

**ENVIRONMENTAL COMPENSATION FOR PORT EXTENSION:
THE CASE OF ROTTERDAM HARBOR AND NATURE
COMPENSATION, POLICY AND PRACTICE***

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ABSTRACT: The port of Rotterdam (the Netherlands) recently built a large extension, Maasvlakte 2. It was built in an area with valuable coastal ecosystems belonging to the EU Natura 2000 network of European conservation areas. The construction and use of Maasvlakte 2 causes considerable damage to existing Natura 2000 sites. According to EU regulations this damage should be compensated by creating new nature. In the case of Rotterdam, the compensation was twofold: a marine and a terrestrial part. The paper describes the design and the actual lay-out of the compensation works. It also reports on the monitoring that is ongoing to assess the damage to existing nature and the quality of the new (compensated) nature.

Keywords: port extension, environmental damage and compensation, EU Natura 2000, building with nature.

INTRODUCTION

The Dutch government decided in 2003 to develop a policy which enabled a new harbor extension (called Maasvlakte 2), in order to receive and handle the world's largest container ships, starting from 2015. Maasvlakte 2 (net 1000 ha, which is 20% of the already existing harbor area) was built between 2008 and 2014 by reclaiming part of the North Sea with foreshore nourishment (365 Mm³). It is expected that the new harbor will be in full operation by 2030.

Maasvlakte 2 extends in the middle of an environment with valuable coastal and marine ecosystems. They are under protection of the EU-Natura 2000 network. In such a case, EU-regulations state that construction is only allowed when there are imperative reasons of overriding public interest to carry out the plan, when there is no alternative and the submitter of the plan commits himself to compensate for the damage caused by the plan. It concerns the environmental damage to Natura 2000 sites that will be caused by the new harbor and harbor activities.

It is important to understand that the compensation activities should start at the same time and parallel with the activities for the new harbor, and not, if at all, afterwards.

To convince possible opponents it was decided by the EU-permits to start with the compensation measures before or at least at the moment of start of the extension.

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Compensation is realized at other locations nearby the port extension (Figure 1). It involves marine ecosystems (fish, sea bottom fauna and bird communities) as well as land ecosystems (beach and dune ecosystems).

Marine compensation is necessary because the new harbor was reclaimed from the sea, causing loss of habitats and foraging areas. Beach and dune compensation was necessary because the EIA predicted that important existing dune ecosystems nearby will be damaged by the use of the new harbor (extra air pollution by more harbor traffic). In order to assess whether the predicted environmental damage indeed will occur and whether, in the future, the quality of the new nature indeed will compensate for this damage, an extensive monitoring program is running.

The case of Rotterdam is of importance to mirror with harbor development worldwide to achieve innovative smart solutions in a more sustainable way. Key concepts are compensation of irreversible damage to nature and building with nature.



Figure 1. The Netherlands (inset) and part of the south western Delta coast of the North Sea. In the middle the new harbour extension (Maasvlakte 2) in outline. The dunes of Voornes Duin, Kapittelduinen and Solleveld are nearby Natura 2000 areas that will suffer expected environmental damage. Spanjaards Duin, in the north, is the new dune and beach compensation area. In the south in the Voordelta (a shallow sea in front of the coast, also a Natura 2000 area) is the area where marine compensation measures are taking place (yellow boundary). Image: Google Earth.

DUNE COMPENSATION

Damage to existing dunes and compensation targets

The EIA ¹ for the extension of Maasvlakte 2 predicted that the use of the new harbor would damage important dune ecosystems in the nearby existing dunes. These ecosystems belong to the EU Natura 2000 network and, under European Habitat Directive regulations, have to be compensated. They are: H 2190 (nutrient poor calcareous moist dune valleys, or dune slacks) and H 2130 (nutrient poor, more or less calcareous dry dunes, so-called "Grey dunes") ².

In European context the Netherlands have a special requirement when it comes to maintaining the surface and improving the quality of these nutrient poor (N, P) dune environments. The predicted damage in existing dunes and the compensation targets in the new dunes are given in Table 1.

Table 1. Dune compensation targets in new constructed dunes of Spanjaards Duin in relation to predicted losses in existing Natura 2000 dunes. See also Figure 2.

Dune compensation targets	loss (ha)	compensate (ha)
Moist dune valley (H 2190)	1,3	6,5 (x5)
Grey dune (H2130)	4,2	9,6 (x2)
Species: Fen orchid <i>Liparis loeselii</i>	1 population	1 population
Loss of nutrient poor habitats	Compensate nutrient poor habitats	

The damage to these ecosystems occurs because the use of the new harbor will cause an increase in traffic and industrial activities. This will raise the level of NOx emissions. The extra airborne N-load will affect the nutrient household of the nutrient poor dune ecosystems. The higher nutrient level will cause some common plant species to encroach and take over the space of several rare plants that are characteristic of H2190 and H2130.

Dune compensation and nourishment

In order to compensate for this loss, a new dune and beach area was constructed by beach and fore shore nourishment. The work was done in 2008 in combination with a larger regular nourishment works along the Dutch Delfland coast. The new area covers 35ha and involves $6,5 \times 10^6 \text{ m}^3$ of nourished sand.

The nourishment was done by dredging the sand some 19km offshore and piping it onshore from a close-by connection point (Figure 1). Subsequent shovel work formed the basic shape according to its design (Fig 2): an elevated (5-7m above MSL) dry and undulating ridge, the new frontal dune, and a flat depression (ca. 2.5m above MSL) or dune valley, later to become moist due

to rising fresh groundwater level. Because of sand mobility (see paragraph below), part of the nourished material had to have a specific grain size (180-250 μ), which is slightly smaller than the average sea bottom sediment in front of the coast. However, earlier surveys showed that there was enough material present in the neighbourhood.



Figure 2. Top left: construction of the compensation area in front of the existing coastal fore dunes (at right) by beach and foreshore nourishment. The contours of the designed elongated moist dune valley, a flat depression, are already visible in the middle (photograph courtesy Nico Bootsma, Rijkswaterstaat). Top right: design of the new dune area in front of the Delfland coast. Grey=existing dune, yellow=new beach, orange=new dry dune, green=new moist dune valley. From Veeken et al.³.

Bottom: compensation targets grey dune (left) and moist dune valley (right). The Fen orchid occurs in the latter.

Dune compensation and building with nature

Building with nature is a technique that is being used more and more when constructing, restoring or reshaping landscapes, also at the coast. Applying this technique means that the characteristics and spontaneous forces, materials and elements of the local environment are used as much as possible⁴. For example, to strengthen a sandy coast with sand nourishment and not with hard

materials like concrete or basalt, can be considered building with nature. In the case of the compensation area, building with nature was applied^{4, 5}.

Phases of new dune development

The ecosystems that have to be compensated take time to develop. Grey dunes take 15-20 years. A moist dune valley about 5 years (partly because of settlement of the appropriate groundwater dynamics and quality). The development of the area was foreseen in 4 phases (Table 2) and started from the design (Figure 2). Some phases run successively, like the development of the abiotic habitat conditions first, followed by the biotic elements.

First the basic foundation was laid out by sand nourishment. After this basic foundation, free movement of sand and spontaneous sand transport (erosion and accumulation by wind) was allowed to take place. This causes some remodelling of the basic shape and also the formation of appropriate aeolian initial dune soils, the appropriate condition for colonisation and growth of vegetation. During this phase, the salt/brackish sand material has gradually been desalinated by precipitation; and consequently a fresh groundwater lens will develop in the subsoil, also fed by infiltration of freshwater from the (thin row of) mainland dunes (fig 2, right). After some time (expected 4-6 years in this case) the phreatic level of this lens will rise up to the valley floor, creating habitat requirements for a moist dune valley, and, eventually, moist dune slack vegetation (H2190). Because of sand mobility, part of the nourished material had to have a specific grain size (180-250µ), which is slightly smaller than the average sea bottom sediment in front of the coast.

Table 2. Phases of dune development and building with nature

Phases of development	Natural elements and processes involved
Construct basic foundation	Sand that is characteristic of the region
Remodelling of sand by wind transport Development of appropriate groundwater dynamics and quality	Building of natural dunes and valleys by erosion and accumulation Desalinisation of sand by precipitation
Successive colonisation of plants and development of plant (and animal) communities	Allow spontaneous, natural colonisation, no active, deliberate planting of dune species
Management to steer if needed	Aim at compensation targets

Monitoring

In order to assess whether the dune area develops in the right direction of the target habitats, a monitoring program was established. It concerns dune geomorphology, groundwater and vegetation. Also in the existing dunes are monitoring activities, especially concerning their nutrient (N,P) status.

Results

About 7 years after construction, the area is still very dynamic (Figure 3). Vegetation is scarce. But the abiotic conditions for the development of the compensation targets, the nutrient poor dune grasslands, are nearly in place. Signs of the development towards Grey dunes can be seen. The area functions in a number of ways: for coastal defence, nature conservation and also recreation. In the densely populated environs of Rotterdam harbour in the Dutch Delta, this is regarded as a very positive situation. To ensure that nature development can take place, free access is not allowed. The new area is already under Natura 2000 protection.



Figure 3. The new area development of Spanjaards Duin (2013). Wind activity is clearly visible. Former (existing) coastal fore dunes to the left New embryo dunes formed by wind and sand captured by Marram grass, in the middle. Prospective wet dune valley and new fore dune ridge to the right. Harbor of Rotterdam (Maasvlakte 1) in background. North Sea (just visible) to the right.

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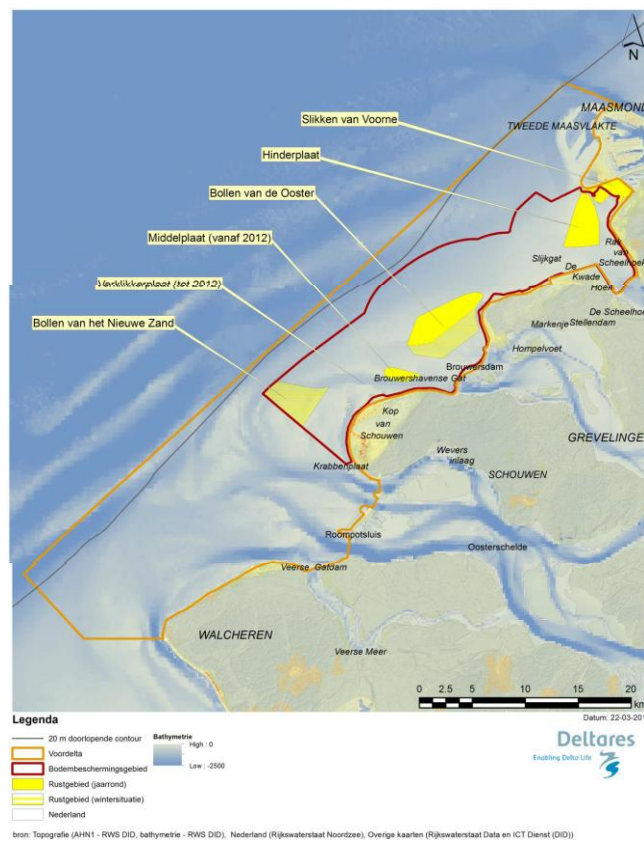
MARINE COMPENSATION

Damage and compensation targets

Maasvlakte 2 was reclaimed from the sea, in this case the Voordelta, a shallow marine environment of high nature value, belonging to the EU Natura 2000 network (H1110, shallow seas with sand flats permanently inundated and tidal inundations).

Maasvlakte 2 has taken away 2,000ha of sea. Rather than creating more new sea, it was decided to improve the quality of existing waters nearby in the Voordelta with ca 10%. Besides the loss of sea environment and sea(bottom) fauna (fish, benthos) there was also an expected damage to resting and foraging areas of seabirds (common scoter, sandwich tern, common tern). These birds are most sensitive to disturbance in their habitats. In time after the construction of Maasvlakte 2, it was expected that currents will create a sea bottom pit (near the sea defense wall surrounding the harbor) of 500 ha, which also needs to be compensated.

The following marine compensation targets were set: (i) create a marine protection area of $2,500 \times 10 = 25,000$ ha in the Voordelta and (ii) within the protected area, establish resting places for the three most sensitive seabird species, Common scoter, Sandwich tern and Common tern (Figure 4)(Table 3).



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Figure 4. Top: Marine compensation in the Voordelta (orange boundaries) and the marine protection area (red) and the resting areas for seabirds (yellow). Bottom: from left to right Common scoter, Sandwich Tern and Common Tern.

Table 3. Marine damage and compensation targets. See Figure 4.

Damage	Compensation target
2,500ha sea(bottom) lost	Establish 25,000ha marine protection area to restore sea bottom (communities) and fish
Resting and foraging places for seabirds lost	Create new resting places within protection area to restore sea bird populations

Compensation measures and monitoring^{6,7}

In the protection area bottom trawling with vessels >260 hp were stopped. It was expected that this would improve the numbers of fish and of sea bottom fauna. And that this would favor the bird numbers because of an increase in food source. In the resting areas all human activity was banned.

Monitoring was set up to see whether the predicted damage indeed could be sufficiently compensated. The monitoring concentrated on (i) benthos (sea bottom fauna), (ii) birds, (iii) fish, (iv) abiotics and (iv) human use of the area. The first phase (T₁) of the monitoring period was from 2009-2013. Before this, a T₀ period was monitored between 2004 and 2007. During T₁ the reference area was the Voordelta area outside the protection area.

Monitoring results

Following results have been obtained after 4 years of measuring. (i). It was not possible to find a significant correlation between the stopping of fisheries activities and trends in the sea bottom. One possible reason for this is that already in 2004 fisheries activities were reduced with 80%. (ii) It was not possible to find a significant correlation between numbers of the three bird species (and

their spatial distribution) and the establishment of new resting places. These results are valid for comparison of the compensation areas both with the reference area and with the T_0 .

As a consequence, at the moment a clear sign that the damage to the marine environment is sufficiently compensated, can not yet be seen.

Discussion

There are several factors that can play a role to explain the results in the Voordelta. Since the closing of the large sea inlets in this Delta area (1960-70ies) as part of the Dutch Delta Plan, this area has not yet reached its new equilibrium. Because of this and by the nature of the environment itself, the area has a high degree of hydrodynamics. There are great autonomous spatial and temporal changes in abiotic conditions of water and soil. These may cause differences in benthos and fish per time lap, which are larger than the consecutive monitoring differences.

Also, the data on numbers of birds and their spatial distribution show large differences between the years, larger than those between the compensation and the reference. In this case, also the monitoring period (4 years) is too short to detect significant effects.

Another important factor is that birds and fish do not stay in the same protected area and reference area. They move to other areas and (may) come back. So, their population dynamics is influenced, not only by ecosystem changes in the area itself, but also in other areas (far away). Thus, it is difficult to attribute changes only to the compensation measures in the marine protected area.

Finally, the monitoring is being done not only to assess whether the compensation is going to be sufficient, but also to understand more about the relationship between the various elements (birds, fish, benthos, nutrients, water conditions) in this marine ecosystem.

The monitoring will continue for at least another 4-year period. This will give more insight in the ecosystems itself (life strategies, carrying capacity, food chains, resilience). It is expected that new answers can be given to evaluate the compensation efforts.

CONCLUSIONS

Large-scale technical activities for harbor extension damage coastal nature. The EU compensation principle can contribute to restoration and new nature development and to more sustainable overall coastal solutions. Key concepts are compensation and building with nature.

Success of a project like this depends on a multidisciplinary cooperation and patience. Close cooperation between civil engineers, policy makers and ecologists is necessary.

Time should be given to nature to develop itself. This time is often longer that politicians can wait. Area protection is necessary to allow for undisturbed developments of new nature.

The case of Rotterdam harbour is of importance to mirror with harbour development worldwide. It is a case that considers, at the same time and right from the beginning, economic development and ecological quality.

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