Apéndice E Impactos ambientales de dragado y de regeneración costera

Ecological aspects of dredging and sand nourishment

Dredging and sand nourishment are disturbances of the seafloor, that have effects on the ecology of the area. These effects can be direct (e.g., killing animals living in the sediment) or indirect (e.g., affecting the habitat quality through release of mud). They can be local and restricted to the dredged or nourished area, or far-field due to the influence on environmental processes.

Direct local effects.

Entrainment

Dredging operations have direct lethal effects on the benthic fauna inhabiting sediments. Benthic fauna is restricted to the upper decimeters of the sediment, and is thus 100% removed due to dredging operations. The extent of this removal is proportional to the area dredged. Per unit of volume of sand dredged, the impact decreases with increasing depth of the borrowing pit. The entrained benthic fauna does not survive the strong mechanical forces during dredging operations, so that the sediment is stripped of its fauna at the moment when it is dumped onto the nourishment area (Newell et al., 1998). Consequently, the dumped sediment will also need to be recolonized by benthic fauna.

Entrainment of fish and pelagic fauna is generally considered to be minor, but it can be a problem for eggs and larvae in spawning areas. Temporal restriction of dredging operations outside of spawning seasons is a necessary precaution to avoid this effect (Todd et al., 2014).

Burial

Recolonization of dumped sediment could, in principle, be done by the animals originally living in the dumping area. However, survival of the burial may be limiting for these animals. The effect of burial depends on the type of sediment used, temperature, speed of burial, and species affected (Baptist et al., 2008). The tolerance of species to fast burial (dumping) is limited to the range of centimeters to a few decimeters. When sediment accretion is gradual as in many natural geomorphological processes, animals can usually adapt much more easily and tolerate much larger burial depths, although some species can be extremely sensitive (an example is Mya arenaria, a big clam that loses its ability to move vertically in the sediment as it grows older – it is fatally affected by both burial and erosion above the range of appr. 5 cm).

The volume and thickness of dumped sediment layers in coastal nourishment usually exceed the tolerance limit of the local fauna. Consequently, the fauna will, just as in the borrow areas, be dependent on recolonization processes for restoration.

Seagrass meadows are very sensitive to burial (Erftemeijer and Robin Lewis, 2006). Burial by as little as a few cm can be lethal for some species, especially for the long-living larger species with the highest biodiversity value. Loss of seagrass at or nearby beach nourishments will decrease the stability of the nourished beach, as seagrass has a strong stabilizing influence on beaches (James et al., 2019; James et al., 2021). Considering the sensitivity of nearby seagrass to burial, any excess nourishment (i.e., nourishment beyond the limits of what constitutes a morphologically stable beach) should be avoided. It would serve as a local source of sand that will deposit onto the seagrass beds and destabilize them, with adverse effects on beach stability as a consequence.

Release of toxicants

Dredging may play an important role in the remobilization of toxicants accumulated in marine sediments. Many toxicants are associated to the fine fractions of sediments. Both natural (e.g., tides and waves, bioturbation) and anthropogenic (e.g., dredging) factors can remobilize these fine fractions and the associated toxic load, which leads to spatial redistribution of pollution but also to exposure of biological communities to the toxic load. The processes have been reviewed by (Roberts, 2012), who reports cases of increased loading of organisms with toxicants around dredging operations, however with few or no cases of acute responses and usually limited scales of distribution of the effects. Disposal of toxic dredge spoils is strictly regulated in most countries, and is therefore not a major source of pollution. It is a condition that needs to be checked prior to the execution of any dredging operation.

Noise

Dredging operations produce noise, that may scare away marine mammals. There are few indications of direct injury to the animals' ears caused by the noise of dredging, but changes in behavior and space occupation by mammals after dredging operation intensified have been observed. The causal link to the noise is, however, difficult to establish. Todd et al. (2014) extensively review the literature on this and other aspects of dredging in relation to marine mammals.

Far-field effects

Turbidity effects

Dredging operations can locally increase suspended sediment concentrations. Fines that are dredges, are washed overboard and create a density current around the ship that can quickly sink to the bottom. From there the fine sediment can settle, or be distributed to a wider area. Increased suspended sediment concentrations have a negative ecological impact because they decrease light availability for primary production by algae and macrophytes, and because they hinder the feeding process of all organisms relying on filtration of the water. Both benthic species (e.g., mussels) and pelagic species rely on that feeding mechanism. It is observed that their feeding and growth depend on the ratio between food (e.g., algae) and inorganic material in suspension. Increased turbidity can both decrease the food content and increase the inorganic content.

Increased turbidity also leads to increased deposition of fine material in the area surrounding the dredging location. The extent of that area depends strongly on the local bathymetry and hydrodynamic conditions. The fines deposited in the area can smother organisms, which can be lethal for sensitive species (Wilber and Clarke, 2001). The effects are particularly important for seagrass and corals, two sensitive groups of species with a very important ecological role. We refer to reviews of the literature on these groups in the sections below.

Turbidity and seagrass habitat degradation

Apart from direct mechanical removal by dredging, seagrass beds suffer mostly from increased turbidity, leading to lower light levels and smothering that have often proven fatal for these very important structuring elements in the ecosystem (Erftemeijer and Robin Lewis, 2006). Past dredging activities have had devastating effects on seagrass beds, as seagrass is very sensitive to both decreases in light intensity and smothering of the leaves. It is, however, possible to model the effect of dredging and dumping and to keep the conditions around the dredging areas within the tolerance limits of seagrass. These careful considerations have reduced the negative influence of dredging on seagrass in recent years (Erftemeijer and Robin Lewis, 2006).

Coral habitat degradation

The vulnerability of corals to increased turbidity and smothering strongly depends on the type of corals present in the area (Erftemeijer et al., 2012). Usually, the resident community is adapted to the local conditions and has a tolerance range that reflects the natural variability in conditions present at the site. It therefore requires careful consideration of the local conditions to determine tolerance limits for dredging operations, in order to avoid overloading corals with fine sediments. In any case, even within tolerance limits the response of corals to the additional stress of increased suspended sediment is costly in terms of energy for the species. It may therefore affect the species' ability to withstand other forms of stress (Erftemeijer et al., 2012).

Effects through biogeomorphological effects

The loss of populations of so-called 'ecosystem engineers' (Jones et al., 1996), species that physically modify their habitat and affect the possibilities of other species to live there, may have large-scale ecological consequences for areas well beyond the area touched by dredging or nourishment. Seagrass and corals are examples of such ecosystem engineering species, as are oyster beds, Ross worm colonies etc. Negative effects on coral reefs leading to mortality of the reef, may lead to drastic changes in the protection of coastal bays from ocean waves (Keyzer et al., 2020). Likewise, seagrass beds have been described to protect beaches and bays from erosion, a biogeomorphologic effect that may be lost if the seagrass are affected by dredging operations (James et al., 2019; James et al., 2021).

Effects through morphology

Dredging and dumping change the coastal morphology and thereby the exposure to physical processes (e.g., bottom shear stress from waves and currents), transport pathways of sediment and organic matter, depth below the surface and light conditions, etc. This will affect the habitat quality and may cause a change of the community in the dredged or nourished area, but also in surrounding areas that are affected by the transport of matter and energy. Steepening the coastal profile, as an example, will change the places where most wave energy dissipates, and will increases the risk for sediment redistribution from the beach to the deeper foreshore. It will also affect the habitat suitability of the profile for organisms.

In a coastal profile, there is an equilibrium between the shape (e.g., steepness) of the coastal profile and the grain size of the sediment. Changing the profile may lead to the loss of some sediment fractions (e.g., loss of fine sediment upon steepening), with knock-on effects on the biological community living in the coastal sands. A reverse chain of effects can occur when nourishing with too coarse sediment. McLachlan (1996) has documented the changes to benthic fauna in a beach nourished with too coarse sediment. He demonstrates that the clear correlation between fauna and median grain size was caused by the morphological adaptation of the coastal profile to the coarser sediment, which in turn led to the spatial concentration of wave energy that limited the occurrence of certain species.

Recolonization

The rate of recolonization depends on the habitat characteristics of the nourished area (e.g., the degree of exposure to waves and currents, grain size distribution, depth etc.) and on the characteristics of the pristine fauna in the area. In regularly disturbed areas, e.g., the shallow foreshore of a beach, or estuarine conditions with highly variable salinity, the local fauna will consist mostly of opportunistic species that can rapidly colonize new habitats. Recolonization in those conditions may be completed in less than one year, especially if the nourished area is also subject to the same forms of stress (Newell et al., 1998). However, recolonization by species of undisturbed mature communities generally takes more time, up to 5-6 years. The time to recolonization may even be longer if the sediment needs time to consolidate and reach biogeochemical equilibrium (Newell et al., 1998).

Habitat change

In general, recolonization will not lead to the same community as was present before the nourishment. The nourishment changes the characteristics of the habitat, and will therefore be recolonized by a community that is adapted to the new habitat characteristics. The most frequent change in habitat characteristics is in the grain size of the sediment. Often nourishments use different grain size, e.g., finer sand in places with gravel substrate. Grain size of the sediment is one of the most dominant habitat characteristics determining the community composition of benthic animals, and consequently a change in grain size will also lead to a different community recolonizing the dredged habitat. Changes in grain size have been observed at nourishment locations (Speybroeck et al., 2006) but also at sand mining locations due to the practice of in-situ screening. It leads to habitat changes that cause prolonged and consistent changes in the faunal community (Barrio Froján et al., 2011).

Landscaping mining pits

Landscaping the habitat of sand mining pits has been used as a way to promote the biodiversity of the recovering benthic fauna in the sand mining operations of Maasvlakte II (De Jong et al., 2016). It has been shown that, depending on the depth of the mining pit, the bottom shear stress in the pit can be modified and the fauna adapts to the bottom shear stress. Richer fauna in terms of productivity and abundance was found at lower values of bottom shear stress. However, these areas also accumulated more fine sediment and more organic matter, thus increasing the risk of hypoxia close to the bed. A modeling approach is proposed to optimize the ecological footprint of sand extraction. By minimizing the surface area affected, the effect is lessened. However, this increases the depth of excavation and with it also the risk of poorly flushed sediments. An optimum can be found in between the extremes of very shallow and very deep excavation. The optimum will depend on the local conditions of currents and sediment composition and has to be re-estimated for every site.

Application to the San Andres situation

Nourishments are one option for the preservation of Spratt Bight Beach along the northern coast of San Andres. Three possible sand sources have been identified: one to the north of the island, one in the harbor access channel and one along the southwestern point of the island.

Several ecological points of attention are important when considering these potential borrow areas.

1. Presence of seagrass and corals in the borrow area

As has been pointed out above, seagrass meadows and coral reefs are sensitive to the release of fine sediment associated with dredging. It can be expected that in the clear Caribbean waters, where high suspended sediment concentrations are not normally observed, this sensitivity will be high. The grain size distribution of the potential borrow areas shows especially elevated fractions of the finest sediment class in the deeper stations of the harbor access channel. This fine fraction is associated with elevated organic content. It is likely that it is composed at least partly of clay minerals, but mineral composition has only been determined on the sand fraction (which is almost totally biogenic and calcareous). In any case, resuspension of this fine fraction during dredging is expected to give rise to light attenuation and smothering problems. The access channel is, moreover, situated close to seagrass meadows and mangrove areas at the coastward side, and coral reefs at the seaward side. It is, therefore, an extremely sensitive area where dredging should only be performed after thorough study of the effects on turbidity and the habitat quality for seagrass and coral. This study includes modelling of the spatial extent of potential fine sediment plumes and effects on light and sedimentation of fines. Precautionary measures can be taken if adverse effects are expected, but these will increase the price of the dredging operations. Careful selection of sands with a very small fine fraction is the better option. This should be the subject of an EIA, including tight measures for field monitoring during dredging operations.

2. Burial of seagrass in the nourishment area

From Google Earth images it appears that seagrass meadows are present close to the shore in the nourishment area. These seagrass beds can be an important factor in stabilizing the beach and preventing erosion. Nourishment of the beach will require extreme care in order not to damage the nearby seagrass meadows by burial or excess sedimentation. This implies that the nourishment volume must be carefully chosen so as not to lead to any excess unstable sand along the beach, as unstable sand will eventually move offshore and sediment in the seagrass meadow. Once the stabilizing influence of the seagrass meadows would be lost, more beach erosion could ensue and a vicious circle may start.

3. Effects through morphology

It has been discussed in (Powerpoint Deltares Pres4Coralina), the harbor access channel is situated across a sediment transport pathway that connects coral reefs at the seaward side to shallow bays with beaches, seagrass and mangroves at the coastward side. Deepening this passage will create a sediment sink that interrupts the natural flow of sediment towards the coast. It might therefore have long-term effects on the stability of the coastline and the preservation of the important natural coastal areas to the west of the access channel. This effect should be thoroughly studied in order not to create coastal instability in this area, while attempting to stabilize the coast in another area.

Morphological change can also be anticipated in the southwestern potential borrow areas. These sandy areas are situated at limited depth with great importance for the stability of the sandy coastline. Sand mining in this borrow area will significantly steepen the coastal profile and may destabilize the coastline in this part of the island. It will also decrease wave damping offshore and contribute to more focus of wave energy on the coast. Ecological consequences, as well as societal problems, may be caused by mining this sand resource so close to the coastline.

4. Effects through grainsize

From the survey by Invemar, it appears that suitable sand with a grain size composition similar the grain size composition of the Spratt Bight beach, is available. It is very important that the correct grain size is used, as the morphology of the beach will adapt to the grain size of the nourishment and this may lead to destabilization of the current beach.

5. Pollutants

Data on pollutant concentrations in the potential borrowing areas were not yet available at the time of writing of this note. Of all borrowing areas, especially the harbor access channels deserves attention in this respect. Not only is the harbor a potential source of pollution, but the sediment also has a high fine fraction to which most toxicants will adsorb.

6. Effects on fish, birds, reptiles, and mammals

Disturbances due to the dredging and nourishment operations may disturb local populations of fish, birds, reptiles and mammals. No long-term consequences of this activity should be expected, though. What could be much worse is a change of habitat (e.g., destruction of seagrass or coral reefs) that would affect the habitat of the emblematic species and would decrease the value of the area from a natural and touristic point of view.

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