also seek to reduce carbon dioxide emissions from concrete production, which, according to a study undertaken by Chatham House, accounts for up to 8 per cent of global CO₂ emissions (Lehne and Preston 2018).

A number of different potential materials may present viable substitutes. These include, but are not necessarily limited to:

- manufactured sand and crushed rock;
- industrial by-products (such as fly ash, ore-sand and copper slag);
- recycled construction and demolition waste and wood production residuals; and
- residual materials (such as kaolinitic waste, sewage sludge, schist fines and wasted glass to create light weight granules suitable for light concretes).

The use of certain alternative materials may complicate the recycling process or may result in other unintended impacts such as the release of toxins. Careful analysis of the environmental and social-economic consequences of alternative materials is needed to determine the pros and cons compared to aggregates. Moreover, while numerous alternative options have been identified, and the development of alternatives is an active area

of research, a recent study by WWF notes that more information is still required into the uptake and performance of concrete containing sand substitutes (Koehnken 2018, p. 94).

Recycling products from sand and gravel

Recycling products derived from sand and gravel, and the production of co/by-products have four important functions : (1) create substitutes for sand and gravel, (2) retain the value of sand and gravel products over multiple use cycles, (3) ensure that waste is well managed, and (4) lower the risk of environmental pollution by waste (UNEP 2022).

Promote changes to design and construction methods that reduce the need for marine dredging and aggregates

Given that concrete is currently the most widely used building material, options to influence the design and construction methods offer another way to reduce the dependence on concrete (and therefore the aggregates used to manufacture concrete).

The following approaches to reducing concrete use during construction are highlighted in a recent study by WWF (Koehnken 2018, p. 94):

- Lighter-weight concrete panels produced by 3D printers that use less concrete and are applicable to light-weight construction;
- Construction designs that rely on the strength provided by tight-fitting light-weight blocks;
- 3D printing of concrete moulds from reusable wax (FreeFab) which produce concrete shapes more efficiently and faster.

Financial institutions should ensure responsible sourcing across the aggregates supply chain

To prevent an ever-growing number of avoidable environmental and sourcing problems, it is important that every stage in the supply chain understands their responsibilities and can be held accountable.

Financial institutions supporting a construction project can require responsible sourcing frameworks to influence expectations and behaviours in procuring the raw materials and associated products through the supply chain. By defining standards and expectations, any party looking to supply a project is required to provide evidence where the materials they are supplying have come from. This not only includes the products themselves—such as ready-mix concrete or concrete products—but also the raw materials used to produce them.

The application of global standards around responsible sourcing of construction materials (for example *BES 6001: Responsible Sourcing of Construction Materials*) in financial agreements and project finance would go a considerable way towards ensuring the uptake of responsible sourcing frameworks in project design.

In the context of responsible sourcing, alternative sources of material (for example dry mining of floodplains or other deposits where mining does not affect marine or riverine systems [Koehnken 2018]) should be assessed to determine which materials will result in the lowest overall environment impact. The identification of alternative sources of materials requires a holistic evaluation of the broad range of environmental and social costs and benefits of the options, such as: the long-term stability and suitability of the material; energy use required for production and transport; and, potential waste generation and disposal issues over the life cycle of the material (Koehnken 2018).

Reduce the environmental footprint of dredging and application of best practice management

By applying rigorous environmental performance standards to dredging operations, as an absolute minimum, many of these impacts may be avoided, minimized or mitigated. Numerous “industry guidelines” exist. However, more relevant from a financial institution are the various environmental, health and safety guidelines prepared by the International Financial Corporation, including those specific to ports, harbours and terminals and mining.⁷

In this regard, financial institutions should also assess whether any dredging or aggregate extraction activities are undertaken within the scope of a broader marine spatial planning (MSP) framework.

Marine Spatial Planning

As demand for coastal resources increases, more efficient ocean-use strategies are needed that balance economy, environmental protection and social demands. To this end, marine spatial planning (MSP) has developed as one tool that can help address complex conflicts in coastal and marine areas.

MSP provides a way to balance demands for development with the need to protect marine ecosystems, and to achieve social and economic objectives in a transparent and structured way. In this regard, MSP is increasingly being applied to develop marine zoning and allocation plans that address multiple-use conflicts and is, therefore, essential for implementing the sustainable blue economy.

Financiers should also be looking to **adopt emerging technology that can reduce the overall impacts of dredging and aggregate extraction**. Most notably, investments in upstream sediment control measures and adaptive maintenance dredging based on real-time data and modelling can reduce the need for ongoing maintenance dredging. Similarly, investment in electric propulsion and power systems will allow the dredging sector to significantly reduce its overall GHG emissions.

⁷ [ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines](https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines).

Global sustainability initiatives and environmental standards are needed, although a small number currently exist that may be applicable:

- **World Port Sustainability Program (WPSP):** Established in 2017 to enhance and coordinate future sustainability efforts of ports worldwide and foster international cooperation with partners in the supply chain.
- **Cement Sustainability Initiative:** Established to promote understanding, managing and minimizing of the impacts of cement production and use by addressing a range of issues, including climate change, fuel use, employee health and safety, airborne emissions, concrete recycling and quarry management.
- **Concrete Sustainability Council:** Established to support the development of a global responsible sourcing certification system, designed to help concrete, cement and aggregate companies demonstrate they are minimizing impacts and operating in an environmentally, socially and economically responsible way.

Financiers and insurers are encouraged to seek out opportunities to partner with relevant organizations to help reduce negative social and environmental impacts from dredging. Understanding how and where dredging sits within a broader project supply chain presents financiers with an opportunity to influence positive change and move away from harmful practices to ones that support sustainable development opportunities.

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Annex: Financing the sector

Marine dredging is highly capital intensive, due to the complexities of the plant and machinery required for different applications. For this reason, dredging services are generally provided by commercial dredging companies, which can be placed in three strategic groups:

Multinational construction companies: Besides dredging, these companies are primarily active in construction and the manufacturing of construction materials. In some cases, dredging companies are wholly owned subsidiaries of such companies. In these cases, the supply of aggregates and dredging services is part of the internal company supply chain and is financed directly through internal company transfers. These companies are often publicly listed and thereby able to raise finance on capital markets.

Multispecialist dredging companies: The core activity of such a company is dredging. They perform all kinds of dredging activities, such as capital dredging (new projects), maintenance, etc. These companies are active globally. Funding for these activities comes directly from project contracts thus, what is of interest from a financial perspective is which entities and what forms of finances are involved in the project finance.

State-owned players: In some parts of the world dredging and reclamation work is undertaken by large-scale state owned enterprises. These companies typically operate within the territory of the relevant state and are active in state-funded port and coastal infrastructure development projects.

Regional players: These companies' core activity is also dredging, but only in their own region instead of worldwide.

Although dredging is, on the whole, a private sector activity, the essential services that the sector provides into the global construction industry demands that finances flow from both public and private sources, particularly with respect to supplying services and materials for infrastructure projects. Hence, from a financial perspective it is possible to categorize two groups of projects that utilize dredging services, based on the origin of the cashflows with which the financing of investment costs can be serviced (Hijdra *et al.* 2021):

Public service projects (e.g. coastal protection or large-scale transport infrastructure): These projects provide a public service and are therefore initiated and funded through public funds. Particularly in the developing world, loans and technical support may be provided by international financial institutions (IFIs).

Commercial projects (e.g. property developments or port development): The users or beneficiaries pay for the project's results or services. Cashflow is generated based on the project's business model.

Different project finance models may use exclusively public or private finance. Many infrastructure projects use blended finance approaches to reduce investor risk. As such, private capital can play a role in both types of projects.

According to International Association of Dredging Companies (IADC), in 2019, the total turnover of the dredging industry for projects in the open market was relatively stable at EUR 5.2 billion (IADC 2019).⁸ This included mainly projects relating to: coastal protection; urban development; energy development (e.g. offshore wind); tourism; and trade (e.g. port and waterway development).

Capital infrastructure projects constituted 43 per cent of turnover, with a majority of works realized in Europe, followed by Asia, the Middle East and Africa. Maintenance of existing infrastructure constituted 21 per cent of turnover, with the largest shares taking place in Europe and Central and South America.

Major infrastructure projects will generally be funded through:

- Public investment, where the government invests directly in the infrastructure that supports its economy; and
- External investment by organizations that fund growth and development such as the World Bank, sovereign wealth funds or other forms of global investment—hedge funds, pension funds or loans and grants from other governments.

Thus, the critical element in characterizing financial support for dredging and aggregate extraction lies in understanding the financing used to support these different project types. These will include a complex array of stakeholders including: operators of large-scale infrastructure assets (e.g. ports), banks, sovereign wealth funds and pension funds, project financiers, insurers, private equity firms, infrastructure funds, development banks and industrial conglomerates. According to the OECD, institutional investors (which include pension funds, insurers, and sovereign wealth funds) in particular, are increasingly allocating assets to infrastructure, largely driven by a search for enhanced diversification and yield.⁹

Finally, since dredging is primarily a maritime activity with many of the larger vessels being subject to IMO standards, maritime insurance is also an important element in the overall financing picture. The two types of marine insurance most relevant to dredging are protection and indemnity (P&I) insurance and hull and machinery (H&M) insurance. Cargo insurance is not generally applied to aggregates but may be required for high-value mineral products. However, dredgers are also often required to have “specialist operations” cover—to reflect the fact that the dredging activity (and associated equipment) is very different to other forms of maritime transport.

8 About half of all dredging projects take place in open markets and half in closed markets such as China, USA and Japan. The IADC does not publish information about projects in closed markets such as China and the United States as the data cannot be verified and therefore are not reliable.

9 oecd-ilibrary.org/sites/056af93d-en/index.html?itemId=/content/component/056af93d-en.

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