Wrap up of exploring long-term maintenance strategies and tools for the Holland Coast

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1. Introduction to the Holland Coast

Present policy

The Dutch coastline along the south-western part of the North Sea is about 350 km long of which 75% are dune areas of varying widths from less than 100 metres to several kilometres. The primary function of the coast is protection of the low-lying hinterland against flooding. The sandy coast however represents important values to other functions as well: ecological values, drinking water supply, recreation, residential and industrial functions. Coastal erosion, dominant along half of the Dutch coast, is endangering these functions.
In order to stop structural erosion, in 1990 the Dutch government decided on a policy of "Dynamic Preservation", using nourishments as the preferred intervention to maintain the coastline. Defining the 1990 coastline position as the reference coastline, the main objective of the policy is sustainable preservation of safety against flooding and of functions in the dune area.

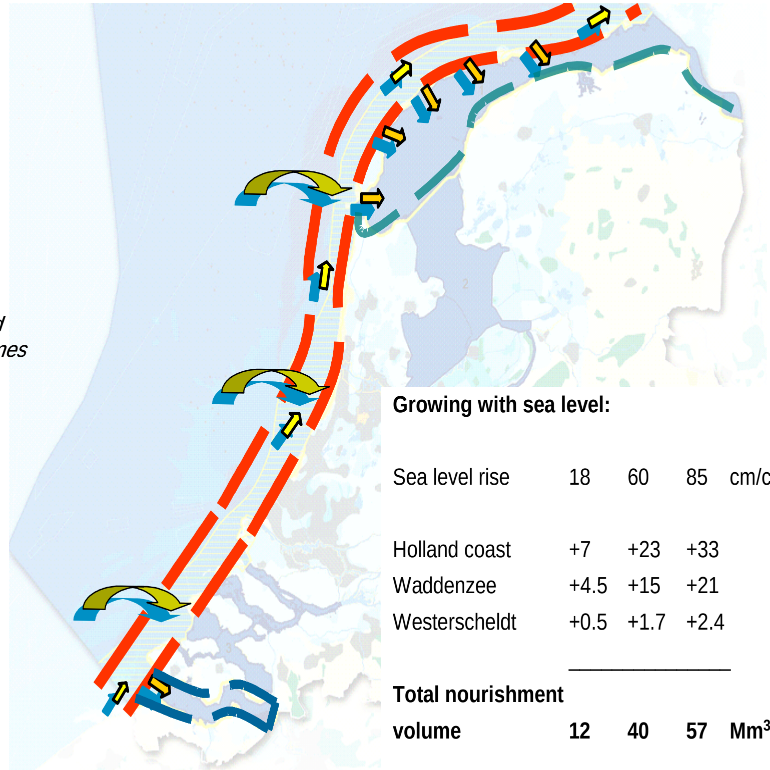
In 2000 it was decided that in order to achieve sustainable preservation, it was necessary to extend the policy to a larger scale. In addition to the tactical objective of maintaining the coast line, a second (larger scale) tactical objective was defined: maintaining of the sand volume in the coastal foundation i.e. the active sand volume in the area between the -20 m depth contour and the landward boundary of the dune massive. The annual average nourishment volume, 6 Mm^3 since 1990, was raised to 12 Mm^3 (see e.g. Van Koningsveld and Mulder, 2004).

The nourishment policy since 1990 has been successful in maintaining the Basal Coast Line. The number of locations where the BCL is endangered, over the years remained constant.

Future climate scenarios

In the past century the sea level along the Dutch coast has risen by about 18 cm with respect to Dutch Ordnance Datum NAP. According to the 2007 IPCC report, in 2100 we shall be faced with temperatures from 1.5 to 6°C higher than they are now. In combination with other assumptions incorporated in these scenarios, this means that at the end of the present century, given a temperature increase of 6°C, we may expect a sea level rise (including mean land subsidence along the Dutch coast) of 0.55 to 1.3m in 2100 (Deltacommissie, 2008).

The conclusion is that - in order to achieve the objective of maintaining the active sand volume of the coastal foundation - nourishments would need significant upscaling. Volumes depend a.o. on the rate of sea level rise.



Growing with sea level:

Sea level rise	18	60	85	cm/century
Holland coast	+7	+23	+33	
Waddenzee	+4.5	+15	+21	
Westerscheldt	+0.5	+1.7	+2.4	
Total nourishment volume	**12**	**40**	**57**	**Mm^3/year**

Sketch of artificial sand transport and nourishment volumes related to the sea level rise.

Maintenance strategies

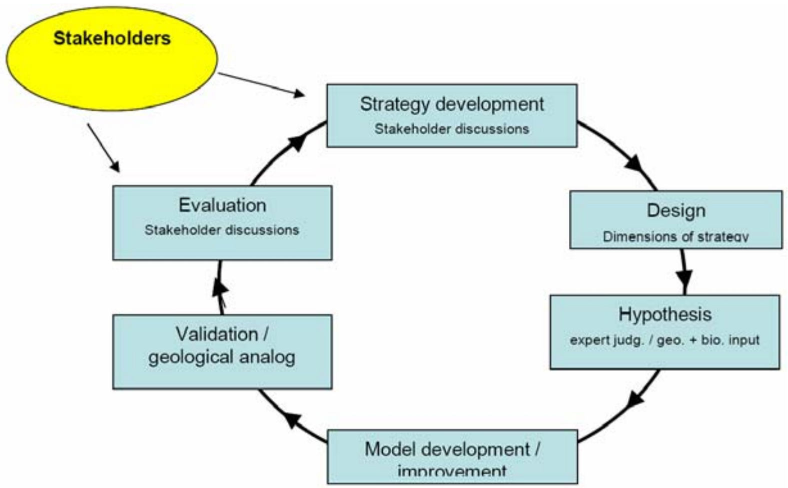
Adaptation to climate change during the coming century, for the Holland coast will require a considerable upscaling of present nourishment volumes. A sustainable development of the Holland coast asks for long-term strategies of nourishments and sand mining that provides optimal conditions for safety against flooding and for ecological and socio-economic developments. There is a need for exploration of most effective and cost-efficient methods of nourishments (upscaling volumes and downscaling frequency vs. downscaling volumes and upscaling frequency) by learning from pilot projects.

Objective and approach

This memo presents a palette of long-term strategies for the sustainable development of the Holland coast, in which three building blocks have been identified:

- strategy development
- model development and
- stakeholder communication.

An iterative, cyclic design approach was applied in which the strategies are designed, evaluated and optimised in a series of cycles. These building blocks have been combined through a cyclic design approach in which
For the development of strategies a state-of-art design tool is used to define viable approaches towards coastal maintenance. The benefits and drawbacks of coastal interventions can be evaluated with this tool on a large number of relevant coastal indicators. In order to be able to tailor the nourishment strategies as much as possible to the needs of different stakeholders, both the development of strategies and of the design tool took place in close cooperation with a stakeholder platform. With these results in mind, new strategies were developed and optimized during the session.



This study does not define a single optimal long-term maintenance strategy for the Holland Coast. The optimal strategy strongly depends on the priority of functions, which differ between stakeholders, scale of the problem at hand and setting of the discussion. We therefore focussed on demonstrating the range of possible strategies backed up by the coastal design tool. These strategies provided interesting coastline developments that turned out to be of value during stakeholder discussions. These strategies were presented as starting point at a stakeholder work-session.

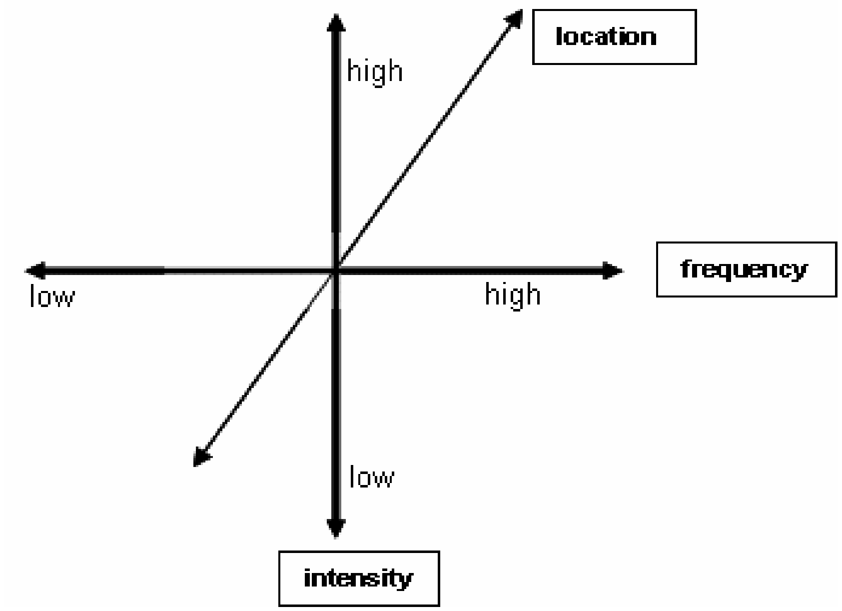
Nourishment and sand mining strategies

Potential nourishment and sand-mining strategies may be defined on the basis of *nourishment possibilities* and/or *different objectives*.

The overall objective, as indicated by the DeltaCie, is the long-term preservation of values and functions of the coast, under conditions of accelerating sea level rise. Basically this objective is defining the total nourishment volume to be applied per unit of time. The distribution of this volume in time and in space (i.e. the nourishment strategy), is determined by the spatial differentiation in requirements related to different functions.

Primary function in this regard is *safety against flooding*. In addition, benefits of a gradually widened coast according to the DeltaCie, are related to the creation of more space for *nature,* for *recreation*, and *locally* for *high-grade, flood-proof buildings*, so that existing coastal resorts can continue to exploit the advantages of their seaside location.

Regarding nourishment- and sand-mining possibilities, the range is determined, on the one hand, by a variation (per individual event) in nourishment- and sand mining *intensity* and in distribution over time (*frequency*) and space (number of *locations*).



On the other hand, nourishment possibilities are restrained by limitations in dredging technology (available technology), in availability of suitable sediment, in finances (available financial resources), in regulations (existing flood risk-, nature- and environmental regulations) and in societal / political support.

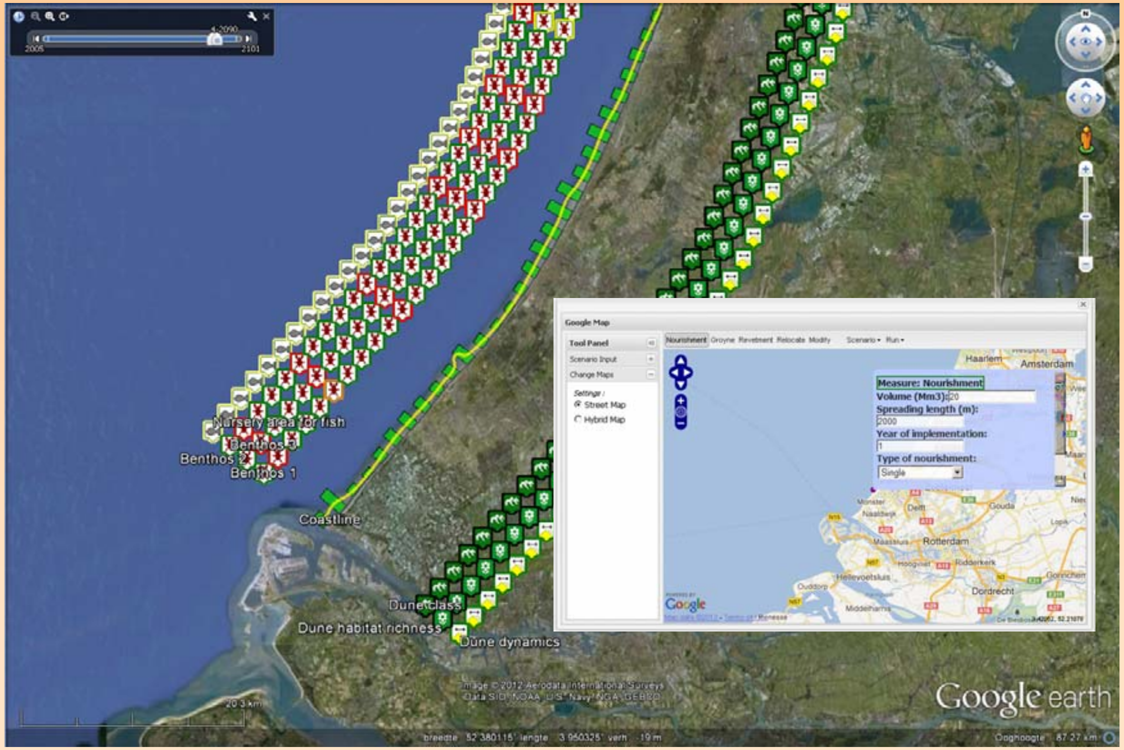
In this memo the exploration of potential nourishment and sand mining strategies, starting from the definition of a number of potential strategies related to one specific objective. Then in a later stage, the feasibility (in terms of technology, finances, regulations and support) will be tested through stakeholder involvement.

2. Development of design tool

In this study an interactive coastal design tool has been developed for maintenance strategies along the Holland Coast (see box). This tool combines a shoreline model with several empirical relations for ecological indicators, such as fish and benthos, but also fresh water storage, dune development, recreation, and cost estimates. The tool allows an evaluation on multiple indicators with temporal and spatial variations. Depending on the stakeholder / setting an appropriate selection of indicators can be made to visualise.

Coastal Design Tool

The Interactive Design Tool for the Holland Coast consists of a user interface (web based front-end), a set of models that forecast the long-term coastline changes as a result of nourishment strategies and post-processing routines for several (ecological) indicators. Simulations with the ITHC were performed for a period of about 100 years. The ITHC is intended for use in stakeholder sessions, where nourishment strategies can be designed and evaluated on the spot. The model runs is computationally efficient (i.e. several minutes processing time for 100 years of simulation for the entire Holland coast). The core of the model consists of the UNIBEST module which simulates coastline changes. The impacts on ecological indicators are calculated separately in post-processing modules, based on the outcomes of the UNIBEST model. These post-processing modules consider benthos (this report), juvenile fish (this report), and dunes (De Groot et al., 2012 in prep.). The results can be exported to Google Earth, in which the users can visualise the results in time and space. Next to the predictions, an important aspect of the tool is to visualise aspects related to nourishments that are little known by most stakeholders. In this case that includes the alongshore effect of nourishments (UNIBEST) and the possible contrasting effects on parts of the ecosystem.



Linking effects to coastal indicators

The effectiveness of a coastal strategy can be clarified by looking at its functional performance. This functional performance can either be related to the impact of the measures on coastal functions as well as to inherent qualities of the measure. Both performance types can be detailed out into a limited number of relevant indicators and linked to measurable parameters. These parameters may, for example, relate to the measures (e.g. volume of nourishment sand), the computed impact (e.g. coastline position) and available relevant information on the considered coast (e.g. dune width). The performance indicators are divided over the following categories:

- Safety
- Economics
- Residential
- Recreation
- Ecology
- Policy
- Costs

A number of performance indicators are shown here:

Impact on benthic species

Nourishment directly impact the benthic species at the seabed locally as they are buried under a large amount of sand at the nourishment site. An evaluation of the impact is made on the basis of assumptions for the impact of nourishment types on the local benthic community and the habitat carrying capacity. A logistic growth function is then used to assess the restoration of the benthic species in time.

The impacts are assessed separately for three benthic species:

- Capitella capita (r-strategist)
- Macoma balthica
- Echinocardium cordatum (k-strategist)

Safety

The safety of the primary water defenses is considered as the primary aim for most coastal policies. First of all, a minimum position should be maintained. Secondly, the safety of the primary water defenses can be related to the coastline position. A coastline change of about 30 meter can be used as a proxy for a factor 10 difference in the safety level.

Safety of structures outside a dyke ring is also important for a coastal strategy. A somewhat larger risk of failure may, however, be accepted for these structures than for a dyke ring. This indicator is assessed similarly on the basis of the coastline position at locations along the coast where structures are present.

Dune habitat

To calculate this indicator a new approach was developed for the long-term modelling: a combination of data-driven modelling (Bayesian network modelling) and rules based on expert judgement. This method results in a general classification of the expected dune habitat that may develop at a specific location along the coast. The dune habitat type relates to the biodiversity.

Costs

The direct cost price of the nourishments (without discounting) is computed roughly on the basis of an estimated cost price of the sand. This cost price depends on a variety of factors, like:

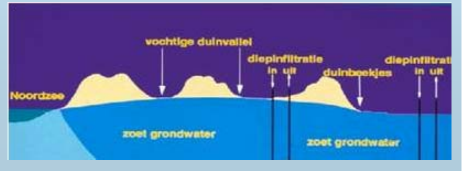
- method of nourishing,
- volume of the nourishment,
- transport distance, and
- complexity of the work.

Oil price and economic conditions should be specified through partial cost prices (no variation in time). The order of magnitude of the direct costs of long-term coastal maintenance policies can be investigated.

Drinking water dunes

The drinking water companies use the dunes as an infiltration area for river water. The infiltrated water is then pumped up from the ground water and used as drinking water. The availability of fresh water depends on the volume of the dunes as well as on the amount of water that is infiltrated. Increasing the width of the dunes can result in a larger volume of water (not salt) that can be used. Increasing the width of the dunes may therefore bring an economic benefit for such companies.

The freshwater storage volume is calculated using a relation that has been derived from several Modflow simulations for typical situations that are found along the Holland coast.



Nursery area for juvenile fish

Continuous nourishments may significantly build out the coast in seaward direction. This may, however, affect the available foreshore area which is of vital importance for the nursery of juvenile fish. The foreshore width (up to about NAP-15m) is therefore used as a proxy for the evaluation of the impacts on the nursery function of the coast for juvenile fish. For this purpose an average coastal width of about 10 km was assumed. The impacts were assumed to be linear with the increase or decrease of the foreshore width.

Beach and dune recreation

It is assumed that most beaches get more attractive for recreation if they are wider. So, a relation between beach width and beach recreation could be adopted. This holds especially for the area that is still dry at high water. However, for very wide beaches the effect is expected to have a negative effect, as the walking distance towards the waterline will become large. It is noted that substitution between beaches may play a role (i.e. visitors are attracted from other beaches), which means that there is only a local benefit. Some relation between beach width and attractiveness for recreation is however expected to be present. Similarly, the recreational attractiveness of dune areas may be somewhat impacted by a widening of the dunes.

Groundwater

Ground water levels at residential areas behind the dunes can be impacted by the seaward extension of the dune front. This impact is related mainly to the width of the dunes (wider dunes relate to a higher phreatic level) and the type of coastal nourishment (e.g. a dune lake at the existing dune face may reduce the impact). It is noted that the influence on the ground water is only relevant at residential areas.

3. Development and comparison of maintenance strategies

Developing long-term maintenance strategies

This study does not define a single optimal long-term maintenance strategy for the Holland Coast. The optimal strategy strongly depends on the priority of functions, which differ between stakeholders, scale of the problem at hand and setting of the discussion. We therefore focussed on demonstrating the range of possible strategies backed up by the coastal design tool. These strategies provided interesting coastline developments that turned out to be of value during stakeholder discussions. These strategies were presented as starting point at a stakeholder work-session. With these results in mind, new strategies were developed and optimized during the session.

The following maintenance strategies for the Holland Coast until 2100 are considered:

1. **No interventions**
   Autonomous development with no coastal intervention.
2. **Minimal consolidation**
   a. <u>Yearly nourishments at coastal settlements</u>
      Settlements and other risk areas are protected against erosion by yearly nourishments of in total 2.7 million m^3 per year, whereas other locations do not receive nourishments.
   b. <u>Five-yearly nourishments at coastal settlements</u>
      Minimal protection of the coast at coastal settlements with shoreface nourishments of 13.5 million m^3 every 5 years.
   c. <u>Five-yearly nourishments distributed along the Holland Coast</u>
      Protection along the whole Holland coast with equally distributed nourishments of 13.5 million m^3 every 5 years.
3. **Seaward**
   a. <u>Ten-yearly sand engines (20Mm^3) at five locations</u>
      Extending the coastline gradually seaward with the help of mega-nourishments of 20 million m^3 each, that are applied every ten years at five locations along the coast (Vlugtenburg, Katwijk, Zandvoort, Egmond and at the Hondsbossche zeewering).
   b. <u>Yearly sand engines (10Mm^3) “moving” along the coast</u>
      Extending the coastline gradually seaward with the help of mega-nourishments of 10 million m^3 each. The nourishments are implemented every year at different locations along the Holland Coast to obtain a more even distribution of the sand than in scenario
4. **Revetments**
   Revetments protecting the coastal settlements (no additional nourishments). At the locations in between natural dynamics are allowed.

Effects of long-term maintenance strategies

One of the strengths of the design tool is that the effects of the long-term maintenance strategies for the Holland Coast can be visualized dynamically in time and space. In this report time is fixed to a “snapshot” of the dynamics in 2050 to evaluate the maintenance strategies. In the next pages the strategies are discussed by means of figures and text boxes containing interpretation of the results. A “reading guide” as well as a legend are provided to improve the readability of the figures. To limit the amount of information only the coastal, dune and ecological indicators are shown and discussed. For all strategies the effects of a 2 mm/yr sea level rise are taken into account (in a schematized way).

Reading guide for figures

The figures contain the results for the total Holland Coast, indicated on the x-axis from Hoek van Holland to Den Helder. The types of dune and ecological indicators are presented on the left y-axis, where their state is expressed in a colour range (where the colour ranges depend on the type of indicator – see legend). The coastline change (relative to its initial position) is presented by the blue line with its scale on the right y-axes. The initial harbour dams of Scheveningen en IJmuiden as well as the revetment of the Hondsbossche Zeewering are included in all strategies.

Legend (icons sorted from positive to negative impacts)

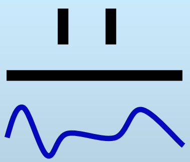
Dune classes

Habitat richness

Dune dynamics

Nursery area fish

Impact benthos



Harbour Dams

Revetment

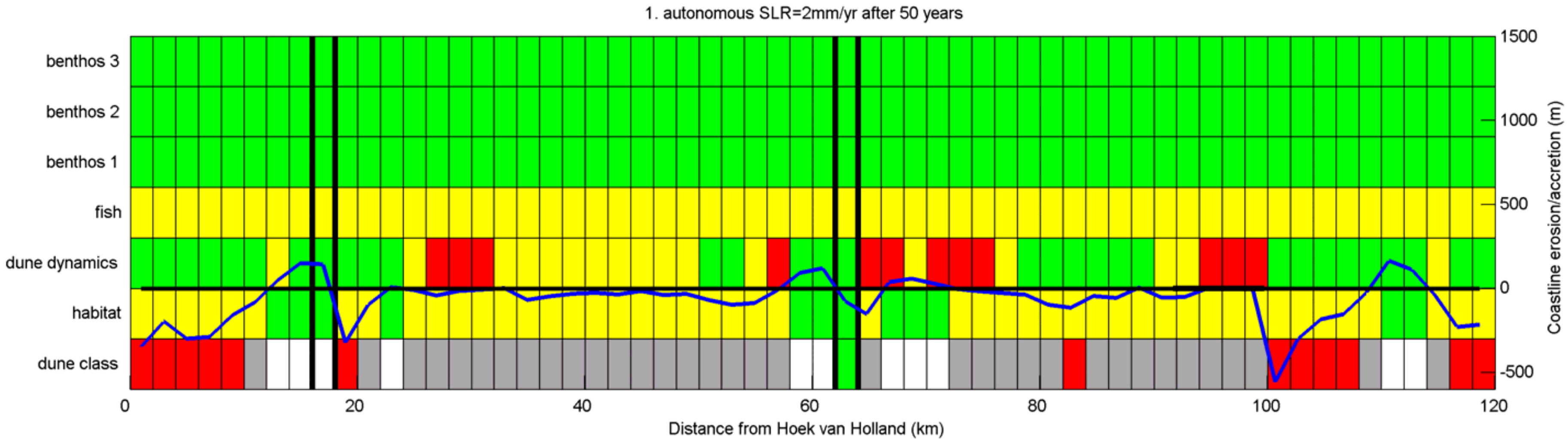
Coastline change

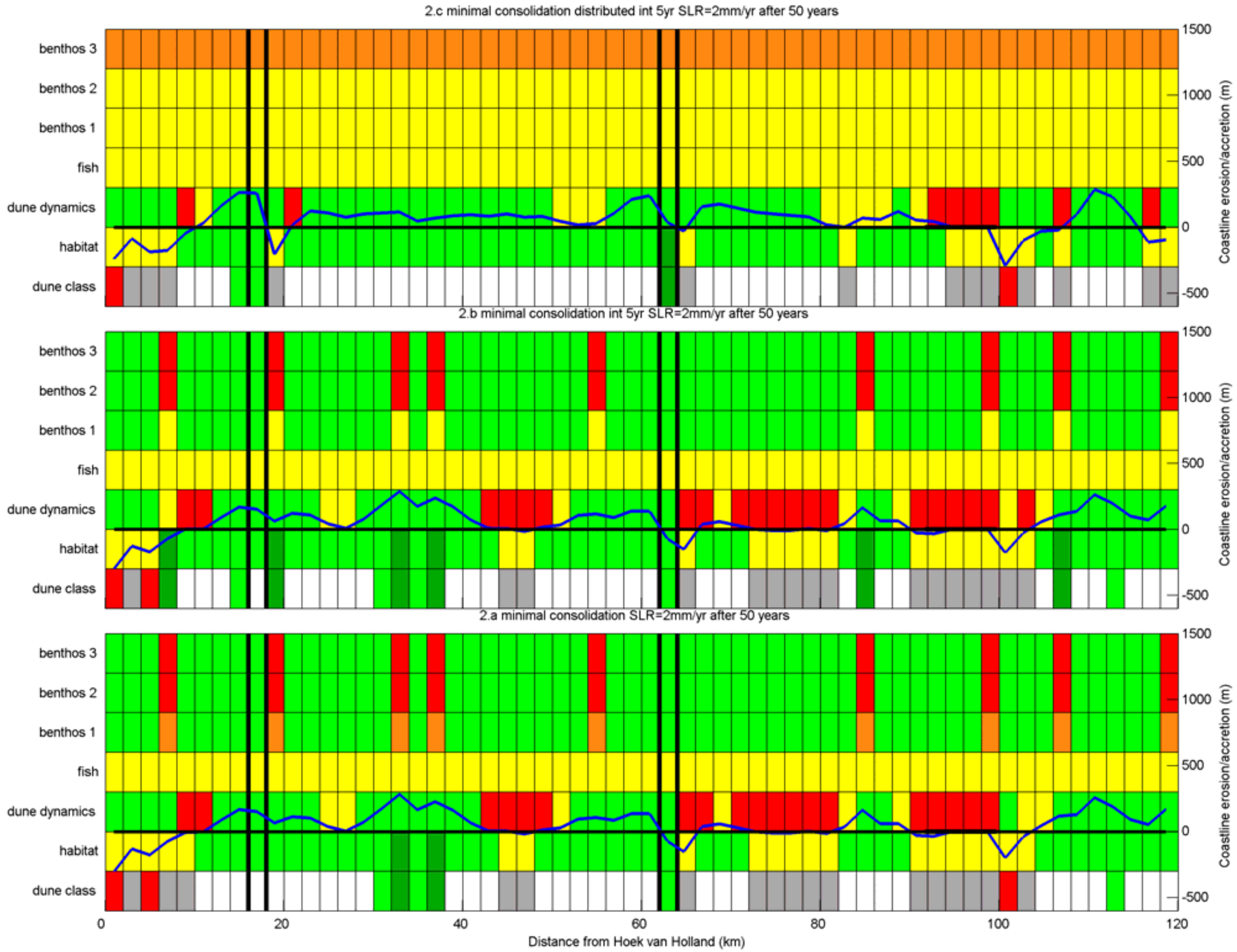
Autonomous strategy

The autonomous strategy shows a small coastal retreat at most locations along the coast as a result of sea level rise. Around the hard structures (groynes and revetments) the coastal changes are more profound. As the net sediment transport is directed northward (i.e. away from Hoek van Holland), the coastline accretes at the south side of the structures (due to sediment blockage) and erodes at the north side (due to sediment deficits).

The indicators for dunes and ecology are related to the coastline changes. Generally, dune growth and habitat richness increase where the coastline accretes and vice versa. Dune dynamics are related to coastline changes in general and do not depend on the direction of the change (i.e. erosion or accretion). As the coastline changes in this strategy are most dominant near the structures, the response of the dunes is most profound at these locations.

The impact on the benthos depends on the type of coastal intervention that is implemented and the response of the type of benthos to this intervention. As no interventions are implemented in the autonomous strategy, there is no impact on the benthos. The impact on fish depends on the change in habitat size for fish. As coastal changes need to be huge before the habitat area of fish is significantly affected, the impact for fish in this strategy is negligible.

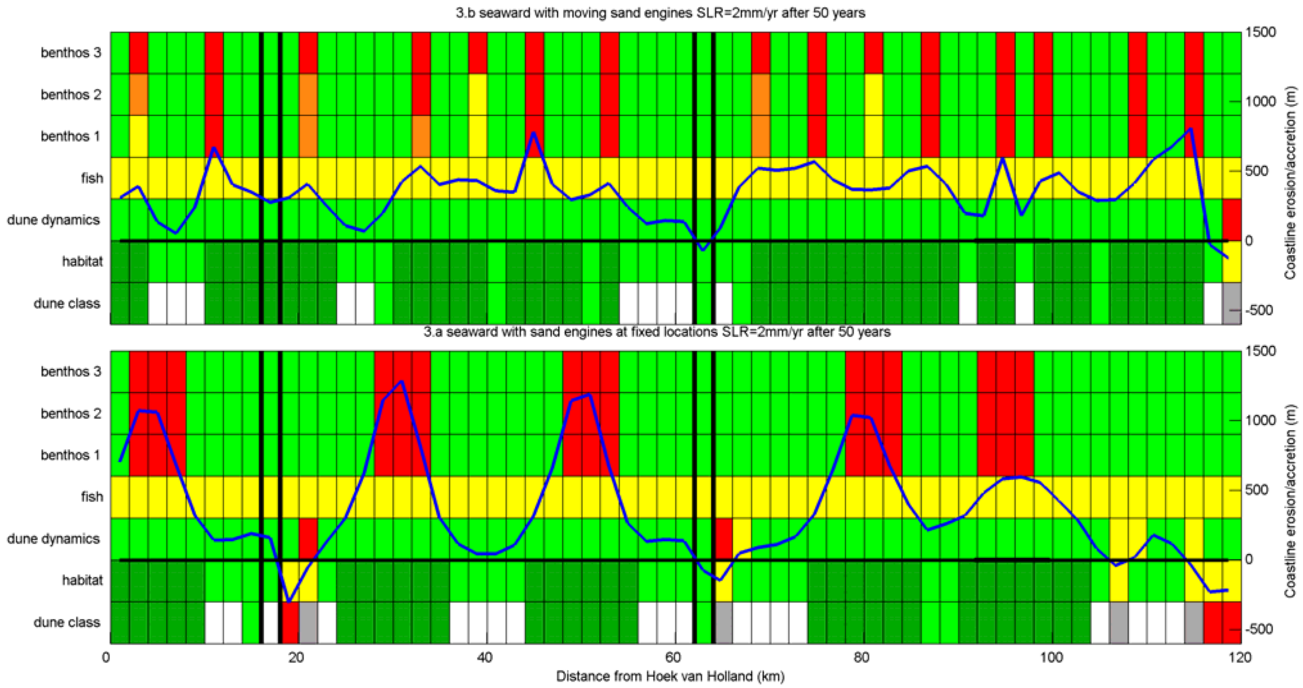




Minimal consolidation strategies

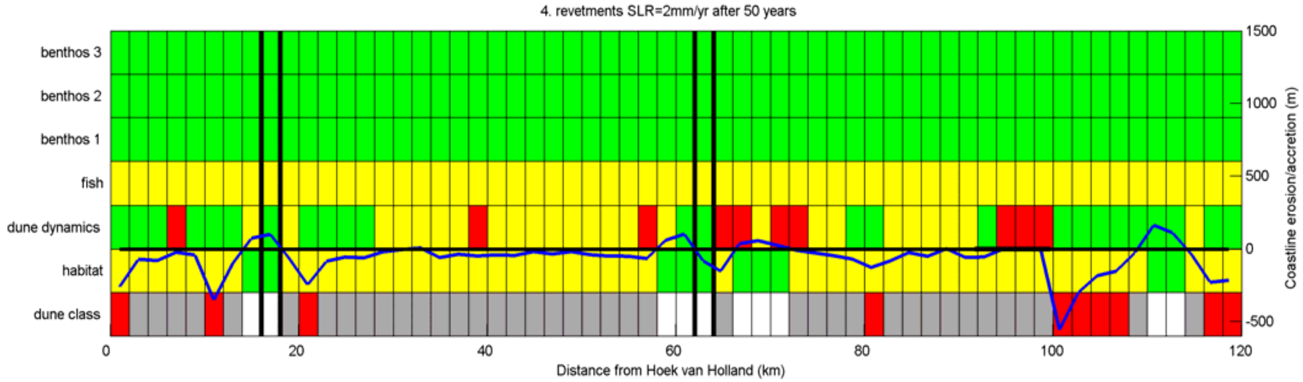
The strategies for minimal consolidation have more or less the same objectives in terms of coastal safety (i.e. keep the coastline in place), but a different implementation strategy. Therefore, the results in terms of coastline and dunes are similar, except for the stronger focus on coastal settlements in strategies 2a and 2b as compared to strategy 2c. The main differences are in terms of ecology, as this mainly depends on the implementation strategy. The difference between strategies 2a and 2b is that the benthos does not get time to recover from a nourishment in strategy 2a, where it does in strategy 2b.

The profoundness of these differences depends on the moment in time (i.e. compared to the last nourishment) and the resilience of the species. In strategy 2c the same volume of sand is spread over the whole Holland Coast. Therefore, the impact is spread over the whole coastline, but it is less intense (as the volume of sand per meter coastline is less than in the other two strategies).



Seaward strategies

As for the consolidation strategies, the seaward strategies (i.e. 3a and 3b) have more or less the same objectives in terms of coastline position, i.e. extending seaward. The main difference is again in the "how". By focusing the sand engines at fixed locations (i.e. strategy 3a), the coastline gets a more "bumped" shape, which will be flattened by diffusive processes as soon as the nourishments stop (not shown in figure). For a randomly changing location of the sand engines in time (i.e. strategy 3b), the sand is distributed more evenly along the coast. These distributed nourishments have positive effects for the dunes over a wider stretch of the Holland Coast compares to strategy 3a. On the other hand the (negative) impacts for the benthos are also more spread along the coast, but as the return frequency of the nourishments at a certain location is low, the benthos has time to recover.



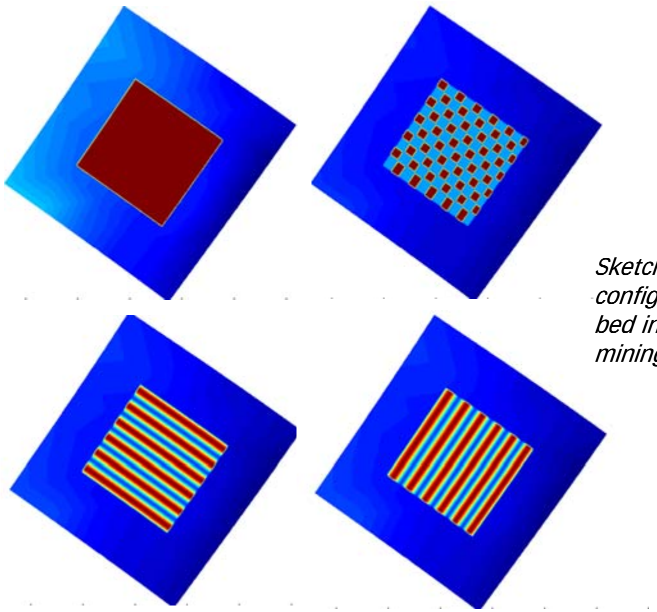
Revetments

This strategy is fairly similar to the autonomous strategy, except that the coastal settlements are protected by revetments. This is most apparent near Monster and Scheveningen. As no nourishments are applied, the negative impacts for ecology are negligible and the dunes are stable or erosive, depending on the stability of the coastline.

4. Sand Mining

To obtain the sand required for the nourishments sand will be mined beyond the -20 m following present policy. As larger sand volumes are required for nourishment the sand mining volumes will also increase. Sand mining pits or large trenches will be created due to the extraction of large volumes of sand. This offers the opportunity for designing extraction sites in such a way that optimum (physical parameter) combinations are created to enhance the development of preferred ecological habitats and flora and fauna communities. This could for example result in more biodiversity and biomass in the sand winning area after the dredging activities have ended. An ecological design of an extraction area could help to increase the potential post-dredging value of the area and opportunities can be taken to improve and add to the overall sustainability of the sand winning project.

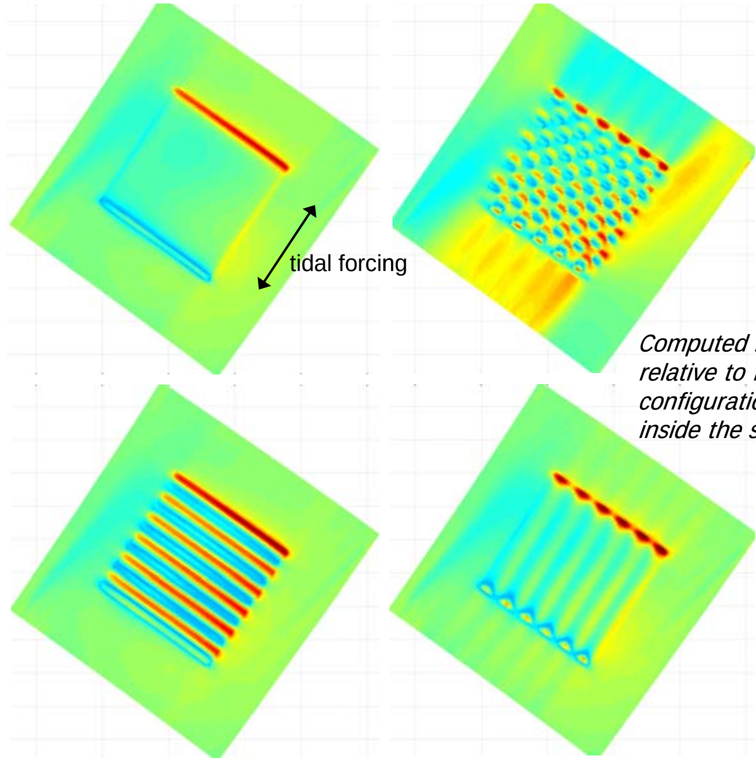
Discussions with ecologist yielded that variations in the bed and hydrodynamic forcing enhance the ecological diversity.



Sketch of four different configuration of the sea bed inside the sand mining pit

Designing sand mining pits

A schematised Delft3D model has been developed forced with conditions found at the present sand mining area for the Zandmotor. The plots below illustrate the tide-averaged difference in bed shear stress compared to the reference case of a flat bed. The yellow-red colors indicator higher bed shear stress while the blue colors represent lower values.



Computed bed shear stress relative to flat bed case for four configurations of the sea bed inside the sand mining pit

The above designs may give inspiration in future developments in designing such sand mining pits, in combination with more knowledge on the relations of species, communities and diversity (under development by PhD’s).

5. Stakeholder communication

In order to be able to tailor the maintenance strategies as much as possible to the needs of different stakeholders, both the development of strategies and the design tool took place in close cooperation with a stakeholder platform. The platform was provided by the "Initiatiefgroep Atelier Kustkwaliteit (AKK - Design Workshop Coastal Quality)", with support of representatives of different levels of government (Deltaprogramma Kust / *national*, Provinces of North- and South Holland and Zeeland / *provincial*, Hoogheemraadschap Hollands Noorderkwartier, Rijnland en Delfland / *water boards* , various municipalities and TU Delft / *universities)*.

Atelier Kustkwaliteit (AKK)

Atelier Kustkwaliteit "aims to develop, design, deepen, spread and discuss new ideas for safety and spatial quality for the Dutch Coast". It does so by bringing together people, knowledge and experience from different disciplines in order to connect coastal safety to economical opportunities and spatial quality.

For more information:
http://www.atelierkustkwaliteit.nl/

AKK has organised a number of design workshops at different locations along the Dutch coast, focusing on local and regional aspects of coastal development. Participants of the workshops were government representatives of different levels, landscape architects, ecologists, people from local trade, beach club owners, industry and utilities (e.g. drinking water companies) and NGOs. During the workshops we have provided input on the functioning of the physical system, the principles and background of nourishments, potential maintenance strategies and feasibility of different designs of coastal development. During the process valuable feedback was received on essential functionalities of the design tool – e.g. leading to an extension of the number of indicators –, and on favourite development strategies for the coast (including nourishments as a favourite maintenance approach).

The design tool itself has proven to be a crucial instrument to communicate the dynamic character of the coast and long shore interdependency of different maintenance strategies. The ability to produce, already during the discussions, rough indications of the effects of different maintenance strategies over time and space, effectively contributes to an awareness of the feasibility of various designs.

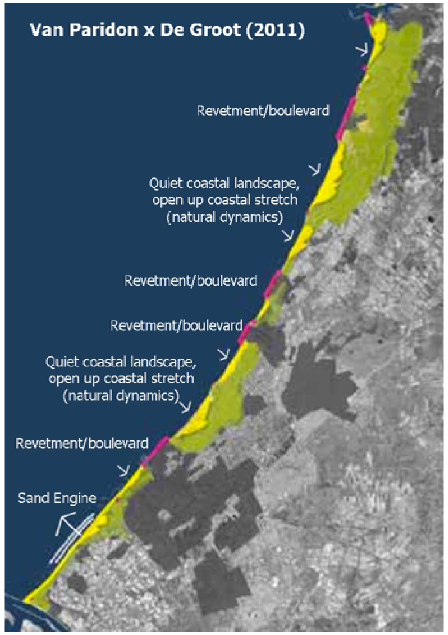
Favourite designs of coastal development

With regard to the favourite designs of coastal development - taking account of the typical sandy character and socio-economic potential of the Dutch coast and of the possible effects of an increase of sea level rise due to climate change – from the workshops, generally two main characteristics stand out:

1. The coastline along coastal cities should minimally be maintained at the current position, but preferably be extended seaward to enable economic development;
2. Extension or even maintenance of the coast line position at locations with a wider dune belt, is considered less crucial; on the contrary, from an ecological and landscape point view at some locations the creation of erosive conditions is advocated.

With these characteristics in mind two "minimal designs" are discussed:

A. Maintenance by revetments
B. Maintenance by nourishments



A. Maintenance by revetments

In this design the coastline at the coastal cities along the coast of Zuid Holland is maintained by means of revetments without any additional nourishments, except for a Sand Engine type of nourishment in the south near Monster. The design (left figure) indicates the anticipated/desired results i.e. a stable coastline at the coastal cities and a retreating coastline in the wide dune areas in between.

The indicative results of simulations with the design tool (right figure), implementing the proposed design for a period of 70 years, obviously show that the desired retreat of the coastline in the wider dune areas will be hardly realised. A disadvantage of this method is the lack of flexibility to respond to future developments such as sea level rise or climate change.

B. Maintenance by nourishments

In this design the coastline at the coastal cities is not maintained by revetments, but by regular nourishments. Again the left figure shows the anticipated/desired results of a more or less stable coastline at the cities and a retreating coastline in the dune areas in between.

According to the model simulations with the design tool (right figure), the design is successful near the coastal cities, but the longshore redistribution of the nourished sand (due to diffusive processes) prevents any retreat in the areas in between.

Quotes from stakeholders about design tool:

"The design tool gives a quick indication of the order of magnitudes and relative effects"

"Ideas can be tested on site"

"The tool is a black box"

"Expert is needed to interpret/analyze results"

6. Lessons Learned

This study has shown that there is a broad palette of long-term maintenance strategies for sustainable development of the Holland Coast, i.e. long-term preservation of its values and functions under conditions of (accelerating) sea level rise. The focus is not on defining one single optimal strategy but rather on providing the tools and insights to develop these strategies for different settings (i.e. priorities/preferences of stakeholders, scale of interest, setting of discussion, etc.). This chapter summarizes the findings of this study in lessons learned grouped to the themes that have been discussed in this report, i.e. the design tool, coastal maintenance strategies and stakeholder communication.

Lessons Learned from Developing Coastal Maintenance Strategies

- In contrast to hard coastal structures, nourishments are a flexible measure, which allow designers to respond to uncertain future developments such as sea level rise and climate change
- Mega nourishments with a low return period may have a bigger initial impact on the benthic communities living in the areas where the sand is mined and nourished, but allow benthic communities to recover (as opposed to the traditional small-scale nourishments with a high return period)
- Hard coastal structures hamper dune dynamics and growth (in contrast to nourishments)

Lessons Learned from Developing a Design Tool

- Stakeholder feedback is essential in developing a functional design tool
- Providing stakeholders with quick insights on the consequences of their choices facilitates stakeholder discussions/decision making processes
- Showing results varying in space and time is useful for stakeholders to gain a basic understanding of the underlying physical principles
- Showing results for different indicators simultaneously allows stakeholders to gain insight in the interaction between these indicators, but may also complicate the interpretation of the results (more is not always better)
- A design tool remains a black box for stakeholders; an expert is always needed to interpret the results and put them into perspective
- Stakeholders tend to interpret nice-looking visualizations (on Google Earth) as the truth; it turned out that sensitivity bands around the computed coastline positions aided to demonstrate the uncertainty in the predictions
- Developing a design tool requires to make a trade-off between model accuracy and simulation speed; the development of design tools can run parallel to the design process: more detailed models can be used in the final stages of the design process

Lessons Learned from Stakeholder Communication

- Stakeholders tend to interpret the coast as a static rather than a dynamic feature
- Designers tend to focus on the final design and not at the stages in between (i.e. the road to the final design)
- Development of multiple coastal maintenance strategies within one session allows for strategy optimization (interactive character)
- In developing coastal maintenance strategy stakeholder showed a preference for minimally maintaining the coastline at its current position along coastal cities, but preferably extending it seaward to enable economic development. In the wide dune areas between coastal cities stakeholders advocate coastal retreat from an ecological perspective. Indicative model simulations with the design tool showed that both desires can hardly be realized at the same time.
- In case of applying nourishments, most of the stakeholders tend to have a preference for mega-nourishments
- Wider beaches are not always better; the maximum desired beach width is 300 – 400 m.
- Increased fresh water storage is not always desired (the current storage volumes are already optimized with the demand)
- Stakeholders better understand the position of other stakeholders

Reports, references and contributions:

Most of the Holland Coast work packages have contributed to this work. PhD's that have contributed are: Sierd de Vries, Matthieu de Schipper, Maarten de Jong, Carola van der Hout and Stephanie Janssen (GOV). The HK4.1 project shared ideas with the project *Alternatieve Lange-termijn Strategieën* by Waterdienst and Deltares and with Southwest delta (ZW4.1).

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