Environmental impacts associated with the planned expansion of Karel's Beach Bar, Bonaire

October 2011

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1.0 CONTEXT

Coral reefs are one of the most biologically diverse ecosystems in the world – they occupy less than 1% of the ocean floor, but are inhabited by at least 25% of all marine species. Thirty-two of the 33 animal phyla are found on coral reefs, compared with nine in tropical rain forests. The island of Bonaire is completely surrounded by coral reefs that extend between the low water mark to a maximum recorded depth of 132m. There is an overwhelming concern that coral reefs are in worldwide decline through the activity of man. Coral bleaching, coral diseases, global change, environmental degradation and over-fishing are listed as the prime factors. Much of the acute anthropogenic influence is at present limited to shallow water reefs. The effects of shoreline development, physical destruction of corals, land-based changes such as increase in runoff and pollution, artisanal fisheries and even global change such as ocean warming are at present largely limited to the most superficial layers of the ocean (Bak et al. 2005).

Bonaire is no exception to this worldwide pattern of reef deterioration **(Figure 1)** and coral cover has decreased in shallow water (<20m) from ~44% to ~18% between 1973 and 2003. These trends have been confirmed by other studies (e.g. Steneck and Arnold 2009, Bal et al. 2005, Grimsditch et al. 2011) clearly

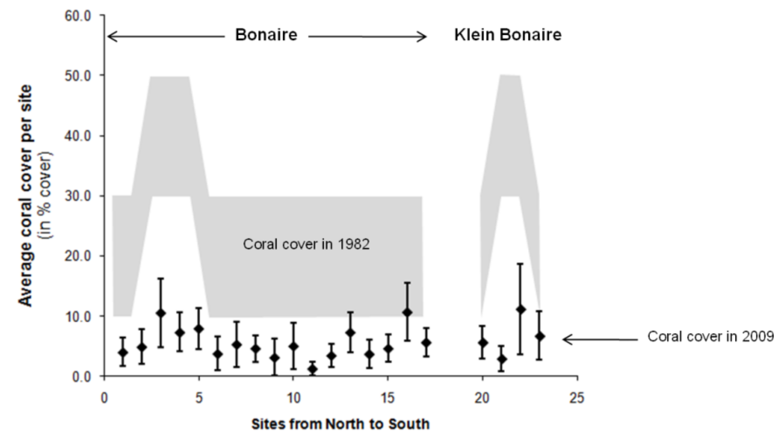

Figure 1. Change in coral cover from 1982 (estimated range calculated from Van Duyl 1985) to 2009 (values are average cover as calculated by an IUCN expedition to Bonaire in 2009; error bars are 95% confidence intervals). In total 17 sites were monitored from North to South on Bonaire (sites 1 to 17) and 4 on Klein Bonaire (20 to 23). All measurements were taken between 8 and 10m.

indicating that the current degree of development and resource extraction on Bonaire is presently too high to allow coral reef systems to persist. Because coral reefs form a base for tourism and local fishing activities, people have recently began to estimate their monetary value. Reefs also contribute to coastal protection and generate the sand that forms tropical beaches. Caribbean countries, which attract millions of visitors annually to their beaches and reefs, derive half of their gross national product (GNP) from the tourism industry, valued at US$8.9 billion in 1990 (Jameson et al. 1995). Because reefs provide so many benefits, their degradation is costly.

A recent study found that the costs of destroying just 1 kilometer of reef range from about US$137,000 to almost US$1.2 million over a 25-year period, just counting the economic value of fisheries, tourism, and shoreline protection (Barber and Pratt 1997). These estimated are now believed to be a gross underestimation of the true value that reefs represent.

At the national and local levels, a number of governments and communities have taken steps to protect and restore coral reefs. In general, these examples of good stewardship involve a combination of planning, management, law enforcement, environmental education, and legal protection. Approaches range from building sewage and industrial waste treatment facilities, to regulating access and use of reefs (for example, by establishing community ownership over reef fisheries), to restricting development in sensitive coastal areas (Bryant et al. 1998). Bonaire has also undertaken such actions to relieve its reef systems from some of the stressors that have recently caused these systems to degrade at an increasingly faster rate. Examples include the implementation of a zoning plan, the formation of no-fishing zones and the construction of a sewage treatment plant.

2.0 PURPOSE

This document overviews the expected impacts on the marine environment of the proposed construction of a pier and a bar/(temporary) restaurant/dive school next to Karel's Beach Bar as visualized on blueprints provided by Ir. K. Visser to Carmabi on October 18th 2011. The future usages of the pier were explained in subsequent communications with Ir. K. Visser and DROB (Bonaire). This report builds on an earlier report (*Possible environmental effects of the construction of a pier and its future usages near Karel's Bar, Bonaire*; Carmabi 2011) that only focused on the expected environmental impacts of the placement of 36 steel pilings that will support part of the proposed pier facilities. Here, additional information is provided on the effects on the marine environment that can be expected (1) during the pier's construction, (2) once it is present and (3) from the activities that are planned on the pier once it has been built.

This document only provides an overview of potential environmental concerns and should be used within a wider context that takes into account local laws regarding building guidelines and actions allowed in the Bonaire National Marine Park in addition to laws that have recently have come into effect after Bonaire became part of the Netherlands such as The Marine Law BES (art. 20 and 21) that are enforced by the Dutch Ministry "Verkeer en Waterstaat" and overseen by Rijkswaterstaat (Netherlands).

This document is based on the latest published scientific information and as such does not necessarily represent the opinion of its writer.

2.0 PROJECT DESCRIPTION AND DESCRIPTION OF THE PROPOSED ACTION

Karel's Beach Bar intends to expand its existing waterfront facilities located in the centre of Kralendijk, Bonaire. The current pier on which two bars are present will be expanded by a second pier that attaches the end of the existing pier to shore. The proposed pier will be made of wood that will rest on a concrete frame that itself will rest on 36[1] steel pilings (Ø 76 cm, 2 cm thick and 6 m tall[2]; specifications provided by Cashman Enterprises) that were placed on the shallow reef terrace in October 2011. On the shore side, this

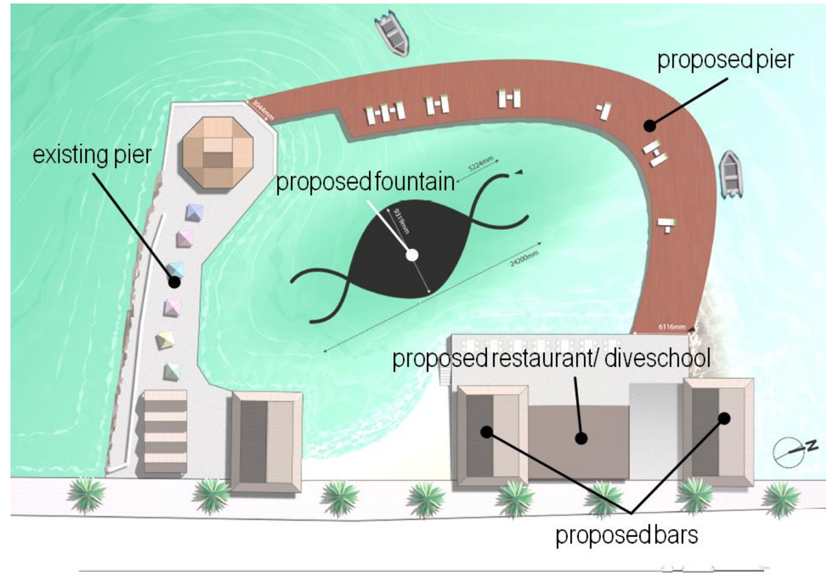

Figure 2. Proposed design for the new facilities near Karel's Bar in Kralendijk, Bonaire.

pier connects to a deck on which several buildings are planned: 2 bars, a (temporary) restaurant and a dive school. This deck measures approximately 30.8 m along shore and extends approximately 14.6 m seaward. It will be constructed from part wood, part concrete and rest on 6 of the aforementioned 36 pilings and a construction of prefab concrete blocks that will be placed closer to shore on a shallow limestone cliff. Based on the blueprints provided, the entire construction aims to provide facilities to approx. 100 persons based on the number of chairs shown. Based

[1] It needs to be noted that permission was granted (WSH/2011/1553) for 36 pilings. On the drawings provided from Cashman Enterprises only 34 pilings are indicated.

[2] It needs to be noted the pilings that have been placed in October are smaller than the ones referred to in the permit. Both their diameter and thickness are less than specifications provided earlier though exact measurements were not carried out during the site visit.

on communications with Ir. K. Visser and DROB Bonaire (Mr. M. Gravenhorst), the pier will become part of a larger project, i.e., a hotel complex that will be built on the grounds on which (among others) hotel/ restaurant Zeezicht is currently present. Once the former establishment is removed to start building the new hotel, its restaurant will be temporarily moved to the proposed pier until the construction of the hotel is completed (expected 2.5 yrs after the start of construction). After the restaurant has been moved back to the new hotel, the building on the pier will be used as a dive school. It is assumed that the two bars remain at their planned location after this period. In addition to aforementioned functions, the pier will serve as a marina for larger yachts that will be connected backward at the far end of the pier. A fountain will be built inside the piers, i.e., the existing pier of Karel's Bar and the proposed pier. A natural beach is expected to from directly south of the concrete foundation on which the bars/ restaurant/ dive school are planned. A general overview of the proposed facilities is shown in **Figure 2**.

2.1 Project Setting

The construction activities are proposed directly west of the existing facilities of Karel's Bar in the center of Kralendijk. The coast is heavily developed, primarily by tourism-related infrastructure. The pier is planned at a location where the reef bottom mainly consists of sand or sandy rubble fields extending out to the reef drop-off at approximately 8-10 m depth, where the reef slopes down to greater depths. Excess sedimentation in the past from construction activities, continuous terrestrial run-off (e.g., subterranean sewage fluxes, storm water, etc.), (accidental) dumping of (wind-blown) debris and trash, anchoring, as well as several storms (e.g., tropical storm Omar, Hurricane Lenny) are likely responsible for the fact that the area directly (i.e., < 30 m) around the proposed pier is largely devoid of marine life (but see: "3.0 Observations").

2.2 Summary of Project Need

Ir. K. Visser aims to build the project described in "2.0 Project description and description of the proposed action" to create new infrastructure to accommodate Bonaire's growing tourism industry.

2.3 Similar Projects

There are not many examples of projects that have used similar methodologies. The proposed construction method where a pier is set on metal pilings is the preferred construction method for pier construction as outlined in the "Construction Guidelines" that have been produced by STINAPA and the Bonaire National Marine Park in conjunction with Department of Physical Planning (DROB), SELIBON NV, Fundashon Tene Boneiru Limpi, L.V.V, Amigu di tera, construction companies, land owners and developers. These guidelines were subsequently endorsed by the Government of

Bonaire in 1993. Several piers constructed in a similar way are found around the island and seem, when built properly, the least damaging to the marine environment. Local regulations further stipulate that private pier dimensions cannot exceed 10 x 2 m or extend seaward more than 15 % of the distance to the drop-off.

On Curacao, Bonaire's sister island, several piers have been built in the past to support similar functions as the pier proposed by Ir. K. Visser, which is to some extend also similar to the existing pier of Karel's Bar. Surveys around such piers have resulted in the following findings and observations: (1) during severe storms such as Lenny (1999) or Omar (2008) piers that extend from shore always get damaged to some degree and sometimes even destroyed completely (Figure). (2) When a bar is located on or directly next to the pier (e.g., Karel's Bar, the Octopus Bar, Waterfront Arches, Pirate Bay, Komoko, Seaside Terrace) trash ends up in the water as a result of recreational activities on the pier. Some of this debris is worse than others depending on the fact whether the debris/ trash sinks (e.g., glass bottles) or is carried away by passing currents (e.g., plastic cups, scraps, storm induced debris, cleaning products). The fact that piers extend the land into the ocean will always cause a local increase in debris entering the water. The functions on the pier as well as the number of people generally present on the pier will ultimately determine how much and what kind of debris and trash enters the water.

2.4 Project Concerns

Main concerns regarding the pier construction and use concern the potential damage to marine life, archaeological sites or artifacts and its potential danger to maritime operations in the area.

3.0 OBSERVATIONS

The pier and its surroundings were surveyed (October 24, 2011) in order to determine whether its construction so far (i.e., the placement of 36 pilings), future construction to finish the pier and other facilities and the use of the pier (as described in 2.0) have or will result in any damage to the marine environment at this location.

The 36 pilings are constructed on a sandy underground and as such did not seem to have caused any damage on reef communities that might have been present at this site. Corals were not observed near (<4 m) the pier. Around the existing pier of Karel's bar a large amount of debris is present that ranges from parts of the pier that were scattered across the reef flat by earlier storms, chairs, a large amount of glass bottles floating cups and other debris, remnants of

Figure 3. A small colony of the coral Acropora palmata growing on a shallow ledge near the proposed construction location. While large colonies are not very abundant, many juvenile colonies were observed growing on the same ledge.

Figure 4. While not very charismatic in appearance, the sea urchin Diadema antillarum is considered crucial for the well-being of Caribbean reef systems. The ledge mentioned in the text harbors a large number of these animals.

cleaned fish and concrete pilings that probably supported an earlier pier at the same location that was also destroyed by past storms. Two areas that will be impacted by the proposed construction harbor marine communities that still have ecologically meaningful functions/ values: (1) the nearby reef, deeper than 10m and (2) the ledge directly bordering the shore. On the reef corals (mainly *Montastraea annularis*, *Agaricia* spp., *Madracis mirabilis*, *Eusmilia fastigiata*) occur in unexpectedly large numbers for a location facing observed levels of terrestrial run-off and pollution. Sponges are widely abundant and macroalgae are largely absent. Especially the latter observation is noteworthy as the absence of algae theoretically allows for the recovery of corals (e.g., Vermeij and Sandin 2008, Ritson-Williams et al. 2009, Vermeij et al. 2010) that once were abundant on this location (Van Duyl 1985). In other words the fact that much of the affected area currently lacks significant coral development does not preclude that such areas could recover, a phenomenon that has occurred for example near heavily developed shorelines on Curacao (Vermeij, pers. obs.). The possibility for coral recovery that exists at the location should therefore be considered during future decision making processes.

The second area that is of ecological importance is the ledge[3] directly bordering the waterline. This area, though small, comprises the following ecological values: (1) it provides suitable substrate for the endangered coral *Acropora palmata* (Elkhorn coral; **Figure 3**), (2) it provides habitat for the most important Caribbean herbivore, the sea urchin *Diadema antillarum*, a species that experienced a massive Caribbean wide mortality event in 1983 and now is now slowly recovering (**Figure 4**) and (3) it serves as a nursery for juvenile fish especially grunts that seek shelter under the aforementioned ledge (**Figure 5**).

Regarding the first, it needs to be noted that although adult colonies of *A. palmata* are relatively rare at the planned construction site, many juveniles of this species (i.e., colonies < 1cm

Figure 5. Many fish species such as these juvenile grunts use the ledge mentioned in the text as a shelter or nursery habitat where they escape predation. Reefs bordering such nursery habitats generally harbor larger fish of the same species.

in diameter) were observed on the ledge. This species is listed as "threatened" throughout their distributional range (i.e., including Bonaire) under the US Endangered Species Act since 2006. In 2008, the National Marine Fisheries Service (NMFS) and the National Oceanic and Atmospheric Administration (NOAA) determined that in order to protect *A. palmata*, its habitat should also be protected (Federal Register 2008).

[3] It should be noted that placing the proposed concrete blocks on top of this ledge might cause this ledge (and the construction on top of it) to collapse given the fact that the ledge is generally undercut (sometimes >1.5 m deep) and does not represent a massive limestone platform.

The long-spined sea urchin *Diadema antillarum* used to be a common species that occurred in mean densities of 3–20 ind. m^{-2} on the shallow fore-reef along the leeward coast of Curaçao and Bonaire (Bak et al. 1984). In 1983, an unidentified disease caused *Diadema* to become almost extinct in the Caribbean (Lessios 1988). *Diadema antillarum* was an important benthic herbivore and turf/macroalgae increased in abundance after the species' die-off (Hughes et al. 1999). Because algae compete for space with juvenile corals, the *D. antillarum* die-off indirectly caused a reduction in the number of juvenile corals after algae had become more abundant (Edmunds and Carpenter, 2001). Therefore, many reef scientists consider the *D. antillarum* die-off as one of the main factors contributing to the overall decline of Caribbean reef ecosystems and *vice versa* that their presence is essential for well functioning Caribbean reef systems.

The aforementioned ledge also functions as a nursery for juveniles of at least 12 different reef fish species, many of them commercially important to the reef fisheries (Nagelkerken et al. 2000a, b). Surprisingly, the shelter provided by this ledge therefore acts much like mangroves or seagrasses in which such species normally seek protection. Secondly, the abundance of adults of the same species is shown to be higher on reefs bordering habitats with a "shelter function" compared to locations that lack such nursery habitats (Nagelkerken et al. 2000a, b).

Combined and counter-intuitively, the area of the proposed construction does represents three important ecological values that are generally considered important for the functioning of Caribbean reef systems. All these functions are found in the area on which the restaurant/bars/ diveschool are planned and do not occur in the area where the pier is proposed. These values need consideration in any future decision making regarding the construction of the proposed facility.

3.1 Physical Impacts

Structures placed in moving water have the capability to disrupt the water's flow. Piles may cause locally increased flow rates immediately around their base leading to scour and erosion. They may also lead to a general slowing of flow over the area of the dock, resulting in settling out of sediments carried by the current. The resulting changes in sediments caused by scour or deposition may affect marine life in the area and/or coastal morphology due to changes in near shore water flow. There appears to be few research results available on the changes in local sedimentation regimes caused by pile supported structures. In an engineering study, Poole (1987) suggests that, "At a wind angle of 90º to a 15 m long pier

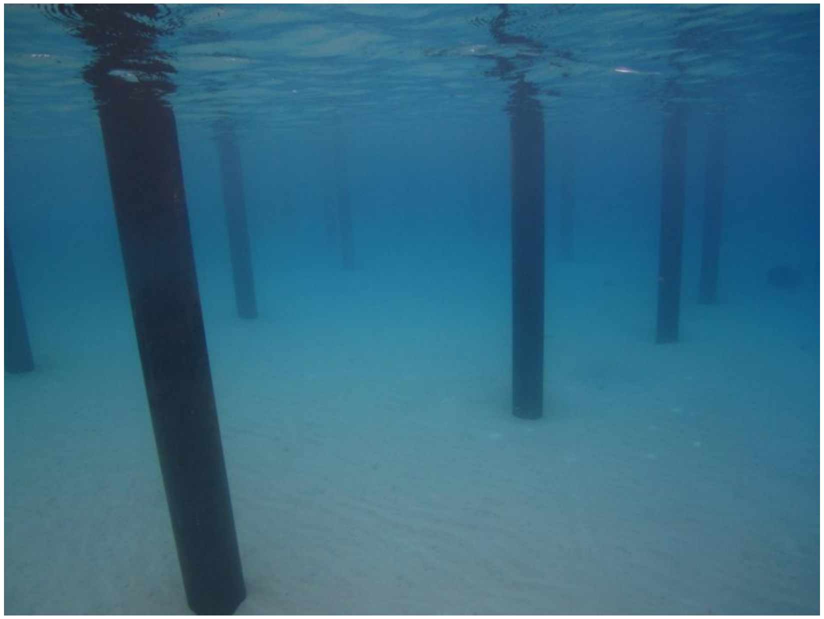

Figure 6. Overview of the landscape in which 36 pilings were placed in October 2011.

with 5 pilings on each side [diameter of pilings not noted] can produce eddies and flow friction 2 times the diameter of the pilings—minimally. This means a 30 percent reduction in flow. The area affected by the flow reduction would be a factor of 2 to 3 times the pier length. Properties within 30 to 50 m of a 50–foot pier could be subjected to drifting algae and trash accumulation, sand deposition and changes in local marine communities." This evaluation cites no research results and appears to be based on predictive engineering calculations. However, this study shows that changes in water flow can be expected for a pier on pilings, though such design is generally preferred by local authorities to allow the water to flow "trough" the structure. Nevertheless, it seems inevitable that a pier on pilings and especially the massive foundation planned underneath the deck on which the bar/restaurant/dive school are planned will change near shore currents.

3.2 Environmental Impacts

Various impacts can be expected during various phases of the pier's construction and operation. These are all listed below and serve to provide a concise evaluation of the current knowledge on each topic.

3.2.1. Placement of the 36 pilings

Environmental impacts are minimal because the pilings are placed in an area devoid of marine life (**Figure 6**). One observation made during the site visit on October 24th, 2011, was that large amounts of groundwater exited the reef sediments near and around the area where pilings were placed. Intensive land development as a result of the rapidly growing tourism industry may result in contamination of groundwater resources that eventually discharge into local coastal ecosystems. Pharmaceuticals, personal care products, runoff from roads and other impermeable surfaces, pesticides are all carried to the ocean by groundwater in limestone systems very similar to the Bonaire situation (Metcalfe et al. 2011). Natural groundwater flow is always present, though easier to detect after rain events. After rain falls on land, it enters the bottom and eventually part of it flows underground to the ocean where it exits the reef bottom in areas that are not capped by e.g. limestone structures. Along developed shorelines, groundwater transports a variety of pollutants (see above) but also sewage leaking from dysfunctional cesspools and septic tanks.

While such process is probably continuously occurring, the possibility exists that the placement of the pilings is presently facilitating the release of polluted groundwater to the near shore waters. While the geomorphology of the site is unknown, the possibility cannot be confirmed nor denied. Water measurements taken during the field visit indicate a large number of pathogenic bacteria (*Vibrio* spp.; > 1600 bacteria per ml) to be present in the water (normal concentrations are 0-10 bacteria per ml). While the source of these bacteria cannot be determined, the extremely high abundance of only one indicator species already indicates that the water at this site is severely polluted, possibly already with risks for human health and local reef systems. This aspect deserves critical attention in the near future as it not only affects the "health" of nearby reef communities, but also that of people swimming in the vicinity of the pier. Prevention and mitigation measures are needed to ensure that future developments do not impact the marine environment and human health, thus damaging the tourism-based economy of the island.

3.2.2. Future construction of the pier, deck and other facilities

Any construction at or near the water edge, or where debris (including sand and plastic) can be washed or blown into the water, should be surrounded by silt screens, which must be placed before the work starts. The screens should also be placed around storage areas, to prevent waste from blowing away and to prevent sediment run-off into the sea. In addition to silt screens, building guidelines of the Bonaire National Marine Park require that storage areas for sand and soil, and all work areas, must be at least 20 meters away from the high water mark and construction equipment must not be cleaned or washed within 50 meters of the high water mark. Cement used to make concrete can be carried to nearby reefs with local currents. Because cement raises the pH of the surrounding seawater considerably (Stark 1955), cement used to construct the proposed pier has the potential to affect the relatively well-developed coral communities that exist < 1 km down-current of the construction site. During the site visit on October 24th, 2011, it was noted that the pilings of the pier that were placed are smaller than the ones shown on the drawing provided earlier. It is however presently unclear whether the construction of the pier with smaller pilings has implications for the pier's structural integrity during daily operations, during storms or whether large yachts can still attach to the pier. The proposed foundation of concrete filled in with sand (on which the bars/restaurant/ diveschool) will be placed will destroy some of the ecological values described in "3.0 Observations": (1) habitat for the endangered coral *Acropora palmata* (Elkhorn coral), (2) habitat for the most important Caribbean herbivore, the sea urchin *Diadema antillarum*, and (3) the nursery function for juvenile fish especially grunts. While this habitat is also present along other sections of the Kralendijk shore line, the proposed construction will cause a reduction of this habitat of approximately 5%.

3.2.3. Debris, waste and trash entering the ocean

The future usages of the pier include the following: a dive school, a bar/restaurant and presently unknown functions related to the planned inclusion of the proposed pier and associated facilities in a hotel-complex that is planned for construction on a nearby site. Given the variety of usages associated with the pier and the large number of persons expected to participate in these activities (the facility can seat at least a 100 persons), disposal of sewage and

Figure 7. Example of debris that is commonly found around piers.

waste (generated by customers and the restaurant/bar facilities) deserve the utmost attention to prevent these materials from entering the nearby reef waters. Disposal of liquid waste (with sewage being the major concern), should occur by connecting the facilities to the Bonaire waste water system. Any type of liquid waste (including sewage, water used for washing, particulates, organic waste, chemical/ cleaning products, see also "3.2.5. Contaminants from treated wood used for decks") is extremely detrimental to tropical marine communities and can easily affect marine ecosystems downstream of the construction site (where relatively healthy coral communities are found) as waste easily travels with local currents. It is therefore of paramount importance that all waste generated by the proposed facility (in the broadest sense of the word) does under no circumstances enter the surrounding waters. For a more detailed overview of the effects of commonly used chemicals on coral reef communities, see: Sanchez-Bayo et al. (2011).

Furthermore, many people using the bar/ restaurant facilities on the pier will cause a large flux of waste (i.e., napkins, plastic cups etc.) into the ocean as the wind will blow such items from the pier, a phenomenon also observed around Karel's Beach Bar (**Figure 7**) and similar establishments on Curacao. It is presently unclear how the proposed facilities aim to address this concern, but based on experiences elsewhere (see: "2.3 Similar Projects") it can be expected that such influx of (accidental) debris and waste can be substantial and generally causes the area around such piers to become devoid of any form of marine life. Secondly, turtles and birds often mistake plastic bags and cups for (jelly)fish and eat them. Plastic blocks the animals' digestive tract, causing it to starve to death. The influx of (accidental) debris and waste will increase during storms that have removed entire facilities from near shore positions, even when these were not built on a pier. The possibility that an entire near shore facility disappears below the waves during a storm is best exemplified by the destruction of the Green Parrot restaurant in November 1999 due to storm Lenny causing the restaurant's structure, furniture and appliances to become scattered across the nearby reef.

Figure 8. Example of a severe weather event (Tropical storm Omar in 2008) that affected Karel's Bar (shown) directly next to the proposed construction location of the new pier

Lastly, since the pier will (at least in part) serve as a bar/ restaurant, regular cleaning will be required as demanded by local health authorities. Cleaning such a large pier, which is to some degree largely open structure that facilitates the leaching of chemicals, will cause the input of cleaning products as well as nutrients (e.g. phosphates), to the water where they will increase growth rate and abundance of a variety of planktonic and benthic algae (e.g., McCook 2001, Smith et al. 2002, Szmant 2002, McManus and Polsenberg, 2004) that can then outcompete corals. Because such chemicals will be transported by local currents, their effect is not limited to the area where they initially entered the water.

3.2.4. The effects of storms

Experiences from both Bonaire and Curacao have shown that facilities located on piers are generally too weak to withstand occasional severe weather events (**Figure 8**). In the recent past, tropical storms Lenny (1998) and Omar (2008) destroyed a significant number of piers and near shore facilities on both islands. While it is presently unclear whether the proposed facilities are designed to withstand such storms, this matter deserves critical attention. Destruction of all or part of the proposed facilities by a storm will cause a large flux of debris to nearby marine and coastal environments. Such concerns go beyond structural aspects and also include precautionary measures to protect waste water systems etc. from being damaged during such events.

3.2.5. Contaminants from treated wood used for decks

The most common contaminant-related concern associated with small docks is leaching of wood preservatives. Wood continuously exposed to water can decay rapidly. To protect the wood and ensure piers will have a reasonable lifespan, the wood is typically treated with preservative chemicals that, in turn, can leach into surrounding waters. Historically, the most commonly used materials were oil-based: creosote or pentachlorophenols. Presently, wood products pressure-treated with chromated copper arsenate (CCA) are the most common material used for dock construction. In laboratory studies, researchers found that leaching occurs in saline waters and that it can have toxic effects. The leaching rate decreases by about 50% daily once the wood is immersed in seawater. Approximately 99% of the leaching occurs within the first 90 days in the marine environment (Sanger and Holland, 2002). Elevated concentrations of metals from CCA-treated wood can be found in organisms living near to the pilings (Weis and Weis 1996) and in sediments with higher contaminant levels, species richness was depressed (Weis and Weis 1998). Factors involved in impacts to biota appears to include sediment type, amount of CCA-treated material, length of time the CCA-treated material has been immersed in marine waters (more than or less than 3 months), and the flushing rate of the water body. Sanger and Holland (2002) report that, “it is unlikely that the bioaccumulation of dock leachates by marine biota is having or is likely to have an impact on living resources in South Carolina estuaries and tidal creeks”.

Reasons given are that approximately 99% of the leaching takes place in the first three months after installation, the fact that the size of the area around the dock that might be affected is generally small, and high rates of tidal flushing will dilute and flush any accumulations in the water column. It is however unknown how reef organisms respond to such chemicals in a system characterized by minimal tidal flushing.

3.2.6 Effects from boats using the docks

Fueling that takes place at small docks generally consists of pouring fuel from a portable tank into an outboard engine's fuel tank—often with the engine attached to the stern of the boat directly over the water. This offers the opportunity for spillage or overflows. Poorly designed or maintained engines may also discharge fuel during operation. Petroleum products in marine waters can have significant impacts. Outboard motors have long been associated with polluting of waterways (Milliken and Lee 1990). It is however difficult to differentiate between general recreational boat use and that associated with small docks. Additionally, boat wakes, which lap at the shoreline, can contribute to increased shore erosion (Zabawa et al. 1980). If boats are moving at a speed slow enough to avoid leaving a wake, there will not be shoreline erosion. There was little found in the literature that pertained specifically to boats maneuvering near docks or landing areas, where the effects of secondary wakes (or "prop wash") cause sediment to become resuspended and transported elsewhere by the prevailing currents. Since no information was provided on the types of boats expected to moor to the proposed pier, no predictions can be made of how severe these potential impacts will be.

3.2.7 Artificial beach construction

South of the proposed dive school/bar/ restaurant a small beach is planned. It is currently unclear whether it is expected that such beach forms naturally or whether it will be created artificially. In case of the latter, it needs to be noted that artificial beach creation has generally been unsuccessful in the region and generally results in excessive sedimentation on nearby reefs. This aspect of the proposed activity needs additional clarifications before its potential negative impacts can be assessed.

3.2.8 Boating and navigational issues

The planned pier will be connected to an existing pier that has existed > 15 yrs and therefore results in minimal changes in the seascape as relevant to boaters.

3.2.9 Existing water quality issues

As mentioned in "3.2.1. Placement of the 36 pilings" there are concerns about the water quality at the proposed construction site. This has serious implications for the recreational activities that will take place around the pier, but are also relevant for the planned fountain. Cheng et al. (2010) and Backet er al. (2005) have shown that spray from degraded water bodies due to an increased abundance of pathogenic microorganisms, will affect people who breath it. Similarly Schoen and Ashbolt (2011) have shown that pathogenic microbes residing in fresh water systems (*Legionella*) affect mostly the elderly after such water was "misted". Research in this area is rather scarce, but the examples mentioned above suggest a causal link between reduced human health and breathing aerosolized vapors containing waterborne pathogens. The fact that potentially pathogenic bacteria species were observed at the location of the future pier and the fact that degraded reefs (i.e., those near Kralendijk, IUCN 2011) harbor greater abundances of pathogenic microbes (Dinsdale et al. 2008) caution against vaporizing/ spraying such water near age groups most sensitive to health risks such as the elderly and infants/ children.

3.3. Mortality of in-situ Organisms

The proposed foundation of concrete filled in with sand (on which the bars/restaurant/ dive school) will be placed will destroy some of the ecological values described in "3.0 Observations": (1) habitat for the endangered coral *Acropora palmata* (Elkhorn coral), (2) habitat for the most important Caribbean herbivore, the sea urchin *Diadema antillarum*, and (3) the nursery function for juvenile fish especially grunts

3.4Compliance with Environmental Requirements

While the pier on pilings does not pose a significant impact on local or nearby marine communities, its construction requires a permit because it is constructed within the boundaries of the Bonaire National Marine Park (Marine Environment Ordinance A.B 1991 Nr.8) which is indicated in the "Construction Guidelines" put together by STINAPA/Bonaire National Marine Park. These guidelines are available online at:

http://www.bmp.org/rulesandregulations2.html.

It needs noting that if the pier will serve as part of a marina, an additional Environmental Impact Study or "milieu effect rapportage (MER)" is required. In addition to laws have recently have come into effect after Bonaire became part of the Netherlands such as The Marine Law BES (art. 20 and 21) that are enforced by the Dutch Ministry "Verkeer en Waterstaat" and overseen by Rijkswaterstaat (Netherlands).

3.5 Areas of Archaeological or Historical Significance

None. The area has been intensively used by the hotel industry for several decades and associated developments, including the pier's predecessor, have modified the environment to such degree that historic artifacts are longer expected to be present.

3.6 Navigational Concerns

Expected to be minimal. However, since no information was provided on the types of boats expected to moor to the proposed pier, no exact predictions can be made of how severe these potential impacts will be.

4.0 ALTERNATIVES

None. This is a stand-alone project in a heavily developed area that lacks space to build the proposed structure elsewhere.

5.0 CONCLUSION

The proposed pier cannot be built without causing several detrimental impacts to the marine environment. These can be summarized as follows: (1) a reduction in habitat for the endangered coral *Acropora palmata* (Elkhorn coral), (2) a reduction in the habitat for the most important Caribbean herbivore, the sea urchin *Diadema antillarum*, (3) a reduction in nursery habitat for juvenile fish especially grunts, (4) an alteration in near shore currents, (5) increased influx of nutrients/ chemicals causing algal growth down current of the proposed pier, (6) a large increase in debris/ trash entering the near shore water that will also be transported down current with prevailing currents and affect sea turtles and birds, (7) a large increase in debris resulting from the fact that severe storms will eventually hit the proposed bars/restaurant/ diveschool, (8) increased chemical pollution from fuel spills from boats using the pier/ marina facilities and (9) potential human health risks as polluted water will be aerosolized in a planned fountain.

6.0 CONSULTED LITERATURE

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