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# Quick Scan Marine Environment

Commandeursbaai, Savaneta Nature Reserve

Impacts of Aruba Ocean Villas development



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## Introduction

This Quick Scan Assessment Report of the Commandeursbaai, Savaneta Nature Reserve (GEBIED 12C/12.11) was executed as a follow-up to the previous Quick Scan Assessment provided by the Dutch Caribbean Nature Alliance (DCNA). In 2021, this area was surveyed at the request of the Aruba National Park Foundation (FPNA), to gauge the potential impacts of the Aruba Ocean Villas expansion project. Currently, the development of Aruba Ocean Villas is still in progress. The aim of this Assessment report is to demonstrate the effects that the development project has had on the mangrove and seagrass area and shallow lagoon directly adjacent to the development. This mangrove area and lagoon is a protected area (AB 2020 no. 67) and under the management of FPNA, see figure 1.

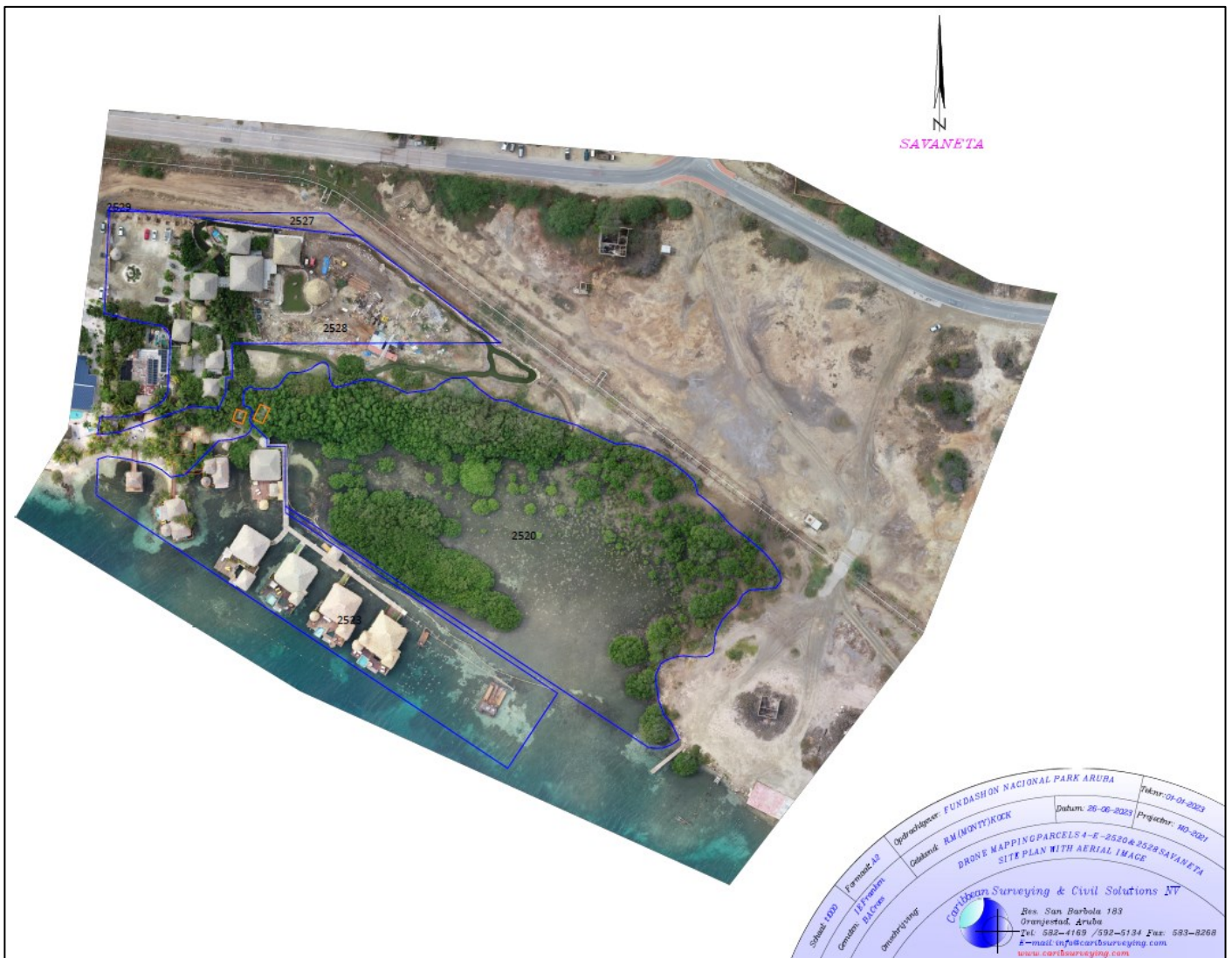


Figure 1. The protected area under management by FPNA (2520) and the adjacent Aruba Ocean Villas development (2523, 2527, 2528, 2529)

In 2020, numerous mangrove areas were placed under management of Fundacion Parke Nacional Aruba (FPNA) via “AB 2020 no. 67, LB 2020 no. 1” with the primary goal of conserving their ecological function and natural values. However, one of these areas, Commandeursbaai, Savaneta Nature Reserve (GEBIED 12C/12.11) is under significant pressure from nearby anthropogenic development and ensuing (operational) activities. The

building and expansion of Aruba Ocean Villas into the adjacent salina as well as the over-water bungalow park right next to the protected area, has raised concerns here. Although the footprint of the project expansion is not directly within the protected area, it is immediately adjacent to it. Hence not providing any buffer function against the negative impacts of both the project construction as well as the impacts which will invariably arise in this sensitive mangrove and seagrass habitat from the operational use of the water bungalows and salina expansion.

## Importance

Commandeursbaai provides several ecosystem services. The functions that this biodiversity hotspot serves include; nursery areas for reef and fisheries target species, habitat provision for resident and migratory birds and crustaceans, seasonal wetland, carbon sequestration, water filtration, erosion mitigation, coastal shelter and protection and more.

### Mangroves

Mangrove ecosystems support important commercial and subsistence fisheries. Many commercially valuable fish species, including snappers, groupers and shrimp rely on mangroves as nursery habitats during their juvenile stages (Hutchison et al., 2014). Besides harboring economically important species, it also provides breeding grounds and shelter for numerous other species of invertebrates, fish, birds, and mammals. They are highly efficient at sequestering carbon dioxide from the atmosphere. The organic matter that accumulates in mangrove soils stores significant amounts of carbon, making mangrove forests one of the most carbon-rich ecosystems on the planet. Recent research has valued mangroves forests at more than \$900,000 per square kilometer per year (United Nations Environment Program). They serve as storm buffers, filters of run-off, supply fisheries, support birdlife, and provide aesthetic enjoyment.

Table 1. A summary of the characteristics of the different vegetation zones within a mangrove forest.

A	Terrestrial vegetation	Vegetation that grows on land and is intolerant of salty soil or water, such as Macubari ( <i>Gaupira pacurero</i> ), Watapana ( <i>Caesalpinia coriaria</i> ) and Wayaca ( <i>Lignum Vitae</i> )
B	White Mangrove zone	The White Mangrove, <i>Laguncularia racemosa</i> , usually occupies the highest elevations farther upland than either the red or black mangroves. Unlike its red or black counterparts, the white mangrove has no visible aerial root systems. The easiest way to identify the White Mangrove is by the leaves. They are elliptical, light yellow-green and have two distinguishing glands at the base of the leaf blade where the stem starts
C	Black Mangrove zone	The Black Mangrove, <i>Avicennia germinans</i> , usually occupies slightly higher elevations upland from the red mangrove in tidal areas that are inundated during high

		tides. The Black Mangrove can be identified by numerous finger-like projections, called pneumatophores, which protrude from the soil around the tree's trunk.
D	Red Mangrove zone	The Red Mangrove, <i>Rhizophora mangle</i> , is probably the most well-known. It typically grows along the water's edge, especially along Aruba's southern coast. The Red Mangrove is easily identified by its tangled, reddish roots called 'prop roots'. The roots are usually exposed at low tide but covered at high tide.

### Seagrass

Seagrass ecosystems are considered to be amongst the most productive in the world. An average growth rate of seagrass leaves is about 5mm per day, with entire stands of seagrass being turned over every 16 weeks with 3-4 crops annually. In addition to this, the blades of seagrasses provide a huge surface area for settlement of epiphytes (plants that live on the surface of another organism such as calcareous green algae, crustose coralline red algae, cyanobacteria, diatoms) and epifauna (animals that live on the surface of another organism such as sponges, hydroids, bryozoans, foraminifera's). For a square meter of seabed, a dense seagrass stand may have 20m<sup>2</sup> of leaf area for other organisms to settle on. The productivity of the epiphytes can be twice that of the seagrasses themselves. Through a succession of growth seagrasses turn vast areas of unconsolidated sediments into highly productive plant dominated, structured habitat with a diversity of microhabitats.

### Corals

Coral reefs are among the most diverse ecosystems on the planet, giving shelter to many currently endangered species. These reef systems are essential for sustaining fisheries and providing food security. Many commercially valuable fish species rely on coral reefs for breeding, feeding and shelter. These ecosystems have a profound ecological, economic and cultural importance. Their preservation is critical for maintaining marine biodiversity.

### Interconnection

Commandeursbaai is not just an ecosystem on its own. Coral reefs, seagrass meadows and mangroves are interconnected in coastal ecosystems, forming what is known as the 'blue carbon ecosystem' (Henderson et al., 2017) and are considered the power of three (Guannel et al. 2016). They play vital roles in maintaining ecological balance and provide numerous ecosystem services (Dunne et al., 2023). All three habitats provide essential habitat and nursery grounds for a wide variety of marine life (Swadling et al., 2024). Many marine species need all three different habitats at least once in their life stages (Grober-Dunsmore et al., 2006). Disrupting one of the ecosystems could therefore mean that a species which spends its lifetime predominantly in other habitats may still not survive or reproduce due to the loss of necessary habitat for one life stage (Du et al., 2020).

Seagrasses and mangroves play a significant role in nutrient cycling and water filtration (Unsworth et al., 2018). They help to trap sediment and absorb excess nutrients to a certain

extent. Therefore, they help improve water quality and clarity. Coral reefs benefit from clean water as high nutrient levels can lead to algal overgrowth, which can smother corals.

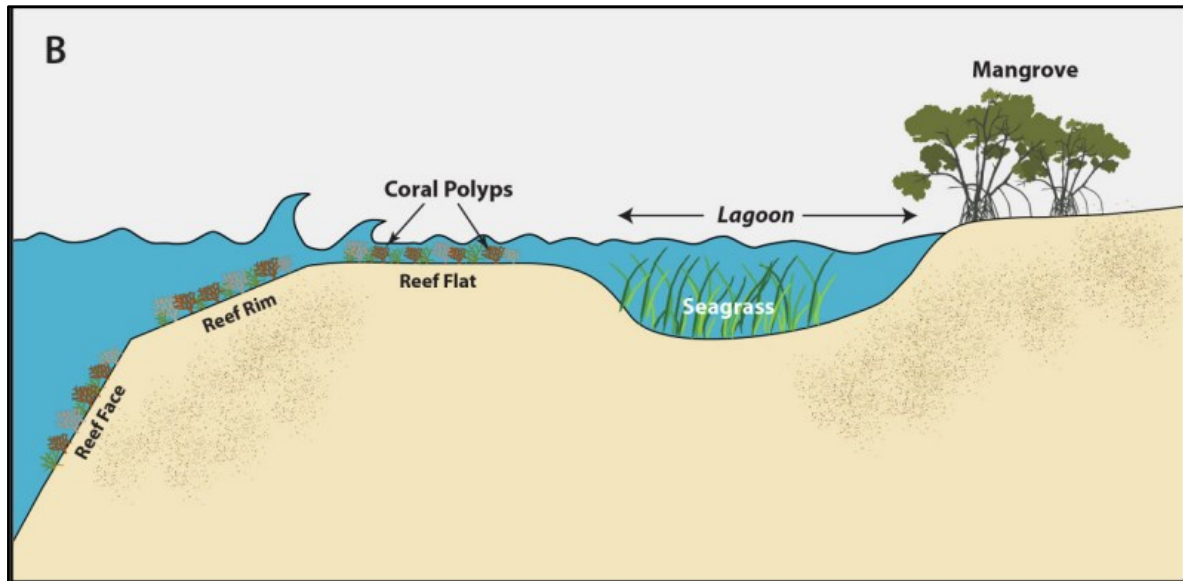


Figure 2. Usual distribution of mangrove, seagrass and coral habitats, and their interconnection (Guannel et al., 2016).

The interconnectedness of these habitats means that disturbances affecting one can have cascading effects on the others (Guannel et al., 2016). Excessive nutrient runoff can disrupt an ecosystem's balance significantly (Quigg et al., 2023). Increased nutrient levels that cannot be handled by the seagrass meadows and mangroves can lead to algal blooms, which block sunlight that is essential for their growth. This process, known as eutrophication, will result in an exponential effect which ultimately impacts an entire coastal ecosystem. Furthermore, destruction of mangroves or seagrass beds can deprive coral reefs of essential nursery areas and disrupt the food chain. Cascading effects will then also be observable in other ecosystems.

## Methods

This Quick Scan was conducted during daylight hours, through surveys using visual assessments, including photo analysis along 3 30-meter transect lines perpendicular to the shore - above seagrass meadows and adjacent to mangrove areas. Various measurements were taken along these transects, including position and visual estimations of seagrass cover and composition, as well as density and productivity of mangroves. Benthic species composition was recorded by taking images every other meter, yielding 15 data points per transect line. The positioning of the transect lines is shown in figure 3. Supplementary work was carried out, including camera surveys to determine the total species composition of the area and water quality testing.

The area was not surveyed for soil, light, air, and sound pollution during this Quick Scan.



*Figure 3. The placement of the three 30-meter transect lines in the surveyed area. The transect line at the sea-ward side, furthest away from the villas is referred to as number 1. The transect line in the middle, above the seagrass meadow is number 2. The transect line closest to the villas, in the sewage-outlet area of the Aruba Ocean Villas is referred to as number 3.*

Furthermore, tests for water quality and nutrient levels were conducted. Three water samples were taken, each at the center of a transect lines. These tested parameters comprised: dissolved oxygen (DO), acidity of the water (pH), the salinity, alkalinity, the amount of phosphate (PO<sub>4</sub>), Nitrite (NO<sub>2</sub>), Nitrate (NO<sub>3</sub>), ammonia (NH<sub>3</sub>) and ammonium (NH<sub>4</sub>).

## Results

### Development

Below, an overview of the development of Aruba Ocean Villas and the accompanying change in the surveyed area is shown over the course of approximately 2 years (Figures 4-7).



*Figure 4. The area under management by FPNA and the adjacent Aruba Ocean Villas development, Google Earth image of February 2021 (12.26'37"N 69.56'31"W).*



*Figure 5. The area under management by FPNA and the adjacent Aruba Ocean Villas development, Google Earth image of May 2021 (12.26'37"N 69.56'31"W).*





*Figure 6. The area under management by FPNA and the adjacent Aruba Ocean Villas development, Google Earth image of January 2022 (12.26'37"N 69.56'31"W).*



*Figure 7. The area under management by FPNA and the adjacent Aruba Ocean Villas development, Google Earth image of April 2023 (12.26'37"N 69.56'31"W).*

As viewed from above, the development in the area can clearly be observed. Not only are villas built around the protected area, but the area itself has also been altered. Near the original water bungalow), sand has been deposited in May 2021. As a consequence, the seawater flow-through is altered. The latest open-source aerial footage is from April 2023. Development has been ongoing up to this moment. This imagery shows an unfinished part

of a jetty. This indicates that development has not been finished yet. Also, from the moment some villas were finished, and people could start using it, brighter green parts can be seen in the open water of the area closest to the new villas (location of transect line 3), these are filamentous algae that have been growing since then. High amounts of filamentous algae are indicators of eutrophication. Eutrophication is a process wherein a body of water becomes overly enriched with nutrients, particularly nitrogen and phosphorus. This excessive nutrient presence often originates from human activities such as sewage discharge, agricultural runoff, and the use of fertilizers (Crowe, 2015; Probert, 2017). In this case sewage influx is the most likely cause. The abundance of nutrients stimulates the rapid growth of algae and other aquatic plants, leading to a phenomenon known as an algal bloom. As these plants die and decompose, oxygen in the water is consumed, resulting in a depletion of oxygen levels, a condition known as hypoxia or anoxia. This oxygen depletion can lead to the death of aquatic organisms, causing a decline in biodiversity and sometimes resulting in "dead zones" where marine life cannot survive (Crowe, 2015; Probert, 2017).

Overall, eutrophication disrupts the balance of aquatic ecosystems, degrading water quality, harming aquatic life, and impacting human activities such as fishing, recreation, and drinking water supply. It is considered a significant environmental issue worldwide (Crowe, 2015; Probert, 2017).

## Mangroves

The mangrove forest in the surveyed area was composed of three different species: White mangrove (*Laguncularia racemosa*), Black mangrove (*Avicennia germinans*) and Red mangrove (*Rhizophora mangle*), all of which are protected under the local legislation (AB 1995 no 2, Art. 4 & AB 2017 no 48). The zonation of these species is shown in figure 8.



Figure 8. The composition of mangrove species in the surveyed area. Red mangroves (red) were dominant and inhabited the shoreline. The outer layer, further from the shoreline, was inhabited by Black mangroves (black), and some White mangrove (white) trees were found, furthest from the shoreline.

Many Red mangrove shoots and young Red mangrove trees were found in the central offshore area, which was previously mostly dominated by seagrass. This finding suggests a change in the environmental conditions, favoring the growth of mangroves, which is confirmed later in the report. However, the growth of these mangroves will be inhibited over time, due to the lack of space for expansion. Black and white mangroves were less frequent due to their expansion area being very limited.

### Species composition

During this assessment, only 18 species were observed in comparison with the 2021 observations of 26 species by DCNA. There were especially less species of arthropoda, chordata, porifera, enchinodermata and cnidaria. See the complete overview of observed species during the survey in table 2.

Table 2. Species composition of the surveyed area

Common name	Scientific name	Art. 4 (AB 1995 no. 2)	SPAW annex	IUCN status
<b>Fish</b>				
Bicolor damselfish	<i>Stegastes partitus</i>			LC
Schoolmaster	<i>Lutjanus apodus</i>			LC
Silversides	<i>Atherinidae spp.</i>			LC
French grunt	<i>Haemulon flavolineatum</i>			LC
Great barracuda	<i>Sphyraena barracuda</i>			LC
Striped parrotfish	<i>Scarus iserti</i>	2b		LC
<b>Invertebrates</b>				
Upside-down jellyfish	<i>Cassiopea xamachana</i>	1b		
Mangrove tunicate	<i>Ecteinascidia turbinata</i>			
<b>Mangroves</b>				
Red mangrove	<i>Rhizophora mangle</i>	2a	III	LC
White mangrove	<i>Laguncularia racemosa</i>	2a	III	LC
Black mangrove	<i>Avicennia germinans</i>	2a	III	LC
<b>Macro algae</b>				
Saucer blade alga	<i>Avtainvillea asarifolia</i>			
Bristle ball brush	<i>Penicillus dumetosus</i>			
Flat green feather alga	<i>Caulerpa mexicana</i>			
Green net algae	<i>Microdictyon boergesenii</i>			
Leafy flat-blade alga	<i>Styopodium zonale</i>			
<b>Seagrass</b>				
Turtle grass	<i>Thalassia testudinum</i>	2a	III	LC
Broadleaf seagrass	<i>Halophila stipulacea</i>			LC

## Seagrass

Seagrass cover has reduced compared to 2021. The 90% cover seagrass that DCNA found back then, has reduced to 66.3%. This excludes the extremely low 17.3% nearest to the sewage influx, as DCNA had also indicated a lower value in this area. Whereas back then seagrass was fairly distributed at all places, now more open patches were found along transect 1 and 2. This became worse along transect 3, which is closest to the Aruba Ocean Villas. Here, a large part of the seagrass was outcompeted by macro algae due to eutrophication.

During the survey, some mats of the invasive seagrass *Halophila stipulacea* were discovered. This invasive seagrass becomes dominant in areas where native seagrass mats have become eroded due to various activities, including dredging and driving of stabilizing piles. Having an area dominated by *H. stipulacea* will result in a less functional ecosystem, resulting from a significantly less caloric value of the invasive grass than that of the native Turtle Grass (*Thalassia testudinum*) monitored in the survey area more away from the structures in question. If *H. stipulacea* expands into existing seagrass beds, it may result in the loss of biodiversity. In biologically depleted zones such as the area impacted by the development, the rapid colonization of recently disturbed habitats by *H. stipulacea* could interfere with natural seagrass succession. Likewise, if *H. stipulacea* displaces native seagrasses in any coastal area around the island, a loss of seagrass biodiversity may occur. The displacement of a native species may not only compromise that species (for examples, see Race, 1982; Fogarty and Facelli, 1999), but may also have a cascading effect on any organisms supported by that species (for examples, see Spencer et al., 1991; Levin et al., 2006; Khan et al., 2003; Byrnes et al., 2007; Daskalov et al., 2007), such as sea turtles that rely on Turtle grass (*T. testudinum*) with a higher nutritional content. *H. stipulacea* patches often occurred exclusive of the otherwise dominant seagrasses of the Caribbean (Willette, Ambrose 2009). The potential for the expansion of *H. stipulacea*, combined with its tolerance for a wide spectrum of environmental conditions, positions it as a serious potential threat to local and regional biodiversity.

Table 3. Average percentages of sea floor cover. The percentages of the two seagrass species are part of the total seagrass cover.

Transect	Av % total seagrass cover	Av % <i>Thalassia testudinum</i> cover	Av % <i>Halophila stipulacea</i> cover (invasive)	Av % Macro algae cover	Av % sand cover
T1	71.3	78.0	22.0	0.0	28.7
T2	61.3	93.3	6.7	0.0	38.7
T3	17.3	53.3	0.0	48.7	27.3

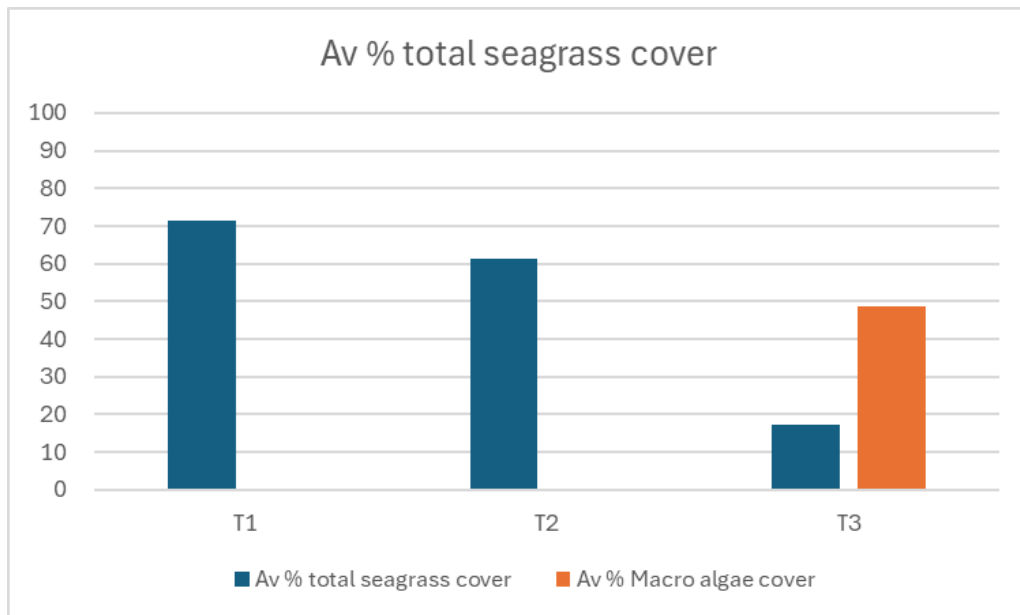


Figure 9. Total (average) seagrass- and macro algae cover. Seagrass decreases closer to development site whereas macro algae increase.

## Macro algae

Due to the increased nutrient availability, caused by the wastewater disposal of the Aruba Ocean Villas, macro algae have increased significantly in this protected nature area. These green net algae are thriving, especially around the area where the establishment releases its sewage water, see figure 10. These algae cover most of the water surface, shielding the area underneath from sunlight. This deprives the seagrass of necessary sunlight, limiting their potential to grow or even survive. This causes a regime shift, toward a eutrophic, nutrient rich and algae dominated state (Levin et al., 2001). This has negative implications for the seagrass, but also for the fauna species benefiting from seagrass meadows (Zaldívar et al., 2009). Furthermore, this influx of nutrients unnaturally favors the growth of mangroves, further outcompeting the seagrass.



*Figure 10. A top view above transect line 1, closest to the sewage water outlet of the Aruba Ocean Villas.*

## Water quality

The water quality samples yielded the averages seen in Table 4.

Table 4. Average values of the water quality parameters tested on the 3 transect lines at the nature area adjacent to Aruba Ocean Villas.

DO (mg/L) (Dissolved oxygen)	pH	Salinity (ppt)	Alkalinity (mg/L)	PO4 (mg/L) (phosphate)	NO2 (ug/L) (Nitrite)	NO3 (mg/L) (nitrate)	NH3 (mg/l) (ammonia)	NH4 (mg/l) (ammonium)
7.72	8.36	41.50	152.67	0.09	4.00	4.10	5.23	5.68

DO, pH, salinity and alkalinity showed normal values for marine coastal systems. Phosphate was not detected as well as nitrite. Especially the latter is an important indicator as this chemical, an intermediate product of the nitrogen cycle, is very toxic to aquatic life. Organic waste, such as sewage, is rich in nitrogen, usually in the form of ammonia (NH<sub>3</sub>). This substance is transformed by bacteria to nitrite (NO<sub>2</sub>), which quickly needs to be transformed by other bacteria to nitrate (NO<sub>3</sub>). The nitrate can be used again by plants and algae for growth and thus is taken up from the water column again. An overload of waste can disrupt this process, resulting in bacteria not being able to transform all the intermediate products quickly enough causing a build-up of nitrite (NO<sub>2</sub>) or a surplus of nitrate (NO<sub>3</sub>) in quantities which cannot be taken up anymore by the plants/algae present. Although less toxic than nitrite (NO<sub>2</sub>), nitrate (NO<sub>3</sub>) is also harmful to aquatic life. As a result, the Ministry of Environment of British Columbia (CAN) defines a safe level for nitrate (NO<sub>3</sub>-N), as the 30-d average concentration of 3.7 mg/L to protect marine aquatic life (Nordin et al., 2009). For Ammonia (NH<sub>3</sub>) 30-d average safe levels range between 0.5 and 1.8 mg NH<sub>3</sub>-N/L (at a salinity of 30 ppt, temperature of 25 degrees Celsius and pH values of 7.6 to 8.2; Nordin et al., 2009). Although the current measurement represents a snap-shot in time and not a 30-d measurement campaign, the observed levels of both nitrate (NO<sub>3</sub>-N) and ammonia (NH<sub>3</sub>-N) exceed these safe levels and therefore give reasons for serious environmental concern to have detrimental consequences for both flora and fauna (Franklin et al., 2019). These values suggest direct disposal of raw sewage water into the ocean, leading to eutrophication and making the area unfit for most marine species.

## Conclusion and Recommendations

Aruba Ocean Villas has kept on expanding and with that altered the environment around it in such a way that changes can be significantly observed in the time span of approximately three years, both from above as well as on location. Not only were villas built, but ocean floor was altered in the process and wastewater is clearly being dumped into the ecosystem, significantly influencing many ecological factors. Species composition has been altered, and the overall health of the seagrass bed has decreased, and algae growth has accelerated. Furthermore, the species list consists of significantly less species compared to 2021. The extremely high ammonia values suggest serious eutrophication of the area, causing even further harm to the ecosystem and eliciting a regime shift.



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