SMARTSEDIMENT SUMMARY REPORT

SEDIMENT: FROM RESIDUAL PRODUCT TO VALUABLE BUILDING BLOCK IN NATURE RESTORATION

August 2020

Interreg
Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

COMMON TERN

The common tern, with its white body and black head, its jinking flight and plunging dives for fish, is one of the jewels of the Delta. It can also be found on the inland side of the dykes. Common terns like to breed in colonies. They don't put much effort into the nest; it isn't much more than a pit they dig by wriggling their rump, lined with a few shells or strands of plant material. The tern is a pioneer – not surprisingly for a bird that breeds in bare soil – and will soon spot promising new breeding grounds.

Foreword

DEPOSITING SAND SMARTLY; LETTING WIND AND WATER DO THE WORK

Over the past four years, the Dutch and Flemish public authorities have joined forces with nature organisations and science institutes to carry out the Smartsediment project in the Flemish-Dutch Scheldt Delta. This project aims to conserve and, where possible, increase biodiversity through an innovative approach to sediment management in the Sea Scheldt, Western Scheldt and Eastern Scheldt.

All measures are expressly geared to this ecological function of the Scheldt Delta. The investment is an investment in the natural wealth and the biodiversity of this valuable Flemish-Dutch delta. Public acceptance has largely been good, although there was some resistance among mussel farmers in the Eastern Scheldt, who were afraid that the sand replenishment might have an impact that would harm their interests. To increase public support for the measures and the associated costs, Smartsediment wants to boost the other 'ecosystem services', as they are termed, or 'nature benefits' (for example, safety, recreation and accessibility) in the Scheldt Delta. Smartsediment is explicitly a research programme as well. Closely monitoring the effects of the interventions and keeping track of problems and solutions should make it possible to improve the method for sediment replenishment. By no means all the questions have been answered. Monitoring and research will continue to be required in the years ahead.

Smartsediment partners

Provincie Zeeland

Natuurmonumenten

De Vlaamse Waterweg nv

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

Vlaanderen
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BIODIVERSITY IN THE FLEMISH-DUTCH SCHELDT DELTA

The Flemish-Dutch Scheldt Delta contains several Natura 2000 areas that have been designated internationally as the home for 33 endangered animal species. They include the Sandwich tern, the common curlew, the sea lamprey and the twaite shad. The Scheldt Delta's huge value for nature is due to the salinity gradient of the water (from freshwater to pure saltwater), the varying depths and the presence of salt marshes, flats exposed at low tide, silt and shallows. What is more, the delta lies on the migration routes for many birds. The delta's value for nature, in large part because of the high biodiversity, is however under considerable pressure. There is less and less room for birds, fish, seals and shellfish due to the erosion of the tidal flats (partly as a consequence of the construction of the Eastern Scheldt storm surge barrier), the loss of shallow zones (with the deepening of the Western Scheldt) and economic activities.

Getting started for biodiversity recovery

Biodiversity in the Scheldt Delta has declined in recent decades and is under increasing pressure. Large numbers of birds are losing the habitats where they rest, forage and breed. Fish populations and the number of different fish species are falling fast, the flora is deteriorating and insect diversity is decreasing too. As said, key causes are the hydraulic engineering works such as the construction of the storm surge barrier in the Eastern Scheldt, the work to make the Western and Sea Scheldt deeper and the dyke-building there. These interventions have reduced the area that is exposed at low tide (which has disadvantages for birds and seals) and led to the loss of shallows (spawning and nursery areas for fish). Increasing levels of recreation and the associated disturbance, along with climate change and the resulting loss of sand flats and mudflats, are further reducing the natural riches. Smartsediment should not be seen as a solution to these problems. Only a better effort to maintain and increase biodiversity – one that enjoys public and political support – can offer relief. Steps are being taken in that direction too. Only then can the continuing decline be brought to a halt.

GETTING DOWN TO WORK

The guiding principles and tasks for Smartsediment:

1 Smartsediment aims to use sediment in sophisticated ways to help **restore habitats**.

Specifically, carrying out interventions in areas totalling about 220 hectares to foster nature restoration and protection:

- In the **Eastern Scheldt**, an intertidal area of 200 hectares on the Roggenplaat flats is being replenished. This replenishment will have an impact over a much greater area (1,900-2,000 hectares). The replenishment is raising Roggenplaat so that the flat land is exposed for longer during low tide. This extends foraging opportunities for birds and the period during which seals can rest.
- Raising the seabed in the **Lower-Sea Scheldt** next to Fort Sint-Filips has created 20 hectares of intertidal areas and shallows (nurseries for fish and places where birds can find food).
- In the **Upper-Sea Scheldt**, sediment is being deposited back at three locations for as part of navigation channel maintenance and for reinforcing nature where possible. The aim here is mainly monitoring and knowledge development. More specifically, the intention is to create 1.5 hectares of shallow littoral zones. All in all, replenishment of Roggenplaat will lead to improvements across 2,000 hectares in the habitat for 33 dependent and endangered animal species.

2 Monitor the effects of four innovative Smartsediment projects on both morphology and sediment movements will lead to **new knowledge**, which will benefit future sediment interventions.

3 The Scheldt Delta provides important ecosystem services (ES). Some examples are safety, accessibility, food supplies and recreation. Smartsediment also includes an analysis of the impact of the sediment management on various ecosystem services. An **ES tool was developed** to that end.

4 The expansion of biodiversity and knowledge development regarding nature restoration, ecosystem services and hydraulic engineering supplemented with effective communication will lead to **broader support** for these forms of innovative sediment management.

SEA LAMPREY

The sea lamprey hardly looks like a fish at all. Rather than a standard fish mouth, the lamprey has a strange disc for a mouth full of sharp teeth. The creature, which can grow up to 60 centimetres long, uses this to attach itself onto other fish and members of the whale family and devour their body fluids.

WHAT DID WE DO AND WHAT HAVE WE LEARNED?

1. Hydraulic engineering

Eastern Scheldt site

The big problem in the Eastern Scheldt is the need for sand. The construction of the Eastern Scheldt storm surge barrier (in 1986) changed the tidal flows in the sea arm completely. Less sediment is brought in at high tide than is taken away at low tide and during storms. As a result, the sand flats and mudflats are eroding. This is called ***zandhonger***, or 'sand depletion'. The net result is that the sand and mudflats spend less time exposed at low tide, leaving less area and a shorter time in total for birds to forage and seals to rest. In other words, the key features of this Natura 2000 area are being severely damaged.

Sand replenishment cannot resolve the issue of sand depletion – only changes to the hydraulic engineering works can do that – but it can ensure the preservation of the ecological features for decades. Even before Smartsediment, three replenishment tests were carried out in the Eastern Scheldt at the locations Galgenplaat, Oesterdam and Schelphoek. Of course, the experiences with these tests were taken into account in Smartsediment. The elevation of the flats known as Roggenplaat was the first Smartsediment project. It was known that there was considerable erosion on the south side of Roggenplaat in particular and that the flats are now too low-lying to be of much value to birds. An extensive project study followed: what would be the best way of helping the birds, how can the deposited sand be made to remain as long as possible on the flats and what approach would optimise habitat restoration.

Based on that design study, 200 of the 1600 hectares of flats known as Roggenplaat were covered with seven separate replenishments. In each replenishment site, it now takes at least one to two hours longer for the tide to cover the site with water again and so birds have at least four more hours a day to find food there. The sand that has been deposited will be shifted by the wind and the waves, ultimately – after decades – disappearing back into the water channels. During that journey, the sand will also reinforce parts of the flats that were not replenished. An additional challenge here was the mussel farms in the vicinity. Mussels can't cope with suddenly being covered by a layer of sand. To obtain the support of the mussel farmers for the intervention, the project

Working in intertidal areas entails particular problems for the contractors. It is only safe to use bulldozers on Roggenplaat when the tide is out. That meant that every time it was high tide, the bulldozers and trucks had to be driven onto the floating pontoons moored off the flats. The drivers had no choice but to wait for the tide to turn, just like the birds.

team had to make sure the sand did not fall onto the neighbouring mussel beds. The project study made use of quite innovative 3D hydromorphological model simulations.

Implementation

The replenishments were carried out in the space of three months. A key role in the construction work was played by a trailing suction hopper dredger, which sucked up sand from a source site, moved it to Roggenplaat and ejected it through an ingenious system of tubes onto the replenishment site. Bulldozers then moved the sand to the right place on the replenishment site. This work continued for as long as the tide allowed. The construction site was under water twice a day. In the intervening periods, the bulldozers worked on, whether it was dark or light. The wind, sediment shifts, soil life and the effect on the birds were all carefully monitored. These results will be explicitly taken into account in the (unavoidable) future sand replenishments in the Eastern Scheldt. A replenishment planned in the short term is the Eastern Scheldt Nature Impulse, in which dredging spoil from regular management activities will be used to strengthen mudflat areas in the eastern section of the Eastern Scheldt. In the somewhat longer term, there are plans to restore the heart of the Eastern

"This was something special. Never before has so much sand been deposited on a mudflat on this scale for nature conservation purposes."

Eric van Zanten
Dutch Directorate-General for Public Works and Water Management

ROGGENPLAAT SAND REPLENISHMENT: MANAGING THE CONTEXT

Public communication

Efforts to get residents and tourists in Zeeland involved played an important role in the Roggenplaat sand replenishment. After all, this was all about preserving the characteristic Eastern Scheldt landscape in which they live, work and enjoy leisure activities. Natuurmonumenten, the Dutch society for the preservation of nature, had used various campaigns in earlier years – such as the 'A sandwritten message' campaign – to draw attention to the sand depletion issue in the Eastern Scheldt. In 2014, Natuurmonumenten joined forces with the Eastern Scheldt National Park to organise the crowdfunding action 'Help! The Eastern Scheldt is drowning'. Members of Natuurmonumenten, local Zeeland residents and tourists raised over €13,500 in total for the project. This was ultimately a reason for the positive decision taken by the minister, Melanie Schultz van Hagen. During the execution of the project, various boat trips were organised so that these donors could see the results of their contributions. Furthermore, many residents and tourists were informed about the project at the Plompe Toren tourist site and the Delta Wagon, with an infographic, folders and interactive games. During Eastern Scheldt Week, Natuurmonumenten members could pick up a free bag of shortbread biscuits (literally 'sand biscuits' in Dutch!) from the Delta Wagon, with info about the project. There was also an information banner in the Plompe Toren building, which receives over 10,000 visitors a year. And of course, there were continuous updates on social media and in other media about the sand replenishment, aimed at a broad audience both in Zeeland and the rest of the Netherlands.

Communication with stakeholders

Stakeholder communication was another key aspect of the project. Stakeholders working for nature and the environment and stakeholders in the recreation sector took a positive attitude to the initiative to replenish Roggenplaat. From the feasibility study stage onwards, meetings were held to keep them informed and ask for their input. There was a great deal of resistance to the plans, however, in the mussel farming sector. There are a large number of mussel plots in the vicinity of Roggenplaat. Although the risks were small, the mussel farmers feared substantial losses in production. From the start of the feasibility study, the sector was consulted intensively about the project design and execution. In addition to monitoring to track the effects of the replenishment, considerable investments were made in analysing and monitor the risks to mussel farmers. The farmers were closely involved in the setup for this and they were able to see the measurements online. In collaboration with the Ministry of Agriculture, Nature and Food Quality, they were also given the option of temporarily moving to another plot if any negative effects were to be experienced in a given plot. All these efforts eventually resulted in the Council of State giving the go-ahead for the execution of the project. The Council of State declared that the interests of the mussel-farming sector had been sufficiently taken into account and sufficient effort had been made to meet the wishes of the sector. The need to prevent any negative effects on the mussel-farming sector also played a key role in the tendering process for this project. Potential contractors were given the challenge of translating the risks for the mussel-farming sector into tangible mitigating measures during execution. To date, six months after the completion of the project, there have fortunately been no complaints.

Strong together

The Scheldt Delta is incredibly important to Zeeland as a province, both because of its ecological and scenic qualities and from an economic perspective. The provincial authority of Zeeland is only too pleased to collaborate with other public authorities and civil society organisations in conserving delta waters such as the Eastern Scheldt, and to coordinate the associated processes.

Scheldt, including around the Galgeplaat flats. What is more, knowledge acquired in Smartsediment can be used in projects elsewhere in the Netherlands, for example in the Wadden Sea and the Ems-Dollard estuary. Rising sea levels are also causing flats there to disappear beneath the water, with adverse consequences for birds, seals and soil life.

Western Scheldt site

In the Western Scheldt, work is constantly being done on looking for and assessing the best and most efficient way to deposit dredging spoil from the navigation channel. During a trial deposit on the Suikerplaat flats, it turned out that there were already a lot of shellfish in the soil in the intended shallow section of the flats. As this was evidence that the site already had a high ecological value, the trial deposit was carried out in a slightly deeper area. The monitoring results show that the sand that has been deposited stays in place and does not migrate to the flats, meaning that this location is less suitable as a site for depositing spoil in the longer term. In the future, deposits of dredging spoil in the Western Scheldt will mainly be in the deeper-lying areas. In other parts of the Western Scheldt, deposits on the periphery of mudflats have been carried out since 2010 with the aim of creating a suitable habitat for soil life. The assumption is that soil creatures will colonise the new area if the habitat is suitable for them. One element of Smartsediment was targeted ecological monitoring to investigate whether soil creatures are actually found there. The new sites created by deposits on the edge of mudflats had almost as much soil life and the same species of soil animals as other comparable locations in the Western Scheldt. These results confirm the assumption that soil life will settle in an area with appropriate living conditions. This demonstrates that it is possible to foster biodiversity through the smart deposition of sand.

Sea Scheldt site

In the Lower-Sea Scheldt, an experiment was carried out with a non-invasive method for sampling the new sediment for the presence of soil creatures. Previously, soil creatures were dug up out of the sediment and taken to the laboratory for investigation. However, the experiment had to stop as the soil in the Lower-Sea Scheldt turned out to be too hard for sampling. An investigation was conducted at two locations in the Lower-Sea Scheldt to see how Smartsediment can be used to tackle problems in the passage of shipping by keeping the inside bends sufficiently deep. Mattresses and geotextile elements were added. The mattresses were effective but that was not the case, or less so, for the tubes. With these results, this test proved its worth.

Fort Sint-Filips

The second major implementation project is currently underway. It concerns Fort Sint-Filips, a historic fort in the Sea Scheldt in the Antwerp port area. The fort is severely contaminated as a result of past dumping and incineration of waste from businesses in the Port of Antwerp. The guiding principle for the clean-up operations is to seal off the fort as much as possible to minimise the further spread of the contamination. The contamination will therefore be contained, which is a significant benefit in terms of sparing money. The fort has been isolated by constructing a cement-bentonite wall around it, extending down into the Boom clay layer. It was not possible to avoid removing anything. About 15,000 cubic metres of contaminated silt had to be removed in order to allow a tidal nature area to develop in front of the fort — an assignment in the Smartsediment project. In order to create this ecologically valuable zone, measures had to be taken in the secondary channel between the fort and the sand flats in front of the fort. The

"Remove as little contaminated sediment as possible and use clean sediment for constructing an ecologically valuable zone."

Michael De Beukelaer-Dossche
De Vlaamse Waterweg nv

channel is eroding the water control structure on the side of the fort. The secondary channel has been filled up to a level between high tide and low tide. The construction of a groyne (with half a million cubic metres of uncontaminated sand) is also intended to prevent the erosion of the banks. The groyne diverts the flood current towards the navigation channel. But the groyne also requires protection in turn. To this end, textile sacks full of sand have been placed and covered with willow-wood (osier) lattice frames and riprap (rubble as reinforcement). Smart deposition of sand like this (using the experiences with the Suikerplaat site) has let flats covering 18 hectares develop. The Fort Sint-Filips project is still in the execution phase and will be completed in the course of 2021. A baseline measurement was carried out to determine the flora and fauna present before the start of the project. Further monitoring should show whether biodiversity has increased as intended. The project also includes monitoring from a hydraulic engineering perspective. This will enable lessons to be learned continually.

De Vlaamse Waterweg NV is carrying out the Fort Sint-Filips project in partnership with the Antwerp Port Authority.

2. Ecological aspects

Over the centuries, humans have intervened in the morphology of the Scheldt Delta, making the Western and Sea Scheldt estuaries deeper and constructing the Eastern Scheldt storm surge barrier. The ecological effects of these interventions have been huge. In the Eastern Scheldt, sand depletion is causing sand flats to disappear under water while the increasing elevation of the salt marshes is an issue in the Western Scheldt and Sea Scheldt.

Eastern Scheldt and sand depletion

There are still an awful lot of birds in the Eastern Scheldt as at 2020, but researchers at the Netherlands Institute for Sea Research (NIOZ) and elsewhere are warning that the ecosystem is close to a tipping point. Once it has passed that tipping point, birdlife diversity will decline rapidly. Because such replenishment of intertidal areas in estuaries is almost unheard of in the rest of the world, it is very important to carry out ecological research and monitoring. Smartsediment is therefore very much a research programme as well. In our meta-analysis, termed the Metaplan, we have combined many previous monitoring projects and studies with the investigations in Smartsediment itself in order to identify the key lessons and recommendations for future sediment management exercises. Closely monitoring the effects of the interventions and keeping track of problems and solutions will make it possible to improve the method for sediment replenishment.

As is currently the case for the sand replenishment of Roggenplaat, the earlier replenishment tests in the Eastern Scheldt (at Galgenplaat, Schelphoek and Oesterdam) also including monitoring of the ecological and morphological effects. Galgenplaat (in 2013) turned out to be too small for statistically reliable studies so the subsequent projects were scaled up.

"Sediment is not a residual product as it can be used for nature restoration. Long-term monitoring is necessary. Only then can sediment management become increasingly effective, so that Smartsediment lives up to its name and teaches us how to make smart use of sediment."

Ecoloog Tom Ysebaert
Royal Netherlands Institute for Sea Research (NIOZ)

Soil life was shown to recover eventually at all three locations, but not equally quickly in the replenished area. There was life again in most sites after one year, albeit with different numbers and a different mix of species. For example, soil life in the higher-lying areas recovered less than soil life in the lower-lying areas. After three years of monitoring, it can be concluded that a design with gentle gradients and considerable variation in heights is preferable as this leads to better recovery of soil life. The more variation there is in heights (and thus in the moisture content of the bed), the greater the diversity and numbers of soil creatures. Unfortunately, monitoring has now stopped, even though the soil life is expected to continue to develop. The study of Roggenplaat (in the Eastern Scheldt) got off to

An unexpected development: seagrasses appeared suddenly in the fourth year after sand replenishment next to the Oesterdam. They were only expected to appear later. It is an important development as seagrasses are rare in the Netherlands.

COMMON CURLEW

Weighing up to 1.5 kilograms, the common curlew is the largest wading bird in Western Europe. Its distinctive 15-centimetre beak that curves downwards makes it a 'bird for novice birdwatchers'. Not only is it easy to recognise from its appearance, the sound it makes is also unmistakable and appealing: melancholy, swelling up, oo-OOT, oo-OOT, oo-OOT. The beak is incredibly sensitive. The common curlew can detect earthworms, crustaceans and shellfish perfectly by rooting around in the sand and mud, thanks to hundreds of sensory nerve cells (Herbst's corpuscles).

an unexpectedly extensive start. Because there were delays in starting the implementation, NIOZ and Wageningen Marine Research were able to carry out baseline measurements for three years in a row to determine the presence and diversity of birds, soil life, mussel plots and morphology. To aid the investigation of the recovery in soil life (and of course in search of ecological 'gains'), three trial plots (100 x 50 metres) were primed with soil creatures or with just cockles. The first piles left by lugworms were found immediately after the replenishments had been carried out. Now large sections of the replenished sites are full of this species.

It is thought that the added sediment has a thickness that lugworms can penetrate. Other species were found too in the primed trial plots, such as the Baltic clam.

Western Scheldt and deposits on mudflat edge

In the Western Scheldt, sediment was deposited on the edge of the Suikerplaat mudflat. Sandy dredging spoil was deposited next to the mudflat, which is currently very mobile. The idea is that the addition of sediment will make it less mobile. As a result, shallow zones should develop that can serve as spawning and nursery areas for fish. However, it is not clear whether the sediment does indeed 'behave like this'. That is why long-term monitoring is crucial.

Conclusion

The studies and experiences to date clearly show that sediment should at any rate be viewed far more than in the past as a useful tool rather than a waste product. Nevertheless, constant interventions in the aquatic system remain undesirable from an ecological perspective. Sediment management can never be more than a mitigating measure and it has its limits.

3. Ecosystem services

With a project budget of 3.7 million euros, Smartsediment is contributing to implementation projects and studies in the Scheldt Delta. Such investments deliver immediate gains not just for nature but also for people because they boost various ecosystem services (or nature benefits) as well. Public support can be increased by highlighting the fact that Smartsediment not only has a positive impact on biodiversity but can also increase and/or extend other ecosystem services. The Scheldt Delta has the potential to deliver a large number of ecosystem services. Some examples that could be mentioned are food supplies, safety (the silt and the salt marshes inhibit the waves), navigation and recreation.

Smart sediment management can boost these ecosystem services – within the limits set by nature restoration. However, before the Smartsediment programme started little was known about the diversity and size of the various ecosystem services (ES). That is why an ES tool was developed. This tool encapsulates knowledge about how various ecosystem services function in the Scheldt Delta in a few quantitative rules (formulae). After entering a large amount of hydraulic and economic data, the effect can be calculated of any intervention in the water system on the ecosystem services. The tool therefore makes it possible to assess the effect of new interventions on those services in the preliminary study stage and optimise this within the limiting conditions set by the natural surroundings.

The ES tool, which was developed by the University of Antwerp, uses a number of formulae that give a simplified representation of the real situation. NIOZ has used the tool for several case studies looking at recent interventions in the Scheldt Delta. As new information becomes available in the future about the Scheldt Delta, the ES tool can be adjusted to take this into account.

"The ES tool offers new insights into the effect of sediment projects on other ecosystem services in addition to nature. This is valuable because the tool can be used in scenario analyses for future sediment projects."

Frederik Roose
Flemish Department of Mobility and Public Works

GLOSSARY

Biodiversity – diversity of species (plants, animals and microorganisms) within a given area.

Biotope – a biological, natural living area with roughly the same living conditions throughout, in which certain animal and plant species are found.

Boom clay – a layer of clay in the substrate in the eastern Netherlands and northeast of Belgium.

Cement-bentonite wall – wall created in the ground with a water barrier function.

Deposit on edge of flats – deposit of dredged sediment along the edges of intertidal flats in the Western Scheldt with the aim of restoring eroded flats.

Ecology – the science that focuses on the interactions between organisms, communities and their environments.

Ecosystem – a society of organisms (plants, animals and microorganisms) within a given living environment and the exchange of materials and energy between organisms and between living organisms and the non-living environment (soil, water and air).

Ecosystem service (ES) – a service or added value that an ecosystem 'delivers' to people and society, such as safety due to breaking up waves, accessibility to waterways for ships, food supplies and recreation, as well as the sequestration of carbon by saltmarshes, for example, or the purification of water through the storage of phosphorus and nitrogen and the release of silicon.

Ecosystem services tool (ES tool) – a geographical tool to explore additional benefits that can be delivered by smart sediment strategies. The ES tool indicates potential benefits from improving ecosystem services based on certain ecosystem characteristics and a set of calculation rules.

Erosion – the wearing away of the soil or sand due to the effects of the wind, water currents, sea or ice.

Estuary – a widening river mouth, often in the shape of a funnel, in which freshwater from the river and saline seawater mix, creating brackish water, and where there is a noticeable tidal effect.

Foraging – food gathering by animals.

Geotextile elements – flexible containers made from water-permeable, tough textiles that are filled with sediment, aiming to reduce the sediment's water content and increase its stability.

Groyne – a crosswise dam in a river or estuary placed at right angles to the bank, creating a less dynamic area immediately behind it.

Habitat – an organism's natural living area.

Intertidal area – an area that is exposed at low tide and covered by water at high tide; an intertidal area consists of mudflats and sand flats.

Mattress – a large woven mat of osier (willow) used to protect the river or sea bed from currents and erosion.

Migration – the movement of animals from one habitat to another. Birds' annual migrations are one example.

Mitigate – literally 'to soften' or to alleviate, in particular to alleviate the effects of a spatial intervention on local flora and fauna.

Monitoring – systematically keeping track of developments, for example by sampling or carrying out measurements.

Morphology – science that focuses on the shape of the seafloor or river bed, resulting from sedimentation and erosion processes.

Mudflats – flats that are exposed at low tides in a tidal area adjoining land. The mudflats are covered by water at high tide.

Natura 2000 areas – European network of protected nature areas designated as such under the EU's habitat and bird directives. In Natura 2000 areas, certain animals, plants and their natural living environment are protected to preserve biodiversity.

Non-invasive method – a method that minimises disruption to life in nature.

Pioneer – a species that colonises an area that is empty or almost empty, where that species was not previously found.

Priming – a technique whereby soil life that has previously been dug up is put back in a newly added section of soil after replenishment. The aim is to achieve faster restoration of soil life in this way.

Relocation – human-induced transport of non-contaminated sediment by dredging equipment to a dedicated site in a river, estuary or coastal area.

Replenishment – artificially adding to and raising land using sand or mud transported from elsewhere.

Salinity gradient – change in the salinity per unit of depth resulting from the mixing of freshwater and seawater in the Scheldt estuary.

Salt marshes – land with vegetation that directly borders the sea, without dunes or dykes in between, in delta areas and that is covered in water during storms or very high tides.

Sampling – taking a sample (e.g. sediment, water or soil creatures) with the aim of studying the sample

Sand depletion – eroding sand flats and mudflats because less sediment is brought in at high tide than is taken away at low tide and during storms.

Sediment – deposits of mud or sand transported by wind, water and/or ice Sediment management – using sediment to maintain and improve nature, navigability and safety in the Flemish-Dutch Scheldt Delta, among other places.

Shellfish bank – sea bed that is covered in oysters, thereby forming a reef. This hard substrate is an oasis for a lot of life and an important resource for broad biodiversity.

Soil life – animals that live in or on the soil of the bed of an area of water, e.g. lugworms and cockles.

Spawning and nursery biotope – a biological, natural living space with more or less the same living environment where plants and animals can live, reproduce and mature.

Tidal flats – shallow areas (flats) that are exposed and then covered again by water during each tidal cycle, such as Roggenplaat in the Eastern Scheldt.

Tidal nature – nature that is found in a tidal area that is largely exposed at low tide and covered by water at high tide. The considerable influence of the tides results in constant shifts in the sand and mud and big changes in the soil's moisture content.

Colophon

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More information: www.smartsediment.eu