An assessment of sand quality and potential impacts on corals at the Chogogo Dive and Beach Resort artificial beach

Authors: Erik Meesters, Marjolein de Hart, Gulsah Dogruer

Wageningen University &
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Wageningen Marine Research

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Contents

Summary

The Government of Bonaire has requested Wageningen Marine Research (WMR) to research the composition of the sand used to construct the artificial beach of the *Chogogo Beach and Dive Resort*. The major concern regarding the artificial sand was to evaluate whether the sand used could harm the marine park corals. The sand of the beach of Chogogo was sampled on the 10th of May 2022 and analyzed at the Netherlands Institute of Sea Research (NIOZ) for grain size and organic matter content. Additionally, the natural sand in front of Chogogo and several other places was sampled to better compare the sand that naturally occurs around Bonaire to the artificial sand. The results of the analysis and expert evaluation have provided the following responses to specific questions that have been raised.

What are the potential effects on marine life, specifically corals, in relation to the constructed beach?
There is already sand being transported into the adjacent sea. Corals may already be affected. If so, then stress on corals will be increased. This will affect their metabolism, influencing coral growth and health. Furthermore, a higher sediment load will lead to a higher cover of the bottom by sand and prevent coral recruits from settling. In the longer term, corals more sensitive to sediment will disappear from the location which may be exchanged for more stress-tolerant corals. Generally, these species are less important for maintaining the reef. However, if the sediment load is high (permanently or incidentally), the sea floor may become fully covered by sand, and all corals may disappear. Thus, it is important to monitor artificial beaches for breaks in the retention walls, accumulation of sand along the walls, and make adjustments when necessary. It is important to note that since corals are long-lived organisms, a short-term assessment, as presented within this report, can barely unravel the long-term quantitative impacts on the health of adjacent corals. Thus, long-term monitoring of the coral communities in front of and up-current from (as control) the artificial beach should be favored.

What are the potential effects on the health of the corals under normal weather conditions? Currently, the sand is already moving towards the sea, and it cannot be excluded that there are no negative effects. Potentially, visibility is already lower, and sedimentation has increased. In addition to the recommendations under question 3, we recommend installing (natural) windbreakers to decrease the wind-funneling effect between the resort's buildings in order to decrease wind effects on the sand.

What are the potential effects on the health of the corals during a storm or wind reversal? During a wind reversal or a storm, there is a high chance that waves will reach the retention wall and wash over it. Consequently, large amounts of sand could suddenly be transported onto the reef and cause massive mortality of corals by burial. The fine sand is likely to be transported downstream (generally in a northerly direction) and may lead to decreased light levels, increased sedimentation, and possibly mortality of corals. The exact transport of the sand is very difficult to predict without extensive measurements of current patterns at the location. We recommend that the retention wall be raised to the prescribed height. It may also be an option to put additional structures in place that can be deployed during wind reversals or storms to prevent sand from being washed away.

How important is the origin of the sand, the kind of sand (river or carbonate sand), the quantity of sand, the layout of the beach, and the constructed wall for the effects?
The origin of the sand is very important. Since the sand is not carbonated, it will probably not be processed similarly to carbonated sand. It may be less likely to be cemented into the reef. Compared with natural sand in front of the artificial beach, the grain size distribution is much finer, indicating that the sand, once it travels over the retaining wall, is likely to be washed away by waves and currents. Once the sand washes away, all the negative effects of increased sediment load and sedimentation may occur. The exact location of the beach and the layout, as well as the buildings around the beach, influence the wind erosion of the beach. In this case, local wind conditions transport the sand toward the sea. Even if the retention wall is raised, the sand will continue to be piled up at the downwind side of the beach and will probably need to be redistributed regularly to not end up in the sea. We recommend periodical reinspection and redistribution to ensure that sand is not transported over the retention wall.

Overall, local wind, waves, and current conditions play a major role in the fate of artificial and natural beaches. Since all artificial beaches are on the island’s leeward side, the prevailing wind always blows the sand seaward. Increasing wall height and constructing wind blockers upwind of the beach may provide extra protection against the sand being blown away. Very high waves can accompany wind reversals. This may lead to massive sand transport onto the reef, consequently smothering and killing coral colonies. A general recommendation is to re-evaluate all artificial beaches given the expected consequences of climate change, such as sea level rise and an increase in the frequency of tropical storms, as this may have strong negative consequences for the reef. Current requirements for artificial beaches may have to be reconsidered.

1 Introduction

The Government of Bonaire has requested Wageningen Marine Research (WMR) to investigate the composition of the sand used to construct the artificial beach of the *Chogogo Beach and Dive Resort* (Chogogo) (TOR in the email of the 18th of January 2022). The sand of the beach of Chogogo was sampled on the 10th of May and analyzed at the Netherlands Institute of Sea Research (NIOZ) for grain size and organic matter content. Additionally, the natural sand in front of Chogogo and several other places was sampled to better compare the sand that naturally occurs around Bonaire to the artificially placed sand.

WMR was asked to evaluate whether the sand used to construct the beach of Chogogo Beach and Dive Resort can harm the corals in the marine park.

More specifically, the following questions were posed:

- What potential effects on marine life, specifically corals, in relation to the constructed beach?
- What are the potential effects on the health of the corals under normal weather conditions?
- What are the potential effects on the health of the corals during a storm or wind reversal?
- How important are the origin of the sand, the kind of sand (river or carbonate sand), the quantity of sand, the layout of the beach, and the constructed wall for the effects?

2 A short overview of the possible consequences of excessive sand deposition on nearby coral reefs

Coral reefs and the role of sand. Healthy coral reefs are a source of calcium carbonate sand. This mineral is the main component of the skeletons and shells of corals, clams, and other marine organisms. When these organisms die, these structures are broken apart and ground to bits by the force of waves and water currents and by other creatures. Ultimately, the fine grains that we consider sand are produced. This sand is partly used to fill holes in the reef and is lithified by biochemical processes to create the reef substrate on which new coral larvae settle and coral colonies grow. Carbonate sand is thus of crucial importance for reef growth. Sand also disappears to deeper parts of the reef as it is lifted off the bottom during storms or when sand accumulates on a slope and becomes too heavy to stay in place. Sand channels can be found at many places on the reef, and they should be considered natural pathways to dispose of excessive sand production by a healthy reef. This sand may accumulate at the bottom of the reef and contribute to the seaward extension of the reef[1]. In a healthy reef, the shallow reef bottom grows very slowly upward, and over time the water depth over a reef becomes less if the sea level remains at a constant height. Individual coral colonies grow upwards, and when they reach the water's surface, they will die because the corals become exposed during low sea level stands (for example, during spring low tide). During interglacial periods such as the current period (called the Holocene), temperatures are slowly rising over thousands of years, and sea levels rise as well because more water is melting at the poles in summer than is stored during winter. During glacial periods the opposite happens, and sea levels drop. During these periods, shallow reefs become exposed and die. Healthy coral reefs can keep up with the normal rise of sea levels and attain very high thicknesses. Some carbonate platforms are several kilometers thick from accumulated reef growth during several geological periods.
The borders of tectonic plates can also be pushed up or down as a consequence of the movement of the plates. Bonaire is on the border of the Caribbean plate and is slowly being uplifted. Coral reef remains can be found at several heights on land and at different depths underwater because of the combined effects of different sea level stands and uplifting. For example, there is a reef terrace between 1 and 10m depth, but in several places, there is a terrace between 50 and 80m depth[2].
The last 80 years have unofficially been called the Anthropocene, meaning the geological period where humanity has such large effects on the planet that it surpasses the effects of geological processes. One of these effects is the increased rate of temperature rise (due to excessive carbon dioxide production) and the concomitant rise in sea level.
Coral reefs are extremely sensitive to increased seawater temperatures and sea level rise. Warmer seawater temperatures stress coral physiology and lead to less growth, more diseases, and more coral mortality. Combined with an increase in human populations along coastal borders and an increase in pollution, coral reefs have degraded severely over the last 50 years. Also, on Bonaire, the reef has degraded due to pollution, diseases, and climate change as measured by a 40 year-long study[3]. Early protection of Bonaire's reef by establishing the Bonaire Marine Park guaranteed that Bonaire's reefs are still considered to belong to some of the healthiest reefs in the Caribbean Sea, and diving tourism has remained crucial to the economy of the island.
The current state of the reefs of Bonaire is the outcome of these different geological processes, climate change, and the effects of coastal development during the last 50 years.
Sand as a cause of coral reef degradation. Sand transported to the sea is generally called sediment, whether it originates from natural processes such as the weathering of rocks or from processes like land use and land degradation by coastal development, such as the construction of roads and buildings close to the sea. If the surface has a dense vegetation cover, this can slow down water and sediment runoff to the sea and increase water

infiltration into the bottom. In contrast, coastal development (roads, buildings, and gardens) generally increases the flow rates of water towards the sea, leading to more erosion and decreased infiltration of water into the soil, thereby lowering the water level of the groundwater and leading to less vegetation and a dryer environment, which further reduces the natural water retention capacity of the soil.

On Bonaire, the natural vegetation is additionally overgrazed by free-roaming goats and donkeys, leading to even more erosion and runoff. Consequently, the amount of land-based sediments washed into the shallow coastal zone has increased along with the island's coastal development[4].

Sediment effects on corals. Sediments affect corals in numerous ways, including smothering, abrasion, shading, and inhibition of coral recruitment[5-8]. In the early days of coral reef research, sediment stress was considered the main factor negatively affecting coral reefs[9]. Land-based sand that is washed into the coastal zone is quickly split into two different fractions. The fine grains float in the water column and scatter the sun's light, thereby reducing the amount of light that reaches the sea floor and the plants and corals living there. This leads to less energy for the corals, which lowers growth rates, wound regeneration rates, and reproductive output. The heavier part of the sand quickly sinks to the bottom and covers everything dead and alive. Living corals need to spend energy to get rid of the sand that is deposited on them, which reduces the amount of energy that they can spend on other processes such as growth, regeneration of natural damage, and reproduction. Additionally, bare surface that is covered by sand cannot be colonized by coral larvae, thus reducing settlement opportunities for new corals. Furthermore, chemical compounds attached to the sand may pollute the water and cause diseases or algae blooms[9].

Artificial beaches. Artificial beach construction and sand nourishment have been used frequently in many places. There are very few scientific publications on the effects of artificial beach construction on adjacent coral reefs because monitoring requirements are often lacking or left to project promoters, with no independent peer review[10]. However, existing publications and reports point out the disastrous effects these activities can have[10-13]. A study in Florida[14] showed how most of the sand used in beach nourishment has unsuitable grain size, durability, and hydrodynamic behavior for a beach setting. As a result, the coral and hard-bottom communities lying on the adjacent narrow shelf are being stressed by increased sediment turbidity, siltation, and smothering. In view of climate change and accompanying sea level rise, the risk that artificial beach sand will be washed away at some point seems very high.

Artificial beach construction on Bonaire. On Bonaire, local law[15] requires artificial beaches to be constructed on land, and the sand should be prevented from reaching the sea by constructing a concrete wall. This regulation states that permission to construct an artificial beach can only be given if the nature commission has been heard, if the beach is part of a resort with more than 100 rooms, if the beach is freely accessible at all times, if there is no beach nearby, if the beach is protected by a wall at minimally three sides, not being the land side, and if the sand is of the same quality as the natural marine sand at the same location. Annex II of this regulation specifies even more requirements, among which are that the sand should have the same qualifications as the sand that is originally present at the specific location, that the wall can withstand waves of 1.5m height, the top of the wall is 70cm above normal average sea level, the artificial sand layer is not thicker than 0.2m and minimally 0.2m below the top of the wall (see appendix 2).

3 Materials and methods

WMR was asked to evaluate whether the sand used to construct the beach of Chogogo Beach and Dive Resort can harm the marine park's corals.

Grain size analysis

Sand samples for grain size analysis were collected in 50ml containers, stored in a fridge, and kept cool during transport to the Netherlands. Samples were then freeze-dried for up to 96 hours till dry. Prior to grain-size analysis between 0.5 and 5 grams, depending on the estimated grain size, the homogenized sample was weighed and filtered over a 2 mm sieve in 13 ml PP Autosampler tubes. RO (Reverse Osmosis) water was added, and the sample was shaken vigorously on a vortex mixer for 30 seconds. The particle size distribution of sediments was determined using a Coulter LS 13 320 particle size analyzer and Autosampler. This apparatus measured particle sizes in the range of 0.04–2,000 μm in 126 size classes, using laser diffraction (780 nm) and PIDS (450 nm, 600 nm and 900 nm) technology.

DNA analysis

Sand samples for DNA analysis were stored in ethanol and transported to the Netherlands for analysis.

During sampling, the coordinates of each sample were collected with a handheld GPS (Garmin 78).

Samples were collected on Bonaire on May 10-14, 2022. An overview of the locations sampled is given in Figure 1 and Figure 2.

Figure 1. Samples taken at Chogogo. Black filled circles are samples for DNA analysis, blue circles denote sand samples for grain size analysis. Numbers refer to waypoints used in sample and data processing.

Figure 2. Samples taken at other locations. Symbols as in Figure 1.

4 Results and observations

4.1 Origin of the artificial sand on Bonaire.

The sand used for the construction of the artificial beach originates from Guyana (officially The Co-operative Republic of Guyana) and consists of white silica sand that is declared to be free from pests (see Appendix 3). A request for additional information did not lead to any response from the company that delivered the sand. In the field it can be easily distinguished from the normal calcium carbonate sand that has a more yellowish color. On the seaward side of the wall a foot path has been constructed that is further supported by a wall of coral stones (Figure 3).

Figure 3. Footpath with retaining wall on the right side. Artificial beach sand is on the right side of the wall. Some natural sand is visible on the left of the picture.

4.2 Grain size distribution

Grain size distribution is the most important characteristic of the sand because this determines how easily the sand can be moved from the beach by wind and water. An overview of the grain size distribution of all samples is given in Figure 4. Samples from the natural sand in front of the Chogogo beach generally have a higher peak at the larger classes and often have less sediment in the smaller classes. This indicates that natural sand has fewer fine particles.

Samples can also be analyzed and grouped based on the distribution of the different size classes in each sample (Figure 5). These results also show a relatively large difference between Chogogo and sand samples in front of this beach. The grouping analysis indicates this difference: a number of reference samples are almost immediately split off from the whole group of samples. These are specific samples that are in front of Chogogo beach and appear to have a much coarser grain size distribution reflecting the sorting effects of the local hydrodynamic conditions. Reference samples that are not in this group are closer to the artificial beach and appear to have already been mixed with sand from the artificial beach. Note also that samples from other beaches appear to have a grain size distribution that is more similar to that of the artificial beach sand. This shows how local hydrodynamic conditions can strongly affect grain size distribution.

The median grain size of the samples is often used to describe the major sand size class. A map showing the median grain size values and location of each sample shows how samples become coarser closer to the water (Figure 6). This indicates that the sand that is not washed away by waves and currents has a coarser median grain size than the artificial beach sand. The average median size of the Chogogo samples was 424µm (394-454, 95% confidence limits) and 590µm (455-724) for the samples in front of Chogogo beach. Statistical analysis also indicated a strong difference between samples in front of Chogogo and from the artificial beach ($p = 0.0012$). A similar result was obtained for the mean size (see Appendix 1, $p = 0.015$).

The distribution of grain size over the different size classes can also be tested using an index that considers the percentage in each size class. Such an index is the Euclidean distance: similar samples have a low distance, and very different samples have a high distance. Non-parametric tests using the matrix of Euclidean distances between samples indicate a strong difference between the distributions of the three groups (PERMANOVA, $p = 0.001$). Pairwise comparisons between the groups (Chogogo, in front of Chogogo, other samples) indicated that each group differs significantly from the other groups (all p-values < 0.01).

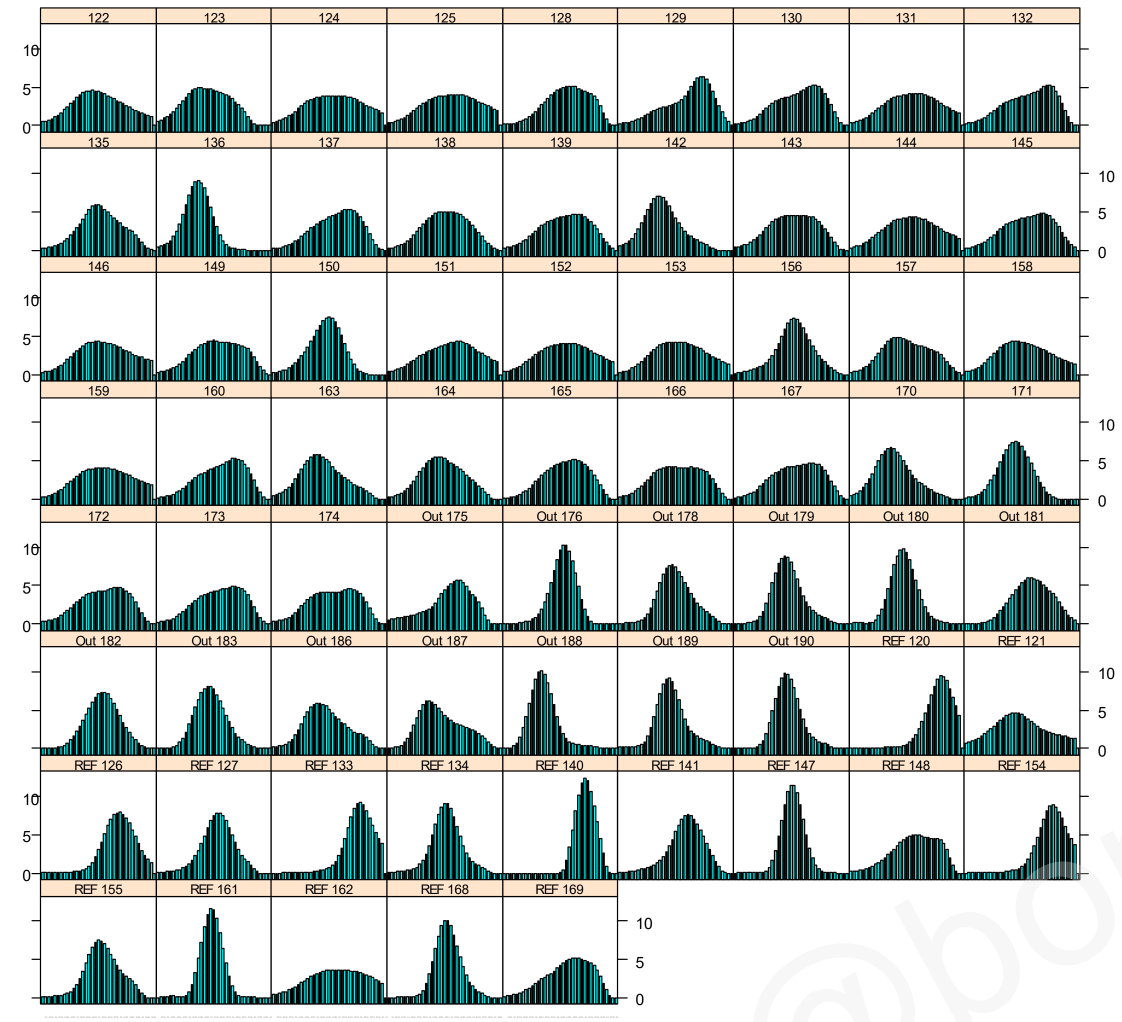

Figure 4. Grain size distributions of all samples. On the top of each graph the waypoint number is shown together with a label indicating whether the sample is considered a reference sample taken from in front of Chogogo beach (REF), a sample from another beach (OUT), or taken at Chogogo beach (only a number). On the y-axis, the percentage of the total weight within each size class is given. Size classes go from 69µm to 2mm.

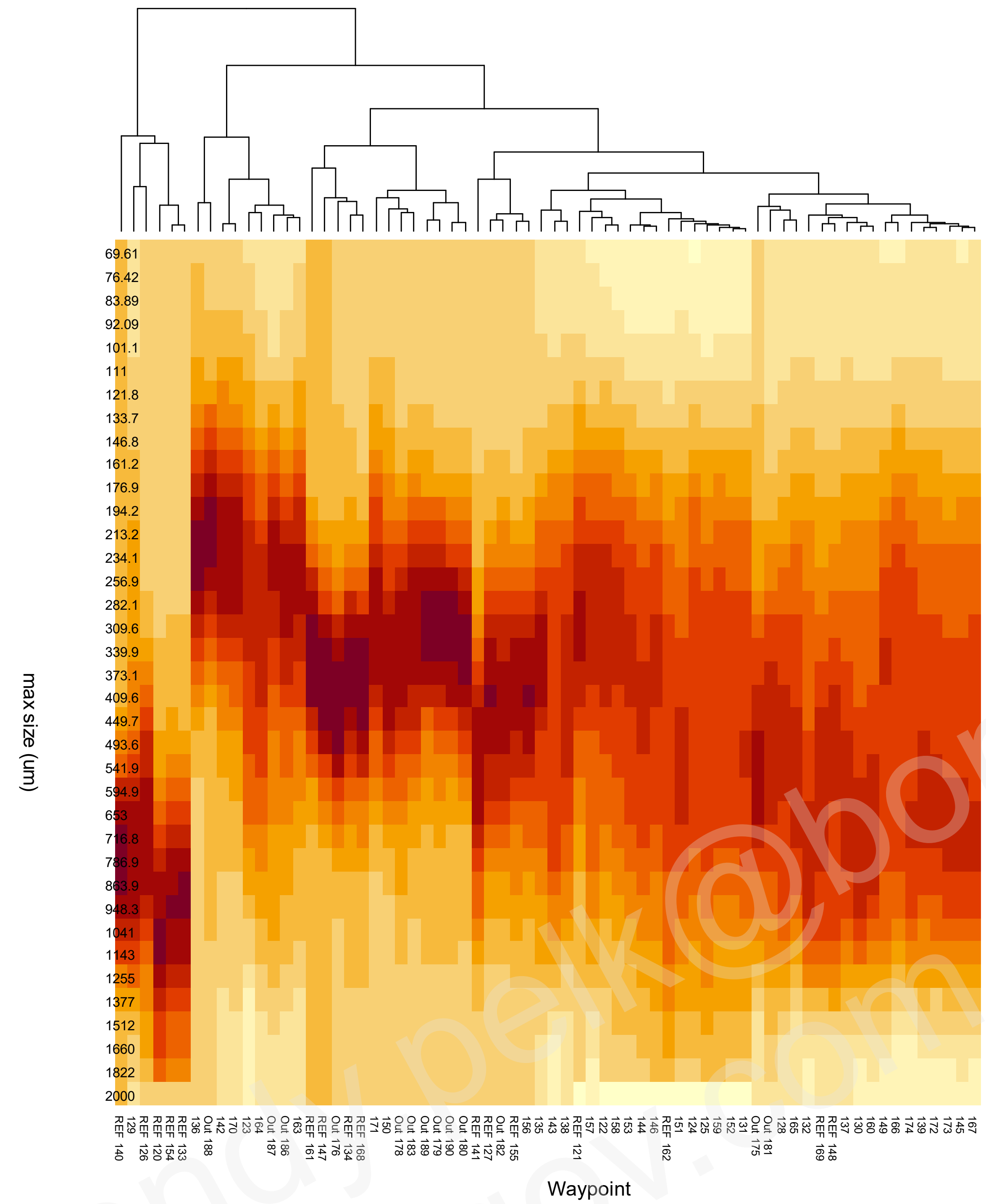

Figure 5. Heat map in which samples are grouped based on the grain size distribution of each sample. On the bottom, waypoint numbers are shown together with a label indicating whether the sample is considered a reference sample taken in front of Chogogo beach (REF), a sample from another beach (OUT), or taken at Chogogo beach (only a number). On the left side, the different size class border values are given, and the result of a grouping analysis is on top. The center image shows the percentage values within each size class, with darker colors indicating higher percentages.

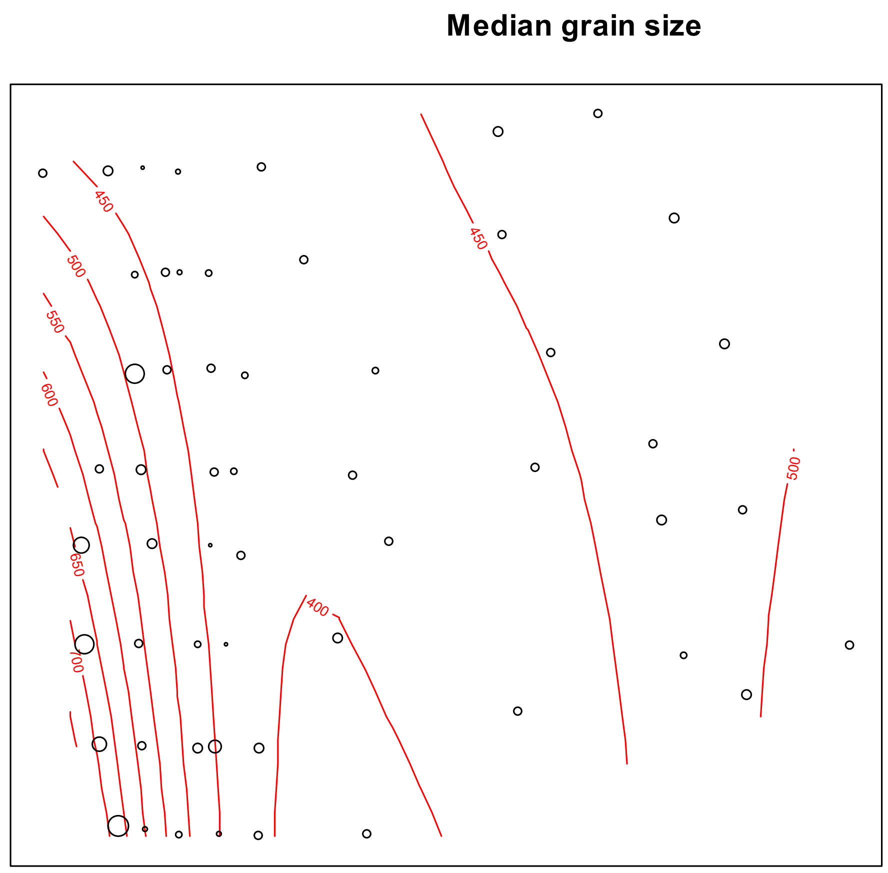

Figure 6. A map of the median grain size of each sample with contour lines indicating the estimated median size. Samples are shown at their relative location and the size of the symbol reflects the median size. Contour line labels give the estimated median size in μm.

4.3 Organic content

The organic matter content of samples in front of Chogogo beach is very different from the artificial sand. On average, the artificial sand includes hardly any organic matter (mean value is 0.3%, 95% confidence limits from 0.13-0.49), while the natural sand has 2.4% (1.9, 2.9). Because the organic matter of the artificial beach sand is so low, the probability of microbial pollution is quite low, and negative consequences for corals from microbial pollution in front of the beach are not expected. However, DNA analysis will give a more definite conclusion.

4.4 Observations

Along most of the walls of the artificial beach, the sand is close to the top of the wall and less than the required 20cm from the top. The sand appears to be transported towards the sea due to the prevailing wind direction (i.e. offshore to the west). Additionally, the wind is being funneled between the buildings of the Chogogo Beach and Dive Resort. In several places, the sand has already travelled over the wall and is mixed with the natural beach sand, which is much coarser. See, for some examples, Figures 7 and 8

Figure 7. Sand can be seen accumulating along the retention wall.

Figure 8. On the southern side of the Chogogo area, the artificial sand has mixed with the natural sand.


Figure 9. The sand in several places is already being transported over the edge of the wall.

5 Conclusions and recommendations

Below are the questions that were asked of Wageningen Marine Research:

1. What are the potential effects on marine life, specifically corals, in relation to the constructed beach?
2. What are the potential effects on the health of the corals under normal weather conditions?
3. What are the potential effects on the health of the corals during a storm or wind reversal?
4. How important is the origin of the sand, the kind of sand (river or carbonate sand), the quantity of sand, the layout of the beach, and the constructed wall for the effects?

For the sake of clarity, we start in reverse order.

Question 4. The origin of the sand is very important. Since the artificial beach sand does not consist of calcium carbonate, it will probably not be processed similarly to coral sand. It may be less likely to be cemented into the reef. When compared with natural sand in front of the artificial beach, the grain size distribution is much finer, indicating that the sand, once it travels over the retaining wall, is likely to be washed away from the shore by waves and currents. Once the sand washes away, all the negative effects of increased sediment load and sedimentation may occur. The exact location of the beach and the layout, as well as the buildings around the beach, influence the wind erosion of the beach. In this particular case, local wind conditions transport the sand toward the sea. Even if the retention wall is raised, the sand will continue to be piled up at the downwind side of the beach, eventually spilling over it, and will probably need to be manually redistributed regularly to not end up in the sea. We recommend periodical reinspection to assess that sand is not transported over the retention wall as well as periodic redistribution of the sand.

Question 3. During a wind reversal or a storm, there is a high chance that waves will reach the retention wall and wash over it. Consequently, large amounts of sand could suddenly be transported onto the reef and cause massive mortality of corals by burial. The fine sand is likely to be transported downstream (generally in a northerly direction) and cause decreased light levels, increased sedimentation, and possibly mortality of corals. The exact transport of the sand is very difficult to predict without extensive measurements of current patterns at the location. We recommend that the retention wall be raised to the prescribed height. It may also be anoption to put structures in place that can be deployed during wind reversals or storms to prevent sand from being washed away.

Question 2. Currently, the sand is already moving towards the sea, and it cannot be excluded that there are no negative effects. Potentially, submarine visibility is already lower, and sedimentation has increased. In addition to the recommendations under question 3, we recommend installing (natural) windbreaks to decrease the wind funneling effect between the resort's buildings.

Question 1. Sand is already being transported onto the adjacent reef. Corals may already be affected. If so, then stress on corals will likely be increased. This can be expected to affect their metabolism, influencing coral growth and health.
Furthermore, a higher sediment load will lead to a higher cover of the bottom by sand and prevent coral recruits from settling. In the longer term, corals more sensitive to sediment will disappear from the location which may be exchanged for more stress-tolerant corals. Generally, the latter species are less important for maintaining the reef. However, if the sediment load is high (permanently or occasionally), the sea floor may become fully covered by sand, and all corals may disappear. Thus, it is important to monitor artificial beaches for breaks in the retention walls, accumulated sand along the walls, and adjust when necessary. The exact impact that the artificial beach is currently having is difficult to assess without monitoring the coral community before and after the construction of the beach. Also, because corals are long living animals, this monitoring should be long-term, ideally including water movement, turbidity, sedimentation rates, and coral cover and diversity compared to a similar control location up-current without the runoff of artificial beach sand.

General remarks
Local wind, waves, and current conditions play a major role in the fate of artificial and natural beaches. Since all artificial beaches are on the island's leeward side, the prevailing wind normally blows the sand seaward. Local artificial beaches probably need to be replenished regularly, which is a clear sign that their sand is being blown into the sea and onto the coral reef. Increasing wall height and constructing wind blocks upwind from the beach may provide extra protection against the sand being blown away.
Very high waves can accompany wind reversals, which may lead to massive sand transport onto the reef, smothering and killing corals. Generally, all artificial beaches should be re-evaluated given the expected consequences of climate change, such as sea level rise and an increase in the frequency of tropical storms, as this may have strong negative consequences for the reef. Current requirements for artificial beaches may have to be reconsidered.

6 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

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Justification

Report C062/22
Project Number: 4315100198

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved:	Dr. Adolphe O. Debrot Senior researcher
Signature:	
Date:	18 October 2022

Approved:	Drs. J. Asjes Manager Integration
Signature:	
Date:	18 October 2022

Appendices

Appendix 1: Statistical analyses

Median grain size

```
Call:
lm(formula = log(Median) ~ where, data = Median)
Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                6.02942    0.04403 136.932  < 2e-16 ***
In_front_of_beach          0.27896    0.08164   3.417  0.00122 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1" 1

Residual standard error: 0.275 on 53 degrees of freedom
Multiple R-squared:  0.1805,    Adjusted R-squared:  0.1651
F-statistic: 11.68 on 1 and 53 DF,  p-value: 0.001223
```

Mean grain size

```
Call:
lm(formula = log(Mean) ~ where, data = Median)
Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)          6.22166    0.04209 147.811   <2e-16 ***
In_front_of_beach    0.19493    0.07804   2.498   0.0156 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1" 1

Residual standard error: 0.2629 on 53 degrees of freedom
Multiple R-squared:  0.1053,    Adjusted R-squared:  0.08844
F-statistic: 6.239 on 1 and 53 DF,  p-value: 0.01563
```

Grain size distribution

```
Permanova test
Permutation test for adonis under reduced model
Terms added sequentially (first to last)
Permutation: free
Number of permutations: 999

adonis2(formula = dist1 ~ Groups)
         Df SumOfSqs      R2     F Pr(>F)
Groups    2   1210.2 0.19377 7.811  0.001 ***
Residual 65   5035.3 0.80623
Total    67   6245.5 1.00000
---
Signif. codes:  0 □***□ 0.001 □**□ 0.01 □*□ 0.05 □.□ 0

Pairwise comparisons
combination                  SumsOfSqs MeanSqs   F.Model   R2        P.value   P.value.corrected
Chog        <->       Out        511.6     511.6     11.4      0.186     0.0009    0.0029
Chog        <->       Ref        535.6     535.6     6.9       0.116     0.00199   0.0029
Out         <->       Ref        904.1     904.1     6.4       0.193     0.00699   0.0069
```

Appendix 2. Legal text (in Dutch) regarding artifical beaches on Bonaire

Paragraph VIII and Annex II of Eilandsbesluit houdende algemene maatregelen van 25 augustus 2010.

- Paragraaf VIII BEPALINGEN OVER STRANDEN
- Artikel 34

Het is verboden zonder vergunning van het bestuurscollege in of grenzend aan het onderwaterpark een strand aan te leggen of aan te vullen of te doen ontstaan.

- Artikel 35

1.Een vergunning als bedoeld in artikel 34 wordt uitsluitend verleend nadat de eilandelijke commissie is gehoord en indien:

  - a. de aanleg, het aanvullen of doen ontstaan van het strand geschiedt in de kader van de bouw van verblijfsaccommodatie met meer dan 100 kamers op een locatie aan zee;
  - b. het strand te allen tijde vrij toegankelijk is;
  - c. er geen strand in de onmiddellijke omgeving is;
  - d. het strand aan minimaal drie zijden, niet zijnde de landzijde, wordt beschermd door een keermuur boven de hoogwaterlijn;
  - e. het zand voor de aanleg of het aanvullen van het strand van dezelfde kwaliteit is als het ter plaatse aanwezige zeezand.

2.Bij het aanleggen of aanvullen van stranden dienen de richtlijnen in Annex II van dit besluit in acht te worden genomen.

- Artikel 36

Voor het gebruik van een aangelegd of aangevuld strand wordt van de vergunninghouder een gebruiksvergoeding geheven als vermeld in Annex l van dit besluit.

Annex II als bedoeld in artikel 35, tweede lid, van het Eilandsbesluit onderwaterpark Bonaire
Richtlijnen aanleggen of aanvullen van stranden
Bij het aanleggen of aanvullen van stranden dienen de volgende richtlijnen in acht te worden genomen:
A. Strand

- **1.** het verloop van het bodemprofiel ter plekke dient minimaal de verhouding 1:20 te hebben;
- **2.** het strand dient aan minimaal drie zijden, niet zijnde de landzijde, te worden afgesloten met een keermuur boven de hoogwaterlijn volgens de onder B vermelde minimum specificaties;
- **3.** bij de aanleg en bij het eventueel aanvullen dient geïmporteerd zeezand van dezelfde kwaliteit als het ter plaatse aanwezige zand of koraalsteentjes te worden gebruikt.

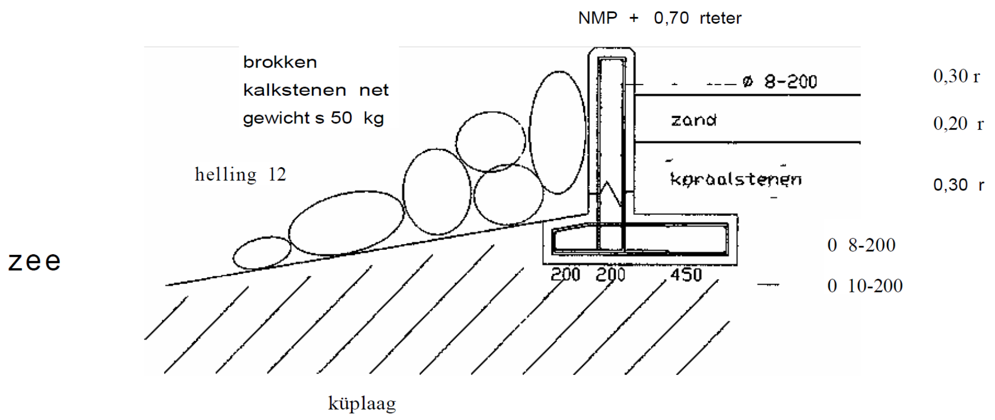
B. Keermuur

- **1.** de keermuur wordt geconstrueerd vóórdat zand wordt aangebracht op het beoogde strand;
- **2.** de keermuur wordt boven normaal midden peil geconstrueerd;
- **3.** de keermuur wordt vervaardigd van gewapend beton;
- **4.** de kruin van de keermuur dient minimaal een hoogte te hebben van normaal midden peil + 0,7 meter;
- **5.** de keermuur dient bestand te zijn tegen golfaanvallen van 1,5 meter;
- **6.** de keermuur dient minimaal 0,2 meter gefundeerd te zijn in de kliplaag;
- **7.** de keermuur dient aan de zeezijde een talud te hebben bestaande uit brokken kalksteen van minstens 50 kilogram zwaar; 8. constructie volgens in deze Annex opgenomen tekening.

C. Overige voorwaarden

- **1.** de bovenzijde van de zandlaag bevindt zich minimaal 0,2 meter onder de kruin van de keermuur;
- **2.** de dikte van de zandlaag is maximaal 0,2 meter;
- **3.** de opvulling onder de zandlaag bestaat uit koraalstenen of koraalvingers tot een hoogte van maximaal normaal midden peil + 0,3 meter.

Afbeelding keermuur


NMP + 0,70 rteter
brokken
kalkstenen net
gewicht s 50 kg
helling 12
zee
ø 8-200
zand
koraalstenen
0,30 r
0,20 r
0,30 r
0 8-200
200 200 450
0 10-200
küplaag

Appendix 3. Description of artificial beach sand

COOPERATIVE REPUBLIC of GUYANA
NATIONAL AGRICULTURAL RESEARCH AND EXTENSION INSTITUTE
National Plant Protection Organisation
PHYTOSANITARY CERTIFICATE

NO: 16950

TO: Plant Protection Organization of Bonaire , ABC Island

1. DESCRIPTION OF CONSIGNMENT

1. Name and Address of exporter: Armoroc Trading Block R Soesdyke Public Road East Bank Demerara Guyana	**2. Declared name and address of consignee:** Chogogo Bonaire OG Bulevar Gabernador Nicolaas Debrot 1 – 7 Bonaire, ABC Island
3. Number and description of package: Bulk	
4. Distinguishing mark (s): As Addressed	**5. Place of origin:** Guyana
6. Declared means of conveyance: MV "Dyna Bulk"	
7. Name of produce and quantity declared: White Silica Sand- Net wgt. 3000 MT	**8. Botanical name of plants** --

This is to certify that the plants, plant products or other regulated articles described herein have been inspected and/or tested according to appropriate procedures and are considered to be free from quarantine pests specified by the importing contracting party and to conform with the current Phytosanitary requirements of the importing contracting party, including those for regulated non quarantine pests.

II. ADDITIONAL DECLARATION

III. DISINFESTATION AND /OR DISINFECTION TREATMENT

9. Date: Nil	**10. Treatment:** Nil
11. Chemical: Nil	**12. Duration of Treatment:** Nil
13. Concentration: Nil	**14. Additional information:** Nil

IV. AUTHORIZATION

15. Date: 8th October,2021.	**16. Place of Issue:** Head Office
17. Stamp of Organization REPUBLIC OF GUYANA NATIONAL PLANT PROTECTION ORGANIZATION	**18. Name of Authorized Officer:** Andre Marks **19. Signature:** A. Marks

No financial liability with respect to this certificate shall be attached to the National Agricultural Research & Extension Institute, National Plant Protection Organization, or to any of its officers.

COOPERATIVE REPUBLIC of GUYANA

NATIONAL AGRICULTURAL RESEARCH AND EXTENSION INSTITUTE

National Plant Protection Organisation

PHYTOSANITARY CERTIFICATE

NO: 16953

TO: Plant Protection Organization of Bonaire , ABC Island

1. DESCRIPTION OF CONSIGNMENT

1. Name and Address of exporter: Armoroc Trading Block R Soesdyke Public Road East Bank Demerara Guyana	**2. Declared name and address of consignee:** Chogogo Bonaire OG Bulevar Gabernador Nicolaas Debrot 1 – 7 Bonaire, ABC Island
3. Number and description of package: Bulk	
4. Distinguishing mark (s): As Addressed	**5. Place of origin:** Guyana
6. Declared means of conveyance: MV "Dyna Bulk"	
7. Name of produce and quantity declared: White Silica Sand- Net wgt. 650 MT	**8. Botanical name of plants** --

This is to certify that the plants, plant products or other regulated articles described herein have been inspected and/or tested according to appropriate procedures and are considered to be free from quarantine pests specified by the importing contracting party and to conform with the current Phytosanitary requirements of the importing contracting party, including those for regulated non quarantine pests.

11. ADDITIONAL DECLARATION

111. DISINFESTATION AND /OR DISINFECTION TREATMENT

9. Date: Nil	**10. Treatment:** Nil
11. Chemical: Nil	**12. Duration of Treatment:** Nil
13. Concentration: Nil	**14. Additional information:** Nil

IV. AUTHORIZATION

15. Date: 8th October,2021.	**16. Place of Issue:** Head Office
17. Stamp of Organization REPUBLIC OF GUYANA ... PLANT PROTECTION ORGANISATION	**18. Name of Authorized Officer:** Andre Marks **19. Signature:** A. Marks

No financial liability with respect to this certificate shall be attached to the National Agricultural Research & Extension Institute, National Plant Protection Organization, or to any of its officers.

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With knowledge, independent scientific research and advice, **Wageningen Marine Research** substantially contributes to more sustainable and more careful management, use and protection of natural riches in marine, coastal and freshwater areas.

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