

# TERRA ET AQUA

## FEHMARNBELT FIXED LINK

Constructing the world's longest immersed tunnel

## DEPLOYING PRIVATE CAPITAL

Paving a way forward to increase the uptake of green solutions

## IADC SAFETY AWARD WINNER

DEME's retractable ladder designed for hydraulic track excavators

## MARINE AGGREGATE DREDGING

REGULATORY CHALLENGES  
AND MANAGEMENT OF THE MARINE  
AREA AROUND ENGLAND



## TECHNICAL DEVELOPMENTS AND INNOVATION

An enduring vision for many decades, a fixed and direct transport connection between Scandinavia and Central Europe is about to be realised with the construction of the Fehmarnbelt Fixed Link. In spite of the large fleet of existing dredgers available for the project, several technical developments took place before actual deployment for tunnel trench excavation. Read the full article on page 16.

SOCIO-ECONOMIC

**Deploying private capital to accelerate the green transition**

Looking at the bigger role that private capital can play in bridging the infrastructure funding gap and increasing the uptake of green solutions.



6



38

SAFETY

**DEME'S award winning retractable ladder design**

Read about this year's winner of the IADC Safety Award and how this invaluable piece of safety equipment is now being shared with other companies.

16

PROJECT

**The Fehmarnbelt tunnel trench dredging project**

An insight into the improved dredging equipment used and the methodology specially adapted in the Fehmarnbelt Fixed Link project, an 18-kilometre-long immersed tunnel between Denmark and Germany.

16

CONTRACTS

**Regulation and management of marine aggregate dredging in England**

As the marine area around England gets busier, competition for space comes with regulatory challenges and an integrated marine management approach that uses a robust planning system is required.

40

EVENTS

**Upcoming courses and conferences**

Check out the many networking opportunities including IADC's 1-day conference on Financing Sustainable Marine and Freshwater Infrastructure Conference in Dubai.

42

BOOK REVIEW

**WEDApedia**

The Western Dredging Association's new online publication provides a glossary of maritime terminology designed to be a dynamic, go-to resource for all parties in contact with the field of dredging.

# A COLLABORATIVE VISION FOR SUSTAINABILITY



if we don't prepare now for the adaptation needed in the future. While the threat to our children and grandchildren's generation is very real, somehow awareness and a platform is lacking in both society and the political sphere.

**The dredging industry can provide large-scale measures to adapt to sea level rise.**

As a dredging industry, we are used to realising solutions in a sustainable way. Already for 20 years, we are aware of the impact of turbidity on corals and plant habitat, and work accordingly. Dredging companies are the frontrunner in the development of nature-based solutions and IADC strongly advocates sustainability. The inclusion of externalities (positive and negative impacts that are not monetised) in project assessments is a necessity to become truly sustainable. In addition, a long-term vision is required if we are to maintain economically successful deltas and create space for living and working in the world's deltas in a sustainable way.

On 25 November 2022, hundreds of young protesters, including Greta Thunberg, marched through the Swedish capital to file a lawsuit against the Swedish state for failing to take adequate measures to stop climate change. With young people around the world taking action and demanding change, what can the dredging industry as a whole be doing to action that change?

The fact remains blatantly clear. Despite the goals of the Paris Agreement still firmly in place, climate change continues. From the heat waves across Europe this summer, to the torrential monsoon rains that triggered the most severe flooding in Pakistan's recent history, extreme weather conditions around the globe show no sign of diminishing.

Meters of sea level rise are no longer a question of "if", but "when". For countries in the Mekong delta region, for example, the impacts of sea level rise will be catastrophic

Sometimes the public is not convinced that the dredging sector can work in a sustainable way. While the industry intervenes in the environment, the positive effects of dredging however are often overlooked. Green solutions are being implemented by clients, contractors and stakeholders in projects all around the world. Using the vast knowledge and creative expertise within the industry, steps are being made in the transition to a net-zero world. Addressing how private capital can accelerate the green transition in marine and freshwater infrastructure is also key and is the topic of a 1-day conference organised by IADC on 9 February 2023 in Dubai.

Looking at the bigger role that private capital can play in bridging the infrastructure funding gap is one of the articles in this last edition of 2022. We also take a look at the regulations in place that manage aggregate dredging around England, dive into the world of technical developments with the Fehmarnbelt tunnel trench project and share DEME's design innovation that won this year's IADC Safety Award. As the year draws to a close, I would like to take this opportunity to wish everyone a happy holiday season and a prosperous New Year.

**Despite the goals of the Paris Agreement still firmly in place, climate change continues.**

**Frank Verhoeven**  
President, IADC



# DEPLOYING PRIVATE CAPITAL TO ACCELERATE THE GREEN TRANSITION

Green solutions in ports, waterways and coastal projects have increasingly become available thanks to many years of research and pioneering efforts in practice. These sustainable and/or nature-based solutions have shown to be good alternatives for classic solutions, but application is far from mainstream yet. One of the major hurdles is the lack of access of private capital to finance these kinds of solutions despite the strong interest of capital markets in green infrastructure opportunities. Identifying the hurdles and paving a way forward to overcome these hurdles could therefore help to increase the uptake of those green solutions.

## A promising perspective

Although state-of-the-art sustainable and nature-based solutions have proven to be effective in practice, application at scale is certainly not the case. A major hurdle is that these types of solutions almost entirely rely on direct public investment and the willingness of governmental bodies around the world to take such a step. This limits the uptake and scaling of such solutions.

From the investment side, limitations in public budgets mean there is a bigger role for private capital to play to finance such projects. Moreover, increasingly this private capital is seeking such green opportunities. This increase is driven by fiscal regimes, regulations and reputational drivers. This capital is deployed, for instance, in wind parks, solar fields, electrification of railways, but seeks further diversification in the infrastructure sector. Deploying

private capital to accelerate the uptake of green solutions for ports, waterways and coastal projects is therefore a promising perspective.

This particular issue came to table in discussions with the Swiss based MAVA foundation in 2019. This foundation aims to push sustainable development in a wide sense. Leveraging the force of capital markets to make real-world impact is a key pillar of their approach. The discussion led to the idea to build an initiative around the topic of financing green infrastructure in and around ports, waterways and coastal areas. This idea quickly took shape in a cooperation between Vital Ports (a Dutch NGO dedicated to this topic), B Capital Partners AG (Swiss-based Infrastructure Investment House), Swiss Re (Re-insurance Company), IADC (International Association of Dredging Companies) and CEDA (Central Dredging Association).

**Financial partners**

The Swiss Re Group is one of the world's leading providers of reinsurance, insurance and other forms of insurance-based risk transfer, working to make the world more resilient. B Capital Partners is an independent investment house established in 2003 in Zurich. They work with, and for, international institutional investors and large family offices, often in close co-operation with developers. In a broader sense, Switzerland positions itself as the world's capital for green finance. Linking these Swiss networks to the networks of the dredging community at large therefore seemed a promising way forward.

A promising perspective however, is not something that will unfold itself to deliver its fruits, as soon became quite clear. To find the synergy, a roundtable was organised in Zurich at the Swiss Re Centre for Global Dialogue. This roundtable, with representatives of all involved organisations and their constituents, took place in February 2020 before the COVID-19 pandemic restricted travel worldwide.

The roundtable clarified a few points. The first being that the financial world and the world of dredging and engineering companies speak different languages. The financial specialists were very unfamiliar with vocabulary, project types and activities of the dredging community. And vice versa. The landscape of financial concepts, specialisations, interests and way of working was a lot to digest for the dredging community. Secondly, it was clear both communities aim for similar goals; increasing the uptake of green infrastructure projects, which is in line with the ambitions of all individual companies

**The financial specialists were very unfamiliar with vocabulary, project types and activities of the dredging community. And vice versa.**

at the table. Thirdly, it was clear that progress can only be made when mutual understanding is further increased.

**A joint study**

The dialogue in Zurich asked for a practical step to gather all current understanding and knowledge about green projects and finance in a dedicated report. Such a report could be used to support further conversation with a wider variety of actors in the field. This led to the publication of the report "Financing of Sustainable Marine and Freshwater Infrastructure: A joint study to explore financing of green coastal, river and port projects". The report is based on the findings of a broad international team of experts.

The study provides six key lessons to enhance the uptake of green investment in this sector. In a later stage, these lessons have been summarised in an infographic. In a series of webinars following the report's publication, further learnings were gathered. This article discusses the key lessons, introduces the infographic and discusses the further reflections on the key lessons from a wider audience. Conclusions and recommendations are also provided.

**Green port and waterway infrastructure**

Before diving deeper into the role of private capital, it is useful to describe what is meant by green port, waterway and coastal infrastructure and how this differs from classic solutions. (Note: terms, such as green, sustainable and nature-based solutions (NbS) are used interchangeably in this article. For specifics of definitions and associated solutions, reference is made to the PIANC and EcoShape website and publications of the EC, UN and other organisations.) The collection of works at coastlines, rivers, canals and port areas are generally required to enable or provide flood protection, urban development, port development, navigable waterways and upgrade of recreational areas. Perhaps most telling is a summary of project types that describe the field. Classic examples, not necessarily green, are:

- land reclamation;
- flood barriers like dams, dykes, dunes;
- beach nourishment;
- integrated coastal zone management;
- riverbank protection;
- dredging of navigable waterways;
- port development; and
- breakwater construction.

Green variants of these assets can be seen as ranging from "more sustainable than a classic solution" up to nature-based solutions where benefits of natural processes from ecosystems help to deliver upon project needs. In general, the sustainable concepts are not only technically different, but also rely on early and extensive stakeholder involvement and execution methodologies with minimised ecological impact. Such green examples are:

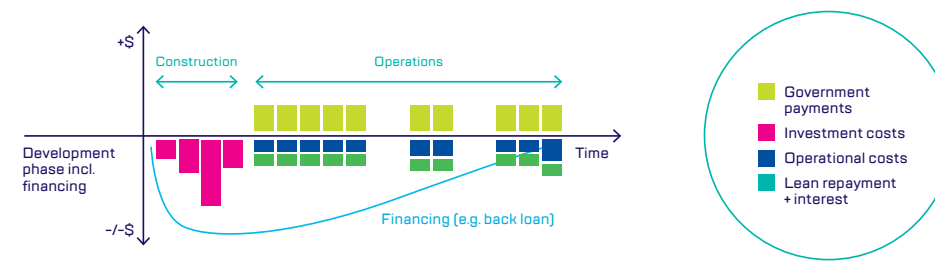
- wetland restoration;
- mangrove forestry;
- coral reef restoration;
- hybrid land reclamation, including habitat improvement and expansion;
- circular use of materials, use of local materials;
- eco-friendly river protection;
- eco-friendly breakwaters;
- bird islands from dredged materials; and
- integrated river system development.

These green solutions are readily available to be applied on the precondition of a suitable financial structure. Important to mention is that all these described concepts are mature solutions and have been applied in real-world situations. For many cases, monitoring and evaluations took place and showed the effectiveness both in terms of services provided as well as ecological quality.

**Financing projects**

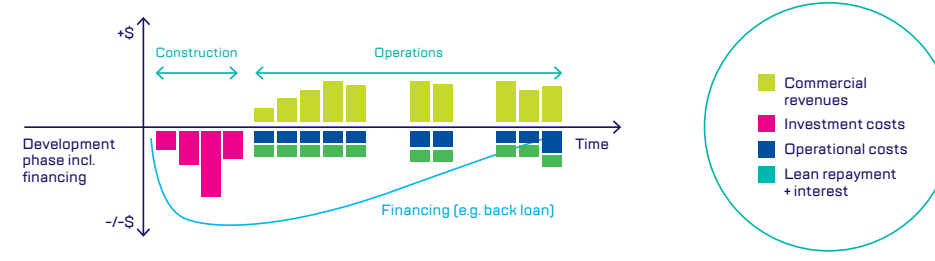
In short, financing means that capital is provided to develop a project where the capital provider expects, in time, to receive or earn back this capital including some interest or profit. However, the majority of marine and freshwater infrastructure projects are traditionally funded by the public sector (i.e. with taxpayers' money), without involving financing. The responsible public agency will pay for project development expenses directly in accordance with the contractual arrangement with the developer/contractor. In contrast, financed projects have a capital provider covering the costs of development with a payback mechanism kicking in after completion of the project. Two different types of financed projects can be distinguished on the basis of the cashflow for interest payments and loan repayments. These broadly fall into two categories based on the origin of those cashflows:

- Public service projects (e.g. coastal protection): The government, as project client, pays periodically after completion, where the payments may be based on performance or availability criteria (Figure 1).



**FIGURE 1**

Public service projects.



**FIGURE 2**

Commercial projects.

- Commercial projects (e.g. private port development): The users or beneficiaries pay for the project's results or services. Cashflow is generated based on the project's business model (Figure 2).

Figure 1 and 2 show graphically how these two types of financing differ. In practice, a wide spectrum of variants and combinations can be used, sometimes referred to under the title of "blended finance".

**Key lessons identified in the report**

Experts from Vital Ports, B Capital Partners, Swiss Re, CEDA and IADC constituents explored what is needed in order to improve the connection between private capital and sustainable waterborne infrastructure projects. One main conclusion is the need to clarify sustainable concepts and associated financial structures in order to introduce the topic to both the financial sector and the dredging community. In addition, to develop ideas on how to bring this to mainstream infrastructure investment asset classes.

The report provides content for further dialogue to foster the uptake of green marine and freshwater concepts by private investors. This dialogue, including a webinar series as part of it, concentrates around the key lessons as identified in the report. These key lessons are:

1. To improve the availability of private capital in this segment, a joint screening by sponsors and private capital suppliers is strongly encouraged. Working jointly early on may avoid following leads, which may be attractive from a mere construction CapEx (capital expenditure) side but are unviable for investors economically and/or sustainability wise. A joint selection effort based on sustainability and contractual solutions can focus scarce resources on the most promising opportunities, with a snowball effect of projects' private funding;
2. Since 2021, the European Commission requires institutional investors, financial intermediaries, lenders and asset managers to comply with a stringent investment process as well as transparent reporting

(Sustainable Finance Disclosure Regulation (SFDR)) with respect to the sustainability and Sustainable Development Goals (SDGs) impact of their investments. These mandatory requirements urge financial investors of all kinds to adopt a pre- and post-investment ESG (environmental, social and governance) risk management and controlling system. Certification of green projects might be instrumental in moving forward;

3. Develop standard frameworks that allow private capital to enter sustainable marine and freshwater infrastructure market – including, for example, updating concession-type legal frameworks that allow public-private partnerships;
4. Reporting tools and harmonised methodologies still need to be built to capture some of the associated benefits that are often overlooked as they are difficult to quantify, particularly in relation to future savings;
5. The insurance industry as a "de-risier" can be transformational in establishing a longer-term investment framework. It can create new types of insurance offerings that make infrastructure projects more standardised, cashflows more predictable and infrastructure as an asset class more attractive to investors – thus unlocking financing; and
6. Green solutions require a more holistic approach and greater coordination, and cooperation. They will also need to be incentivised through policy frameworks that increase their uptake and allow rerouting or unlocking new funds to support them.

Given the size and attractiveness of the sustainable marine and freshwater works segment, and the growing appetite for sustainable infrastructure projects, it is expected that in due time more avenues will open up to pursue the kind of projects featured in the report and more private capital can be put to work.

**Infographic**

The report captures the content and provides examples of the way financing of green infrastructure in port, waterways and coastal areas can be structured. In that sense, it serves its purpose well to support further conversations between the dredging and financial communities. Further outreach was foreseen in a series of webinars, but wider dissemination of a message by means of a report can be challenging. In discussion with



**FIGURE 3**  
Mangrove restoration in the village of Timbul Sloko, Java, Indonesia.

**Green solutions might open up new ways of cost recovery as these solutions typically offer wider societal benefits.**

the MAVA foundation, it was decided the development of an infographic could help in spreading the message to a wider audience.

As an infographic should be self-explanatory, it proved quite a task to bring in all the elements. Projects involving dredging are a world in itself. The meaning of nature-based solutions can fill bookshelves. The same is true of finance and cost recovery models. Bringing this all together for an audience specialised in one sector, but unfamiliar with others, was a challenging task. The resulting infographic (Figure 4), just like the report, is free to use and distribute.

The infographic conveys the message of three steps: basic options and structures for green solutions; the key lessons learned; and the goal of accelerated uptake to be reached through these steps. The element at the left-hand side shows the key parts of a tailor-made puzzle. A desired solution needs to be embedded in a structure where the institutional setting, a cost recovery model and financing fit together.

Cost recovery models require particular attention. Green solutions might open up new ways of cost recovery as these solutions typically offer wider societal benefits.

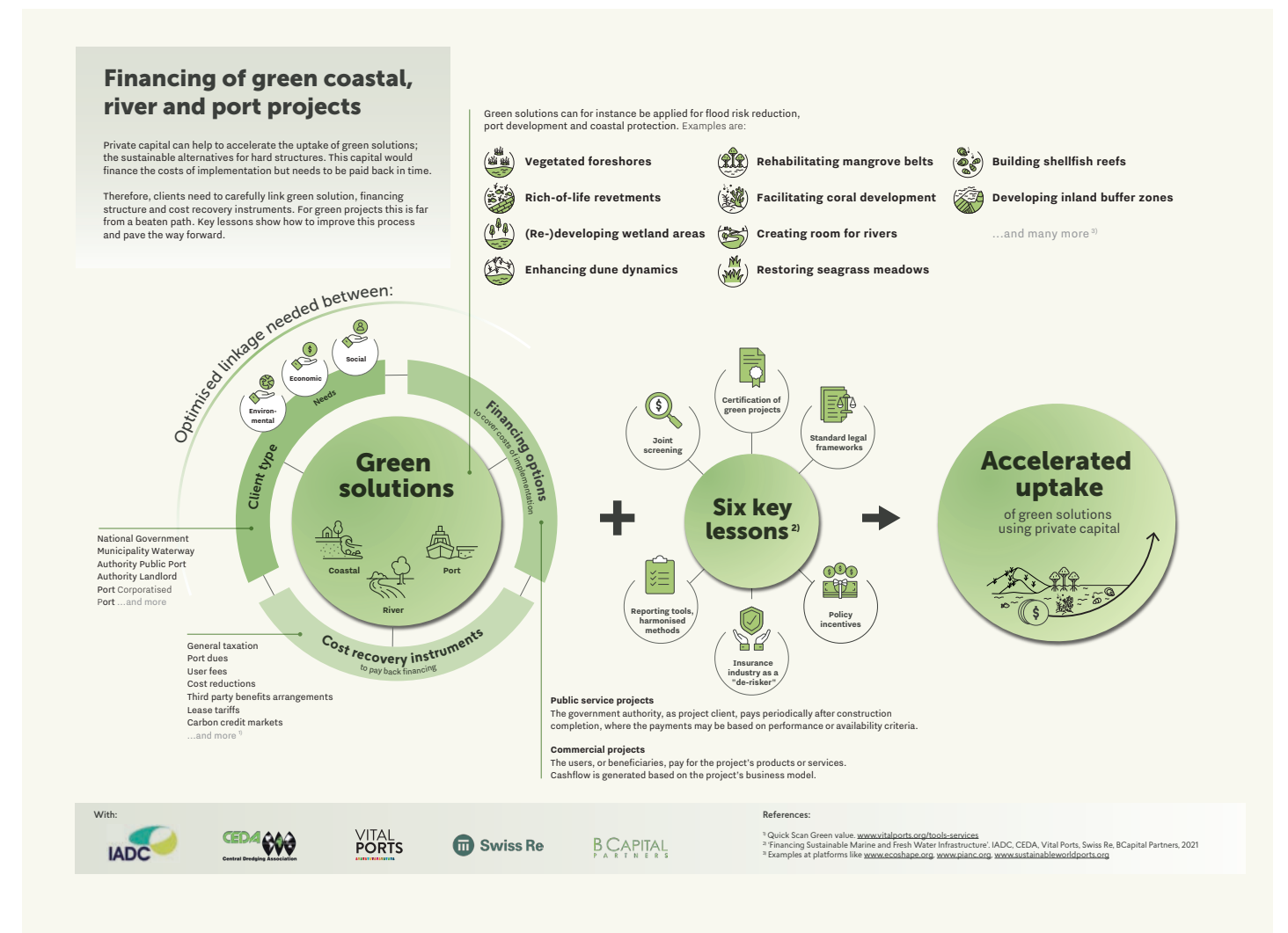
This requires special effort to capture and monetise these societal benefits to ensure these can be of support for the project. Some examples of such models are selling carbon credits (either in voluntary or compulsory markets), habitat banking, inclusion of sources supporting natural development or involve outside beneficiaries (tourism sector, fisheries) with an interest to make the project happen. Figure 5 shows an example of this.

**Further lessons from the webinar series**

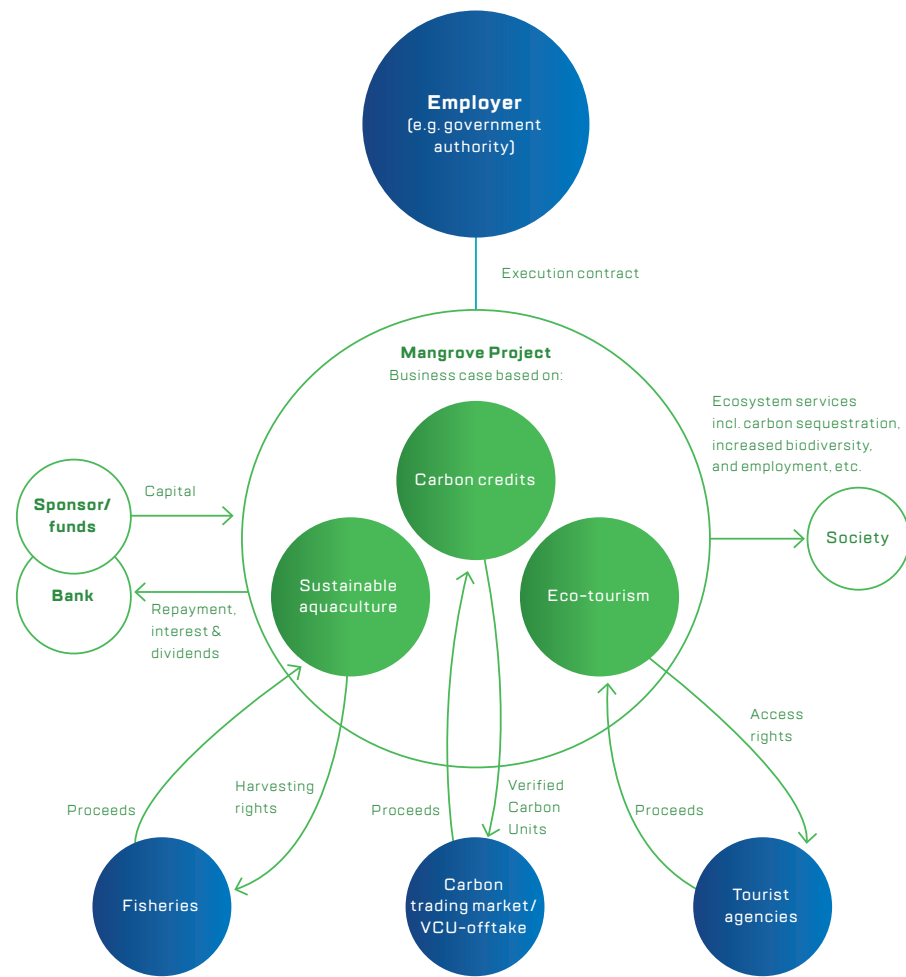
Following the launch of the report in September 2021, a series of three webinars were held to disseminate the results and

stimulate mutual learning on the basis of the findings. These sessions were organised jointly with PIANC, CEDA and IADC and reached an audience of 330 people. The majority of the audience came from the public sector, engineering firms, contractors, infrastructure finance/ investment sector and insurance industry. In all three sessions, the key lessons from the report were discussed and used to spur interaction with the public. The reflections from the audience have been anonymised, sorted and grouped together. These results are summarised below around three main questions.

**Subsequent steps are needed to support the influx of private capital in order to accelerate the uptake of green solutions.**



**FIGURE 4**  
Financing of green coastal, river and port projects infographic.



**FIGURE 5** Example of utilising the wider socio-economic benefits created by a mangrove restoration project.

**Question 1: Do you agree on the key lessons to address as mentioned in the report?**

This question gave a wide variety of responses. The key lessons were generally recognised but triggered other reflections. Many comments were made with regard to determination and uncertainty of the benefits of green solutions. More transparency and knowledge is needed about NbS and the benefits of NbS should be made clear to counter discussions on higher costs. A holistic assessment of projects is lacking, resulting in exclusion of externalities that would tilt the balance more towards NbS. Costs was also an issue, as costs of nature-based solutions are perceived higher than traditional grey solutions. Uncertainty about the costs of carbon credits was seen as an important issue to resolve.

Certification and a common legal framework were also addressed. The legal framework is insufficiently developed to fit the needs of green projects. The expectation was that some of the hindrances around certification and the legal framework would diminish when the EU taxonomy is in place and becomes a familiar concept.

A lack of a proper business model for green infrastructure in the sector was one of the major talking points with the audience. Commercial investors need a proper business model, which is often lacking in NbS projects. Revenue streams can be quantified easily for energy transitions projects such as windfarms, not so much for integrated coastal or river projects. Working with carbon credits and habitat banking is one of the potential solutions. Climate adaptation and coastal

protection projects do not generate a cashflow, which is an important barrier for investors. Blended finance is presented as a potential solution in the report but it takes a long time to organise. This makes it of less interest for tendering parties.

Improving awareness was one of the additional issues that came forward. The financial world is often not aware of waterborne infrastructure projects. Green alternatives in this sector are often considered to be more expensive than classic solutions, which is not necessarily the case. Very often, a green solution is no more expensive than a grey one. The coastal protection project Hondsbossche and Pettemer Sea defence in the Netherlands was considered a clear example of such a case.

**Question 2: How can the identified key lessons be put into practice?**

The most important steps coming forth from the audience were the need to build awareness, develop proper business models and strengthen policy incentives.

Awareness and communication are certainly issues to work on. This counts for the broader public as well as specialised sectors, including the diversified group of investors and financiers. Currently many stakeholders are so called "sea blind", meaning what happens outside our usual direct view, as with what happens outside on the seas, does not feel very familiar. Activities of the dredging industry for instance, are well known in the sector itself, but to a lesser extend to the general public. Raising awareness of all the work that needs to be done, and which can be done, in a sustainable way was therefore seen as helpful.

Again, the absence of clear business models was a major talking point. A potential solution was seen in establishing support from international organisations to develop a classification/certificate system to determine the value of a project. However, this would be a long-term exercise. Public-private partnerships could also be of help. As would realising a dialogue early in the process between private investors and public sector to give the private sector more detailed information. In addition, creating platforms where investors have access to positive externalities was considered helpful to support the sustainable variants of projects. Involvement of contractors on board at an early stage, without limiting them in tendering, could also

**Example solutions at various sustainability levels**

Project	Grey	Hybrid grey-green	Green
Land reclamation	Straightforward new land for desired purpose	Reclaiming land including habitat improvements or enlargements	
		Creation of polders using less material	
		Combine land reclamation with protecting vulnerable low laying areas/ecosystems	
		Use locally sourced materials and apply soil improvement	
Port development	Purpose built port infrastructure	Biodiverse breakwaters fostering marine life	Natural harbour-ports
	Smooth, closed concrete and steel surfaces	Open structure revetments and quay walls	Sheltered waters through ecosystem restoration
Coastal protection	Concrete smooth levees and dykes, dams	Beach nourishments and/or sand dunes	
		Protecting estuaries by movable open barriers	Mangrove forestry
	Closing off estuaries by closed dams	Open structure revetments	Wetland/Marshes restoration
		Habitat improvements and enlargements	Coral reef restoration
Riverine flood risk reduction	Artificial levees, dykes, walls	Green embankments	Restoring natural flood plains
		Open structure revetments	Restoring natural flood plains
		Habitat improvements and enlargements	Wetland/Marshes restoration
Navigational dredging	Dredging and disposal of dredged materials	Dredging and disposal of sediments where beneficial for ecosystems	
		Use of dredged sediments for habitat improvement or enlargement (e.g. wetlands, bird islands)	
		Circular use of materials, dredged materials for construction purposes	
Shore/ bed protection	Concrete slabs	Open structure revetments	Mangrove forestry
	Asphalt embankment and bed lining	Green embankments	Use of local natural materials
	Steel sheetpiling	Biodiverse breakwaters fostering marine life	
Nature development			Ecosystem restoration
			Wetlands, bird islands
			Habitat improvements, enlargement

**FIGURE 6** Grey, hybrid grey-green and green elements in typical marine and freshwater infrastructure projects.

spur the uptake. And perhaps having focus on a subset of projects (e.g. ports), could help drive momentum.

Policy incentives and government backing are also a field where progress can be made. Distinction for these kinds of projects can be made between social goods and commercial goods. Usually, governments pay for social goods. However, only countries with a well-developed tax structure are able to do so. By clearly determining all the benefits coming from NbS and providing a wide societal Cost Benefit analysis, the specific benefits could be allocated to either the public and/or commercial stakeholders. This might enable the possibility of both sectors jointly financing when both private and public sectors benefit.

### Question 3: How can we build momentum to assure steady progress in this field?

This question gave rise to a rich spectrum of suggestions. Broadly, these comments fell into two groups: communication and instrumentation.

On the topic of communication, it was mentioned that financiers and the dredging community need to speak the same language. Contact persons at financial institutions are often unknown because they do not talk to corporations. Collaborating with other NGOs, such as the International Association of Ports and Harbors (IAPH) and the International Federation of Consulting Engineers (FIDIC) could be helpful. An initiative like EcoShape can also help spread the message. Another suggestion made was to develop part two of the report with tailor-made solutions for a selection of barriers mentioned in the existing report. Establishing a dedicated program and taskforce to assure steady progress was also a suggestion from the audience. Make the purpose of this taskforce clear to the outside world as the waterborne infrastructure sector needs a voice.

The other group of comments related to all sorts of instrumentation. This provided a myriad of suggestions. The financial sector is very transactional, which means agreements play a central role and should therefore receive special emphasis to accelerate the uptake of green projects in this sector. Define what "green projects" are and demonstrate the additional values of the sustainable solutions. These green solutions bring more than only the primary aim of the

project. At the same time the European Investment Bank is bound by the EU taxonomy, determining what might be called green or not. On the financial side, new instruments, such as blue bonds and insurance products are considered to be useful to build further momentum.

### Conclusions

The main conclusion of the report and the webinar series is that sustainable waterborne infrastructure solutions are available, have been tested and are economically viable. The potential of these kind of solutions was widely recognised and seen as the way forward.

As clear as this conclusion may stand, the picture becomes far more nuanced when deployment of private capital is brought into the conversation. One of the key issues that comes with this is the necessity of generating cashflows to ensure paying off those loans and investments. Rich discussions took place around appropriate business models, identifying beneficiaries of the wider benefits of sustainable solutions, converting benefits into revenue streams and the roles of the public and private sectors in this. A first general conclusion is that work needs to be done to establish widely acknowledged business models for green port, waterway and coastal projects. Such business models should include clear ways to determine the additional, holistic, benefits of sustainable solutions and ways to monetise these.

Directly following this conclusion is the debate around the definition of "green". Although a diffuse concept in the wider infrastructure sector itself, it is a sensitive and important topic for investors and bankers as well. Defining what is green and sustainable is key considering a large influx of green-labelled capital and potential reputational and financial damage when mislabelling investments. At the same time regulations for utilising these labels and associated benefits, like the green taxonomy in the EU, is growing. However, this is still work in progress in the sector itself and needs further maturing. The conclusion from the report that certification could be helpful was supported by the wider audience and seems like a no-regret step to take.

### Recommendations

In terms of recommendations, it was clear that much work is still to be done.

First, awareness of the possibilities to apply sustainable solutions in the port, waterway and coastal infrastructure sector is to be strengthened. Particularly strengthening outreach to the private capital sector would be helpful. A dedicated programme and taskforce to keep building such awareness was seen as useful.

Developing further instrumentation was another reflection on the report. Proper instrumentation to assess the wider societal benefits of sustainable infrastructure was mentioned in this light. The transactional nature of the entire sector, both developers and investors alike, calls for fitting frameworks and agreements.

In general, the webinars, as learning opportunities based on the earlier report, provided further nuanced insights for the sector. The topic of deploying private capital to accelerate the green transition in this sector has gotten more visible on the agenda of major players in development and financing of such projects. In many aspects, it remains a long journey but support and progress appeared to be strong and feeds a positive outlook.

As the conclusions make clear, subsequent steps are needed to support the influx of private capital in order to accelerate the uptake of green solutions. Carving this path forward is the topic of a dedicated 1-day conference titled "Financing Sustainable Marine and Freshwater Infrastructure", organised by IADC in Dubai on 9 February 2023.

### Acknowledgments

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### For more information

The full report, which is free to download, can be found at [www.financing-smafi.org](http://www.financing-smafi.org) along with the infographic and other background information. Contact the author at [hijdra@vitalports.org](mailto:hijdra@vitalports.org).

## Summary

In the past decades, multitudes of sustainable and nature-based solutions have become available to apply in port, waterway and coastal projects. In practice, the application of such solutions is still far from mainstream. Meanwhile, public budgets for these projects are limited while private capital providers are seeking green infrastructure projects to put their money at work. Unfortunately, the specific field of green port, waterway and coastal infrastructure is mostly overlooked with regard to deployment of private capital.

This topic was the focus of a joint study by Vital Ports, Central Dredging Association (CEDA), International Association of Dredging Companies (IADC), Swiss Re and B Capital Partners, which resulted in the report "Financing of Sustainable Marine and Freshwater Infrastructure". The report provided six key lessons that can help to develop this market: 1) joint screening of projects by sponsors and private capital suppliers; 2) certification of projects; 3) standardised legal frameworks; 4) harmonised methods and reporting tools; 5) utilise insurance industry for de-risking projects; and 6) reinforced policy incentives. In a series of webinars following the publication further learnings were gathered. This article discusses these six key lessons, as well as the further reflections on the key lessons from a wider audience.



**Arjan Hijdra**

A pracademic at heart, Arjan Hijdra has worked his entire career at developing water related infrastructure. His key expertise is optimising societal value and translating this to investment planning. Arjan worked for the Dutch Ministry of Infrastructure and served as a researcher at the University of Groningen, MIT, the U.S. Army Corps of Engineers and the World Economic Forum. He currently leads the Vital Ports initiative, an NGO with the aim to disseminate evidence-based guidance for sustainable port development.

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# THE FEHMARNBELT TUNNEL TRENCH DREDGING PROJECT

A fixed and direct transport connection between Scandinavia and Central Europe has been an enduring vision for many decades. This vision is about to be realised with the construction of the Fehmarnbelt Fixed Link, an 18-kilometre-long immersed tunnel between Rødbyhavn in Denmark and Puttgarden in Germany. When it opens in 2029, the tunnel will be the longest immersed tunnel in the world combining a dual railway and motorway connection. This article provides insight into the improved dredging equipment used and the methodology specially adapted and further developed to the project's requirements.

## Project background

The Fehmarnbelt Fixed Link has been designed and planned by Femern A/S, a subsidiary of the Danish, state-owned company Sund & Bælt Holding A/S. In 2008, a state treaty was approved and signed by the Danish and German governments. Both countries agreed that Denmark would be solely responsible for financing the coast-to-coast project (and the related extension of the Danish coastlines) and therefore be the sole owner of the Fixed Link. In turn, Germany will finance and ensure the timely development of the land works on the German side. The treaty stipulates that the link will consist of a twin-track railway and a four-lane motorway.

The toll station for the users of the Fixed Link will be located on the Danish side of the Fehmarnbelt. Femern A/S was responsible for designing and providing the basis for the official approval of the coast-to-coast section of the Fehmarnbelt Fixed Link on behalf of the Danish Ministry of Transport. After a series of investigations between alternative solutions (an immersed tunnel, a bored tunnel, a cable stayed bridge and a suspension bridge), Femern A/S

recommended an immersed tunnel as the preferred technical solution for the Fixed Link.

The Fixed Link will fill the infrastructural gap between Scandinavia and mainland Europe by means of an efficient and high-quality transport infrastructure. In addition, the railway connection will result in the highly needed release of the Danish East-West rail connection. Freight trains from Zealand, Sweden and Norway will be able to take the direct tunnel into Germany and mainland Europe instead of the current longer route via Southern Jutland and Northern Germany (Hamburg), shortening the rail freight distance by 160 kilometres. Thus, the Fehmarnbelt Fixed Link is part of the Trans-European Transport Network (TEN-T) (Figure 1). TEN-T's policy addresses the implementation and development of a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals. Its ultimate objective is to enhance the efficiency of the European infrastructure so that the EU's single market functions better and with less environmental impact. The tunnel will also offer a new strong link to the Fehmarnbelt region itself, stimulating

growth and prosperity. Nine million people currently live in the region, which extends between the cities of Hamburg, Kiel, Lübeck, Copenhagen and Malmö. The project will not only provide work for local people but will also create jobs at companies in the region supplying the site with raw materials, goods and services.

After an international competitive bidding process, the Tunnel Dredging and Reclamation (TDR) contract was awarded to Fehmarn Belt Contractors (FBC), a joint venture between Boskalis and Van Oord. FBC started preparations in 2019 and actual operations commenced in June 2020 when the first rock was placed to start construction of the breakwaters around the Lolland work harbour in Denmark.

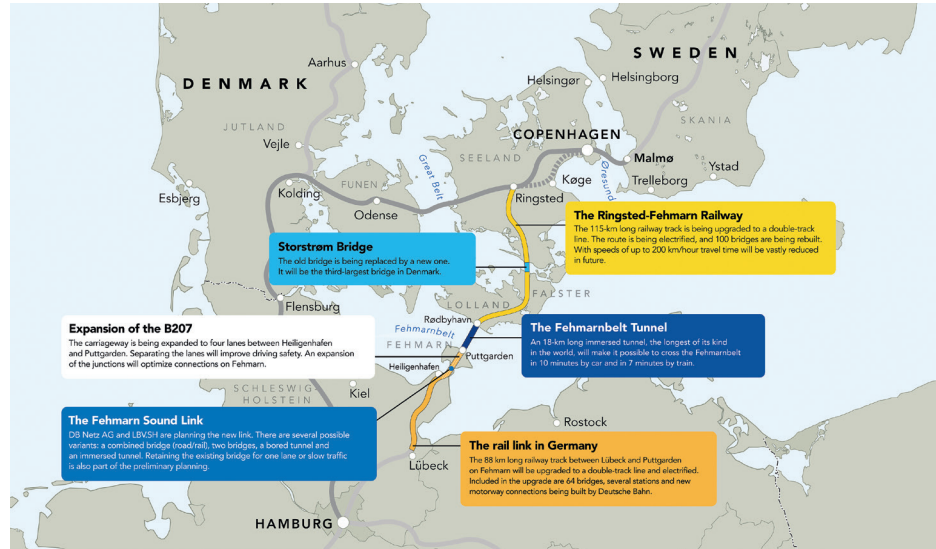
**Geology**

Figure 2 shows the geological longitudinal profile along the tunnel alignment. Both the Danish and German sides have gently sloping near-shore profiles, with a maximum water depth of around 30 metres. In order to accommodate the immersed tunnel the maximum dredging depth will be approximately 46 metres.

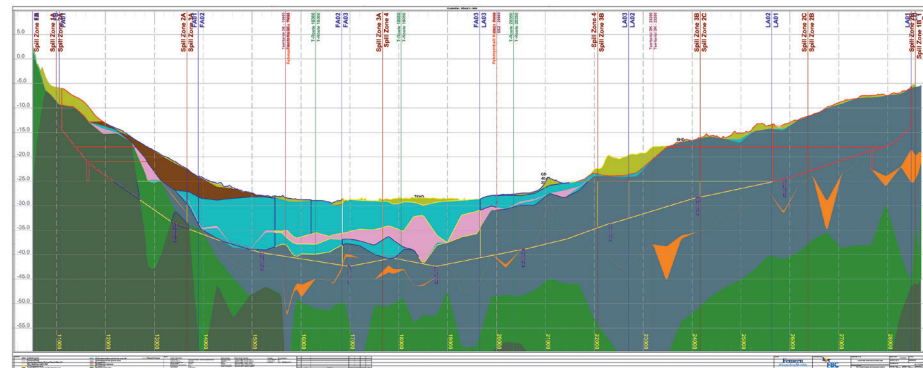
The soils to be dredged for the tunnel trench comprise of upper layers of post glacial and late glacial deposits (gyttja, sand, silts and clays). Underlying layers are made up of glacial deposits (clay and sand tills followed by a Paleogene layer with highly plastic to extremely plastic clay). The German side is characterised by Paleogene clays together with some clay-till and the central basin (the central part of the geological cross section along the tunnel alignment) by gyttja, sands, silt and clays. Thick deposits of hard clay-till dominate the Danish side. In total, eight separate units are distinguished in the geological longitudinal profile of the tunnel trench:

- Unit 1: Postglacial sand
- Unit 2: Postglacial gyttja and freshwater peat
- Unit 3: Postglacial/late glacial clay and silt
- Unit 4: Postglacial/late glacial sand
- Unit 5: Upper till
- Unit 6: Meltwater deposits
- Unit 7: Lower till
- Unit 8: Palaeogene clay

Each unit features different characteristics when it comes to ease of dredging, placement in land reclamation or foundation of tunnel elements.



**FIGURE 1**  
Trans-European Transport Network (TEN-T).



**FIGURE 2**  
Geological profile along tunnel alignment.

**Unexploded ordnance and naval archaeology**

The survey and removal of any potential unexploded ordnances (UXOs) within the respective work areas comprised a series of activities that began in 2011. First, an initial desk study was carried out, followed by detailed surveys and a removal operation.

The desk study included searching for information in the Royal British Navy, German Navy and Royal Danish Navy archives. As a result, it became a precondition that no capital dredging works would be initiated until a full survey and removal campaign had been completed. Overall, the entire UXO clearance works comprised three individual phases: surveys, identification and removal or relocation of identified UXOs.

**UXO and other surveys**

Surveys were carried out by the specialist company Heinrich Hirdes (a Boskalis subsidiary) deploying its state-of-the-art equipped fleet for the purpose. A towed magnetometer array measuring the total field amplitude was deployed within the respective work areas with a line spacing of 1.5 metres between each magnetometer array, in combination with a multibeam and side scan sonar survey. To meet the specified detection criteria, a maximum towing height of the magnetometer of 4 metres above the seabed was used as the threshold.

Based on the magnetometer survey, the target list was correlated to the anomalies detected by the combined multibeam and side scan sonar survey to identify the surficial targets. The survey campaign resulted in a

**The entire UXO clearance works comprised three individual phases: surveys, identification and removal or relocation.**

the EM detection system, an imaging sonar, a dredge pump and finally an orange peel grab for the recovery of an item. The configuration allows for immediate switching between all these individual tools (Figure 4).

**Relocation of identified UXOs**

Further handling of identified UXOs depended on the conditions of each object as concluded by the previous investigations. Therefore, the encountered ammunition objects were classified as follows:

- Any UXO concluded as safe to transport was recovered onto the deck on the inspection vessel and subsequently handed over to the responsible authority in the Port of Kiel, Germany;
- Any UXO not safe to transport on deck was relocated by means of underwater transport facilities to another wet storage location – again in collaboration with the German authorities; or
- In the case of an UXO being neither safely transported nor relocated to another area, the UXO was blasted in situ by respecting the requirements from the respective German and/or Danish authorities.

Within the Danish territory, the Royal Danish Navy monitored and assisted the campaign with the actual identification of UXO items,

and took charge in the event of a removal operation, i.e. explosive ordnance disposal (EOD). In the German territory, Heinrich Hirdes operated on its own until the need for German authorities to remove identified items. A special and an extraordinary set up of requirements of mitigation measures for the removal of any UXO in the areas close and inside the Natura 2000 (a network of core breeding and resting sites for rare and threatened species) were put in place. This is a result of extensive talks with German authorities on enhanced and underwater noise mitigations from the EOD of an UXO, such as double bubble curtains and pingers.

Based on the UXO survey campaign 119 UXO targets were investigated. Of the 119, 104 were cleared as non-UXO targets, one as an old anchor and 12 UXO targets were relocated to a wet storage area in German waters. One UXO target was cleared by the German Navy and one UXO target located in Danish waters was cleared by specialists of Heinrich Hirdes in 2022 by controlled detonation.

**Naval archaeology**

Detailed surveys performed in preparation of the dredging activities also included locations of known historical wrecks; Swarte Arent and Lindormen (found in 2012 during preparatory surveys) and the Danish historical vessel

final target list comprising 2,663 potential targets, approximately half of which were classified as potential UXOs.

**UXO identification and removal campaign**

Subsequent target inspections were performed by deploying a specialised tool operated from a work pontoon within the nearshore area and from survey vessel Kamara covering the offshore areas (Figure 3). The specialised tool combines a group of instruments and equipment for the purpose, including an acoustic profiler system,



**FIGURE 3**  
UXO survey and identification vessel Kamara.



**FIGURE 4**  
UXO survey multitool.



**FIGURE 5**  
Delmenhorst historical wreck. Photo © The Viking Ship Museum, Denmark.  
Photo/illustration: Morten Johansen.

Delmenhorst near the coast of Lolland (found during the detailed UXO surveys). All three vessels were lost in 1644 during the Battle of Fehmarn. Both Swarte Arent and Lindormen are located at larger water depths near the tunnel alignment. Based on the detailed surveys, specific exclusion zones were established to preserve the historical wreckage. Delmenhorst was discovered at a nearshore location within the perimeters of the land reclamation west of Rødbyhavn (Figure 5). In close concert with the Vikingship Museum of Roskilde, it was decided to cover the Delmenhorst wreck with gravel and rock prior to construction of the land reclamation to preserve the wreck and to facilitate possible future excavation within the land reclamation.

**Offshore construction scheme**

Laying close to the existing infrastructure, the alignment for the 18-kilometre-long immersed tunnel passes just east of the existing ferry ports in Puttgarden and Rødbyhavn (Figure 6). The tunnel will be constructed from 89 prefabricated tunnel elements. Each one will be cast in a temporary factory just east of the portal area on Lolland and then towed to the alignment for immersion into the excavated trench below the seabed. The offshore construction activities are planned with a duration of almost 5 years and involve a series of various marine works:

- Constructing containment dykes around reclamation areas;
- Construction of a work harbour for production and towing out of the tunnel elements;
- Dredging of the tunnel trench;
- Placing of a permeable gravel bed for the foundation of the tunnel elements;
- Towing out and immersion of the tunnel elements;
- Backfilling with locking fill;
- General backfilling; and
- Placing of a protection armour layer.

As seen in Figure 7, the protection layer on top of the tunnel will be lower than or in level with the surrounding existing seabed. This means that after completion of the tunnel construction the water depth will be as it is today. This article will describe the first three of the above listed activities.

**Early works**

Before the real coast-to-coast tunnel trenching can commence some major preparatory construction works must be prepared and in place. These early works comprise construction of structures close to shore on both the Danish and German sides, which will support the subsequent construction phases (dredging and reclamation phase and immersion phase). The early works comprise two work harbours,

one on the German side at Fehmarn and one on the Danish side on Lolland. The work harbours are used to provide a safe haven for marine construction equipment, to facilitate the transport of personnel and to provide facilities for supply, stockpiling and load-out of materials and equipment. Furthermore, the tunnel elements are produced and towed out from the work harbour on Lolland. Both work harbours are integrated into the planned reclamation areas.

On the Danish side, the early works started one year before the tunnel trench dredging phase. This is to ensure that the necessary sections of the containment dykes surrounding the reclamation areas are ready to receive the dredged material from the tunnel trench. These early works will continue during the dredging phase and finish in time to ensure that the work harbour is ready for the production of tunnel elements used in the immersion phase. The work harbour on the Danish side also includes dredging of an access channel to a depth of -10.3 metres. On the German side, the early works started around four months into the dredging phase to ensure that the work harbour is in operation during most of the dredging phase and the entire immersion phase.

**Element casting factory and work harbours**

For the production of the 89 tunnel elements, a purpose-built factory has been constructed in the work harbour on Lolland. This harbour will also be the main harbour for servicing and berthing of the construction vessels used by the contractors working for Femern A/S. A smaller work harbour will also be constructed on Fehmarn island, East of Puttgarden ferry harbour.

**Reclamation areas – preparations**

All the dredged material from the excavation of the tunnel trench as well as the work harbours will be placed into reclamation areas at Lolland and Fehmarn. On both sides of the Fehmarnbelt, reclaimed land will be constructed in the form of artificial land reclamations that will extend approximately 500 metres into the sea. Containment dykes will surround the future reclamation areas using stones supplied by rock carriers.

The new peninsula at the northern coast of Fehmarn serves as abutment for the tunnel portal structures and contributes to making the intervention in the existing coastline as gentle as possible. On the Lolland side there

will be two reclamation areas, located on either side of the existing ferry harbour at Rødbyhavn. It is planned that the reclaimed land will not extend beyond the breakwaters of the ferry harbour.

**Dredging and reclamation works**

An approximately 18-kilometre-long trench must be dredged into the seabed of the Fehmarnbelt between Lolland and Fehmarn, representing the majority of the dredging work in terms of the quantity of dredged material and the associated construction time. Excavated into the existing seabed, the

trench will measure up to 90 metres wide and 16 metres deep. It is estimated that the volume of material to be dredged in situ to create the trench is around 14,500,000 m<sup>3</sup> and dredging of the trench is planned to run over a period of 18 months.

**Dredging processes**

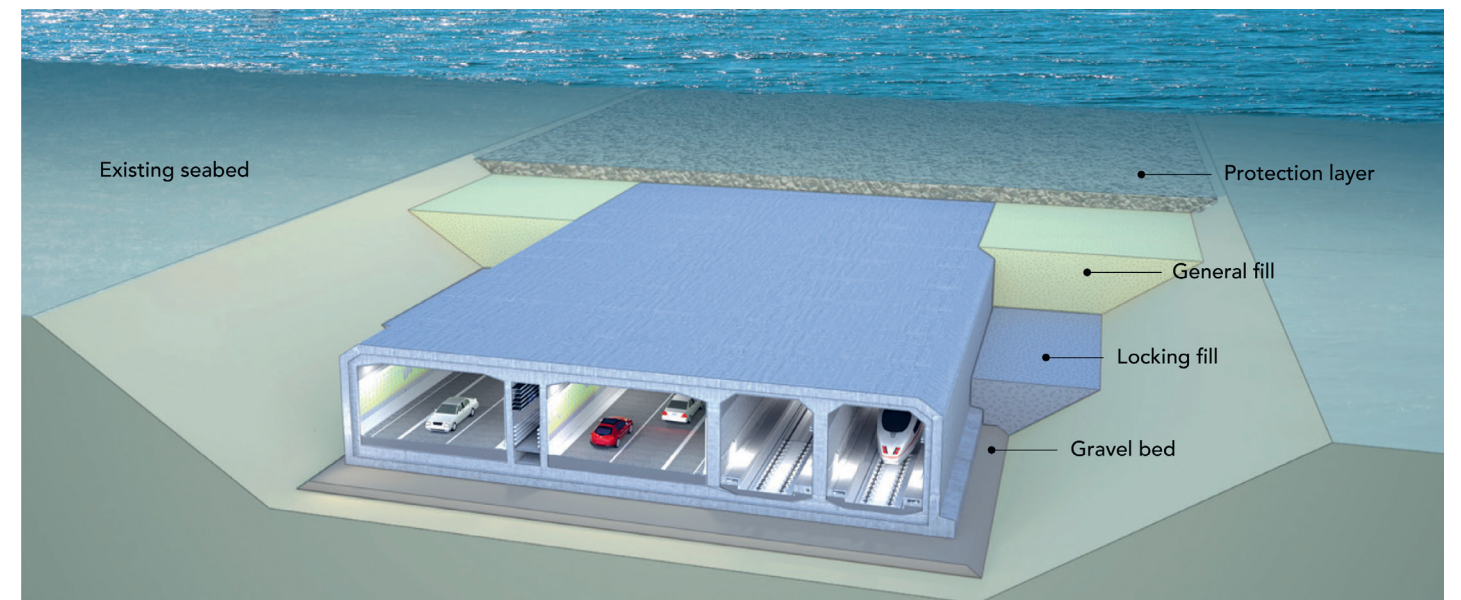
The dredging process comprises dredging of material from the tunnel trench, transportation of the dredged material to the reclamation areas and unloading of the excavated material into the reclamation areas. The applied dredging methodology is a

combination of mechanical dredging with backhoe dredgers (BHD) and grab dredgers (GD) and hydraulic dredging and placement deploying trailing suction hopper dredgers (TSHD). Backhoe dredgers will dredge the shallower parts of the tunnel trench at both the German and Danish sides of the Fehmarnbelt to a depth of approximately -25 metres. Deeper parts below this depth will be dredged by a combination of grab dredgers and trailing suction hopper dredgers.

TSHD's will make use of a special draghead for handling of the very hard clay-till, combined



**FIGURE 6**  
Tunnel alignment between Lolland and Fehmarn.



**FIGURE 7**  
Tunnel element backfill and protection layer.

with a recirculation system that pumps water from the hopper back to the seabed in order to minimise spill of fine sediments into the environment and to optimise the dredging process. The mechanically dredged material is loaded into transport barges that then sail to the nearshore reclamation areas where the soil is unloaded. Both towed barges and self-propelled (split hopper barges) are deployed for the project.

**Boulder removal**

Boulder removal from the dredged till is an essential part of the dredging works and the progress thereof. A TSHD can remove and transport boulders up to a maximum diameter of approximately 0.3 metres as part of the normal dredging and offloading process. This limiting dimension is based on the dimension for dredge pump passage. A grid is installed in the draghead to prevent larger boulders from entering the pump. Larger boulders will remain on the sea bottom but will be exposed by the TSHD to enable other vessels to remove them.



**FIGURE 8**  
Recovery of the boulder removal net.

It is anticipated that one boulder (larger than 0.3 metres in diameter) per 50 m<sup>3</sup> will be encountered on average, which will result in a large number of boulders needing to be removed simultaneously with the TSHD operation. The quantity of boulders left on the seabed will in turn have an effect on the production rate of the TSHD. One unknown is the distribution of boulders, which may be encountered evenly spread over the tunnel trench or found clustered in large quantities (nests).

A large number of the boulders left on the seabed will be removed by a fishing net operation, deploying a medium or large size multicat. After positioning, the net is lowered from the stern of the vessel. During the subsequent towing, the resistance on the net increases gradually. This resistance is continuously monitored on board until time for recovery (Figure 8).

**Sediment spill management**

In view of previous experiences with large-scale marine infrastructure development projects in Denmark, the proper control and management of fine sediments originating from the dredging and reclamation activities are a crucial aspect of all preparations and execution of the project. Following extensive environmental research, a total sediment spill budget was defined before works began. This sediment spill budget is split into smaller



**FIGURE 9**  
Spill engineer taking water samples for calibration and verification of instruments.

parts, distributed by time (months and seasons) and space (eight spill monitoring areas along the alignment of the tunnel trench, including near shore areas at Lolland and Fehmarn). Spill budgets range from negligible or zero in certain environmentally sensitive areas in the summer to several tens of thousand tonnes in less sensitive areas over the winter period. Overall compliance is monitored at all these levels and totals. Contractor FBC has the responsibility to ensure compliance using extensive field monitoring and numerical modelling (Figure 9), including verification of achieved accuracies at the end of all dredging operations.

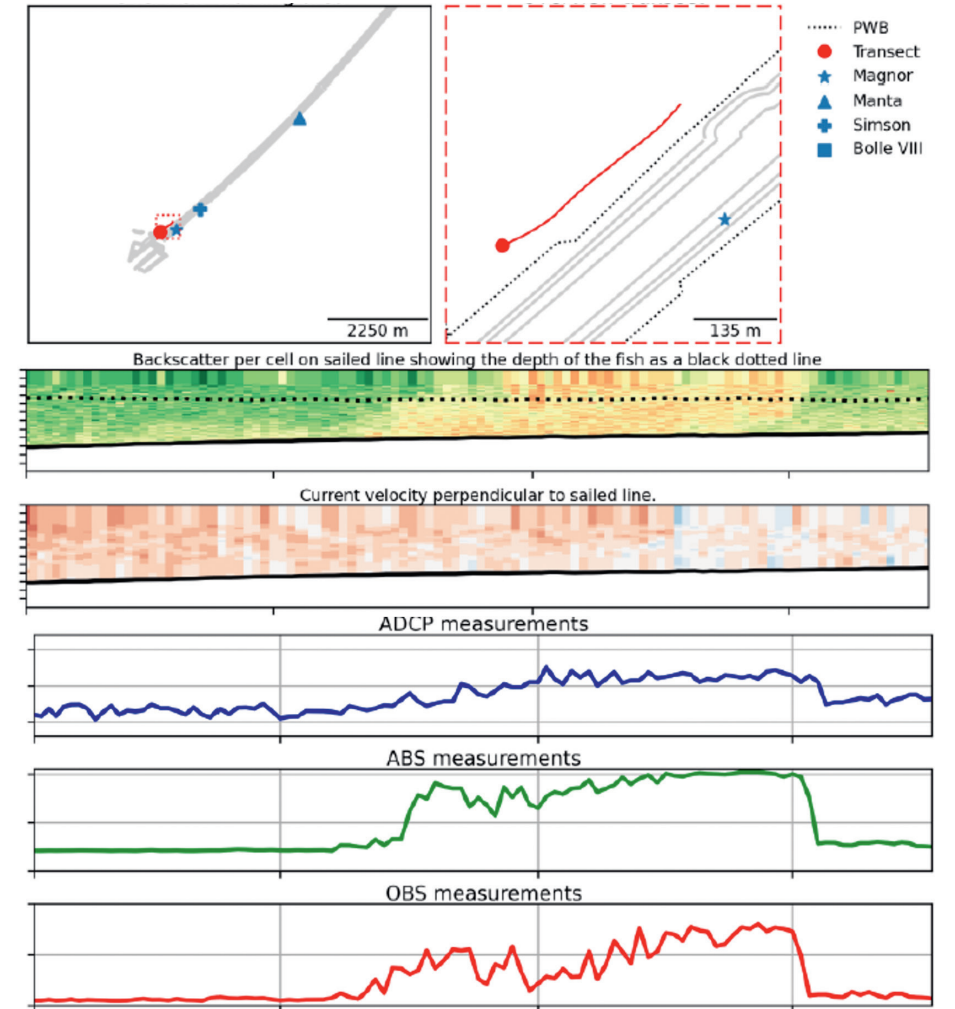
In practice, FBC modelled potential sediment spill originating from different soil units and different dredging and reclamation methods in detail. By verifying applied parameters for this modelling through extensive field monitoring of dredge plumes and sediment concentrations at the permanent works boundaries, the modelling is validated (Figure 10). Results of this modelling and monitoring are published online.

**Reclamation works**

Reclamation works are executed on both the German and Danish sides of the Fehmarnbelt. The largest share of the dredged material will be placed at the Danish side in newly constructed land reclamations. A smaller part of the dredged material will be placed at the German side or in specific stockpiles onshore.

The reclamation areas on both sides consist of bunds constructed of mechanically dredged upper till, quarry run, filter layers and armour layers. The reclamation basins are specifically designed for the purpose of receiving the dredged material from the tunnel trench, which is placed both mechanically by direct offloading from barges or dump trucks and hydraulically by pumping ashore material from hopper dredgers. All reclamation areas are initially accessible for direct placement from transport barges by leaving parts of the reclamation bunds open for marine access.

Some reclamation areas are subsequently closed off in preparation of hydraulic placement of material, for which raised bunds are constructed to manage process water and contained fine sediments. Other reclamation areas are also closed, when transport barges no longer have access due to reduced water depths as a consequence of material placement. Those areas are subsequently



**FIGURE 10**  
Spill monitoring results.

filled to final design levels using dump trucks that are loaded at several temporal or more permanent offloading quays receiving the transport barges.

Specific placement methods, planning and locations depend on several criteria, which are all considered in detail during the design and work preparation stage. Each geological unit dredged in the trench features specific strength and other characteristics, making it more or less suitable for placement at certain locations (see Figure 2):

- Unit 1 (sand found at sea bed level) becomes available in the early stages of the tunnel trench dredging and can be used for (intermediate) bund construction or drainage layers between other units;

- Unit 2 (gyttja, commonly found at higher levels in the tunnel trench) has relatively low strength after dredging and needs to be covered at all times to avoid the material oxidizing. It is therefore placed as fill material in the lower parts of the reclamation areas;
- Unit 5 (upper till, found at all levels in the tunnel trench) has significant strength when dredged mechanically and transported carefully, and can be used for bund construction or construction of the erosion cliff featured at the Eastern extreme of the reclamation areas at Lolland; and
- Unit 3 and unit 8 (silty clays and Paleogene clays) are dredged mechanically primarily and mainly placed as fill material in view of anticipated lower strength after dredging.

Hydraulically dredged material (unit 5 upper till, unit 4 silty sands and unit 7 lower tills) are found at lower levels in the tunnel trench and therefore dredged in later stages of the trench excavation process. These are placed at higher levels in the reclamation areas, as fill or surface covering material only.

Please note these are generic guidelines only, based on actual monitored material characteristics other placement locations or purposes will be selected. In general, there is a shortage of dredged material of sufficient strength to construct bunds and stockpiles on shore. Therefore, careful monitoring of actual behaviour of dredged material, management of transport processes towards all available placement locations and selection of most suitable material is a key success factor in the entire land reclamation process.

### Selection of dredging equipment

The dredging of the tunnel trench requires a small fleet of dredging equipment. Both the geometry of the tunnel trench (depth of the seabed, excavation depth of the trench including deeper special elements) and the geology of the materials to be excavated require specific dredgers to be deployed. Additional requirements related to beneficial use of dredged material in the reclamation areas also need to be taken into consideration when selecting the appropriate dredging equipment.

Firstly, the tunnel trench excavation scope is divided into mechanical dredged parts and hydraulically dredged parts. Hydraulic dredging by TSHD's generally features higher production rates and is therefore considered more cost efficient, although not all geological units can be dredged or



FIGURE 11

Backhoe dredger Magnor and transport barge.

pumped ashore efficiently by TSHD's. However, TSHD require minimum floatation depths and hydraulically dredged and transported material might feature lower strengths after placement when containing large percentages of fines.

Secondly, the mechanically dredged material is partly in reach of backhoe dredgers (depending on the strength of in-situ material up to 25 metres of water depth). Mechanical excavation at greater water depths will be done deploying grab dredgers.

Thirdly, the final choice of dredging equipment also depends on total spill of fine sediments into the environment. During dredging operations, inevitably some percentage of fine sediments is released into the environment, the exact amount of which is largely depending on methods deployed. For each method, a source term of potential spill is determined and the final choice of equipment and methods is calculated for minimisation of total spill.

Taking these considerations into account, three main types of dredgers were chosen for the tunnel trench excavation works:

- The world's largest backhoe dredgers were selected for the shallower parts of the dredging scope at both the German and Danish sides of the Fehmarnbelt, up to water depths of 25 metres in view of efficient dredging of the high strength upper tills (Figure 11);

- Newly built grab dredgers were chosen for mechanical dredging of the deeper parts of the tunnel trench, including the relatively small special elements (Figure 12). Selection of wire cranes is based on optimised hourly productions in specific material to be excavated; and
- Large trailing suction hopper dredgers were selected for the hydraulic parts of the dredging scope (Figure 13).

### Technical developments and innovation

In spite of the large fleet of existing dredgers available for the project, several technical developments took place before actual deployment for tunnel trench excavation. These include the development of a recirculation system for process water used for hydraulic dredging by TSHD's, a system for boulder catching on board of the TSHD's, the development of purpose-built grab dredgers and the development of draining excavation buckets for backhoe dredgers.

The recirculation system for process water reduces the amount of water spilled into the environment during dredging and loading of the water. By recirculating water from the hopper of the dredger towards the draghead, the time before start of overflow is lengthened and the amount of water spilled through the overflow of the hopper is reduced. In view of requirements imposed on dredging operations (mainly related to minimisation of release of fine sediments into the environment), this optimises the loads taken ashore in each dredging cycle.

The system for boulder catching on board of the TSHD used for dredging of upper till is required to avoid build-up of residual loads in the hopper consisting of boulders that are dredged but not pumped ashore. As previously explained, all boulders encountered smaller than 0.3 metres in diameter are dredged and pumped into the hopper. However, boulders larger than 0.2 metres are unlikely to be pumped ashore while unloading, leading to build-up of residual loads over time. To avoid this, a system of boulder catching on deck of the TSHD has been developed, in which boulders sized between 0.2 and 0.3 metres are selected, removed and transported to shore for beneficial use.

The grab dredgers deployed for tunnel trench dredging are purpose-built for the project. Using existing sea going multi-purpose pontoons and newly built wire cranes, optimised production rates for the specific conditions of the Fehmarnbelt project (i.e. offshore workability, optimised dredging cycle times and optimised bucket loads) could be achieved. Specific developments included the design and construction of purpose-built grabs for specific geological units and a system for recovery of energy while lowering the bucket in order to minimise fuel consumption and related CO<sub>2</sub> release.

To preserve as much as possible the strength of upper till during dredging and transport (required in view of beneficial use of upper till for bund construction), several draining dredging buckets were developed for the different backhoe dredgers deployed. Strength of upper till depends to a large extent on the moisture content. Reduction of moisture content or avoidance of increase of moisture content of the upper till is therefore of utmost importance. To achieve this, several skeleton buckets and general purpose draining buckets were designed and constructed.

### Conclusions

After half a year of work on the excavation of the tunnel trench, experience has shown the dredging and reclamation process is as challenging as ever anticipated. Governed by strict environmental requirements, cumbersome COVID-19 challenges and the local climate conditions, the works can be seen as progressing according to schedule.

At the same time, the tunnel trench deposits to be excavated sometimes deviate from original estimates, which were based on extensive soil investigation campaigns, laboratory research efforts and geological modelling. This resulted in a detailed soil model describing predicted distribution of

**The grab dredgers deployed for tunnel trench dredging are purpose-built for the project.**

soil units and related characteristics as in-situ strength and remoulded strength (relevant for placement in the reclamation areas). These small but sometimes relevant deviations from predictions result in the need for highly adaptive management of dredging and reclamation activities, which are implemented in close consultation between Femern A/S and the contractor FBC.

The technical developments already deployed in the works, such as the draining buckets for the backhoe dredgers and the newly constructed grab dredgers, perform according to expectations. Other innovative systems, like recirculation of process water, will only be put to the test in the near future.



FIGURE 12

Grab dredger Manta.



**FIGURE 13**  
Trailing Suction Hopper Dredger, Vox Amalia.

## Summary

This article describes the general background and need for the Fehmarnbelt Fixed Link project; an 18-kilometre-long immersed tunnel between Denmark (Rødbyhavn) and Germany (Puttgarden) – filling the infrastructural gap with a combined motorway and rail connection between Scandinavia and mainland Europe. It first gives a general overview by showing the tunnel alignment and the surrounding areas, including portal and ramp structures, the work harbours as supply points, the

Tunnel Element Factory and the reclamation areas along both the Danish and German coastlines.

More detailed description of local conditions give insight into the contractor's choice of dredging equipment and methodology including the critical handling of the various soil types within the reclamation areas. For example, the challenges of dredging hard till formations containing a large number of big boulders, the construction

of containment dykes around the reclamation areas and the construction of the work harbour breakwaters, basin and access channel.

Further, the article comprises detailed descriptions of the extensive UXD and naval archaeology investigations, which were carried out starting with a comprehensive desk study followed by multiple surveys up to detection, wreck protection and UXD clearance.



### Claus Iversen

With an MSc in Hydraulic and Coastal Engineering from the Danish Technical University and more than 40 years' experience, Claus Iversen has worked as a superintendent or contract director for various large-scale marine related infrastructure projects in Denmark and abroad. Major assignments have included dredging and reclamation projects for the Great Belt Link, followed by the tunnel trench dredging and reclamation for the Øresund Fixed Link. From 2005–2008, Claus was responsible for the supervision of the construction of the deepest immersed tunnel in the world under the Bosphorus in Istanbul, Turkey. From 2008–2021, working for Femern A/S as construction manager (marine works), he was involved in the preparation and permit application for the construction of the Fehmarnbelt Fixed Link project. In between, Claus has worked as an expert consultant to UNDP in Vietnam, to FAO in South Korea and to the Danish International Development Agency (DANIDA) in Sri Lanka and Egypt.



### Arjan van der Weck

After graduating with an MSc in Physical Geography and Coastal Morphology from Utrecht University in the Netherlands, Arjan worked for the Dutch Ministry of Public Works and Water Management and later Delft Hydraulics (now Deltares). He joined Boskalis in 2008 and oversaw the engineering department Hydronamic for 10 years. He was then tender manager and engineering manager for the Pulau Tekong polder construction project in Singapore. Arjan is currently design and engineering manager within Boskalis and a member of the project management team of Fehmarn Belt Contractors (FBC), responsible for design, engineering, equipment development and sediment spill management.



### Pieter van der Klis

Having gained an MSc in Civil Engineering from Delft University of Technology in the Netherlands, Pieter started his career at Ballast Nedam as a coastal engineer. He continued to work for the dredging division and was involved in the Storebaelt Bridge and Øresund Link projects. Since 2004, Pieter has worked for Van Oord. During this time, he was responsible for the design of the northern breakwater of the Maasvlakte II project in Rotterdam and later manager of the engineering department in Dubai serving many projects in the region. He was also stationed as engineering manager in Kuwait for the KNPC project. From 2013–2022 Pieter was design and engineering manager for Fehmarn Belt Contractors (FBC) responsible for the dredging and reclamation contract. He currently works for the protection and rehabilitation of the Romanian coast contract and is chairman of the Environmental Committee of EuDa.

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# REGULATION AND MANAGEMENT OF MARINE AGGREGATE DREDGING IN ENGLAND

Marine dredged sand and gravel make an important contribution to regional supplies of building materials used in England. Marine aggregate dredging however, is known to result in effects to the receiving environment which, if not properly controlled, could cause adverse impacts to a wide range of receptors. As the marine area around England gets busier, competition for space comes with regulatory challenges and an integrated marine management approach that uses a robust planning system is required. This article discusses the regulation of aggregate dredging in England and provides an overview of the sector's importance in providing primary aggregate.

## The importance of marine aggregates

The dredging of marine mineral resources (sand and gravel) from the seabed around England and Wales is an important means of winning primary aggregate (comprising sand, gravel and crushed rock). On average, around 90% is used by the construction sector, meeting 20% of the sand and gravel demand in England and Wales (The Crown Estate, 2021). This makes it a key resource in supporting the delivery of major infrastructure projects that support government policies related to ensuring energy security and combating climate change. For example, marine dredged aggregate is likely to play a key role in future port, nuclear and offshore wind farm developments in addition to beach replenishment and flood defence works. The current annual level of extraction stands at 15-20 million tonnes and has the potential to increase to up to 29 million tonnes by 2030 (The Crown Estate, 2021). This is largely

because of growing constraints on the availability of terrestrial supplies. It is therefore important to ensure this finite, strategic resource is planned for, managed and extracted in the most sustainable manner possible.

## Regulatory background

Aggregate dredging is highly regulated and in England controls have been in place since the 1960s. Historically, The Crown Estate issued "During Pleasure" licences to aggregate operators in its capacity as the owner of the seabed and in turn owner of non-energy marine minerals. In 1968, the non-statutory Government View (GV) procedure was established whereby permission to dredge would only be issued subject to the government being satisfied that predicted impacts to the environment would not result in unacceptable deleterious impacts to marine receptors. The Crown Estate, which lease



FIGURE 1

The trailer suction hopper dredger Britannia Beaver, operated by Britannia Aggregates Ltd, entering the port of Newhaven, East Sussex. Image courtesy of Britannia Aggregates.

marine mineral extraction on almost the entirety of the continental shelf of England, Wales and Northern Ireland, continue to have a role in marine aggregate extraction through the award of commercial licences and such

arrangements have been in place since the mid-1990s. Such production agreements assign exclusive rights to companies to extract sand and gravel through a competitive tender process, subject to any necessary regulatory consent.

The earlier permissions issued to dredging operators lacked robust assessment of potential impacts and formal impact assessments were not routinely undertaken. In 1988, the European-wide directive was introduced on “the assessment of the effects of certain public and private projects on the environment” (85/337/EEC). It requires that an environmental assessment be carried out before consent is granted for projects that are deemed to likely have a significant effect on the environment. This, together with a growing awareness of environmental issues, saw the GV procedure revised.

From 1989, operators were required to undertake an Environmental Impact Assessment (EIA) to support their application

for a dredging licence. Two further pieces of secondary legislation that transpose the EIA Directive into UK law were introduced in 2007. The Marine Works (EIA) Regulations (SI 2007:1518) require activities (such as aggregate dredging) that may pose a risk to navigation could trigger the need for consent under section 34 of the Coast Protection Act (1949) (CPA). While the EIA and Natural Habitats (Extraction of Minerals by Marine Dredging) (England and Northern Ireland) (SI 2007:1067) places further requirements on applicants including monitoring conditions that are attached to “Dredging Permissions”.

More recently, The Marine and Coastal Access Act (MCAA 2009) received Royal assent in November 2009 and secondary legislation was subsequently drafted that repealed the EIA and Natural Habitats (Extraction of Minerals by Marine Dredging) (England and Northern Ireland) (SI 2007:1067). The CPA consent (and licence required under the Food and Environment Protection Act 1985) was replaced from

6 April 2011 and any aggregate dredging activity within the UK marine area (as defined in section 42 of the MCAA 2009) now requires a Marine Licence.

**The Marine Management Organisation (MMO)**

The Marine Management Organisation (MMO) is the marine manager in England (with marine licensing in Wales being undertaken by Natural Resources Wales and by Marine Scotland in Scottish waters) and was established in 2010 through the MCAA 2009. The MMO is the principal body responsible for providing a holistic approach to marine management and licensing around England within the UK marine area. A white paper laid before parliament in 2007 (DEFRA, 2007) included provision for establishing the MMO and set out requirements for modernising the marine licensing system that existed at the time.

An objective of the new marine licensing system adopted in the MCAA 2009 was to provide a regime that is streamlined and designed to provide a better, more consistent and cost effective and efficient system that is easier to use by applicants (DEFRA, 2007). The MMO has a key duty when exercising its functions to be a champion of sustainable development in the marine area. Central to the MMO exercising its functions is therefore to champion sustainable development. Generally, “sustainable development” is defined as development that meets the needs of the present without compromising the ability of future generations to meet their needs (defined in the 1987 Brundtland report). Such a holistic approach allows the MMO to consider the wider benefits of proposed developments alongside potential impacts and ensure a balance is struck between competing uses – an approach that adopts the principles of better regulation and is flexible, targeted, proportionate and risk based.

The Marine Bill white paper set clear guidance for establishing exemptions for activities that are so insignificant that they should not be regulated at all. The white paper established principles to disapply from the licensing regime certain activities that might include minor construction projects. The MCAA 2009 aims to promote a risk-based and proportionate approach to licensing and exemptions. Orders are intended to promote growth while protecting other uses of the sea in a balanced way.

The Deregulation Act 2015 also places certain requirements on regulators to have regard to the desirability of promoting economic growth – known as the “Growth Duty”. The 2015 Act requires regulators to have regard to how their regulatory activities might affect economic growth and competitiveness; under the 2015 Act, regulators must also have regard to the need to minimise any disproportionate impact of regulation on activities with an aim of delivering efficiency in regulating business activities while keeping the costs to businesses to a minimum.

**Marine planning**

The MCAA 2009 established the legal basis for marine planning, while the UK Marine Policy Statement (MPS) (HM Government, 2011) provides the policy framework and the context for marine plans. Marine plans put into practice the objectives for the marine environment that are identified in the MPS alongside the National Planning Policy Framework (NPPF) and the Localism Act 2011 (DEFRA, 2011).

The MPS recognises the contribution of the sustainable marine aggregate extraction

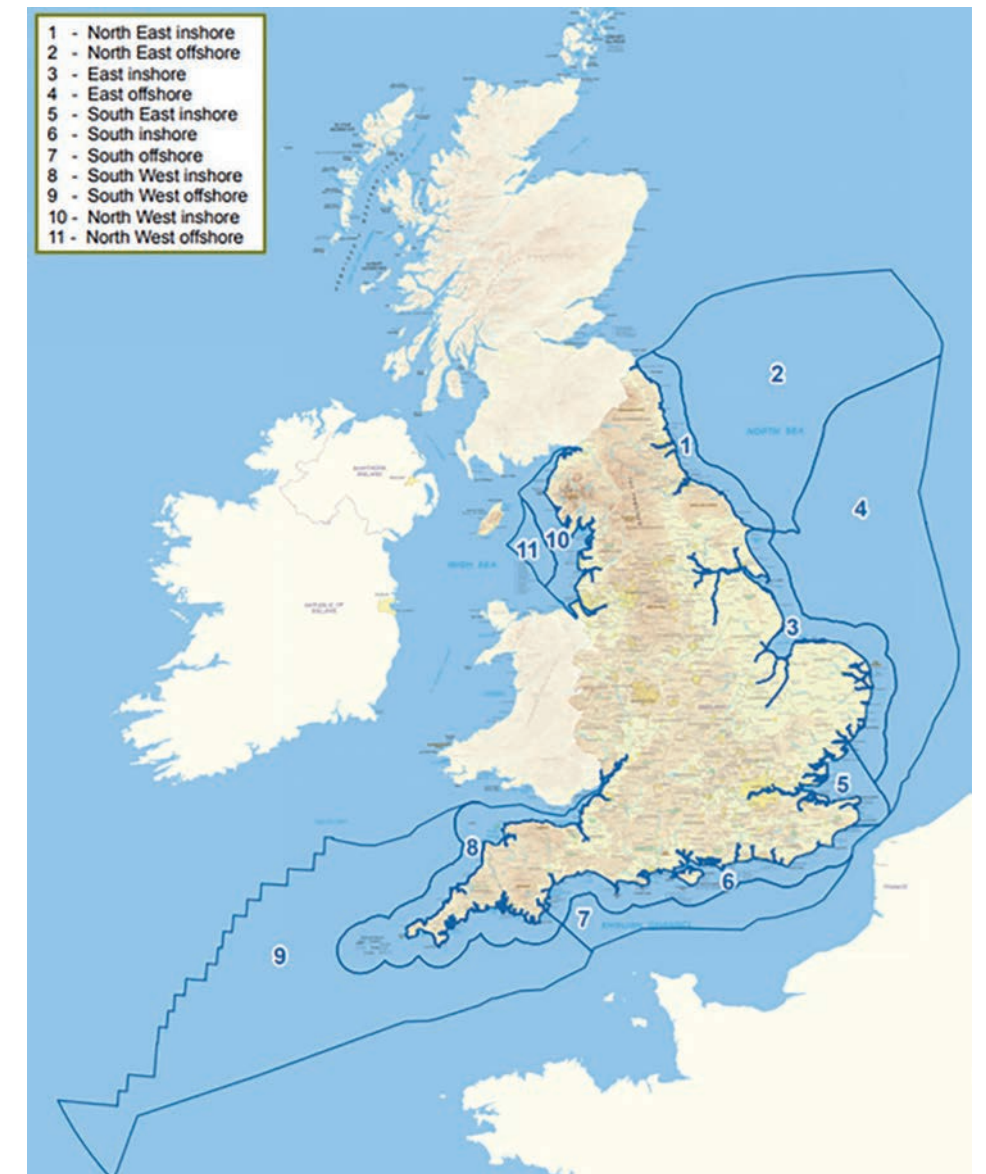


FIGURE 2

Marine plan areas in England.



in section 3.5.1: "The UK has some of the best marine aggregate resources in the world. Marine sand and gravel makes a crucial contribution to meeting the nation's demand for construction aggregate materials, essential for the development of our built environment. (...) The extraction of marine dredged sand and gravel should continue to the extent that this remains consistent with the principles of sustainable development, recognising that marine aggregates are a finite resource and in line with the relevant guidance and legislation."

In relation to marine plans, the MPS states in section 3.5.5 that, "Marine plan authorities should as a minimum make provision within marine plans for a level of supply of marine sand and gravel that ensures that marine aggregates (along with other sources of aggregates, including recyclates) contribute to the overarching government objective of securing an adequate and continuing supply to the UK market for various uses. In doing so, marine plan authorities should consider the potential long-term requirement for marine-won sand and gravel, taking into account trends in construction activity, likely climate change adaptation strategies and major project development."

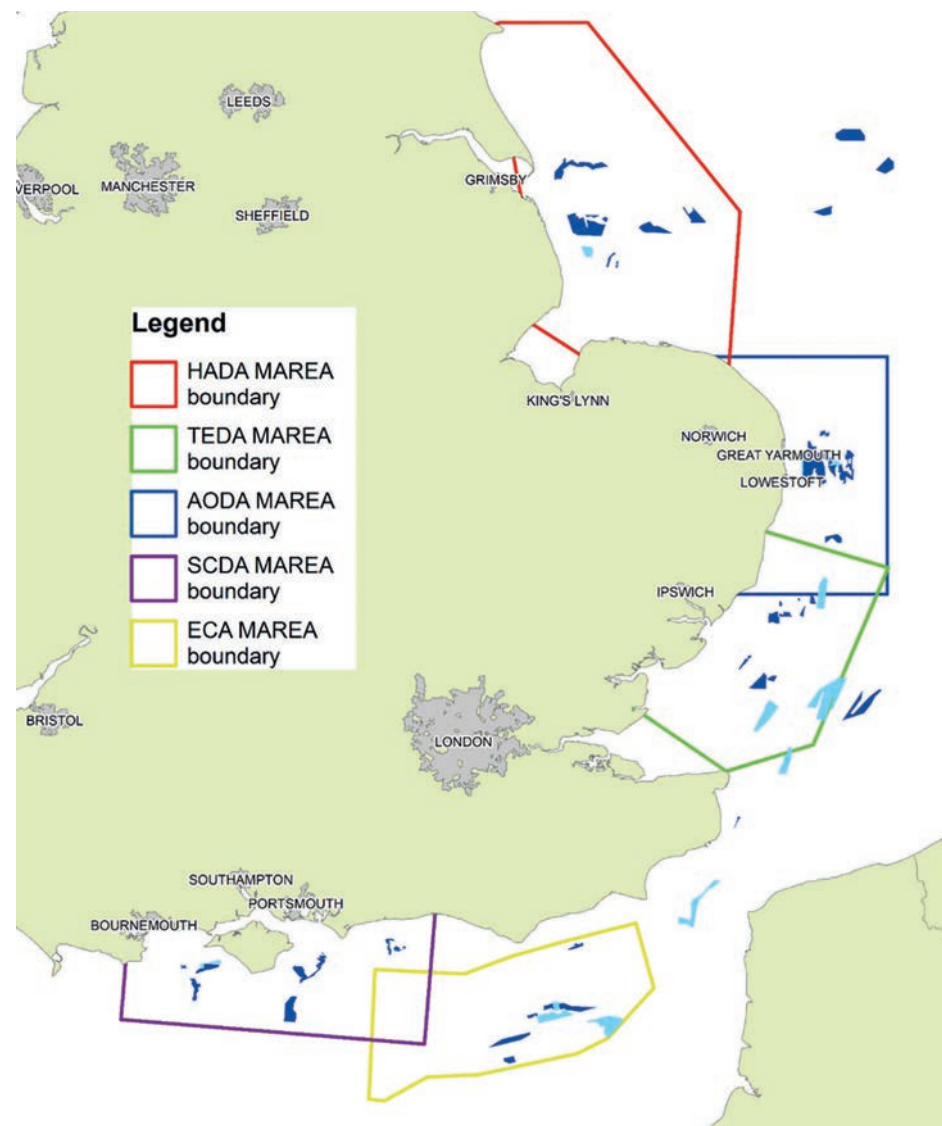
The MPS follows (see section 3.5.6) that regulators should base their decisions on sustainability criteria, taking into account the existing seabed and aggregates usage, along with the need to safeguard reserves for future extraction. The statement concludes that a regulatory approval should only be granted if the proposed aggregate dredging is environmentally acceptable.

Marine plans set out priorities and directions for future development within the plan areas, inform sustainable use of marine resources and help marine users understand the best locations for their activities, including where new developments may be appropriate. The MMO is responsible for preparing marine plans in England. On 23 June 2021, the North East, North West, South East and South West plans were published, joining the existing South and East areas. As result, for the first time all England's seas, an area of approximately 230,000 km<sup>2</sup>, are covered by marine plans (Figure 2). Each of the marine plan areas has a plan with a long-term (20 years) view of activities and will be reviewed every three years.

It should be noted that each marine plan is specific to the area it covers and the policies may vary depending on, for example, available resources, environmental characteristics and sensitivities, and the existing uses of the sea. This is reflected in the policies relating to aggregate extraction.

For example, the plan policies in the East inshore and East offshore marine plan areas apply the intent set out in national policy taking account of the

regional and national importance of the region for marine aggregate supply, and of the spatially discrete areas in which commercially viable deposits of sand and gravel are found. The policies are drafted in a hierarchical way such that policy AGG1 affords the highest level of protection and policy AGG3 requires other forms of marine development to take into account the need to safeguard aggregate reserves for future extraction (HM Government, 2014):



**FIGURE 3** MAREA regions: Humber Aggregate Dredging Association (HADA), Thames Estuary Dredging Association (TEDA), Anglian Offshore Dredging Association (AODA), South Coast Dredging Association (SCDA), East Channel Association (ECA).

**Policy AGG1**

Proposals in areas where a licence for extraction of aggregates has been granted or formally applied for should not be authorised unless there are exceptional circumstances.

**Policy AGG2**

Proposals within an area subject to an Exploration and Option Agreement with The Crown Estate should not be supported unless it is demonstrated that the other development or activity is compatible with aggregate extraction or there are exceptional circumstances.

**Policy AGG3**

Within defined areas of high potential aggregate resource, proposals should demonstrate in order of preference:

- a) that they will not, prevent aggregate extraction.
- b) how, if there are adverse impacts on aggregate extraction, they will minimise these.
- c) how, if the adverse impacts cannot be minimised, they will be mitigated.
- d) the case for proceeding with the application if it is not possible to minimise or mitigate the adverse impacts.

As per section 58 of the MCAA 2009, public authorities (including the MMO) must take any authorisation or enforcement decision in accordance with the appropriate marine policy documents, unless relevant considerations indicate otherwise.

**Marine licensing process**

Section 66 of the MCAA 2009 identifies activities that require a marine licence and specifies in section 66(9), "To carry out any form of dredging within the UK marine licensing area (whether or not involving the removal of any material from the sea or sea bed)". This includes the extraction of marine aggregates from the seabed.

Schedule A2, regulation 10 of the Marine Works (Environmental Impact Assessment) (Amendment) Regulations 2017 (the Marine Works Regulations) lists, "Extraction of minerals by fluvial or marine dredging". Since the activity is listed in Schedule A2 of the Marine Works Regulations, an Environmental Impact Assessment (EIA) is required if it is likely that the aggregate dredging will have a significant effect on the environment. In such cases, the MMO would normally undertake EIA screening by determination to assess the proposed works. In practice, due to the

**All England's seas, an area of approximately 230,000 km<sup>2</sup>, are covered by marine plans.**

characteristics and location of aggregate dredging, most applications for dredging generally require an EIA and are screened into EIA by agreement under regulation 5 of the Marine Works Regulations.

While each application is reviewed on its own merit, aggregate dredging projects frequently require Water Framework Directive (WFD) assessment, along with Habitats Regulations Assessment (HRA) and Marine Conservation



**FIGURE 4** Lincshire Beach Nourishment scheme being undertaken by Van Oord. Photo @ Van Oord.

**In addition to individual surveys, substantive reviews are undertaken for every marine licence every five years.**

Zone (MCZ) assessment if they are capable of impacting marine protected areas. Additionally, aggregate dredging generally requires an assessment of the likely physical effects (e.g. changes in wave height) on the receiving environment and implications the activity may have on coastal erosion. Such assessment is normally submitted in the form of a Coastal Impact Study (CIS). The aggregates industry usually undertakes extensive pre-application engagement to inform their assessments and draft an environmental statement to support the application for a marine licence.

Importantly, environmental assessments for the marine aggregate sector are undertaken at both the individual project (site level), but also on a regional basis. The aggregates industry has voluntarily completed a number of Marine Aggregate Regional Environmental Assessments (MAREAs) comprising broad-scale environmental characterisations covering the main regions of interest for dredging that help inform site-specific assessments (Figure 3). Through the review of MAREAs, the MMO can use the best available evidence to assess the potential cumulative impacts of multiple aggregate sites within each region.

The British Marine Aggregate Producers Association (BMAPA) and The Crown Estate, in consultation with Defra, the MMO, Natural England, JNCC, Historic England and Centre for Environment, Fisheries and Aquaculture Science, have produced Good Practice Guidance providing an overview of the environmental assessments, monitoring, mitigation and management methods in aggregate dredging (BMAPA, The Crown Estate, 2017).

The MMO does not make its decisions in isolation and consults widely on applications for aggregate marine licences. For example, the environmental statement and supporting evidence, are publicised and the MMO consults on the proposed activity for 42 days in accordance with sections 16 and 17 of the Marine Works Regulations. While the exact list of consultees is determined on a case-by-case basis, consultation is typically undertaken with a broad range of advisers including:

- Centre for Environment, Fisheries and Aquaculture Science (Cefas);
- Natural England;
- Joint Nature Conservation Committee;
- Historic England;
- Environment Agency;
- Inshore Fisheries and Conservation Authorities;
- Trinity House;
- Maritime and Coastguard Agency;
- UK Hydrographic Office;
- The Crown Estate;
- Royal Yachting Association;
- Local Port/Harbour Authority; and
- National Federation of Fishermen's Organisations.

The MMO also considers representations submitted by members of the public and stakeholders who may have an interest in the proposed dredging activity. The MMO evaluates representations received and drafts a determination having regard to the need to protect the environment and human health, prevent interferences with legitimate uses of the sea and any other matters the MMO thinks relevant. Following this robust decision-making process, a marine licence may be granted unconditionally, subject to conditions or the application refused.

**Management and monitoring of marine aggregates extraction**

While each aggregate application is reviewed on a case-by-case basis and any regulatory decision informed by the consultation process, there are several measures secured within a marine licence through licence conditions. This ensures that any aggregate extraction is undertaken in accordance with impact prediction and on a sustainable basis.

**Surveys and monitoring**

A marine licence would typically permit 15 years of dredging activity, which is reflected in the term of commercial licences issued by The Crown Estate. However, prior to

commencement of aggregate dredging, the licence holder is required to undertake a number of pre-dredge baseline surveys. Such surveys generally require bathymetry, side scan sonar and seabed grab sample data to be collected. The licensed activity may not commence until the MMO discharges the pre-commencement requirements conditioned on the Marine Licence.

The conditions on the licence will then require various site-specific operational phase monitoring throughout the life of the project to assess the effects of dredging on the environment, with the frequency and coverage of such monitoring specified in the licence conditions. All the information submitted is then summarised through annual compliance reporting.

In addition to individual surveys, substantive reviews are undertaken for every marine licence every five years. Such reviews collate all the data submitted within the preceding 5-year period in order to enable comparison with the predictions in the environmental statement. This enables assessment of the impacts of the licensed activity and informs decisions on future operations.

It is a condition on aggregate dredging marine licences that dredging vessels must be fitted with an approved Electronic Monitoring System (EMS), which automatically records the date, time and location of dredging activities. EMS has been a requirement for marine aggregate extraction in UK waters since 1993. The latest EMS generation comprises a robust, secure black box-based system with an independent GPS to track vessel position and acoustic sensor to indicate vessel dredging status, with a data log recording frequency of 10 seconds. All data recorded are encrypted and analysed to ensure compliance with marine licence conditions. The Crown Estate administer the system, process all EMS records and share data with the relevant regulators. Any irregularities can then be investigated by the MMO who can undertake any necessary compliance enforcement actions. The EMS reports, covering summary of the dredging activities, EMS breakdowns and out of zone dredging, are published annually by The Crown Estate to ensure full transparency (The Crown Estate, RH DHV, 2019).

Following completion of dredging activity, there is a further requirement for post-dredge monitoring in order to assess the condition of



**FIGURE 5**

The trailer suction hopper dredger Sospan Dau, operated by Boskalis Westminster, undertaking beach nourishment work at Elmer, West Sussex. Image courtesy of Andrew Bellamy.

seabed and any changes that occurred as result of dredging.

**Mitigation and management**

The marine licence regulates the amount of material that can be extracted from the seabed (along with the minimum thickness cap of the remaining resource), along with the location and timing of dredging activity and the manner (dredging technique) in which extraction can take place.

Potential impacts on sensitive species or habitats are commonly mitigated through conditions on screening restrictions. Such restrictions may range from a complete ban on "screening" (the mechanical process of re-sizing and separating the material during dredging operations) in a particular location to limiting screening to certain times of the year (e.g. so as to avoid key life stages of commercial fish species). Seasonal restrictions may also be conditioned in order to prevent any dredging activity from impacting environmental receptors during sensitive periods.

The MMO will also condition dredging exclusion zones in order to protect areas

where the thickness of resource remaining on the seabed approaches the capping layer (required to ensure seabed sediments remain similar at the end of extraction) along with conservation and heritage features. Such zones contain a suitable buffer around the receptor to ensure further impacts from ongoing dredging activity are avoided.

In order to protect features of archaeological interest, prior to commencement of dredging, the MMO must approve project-specific mitigation measures developed with archaeological curators in line with the guidance note "Marine aggregate dredging and the historic environment" developed by BMAPA and English Heritage (BMAPA, English Heritage, 2003). The note provides practical advice on assessing, evaluating, mitigating and monitoring the impact of marine aggregate dredging on archaeological features. The protocol states that all finds of archaeological interest should be reported.

The aggregate dredging can also be managed through the use of active dredge areas, which limit the area of seabed that can be dredged at any one time. This restricts the extent of dredging activity within the licensed area,

limiting the potential impacts to the environment and the other uses of the sea. The licence holders' compliance with both dredging exclusion zones and active dredge areas is monitored and enforced using EMS data.

There are a number of other conditions attached to marine licences to manage potential impacts. For example, to manage the spread of invasive non-native species, conditions in relation to hopper washing

**Potential impacts on sensitive species or habitats are commonly mitigated through conditions on screening restrictions.**

restrict the locations and manner in which it can be undertaken. Marine licences generally permit removal of less than 50 m<sup>3</sup> of any residual material and hopper washing outside of any exclusion zones. There are also various steps taken in order to manage impacts to other users of the sea. For example, fisheries liaison meetings are periodically held between the MMO, aggregate operators and fishers to facilitate their co-existence. Marine licences also condition compliance with the Fisheries Code of Practice (BMAPA, MMO, The Crown Estate, 2015) covering requirements of timely pre-commencement notification of active dredge areas and dissemination of updates to the fishing industry throughout the dredging operations. This ensures that the licensed activities do not interfere with any fishing activity.

**Engagement and transparency**

The MMO is fully committed to transparency and maintains a public register in accordance with section 101 of MCAA 2009. The register contains marine licence applications and decisions, along with assessments to support licence applications, supporting evidence and consultation responses. The MMO maintains regular dialogue with the aggregates industry, its representative trade body BMAPA and relevant primary and scientific advisors including Cefas, JNCC, Natural England and Historic England. The MMO also liaises closely with The Crown Estate as the seabed owner.

This extensive engagement enables the MMO to pool the necessary resources and expertise to resolve issues at a strategic level through interaction between the regulators, industry and scientists. The aggregates sector is a mature sector and has benefited from a decade of multidisciplinary research to improve understanding and knowledge of the environmental implications of marine aggregate extraction, funded through the marine Aggregate Levy Sustainability Fund (ALSF) (BMAPA, The Crown Estate, 2013). Strategic oversight of the programme, which ran from April 2002 until March 2011, was delivered through a steering group comprising of the MMO, other government departments, agencies, advisers, the marine aggregate industry and The Crown Estate. Additionally, the outputs from the ALSF helped to inform how the marine aggregate sector is presently managed.

Building on the concepts of the previous ALSF research and strategic cooperation, the

Regional Seabed Monitoring Plan (RSMP) approach was developed and jointly funded by the MMO, marine aggregate industry, Defra, Welsh Government and The Crown Estate. This innovative project delivers the seabed monitoring required to fulfil the conditions of marine licences for aggregate extraction on regional basis, covering the main marine aggregate extraction areas. The RSMP surveys have been undertaken since 2014, providing a robust and coordinated way of data gathering, creating opportunities for cost savings for the industry and helping regulators to evaluate the potential cumulative and in-combination effects of existing and proposed future dredging activity. This wider research effort led to compliance requirements shifting focus towards the seabed conditions necessary for the marine environment recovery and monitoring activities moving away from the traditional analysis of benthic communities to greater focus on changes in seabed sediment type over time. This successful, coordinated approach between regulators, advisers, policy leads and industry is often considered an example of best practice by the wider marine community.

The Crown Estate, BMAPA and the aggregates industry are also committed to improving the effective and sustainable management of the seabed through transparency and accountability. In 1999, The Crown Estate and BMAPA issued a statement of intent (the “Area Involved” initiative) committing to reviewing all marine aggregate extraction over a rolling five-year period with a view to minimise the area of seabed dredged. Included within the initiative was a commitment to surrender areas no longer containing useful resources of sand and gravel, and to publish an annual report detailing the extent of dredging within the licensed areas. The latest (23rd) report (BMAPA, The Crown Estate, 2020) shows the ongoing commitment to this voluntary initiative. The 2019 20-year review of the “Area Involved” initiative (BMAPA, The Crown Estate, 2018) shows an overall reduction in both the area of seabed licensed and the area of seabed dredged, helping to minimise the environmental footprint of aggregate dredging activity.

**Conclusions**

The seas around the UK are becoming busier given the expansion of various activities not least offshore windfarms. Such competition for space comes with regulatory challenges.

An integrated marine management approach using marine planning has been developed, together with a risk-based approach to regulation, to manage competing interests, requiring decision makers to use best available evidence and ensure finite resources are managed sustainably.

**Summary**

The extraction of marine aggregate in the English marine area is highly regulated and must be undertaken in line with relevant policy and plans (unless relevant considerations indicate otherwise). There are several safeguards within the regulatory framework that ensure the risk to environmental receptors and other uses of the sea are minimised. In addition, when production operations cease, the seabed sediments must be left to a similar condition to that which existed before dredging operations commenced to allow for the benthic recolonisation and recovery of dredged areas. The regulation and management of aggregate extraction also require extensive stakeholder engagement so that wider uses are considered, dredging operations are sustainable and the seabed managed effectively. This article discusses the regulation of aggregate dredging in England and provides an overview of the sector’s importance in providing primary aggregate.

**Acknowledgements and disclaimer**

We would like to thank Mark Russell (BMAPA) and Nick Everington (The Crown Estate) for comments on an earlier draft of this paper. Any omissions or errors are those of the authors. The above does not represent statutory advice and licence applicants must seek their own legal advice. Each licence application is considered on its own merit and it is recommended that the MMO is consulted at the earliest opportunity in order to provide case-specific advice.



**Shaun Nicholson**

Shaun is an aquatic environmental scientist with over 20 years consultancy and regulatory experience. He has extensive international experience and has led projects in the UK, Ireland, Kuwait, Hong Kong, Macau, China and St Helena. He is presently the Head of Strategic Marine Licensing at the Marine Management Organisation (MMO), responsible for technical advice to the licensing team, managing the training framework and internal audit, briefing ministers and strategic advice to policy officials. Shaun has managed a diverse range of marine casework including offshore renewable energy installations (wind, wave, tidal), nuclear new builds, carbon capture and storage, pipelines, cables and interconnectors, sewerage infrastructure, port and harbour developments and marine aggregates.



**Eva Szewczyk**

Eva worked as a Senior Licensing Manager and Aggregates Lead at the Marine Management Organisation (MMO). She currently works as a Senior Policy Advisor at the newly formed Maritime Capability Campaign Office at the Department for International Trade (DIT). Eva is also undertaking PhD research at Northumbria University, in the UK, in legal implications of autonomous shipping.

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## DEME'S AWARD WINNING RETRACTABLE LADDER DESIGN

DEME is very proud that its retractable ladder, specifically designed for hydraulic track excavators, won the prestigious IADC Safety Award 2022, and especially because the design of this invaluable piece of safety equipment is now being shared with other IADC members.

Jeffry Bolsens, DEME's Project QHSE-S Manager, explains how this ingenious but simple solution came about. "Stepping on and off excavators is always risky. The standard access steps to these excavators are located inside the boundary of the tracks and when covered in mud, sand and clay it is very easy to slip, which regularly results in accidents, leaving our operators with the risk of cuts and bruised shins."

DEME talked to its operators and the majority said they all have a risk to get scars on their shins as a result of contact with the tracks while stepping on and off the excavators. The QHSE-S team knew

something had to be done and a year ago, they started to consider the advantages of deploying a foldable, retractable ladder. "We saw that there was a significant problem and looked for a safer solution which could replace the existing steps," says Jeffry. "The very large excavators have fixed platforms at the back of the machines that operate automatically, but with smaller reclamation units there is the continual risk of operators' shins making contact with the tracks."

### EN 1090 certification

In a clever solution, the retractable ladder, which has an EN 1090 certification and

complies with all the latest regulations, can be folded up just below the topside of the excavator. Crucially, at all times the operator has a 3-point contact when stepping on and off. Within the Benelux alone, DEME operates approximately 60 track excavators and has 120 operators. These excavators have all been fitted with the new ladder and DEME has also constructed new ladders for its projects worldwide.

### Preventing injuries by sharing knowledge

Jeffry stresses that it was important for DEME to share this vital safety tool with the wider industry, so that other dredging

companies can also prevent injuries occurring to their employees. "We have already had several requests from some of our competitors for the design drawings. Our management took the decision that any company requesting the design should be given access to it. Ultimately, we want every company using this equipment."

"Additionally, many of the big projects we perform are joint ventures with other IADC members, therefore it is important to share lessons learnt, particularly when it comes to the safety of personnel," Jeffry adds. "We want to improve safety for everyone and that each company has the same high standards as DEME." The QHSE-S team were absolutely determined to find a solution to this issue and carried out tests on an existing foldable ladder design. "We could immediately see the potential, with the addition of some modifications, to bring it in line with DEME's stringent safety standards."

Initially some of the excavator operators were not enthusiastic about using the new ladder and there was some resistance to a new way of working. However, when Jeffry sees them onsite nowadays, they are all using it and appreciate that they are much safer.

### Robust design requiring minimal maintenance

The ladder itself is made from a single piece of galvanised steel and is designed for the tough conditions on busy project sites. Self-retracting after use, the ladder can be bolted or welded at the same location as the original access platform. Additionally, it features a standardised, simple system that can be retrofitted on any existing hydraulic excavator.

Another major advantage is that the area between the tracks and upper cabin stays completely free, so there is no contact with sand or mud sticking on the tracks. It can also be conveniently stored without additional risks during operations and transportation. As well as this, it requires minimal maintenance.

### A DEME Safety Success Story

The new ladder is also a DEME "Safety Success Story". Always keen to continually improve safety within the company, DEME promotes the "Safety Success Stories" initiative, where everyone is encouraged to share best practice and tips about improvements they have made in their

department, on a project site or on vessels. These success stories are then judged and the best ones are highlighted on the annual Safety Moment Day.

Jeffry emphasises, "By equipping excavators with the new ladder, our operators can safely

access their machinery under all conditions. We avoid injuries caused by contact with the tracks or falling off the tracks when stepping on and off the excavator. And we are very happy to share this innovation so that every IADC member can equip their excavators with a safe access."



FIGURE 1

Eric Tancre (left), Managing Director Activity Line Infra and Activity Line Dredging, accepts the IADC Safety Award 2022 presented by Frank Verhoeven, IADC President.



FIGURE 2

The ladder ensures the operator has a 3-point contact at all times when stepping on and off.

# UPCOMING COURSES AND CONFERENCES

## Financing Sustainable Marine and Freshwater Infrastructure Conference

9 February 2023  
Mövenpick Jumeirah Beach Hotel  
Dubai, UAE

How can private capital accelerate the green transition in marine and freshwater infrastructure? This is the overarching question that will be explored during the IADC conference based on the recently published report by the same name. "Financing Sustainable Marine and Freshwater Infrastructure: A joint study to explore financing of green coastal, river and port projects."

All stakeholders recognise the importance of sustainable projects. Investors have green labelled funds, governments have a green taxonomy in place and contractors are continually developing nature-based solutions. Everyone it would appear is committed to sustainability, however parties face insurmountable difficulties in bringing it all together in executing projects. How then can parties break the deadlock in the funding of sustainable projects?

### Aim of the conference

The focus of the 1-day conference will address who needs to do what and what is needed to break this deadlock. The event aims to recognise the different obstacles experienced by different stakeholders. By having interactive discussions among stakeholders and audience based on eye-catching marine infrastructure projects, potential solutions to overcome these obstacles will be identified. The final result will be a prioritised list of activities to break down the obstacles. In addition, stakeholders will be named to work on each of these activities. For more information and how to register visit <https://bit.ly/ConfDubai2023>.



## Hydraulic Engineering Structures and Dredging Congress

15-17 February 2023  
Russian Chamber of Commerce and Industry  
Moscow, Russia

The Hydraulic Engineering Structures and Dredging Congress is a unique and highly acclaimed industry focused platform annually gathering stakeholders of hydraulic engineering and dredging works. It is a place for professionals to meet and to sign contracts.

In February 2023, the congress will include the 10<sup>th</sup> International Dredging Forum and the 6<sup>th</sup> Technical Conference 'Modern Solutions for Hydraulic Engineering'. Every year, the event gathers over 400 delegates representing the major stakeholders of hydraulic engineering and dredging works including suppliers of sophisticated equipment and components, designing and engineering organisations and industry-focused universities.

## Dredging and Reclamation Seminar

3-7 July 2023  
IHE Delft Institute for Water Education  
Delft, The Netherlands

### About the seminar

Since 1993, the IADC has regularly held a week-long seminar developed especially for professionals in dredging-related industries. These intensive courses have been successfully presented in the Netherlands, Singapore, Dubai, Argentina, Abu Dhabi, Bahrain and Brazil. With these seminars, IADC reflects its commitment to education, encouraging young people to enter the field of dredging and improving knowledge about dredging throughout the world.

### For whom

The seminar has been developed for both technical and non-technical professionals in dredging-related industries. From students and newcomers in the field of dredging to higher-level consultants, advisors at port and harbour authorities, offshore companies and other organisations that carry out dredging projects. Attendees will gain a wealth of knowledge and a better understanding of the fascinating and vital dredging industry.

### In the classroom

There is no other dredging seminar that includes a workshop covering a complete tendering process from start to finish. The in-depth lectures are presented by experienced dredging professionals from IADC member companies. Their practical knowledge and professional expertise are invaluable for in the classroom-based lessons. Among the subjects covered are:

- the development of new ports and maintenance of existing ports;
- project development: from preparation to realisation;

- descriptions of types of dredging equipment;
- costing of projects;
- types of dredging projects; and
- environmental aspects of dredging.

### Site visit: seeing is believing

Practical experience is priceless and it sets aside this seminar from all others. There will be a site visit to a dredging yard of an IADC member to allow participants to view and experience dredging equipment first-hand to gain better insights into the multi-faceted field of dredging operations.

### Networking

Networking is invaluable. A mid-week dinner where participants, lecturers and other dredging employees can interact, network, and discuss the real, hands-on world of dredging provides another dimension to this stimulating week.

### Certificate of achievement

Each participant will receive a set of comprehensive proceedings and at the end of the week, a certificate of achievement in recognition of the completion of the coursework. Full attendance is required to attain the certificate.

### Costs

The fee for the week-long seminar is EUR 3,100 (out of scope EU VAT). The fee includes all tuition, proceedings, workshops and a special participants' dinner, but excludes travel costs and accommodations. We can assist you in finding a hotel or accommodation. For more information and how to register visit <https://bit.ly/SeminarDelft2023>.



**An on-site visit to the dredging yard or project of an IADC member is an integral element in the learning process.**

# WEDAPEDIA: A GLOSSARY OF MARITIME TERMINOLOGY

As part of the Western Dredging Association's mission to promote the exchange of knowledge, the WEDA Publications Commission launched *WEDApedia* – an invaluable resource for anyone interested in the dredging industry.

Officially released in July at the WEDA Dredging Summit & Expo in Houston, Texas, the online publication by the Western Dredging Association (WEDA) has been designed to be a dynamic, go-to resource for all parties coming in contact with the field of dredging – whether as a maritime professional, a government official or a stakeholder.

*WEDApedia* holds a wealth of information and standard definitions for all aspects of the dredging industry. Free to access by members and non-members, the website is easy to navigate and allows visitors to download individual PDF files from A–Z. For anyone, whether new to the industry or a seasoned professional, it provides an invaluable and concise dictionary of terms, technology and techniques to help get understanding of the intensely technical world of dredging.

The foundation of *WEDApedia* is a database started in the 1990s in collaboration with and peer reviewed by the U.S. Army Corps of Engineers (USACE) Dredging Navigation Branch. The USACE's aim was to consolidate and build upon terminology found in a wide range of their documents.

While many people spent many hours researching, writing and transforming the almost 250-page original hard copy into an updated digital document, WEDA means it to be a living resource that continues to grow. The WEDA Publications Commission encourages readers throughout the dredging

community to send comments, updates and contributions.

The dredging industry does not standstill and WEDA trusts that with continuing input *WEDApedia* will reflect this. In this way, the ongoing review of information will continue and make *WEDApedia* a current, up-to-date database of industry terms.

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**Publisher:** Western Dredging Association  
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<https://www.westerndredging.org/wedapedia>



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### Call for submissions

Published quarterly, *Terra et Aqua* is an educational and professional resource that features cutting-edge innovations to disseminate knowledge throughout the dredging industry. Are you an author, researcher or expert in dredging or a related field? Do you want to share your innovative research, papers or publications with the dredging industry? Then submit your proposals to the editor at [editor@iadc-dredging.com](mailto:editor@iadc-dredging.com) for consideration.

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# ALWAYS READY TO MEET NEW CHALLENGES

IADC stands for 'International Association of Dredging Companies' and is the global umbrella organisation for contractors in the private dredging industry. IADC is dedicated to promoting the skills, integrity and reliability of its members as well as the dredging industry in general. IADC has over one hundred main and associated members. Together they represent the forefront of the dredging industry.

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