

# Adaptive monitoring of sand extraction areas - Maasvlakte 2 extension, NL

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## Adaptive monitoring of sand extraction areas - Maasvlakte 2 extension, NL

*5 Basic steps towards Building with Nature*

**Location:** the Netherlands, Rotterdam port area

**Date:** 2008 – 2013 (first phase) / 2033 (complete project)

**Involved parties:** Client: Rotterdam Project for Mainport Development (PMR). Contractor: PUMA (Projectorganisatie Uitvoering Maasvlakte 2) consisting of Boskalis and Van Oord. Monitoring: IMARES Wageningen U, PUMA, Deltares; NIOZ, IECS, TNO, Rijkswaterstaat Dienst Noordzee.

**Technology Readiness Level:** 9 (operations successfully completed in actual environment)

**Environment:** Sandy shores, ports and cities

**Keywords:** adaptive monitoring, adaptive management, ecology

The Maasvlakte 2 (MV2) case is selected to serve as a hindcast example of possible adaptive monitoring schemes around sand extraction activities, i.e. how could adaptive execution monitoring have helped and/or have added value to the project? For the entire lifespan of the Mainport Rotterdam, extensive Monitoring and Evaluation Plans (MEPs) have been set up, such as the MEP Sand Extraction and the MEP Land Reclamation. Their goal is twofold: (1) verification of how do the actual effects relate to an activity compared to expected scenarios, and (2) gathering data for filling important

knowledge gaps. Every five years, all MEPs are evaluated. If needed, management plans are adjusted. As the scope of the case study is marine sand mining, this historic case description of the Maasvlakte 2 focuses on the MEP Sand Extraction.



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[Frame of Reference for specialist and end-user interaction](#)

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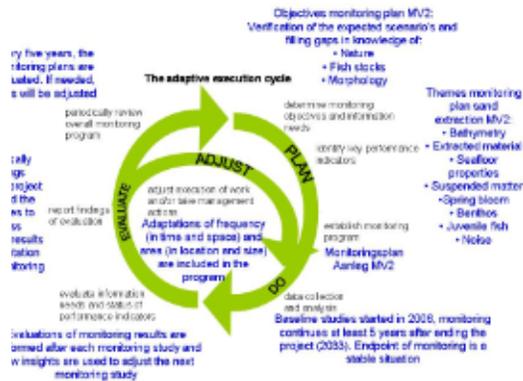
[Monitoring swimmer safety](#)

The objective of the monitoring plan is verification of the predicted scenarios and filling knowledge gaps on nature, fish stocks and morphology. Van Zanten et al., (2008) formulated a monitoring plan with the aim to verify the expected scenarios and fill the most important knowledge gaps. The monitoring plan, presented in the figure, follows the adaptive execution cycle: Every five years, the monitoring plans are evaluated. If needed, the management plans will be adjusted.

Important governance observations from this case study are:

- The authorities were open to new suggestions considering monitoring and allowed deviations from the initial permit requirements.
- Adequate information exchange between the authorities and the initiator is crucial.

## Adaptive monitoring strategies



Considering adaptive monitoring strategies, there are two types of evaluation that can be distinguished: structural evaluation of the complete monitoring plan

Periodic meetings are foreseen to discuss progress and results. Suggestions for adaptation of the monitoring plan can also be discussed at these sessions, e.g. to adjust the monitoring frequency, or to conducting additional measurements.

Based on the baseline monitoring results, adaptations of the initial monitoring plan have already been made for some elements:

Total suspended matter (TSM):

- The number of sampling locations has been reduced, because a link between TSM and juvenile fish could not be observed and spatial correlation showed a redundancy of locations; the number of locations could therefore be decreased from 100 to 50.
- The number of samples taken at each location has been increased, because temporal correlation was found to be only relevant in combination with more frequent sampling. The number of samples taken at each location has therefore been increased from 3 times (at 100 locations) in 2007 to 6 times (at 50 locations) in 2009.

Benthos:

Morphological predictor for mixed beds

Probabilistic analysis of ecological effects - Cause-effect chain modeling

Quick model set-up using open databases - DelftDashboard

Roughness module for sediment dynamic modelling

System Analysis

Visualisation of open-source data - OpenEarth-Viewer

## Related Projects

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Knowledge - Adaptive Management Strategy

- Benthos was monitored to determine the effect of increased TSM. Location and size of the benthos baseline monitoring area in 2006 have been changed, because of new insights into the TSM distribution; the second benthos baseline (2008) was adjusted to the TSM distribution (van Zanten et al., 2008).

Juvenile fish:

- Monitoring of this aspect has ended, because no relationship between TSM concentration and juvenile fish could be determined.

## Planning and design

Monitoring is a condition for permitting under several laws, which already has to be taken into account in the planning and design phase. The permit conditions include requirements for a monitoring plan, its execution and its evaluation. The main monitoring requirements in the case of the sand extraction for Maasvlakte 2 originate from:

- the Nature Law, under authority of the Ministry of Economic Affairs, Agriculture and Innovation (Ministerie van Economische Zaken, Landbouw en Innovatie (EL&I)) and;
- the Mineral Extraction Law, under authority of the Dutch Ministry of Infrastructure and the Environment (Ministerie van Infrastructuur en Milieu (I&M)).

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The themes of the MEP Sand Extraction and the corresponding monitoring elements are listed below. A more detailed description can be found in the report on this study (Tamis & Baptist, 2011).

## Nature Law requirements

Compliance monitoring is conducted as part of the permit conditions required by the Nature Law under the authority of the Ministry of EL&I. These requirements differ per protected area:

- Voordelta
  - Land use (area)
  - Erosion induced by MV2
  - Change of the tidal wave
  - Increased total suspended matter (TSM)
  - Noise, ship movements and light emissions
- Kwade Hoek
  - Deposition of nutrients (N) in the dunes
- Haringvliet/Grevelingen/Eastern Scheldt
  - Effects of increased suspended matter on terns, monitored via TSM measurements.
- Waddensea en North Sea coastal zone
  - TSM concentrations along the Zeeland and Holland coast, by use of modeling, remote sensing and field measurements.

## Mineral Extraction Law requirements

- Bathymetry and extracted material
- Seafloor properties
- Suspended matter and changes in spring bloom
- Species composition on the extraction sites
- Sound

## Monitoring plan

The MEPs for Mainport Rotterdam have a twofold goal:

- verification of the extent to which predicted scenarios of environmental effects correspond with reality;
- gathering data for filling the most important knowledge gaps, as identified by the MER (Milieu Effect Rapport: Environmental Impact Assessment) and Passende Beoordeling (Appropriate Assessment for Natura2000) (van Zanten et al., 2008).

The most important effects of large-scale sand extraction from the North Sea bed are thought to be the destruction of benthos followed by a recolonisation of the seafloor by benthos at the extraction site and its direct surroundings. Furthermore, there are potential effects of dredging-induced turbidity on the natural processes within the food chain and on the abundance of shellfish and birds. The MEP Sand Extraction is conducted by the [Maasvlakte 2 project](#).

## Monitoring reports

Both the Ministry of EL&I (Nature Law) and the Ministry of I&M (Mineral Extraction Law) demand periodic reports.

All monitoring results shall be validated, analysed and reported by Mainport Rotterdam. The results and findings of all measurements completed in one year shall be summarized in an integrated annual report to be submitted to the authorities. This report includes at least an overview of the monitoring efforts, a description of the findings and the conclusion from the analysis and interpretation of results. The results will be compared with the predictions underlying the EIA (Ministry of I&M).

The exact format of the annual reports and the format and frequency of possible interim sub-reports shall be established per monitoring theme in consultation with the authorities. The Mineral Extraction Law requires 6-monthly reporting. Extraction progress shall be reported each month, including the amount of material extracted, location and time of each extraction and the results of granulometric analyses (Ministry of I&M).

The permit under the Nature Law states that each year before the 15th of July the results of the monitoring shall be submitted to the Ministry of EL&I. If necessary, interim reporting can be required (van Zanten et al., 2008).

## Construction

Several aspects were important for the execution phase, namely:

- baseline monitoring
- adaptive monitoring during execution
- structural evaluation of the MEP and legislative requirements

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## Baseline monitoring

In April 2006, the first baseline monitoring study started (Vertegaal et al. 2007). Baseline studies have been conducted for all elements of the monitoring plan (see monitoring plan in the Planning and Design section).

## Adaptive monitoring strategies in the monitoring plan of MV2

The extensive monitoring program of MV2 already includes several adaptive strategies, as discussed below. The adaptations are, however, related to the monitoring itself, rather than to the extraction operations.

The construction of Maasvlakte 2 is a huge project conducted over many years. The complete project is to be finalised in 2033. The first construction phase, from 2008 to 2013, requires 240 million m<sup>3</sup> of sand. The current MEP (van Zanten et al., 2008) focuses on this first phase of the project, because the main effects are expected in this phase. For the second phase (after 2013), the MEP will be updated based on results from phase 1, including the lessons learned. Before implementation of the new MEP, it will be submitted to the authorities for approval.

Considering adaptive monitoring strategies, there are two types of evaluation that can be distinguished: structural evaluation of the entire MEP and evaluation of results within themes.

## Structural evaluation of the entire MEP

According to the website of the [MV2 project](#), the MEPs are evaluated every five years and, if needed, plans will be adjusted. The set-up of the MEP (van Zanten et al., 2008), however, does not refer to such a structural evaluation of the entire MEP: it includes only a periodic evaluation of monitoring plans per theme. The establishment of a separate working group for the monitoring program within the Project Organisation Maasvlakte 2 (van Zanten et al., 2008) makes it possible to maintain an adequate information exchange between the authorities and the initiator. According to the MEP it is preferable to discuss monitoring progress and results at periodic meetings. Suggestions for adaptation of the monitoring program can be discussed there, such as adjusting the monitoring frequency or conducting additional measurements.

Other relevant documents, such as the EIA (Vertegaal et al., 2007) and the conditions of the extraction permit (Ministerie van Verkeer en Waterstaat, 2007), do not mention a structural evaluation of the entire MEP.

## Evaluation of monitoring plans per theme

Two basic conditions in the MEP enable adaptation of the monitoring program:

- The evaluation of the monitoring plan after new results have been analysed;
- The opportunity to discuss the monitoring program with the authorities and, if necessary and approved, to adjust it.

## Monitoring themes as required by the Ministry of EL&I

The monitoring as required by the Ministry of EL&I (Nature law) focuses on the abiotic effects (van Zanten et al., 2008). As long as these effects remain below the limits set in the Appropriate Assessment (Dutch: Passende Beoordeling), the same is assumed for the biotic effects. As potential biotic effects will be caused by changes in abiotic conditions and "worst case" assessments of these effects, this assumption is considered to be justified. According to condition 27 of the Nature Law Permit, additional monitoring shall be considered whenever monitoring results show that the (abiotic) effect is larger than expected or when there is an indication that this might occur (van Zanten et al., 2008).

## Monitoring themes as required by the Ministry of I&M

According to the permit conditions, the monitoring plan shall include for each theme a motivation of the parameters to be monitored, at what locations and with what frequency. Also, criteria shall be given for adaption of or deviation from these definitions and possible measures shall be identified in case environmental effects threaten to exceed the set limits, based on e.g. the impact-response chains as described in the EIA (Ministerie van Verkeer en Waterstaat, 2007). Monitoring is planned in periods in which effects are expected, the monitoring frequency is chosen such, that the data gathered will provide sufficient insight into the relevant effects. In consultation with the authorities responsible (i.e. the Ministry of I&M) and with their approval, the monitoring frequency will be adjusted if the analyses of the monitoring give cause for it (van Zanten et al., 2008).

The monitoring program is set up in such a way, that statistical analyses can detect changes in tidal currents, wave height and water depth. Variations of the monitoring results through the tidal cycle can thus be compensated, for instance, and correlations between measured parameters can be determined (Vertegaal et al., 2007).

The criteria for adaption/deviation of the monitoring plan per theme, as included in the MEP, are presented in the table below. Further details can be found in Tamis & Baptist (2011).

Adaptations in the monitoring program for sand extraction (based on van Zanten et al. 2008)			
Theme	Adaptation	Criteria *	Already executed?
Bathymetry	Lowering frequency and size of monitoring area	Based on the change in bathymetry (effects); Based on a stable situation in (part of) the area; Endpoint is total stable situation	No
Extracted material	No adaptations included	Not relevant	Not relevant
Seafloor properties	Lowering frequency	Based on granulometric analyses (including mud content) of the sediment samples	No
TSM	Lowering number of sampling locations	No observed link between TSM and juvenile fish; Spatial correlation shows redundancy of locations (the number of locations can be decreased from 100 to 50)	Yes
	Increasing number of samples taken at each location	Temporal correlation is only relevant in case of more frequent sampling (the samples taken at each location are increased from 3 to 6 (e.g. from 3x100 to 6x50))	Yes
	Lowering frequency	Relevant after 2010; Data required for model validation and RS-images is sufficient	No
	Additional measurements	When multiple results (e.g. from RS images) show higher TSM concentrations than expected, and a reasonable link between the relatively high TSM concentrations and the MV2 activities can be identified	No
Change spring bloom	No adaptations included	Not relevant	Not relevant
Benthos	Lowering frequency	No observed effects on benthos; Endpoint is total stable situation	No
	Location and size of monitoring area	The TSM distribution for the second benthos baseline (2008) (the original (2006) monitoring area was adjusted to new insight of the TSM distribution. The benthos monitoring area is adjusted to the TSM distribution	Yes
Juvenile fish	Stop monitoring	No relationship between TSM concentration and juvenile fish could be determined	Yes
Noise measurements	No adaptations included	Not relevant	Not relevant

\* Adjustments are only made under agreement by the authorities

## Operation and Maintenance

Because this case description is focused on monitoring of the sand extraction for Maasvlakte 2, 'post-construction' refers to the monitoring phase after the sand extraction has ended.

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## Strategies

The government initially required yearly measurements during the first five years after extraction had ended, and subsequently every five years until no more changes are observed. The actual monitoring plan deviates from this requirement: it suggests to choose an adaptable frequency that enables an adequate description of the developments within the area and to show whether effects have vanished. The monitoring frequency can be adapted in agreement with the authorities (van Zanten et al., 2008).

## Execution

The sand extraction for the Maasvlakte 2 is part of the 1st phase construction, which ends in 2013. The monitoring after sand extraction has ended is therefore expected to start in 2013.

## Lessons Learned

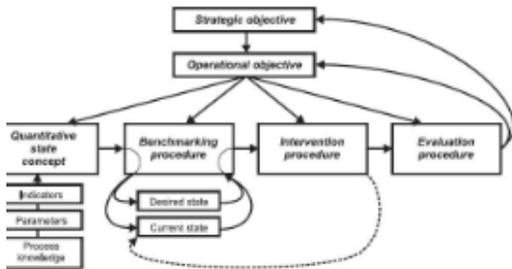
To identify the lessons learned from the monitoring of the Maasvlakte 2 extension, the Frame of Reference (Van Koningsveld, 2003) is applied to the monitoring plan of MV2. The [Frame of Reference tool](#) can be used to support decision making, as well as to set a target for expertise improvement. The main research question is in how far the monitoring program uses adaptive management approaches as set by the Frame of Reference.

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## Objectives

The **Strategic Objective** is: verification of the predicted scenarios and identifying important discrepancies and knowledge gaps in the fields of nature, fish stocks and morphology. In general, the Evaluation Procedure is threefold:

1. are the observed effects as predicted?
2. if not, can this be explained from existing knowledge?
3. If not, what are the most important knowledge gaps and how can they be filled?



The **Operational Objectives** and other elements of the Frame of Reference are described in Tamis & Baptist (2011). In the monitoring plan the operational objectives are described adequately, as well as the quantitative state concept (how to describe the state of the system) and the benchmarking desired state. What is missing in the monitoring plan is the intervention procedure (how to manipulate (part of) the system in order to bring it to the desired state).

## Lessons

Evaluation of the MV2 monitoring program with regard to adaptive monitoring showed that:

- Based on a thorough motivation, the initiating stakeholder was allowed by the authorities to deviate from the permit requirements in the monitoring program of MV2.
- The extensive monitoring program of MV2 already included several adaptive strategies. The adaptations were, however, related to the monitoring itself, rather than the execution of extraction work.

Applying the Frame of Reference to the MV2 monitoring program showed that:

- Almost all elements of the 'basic' frame of reference can be found in the monitoring program of MV2, leading to a successful and coherent approach. The desired state is included for each element and, in combination with the evaluation procedure, enables adaptive monitoring.
- The main 'white spot' is the lack of an intervention procedure which specifies what can be done to bring the system into a desired state.

The MV2 monitoring program is a good example on how to meet the monitoring requirements as set by the authorities without unnecessary monitoring efforts.

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