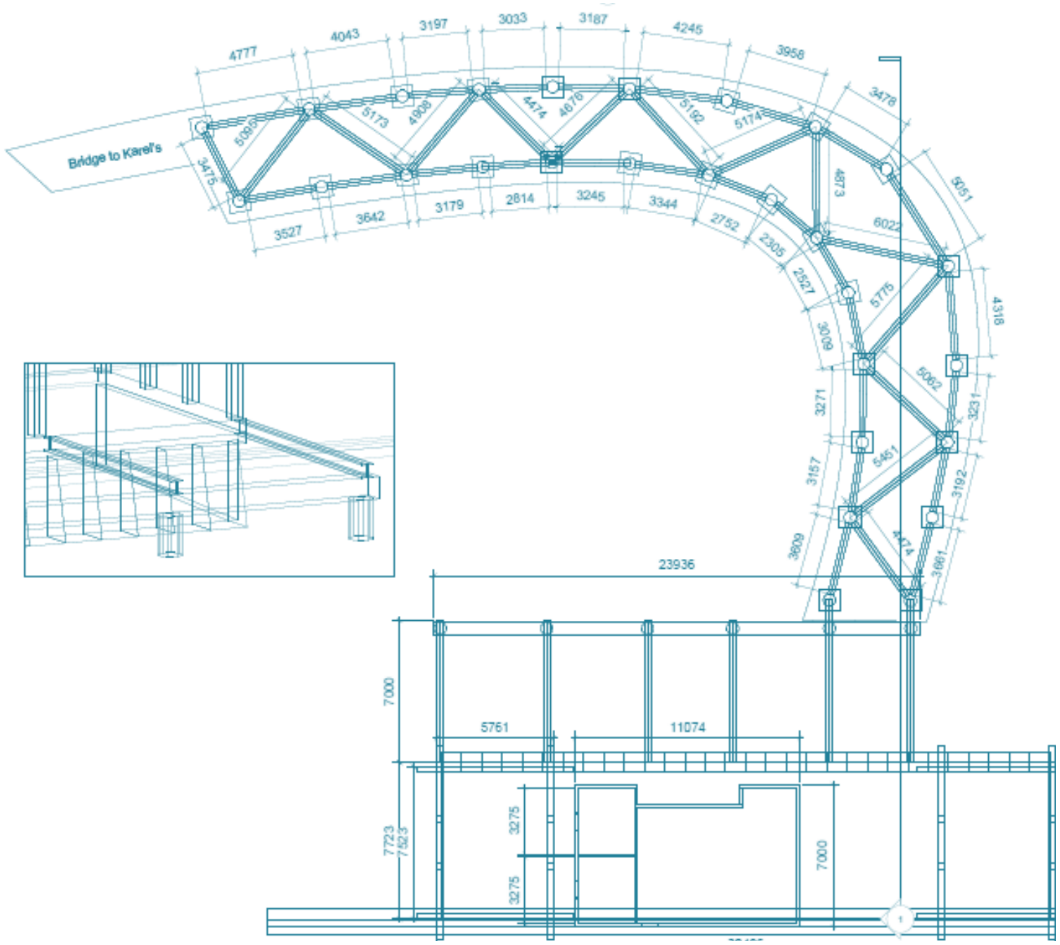

Environmental impact assessment of the construction of a pier and its future usages near Karel's Bar, Bonaire

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PURPOSE

This report aims to overview the impacts on the marine environment associated with the construction and future use of a pier near Karel's Bar in the center of Kralendijk, Bonaire. Following the procedures outlined in the Maritime Law BES, an assessment is needed that overviews the effects on the marine environment caused by the construction of such pier, its presence and future use.

The placement of 36 pilings to support the pier had already started but was halted by local authorities. In addition to permits from local government agencies (e.g., the island resolution marine park Bonaire), a permit required under the Maritime Law BES had not been applied for. Stakeholders (e.g., DROB Bonaire, Rijkswaterstaat) proposed a study to determine if the continuation of the building project (i.e., the construction and use of the pier as dive school/ (temporary) restaurant/ bar) represents an acceptable negative impact on the marine environment. If it is decided that the proposed project does not or cannot confirm to applicable laws or represents an unacceptable level of environmental destruction, it is possible that the pilings have to be removed.

This report builds on an earlier report (Vermeij 2011) that shortly discussed (1) the potential impacts of the construction of the pier beyond the direct impacts of piling installation, and (2) the potential impacts of the pier and its use on the surrounding environment after construction has been completed. Here, I built on this earlier report by elaborating on earlier concerns in greater detail and by discussing the expected effects of alterations in the earlier design as well as the specific information provided by Mr. Visser as to how the facility will be used (described in Mr. Vissers letters d.d.03-24-2012 and 07-10-2012). This relatively short note should be viewed as an expert opinion that evaluates current knowledge related to aspects of the proposed action given the short period of time to compile this advice. 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, actions allowed in the Bonaire National Marine Park and to laws that have come into effect after Bonaire became part of the Netherlands such as The Marine Law BES (art. 20 and 21) enforced by the Dutch Ministry "Verkeer en Waterstaat" and overseen by Rijkswaterstaat (Netherlands). This document is based on the latest and most relevant published scientific information and as such does not necessarily represent the opinion of its writer.

PROJECT SETTING

With increasing coastal development comes a concomitant interest in the construction and operation of waterfront facilities, the use of coastal waterways, and the environmental implications of these activities (Barr 1993). Overwater structures include commercial and residential piers and docks, floating breakwaters, moored barges, rafts, booms, and mooring buoys. These structures are typically located from intertidal areas to areas of water depths approximately 15 m below mean low water (i.e., the shallow subtidal zone). Overwater structures and associated use activities alter (for example) light, wave energy, substrate type, depth, and water quality which are the primary factors controlling plant and animal assemblages found at a particular site. Site-specific factors (e.g., water clarity, current, depth) and the type and use of a given overwater structure eventually determine the occurrence and magnitude of these impacts (Hanson et al. 2003).

The construction activities are proposed directly west of the existing facilities of Karel's Bar. The coast is heavily developed, primarily by tourism-related infrastructure. The pier is planned at a location where the reef bottom mainly consists of a sandy rubble field extending out to the reef drop-off at approximately 8-10 m depth where the reef slopes down to greater depths. On the deeper part of the reef flat and on the reef slope, rubble, i.e., dead pieces of coral, also cover most of the bottom. Communities consisting of corals, sponges, etc. are present locally on the deeper reef slope (>15 m) at this location. Excess sedimentation in the past from construction activities, continuous terrestrial run-off (e.g., subterranean sewage fluxes, storm water, etc.), (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 around the constructed pier is largely devoid of marine life. It needs to be stressed that coral communities in this area, though marginally developed, were present in the area bordering the location of the proposed facility in 1996 (3-5% coral cover; Vermeij, unpubl. data) and were fairly well developed in the early 1980's with coral cover ranging between 10 and 30% (Van Duyl 1985). Consequently it is obvious that the current degree of development in the vicinity of the proposed facility is already providing sufficient stressors that caused coral communities to degrade without the proposed facility even being present.

CORAL REEFS

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, IUCN 2011) clearly 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.

BROADER PERSPECTIVE

It needs to be stressed that the reefs of Bonaire are currently in rapid decline (e.g. Steneck and Arnold 2009, IUCN 2011, IUCN in prep.). Consequently, the current activities on the island represent an unsustainable level of stress and as such every addition to the existing level of stress will further enhance the pressure experienced by the island's reefs. Bonaire's marine resources will decline further in the future and large scale counter measures should be taken to halt and reverse this trend. Individual projects such as the one discussed here should be considered with this in mind and negative impacts associated with the proposed activity also hold for other facilities that are already present on Bonaire. While the effect of each individual project on Bonaire's marine resources habitat may be minimal, the overall impact may be substantial when considered cumulatively.

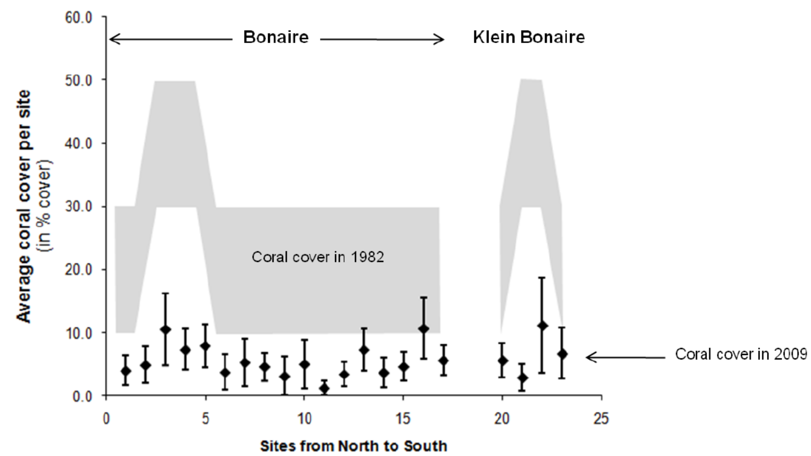

Figure 1. Change in coral cover from 1982 (estimated range calculated from Van Duyl 1985) to 2009 (values are average cover as calculated by an IUCN expedition to Bonaire in 2009; error bars are 95% confidence intervals). In total 17 sites were monitored from North to South on Bonaire (sites 1 to 17)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

WATERQUALITY

Introduction of pathogens to aquatic habitats has become more common and widespread over the last 30 years, and various factors may be responsible, including pollution from urbanized areas (Shuval 1986, O'Reilly 1994). Urban runoff typically contains elevated levels of pathogens, including bacteria, viruses, and protozoa, often a result of introductions of bacteria from leaking septic systems, agricultural manure, domestic animals, wildlife, and other sources of pollution and can lead to beach and harvesting area closures (USEPA 2005). The presence of unnaturally high concentrations of pathogenic bacteria has also been confirmed for Bonaire by measuring the amount of Vibrio spp. bacteria in the water near Kralendijk. Pathogens are generally harmful to human health through the consumption of contaminated shellfish and finfish and exposure at beaches and swimming areas (USEPA 2005). While many pathogens affecting marine organisms are associated with upland runoff, there are also naturally occurring marine pathogens that affect fish and shellfish (Shumway and Kraeuter 2000). Some naturally occurring pathogens can produce blooms that release toxins capable of harming fish and possibly human health under certain conditions (Buck et al. 1997; Shumway and Kraeuter 2000). Although the factors leading to the formation of blooms for these species requires additional research, nutrient enrichment of coastal waters is suspected to play a role (Buck et al. 1997). A facility as the one proposed here, where people come in close contact with nearshore waters in an urbanized area could facilitate their transmission to people visiting the facilities. There is adequate information on the nature of both real and putative dose-response relationships to derive criteria for the relative (conservatively estimated) risks posed by enteric organism concentrations in bathing water, thereby allowing health protection standards to be derived. Nevertheless, such standards currently do not exist on Bonaire and all concerns above are hence listed as a potential (grave) concern.

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 steel pilings (Ø 76 cm, 2 cm thick and 6 m tall2; specifications provided by Cashman Enterprises) that were placed on the shallow reef terrace in October 2011. On the shore side, this 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 concrete foundation closer to shore on a shallow limestone cliff. Based on the information provided (described in Mr. Vissers letter d.d. 07-10-2012), the entire construction aims to provide facilities to approx. 300 people day^{-1} with an expected increase in visitors of 30% yr^{-1}. This number is higher during "special activities" that will be held twice a month during which 700 to 1300 people are expected to be present at the pier and nearby facilities. Also this number is expected to grow at a rate of 30% yr^{-1}. Based on communications with Mr. 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 boats (max: 10) that will be connected backward at the far end of the pier. A natural beach is expected to from directly south of the concrete foundation on which the bars/ restaurant/ dive school are planned (Figure 2).

Figure 2. Artistic impression of the proposed facilities. Note: the fountain will no longer be built as mentioned by Mr. Visser by phone (8-20-2012).

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 Mr. 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. (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, Kokomo, 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. The combination of pier/ bar and boating facilities of a size proposed by Mr. Visser is unique at present and no examples of similar projects on Bonaire or Curaçao of a similar size exist.

PROJECT CONCERNS

Main concerns regarding the pier's construction and its future use are the potential damage to or irreversible loss of marine life, archaeological sites or artifacts and its potential danger to maritime operations in the area. These potential dangers and/ or concerns are considered individually for various aspects of the proposed construction and planned activities thereon.

PIER CONSTRUCTION: POURING OF CONCRETE AND PLACEMENT OF SCAFFOLDING

Main concern: spillage of building materials, debris and concrete to the surrounding water

Proposed mitigation measure(s): placement of silt screens

Any construction at or near the water edge where debris can be washed or blown into the water, should be surrounded by silt screens, which must be placed in the water before the work starts (following regulations set out by the Bonaire National Marine Park; http://www.bmp.org/pdfs/Construction-guidelines-bonaire.pdf). 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. Mr. Visser has agreed to store his building materials away from the shore (stated in his letter d.d.03-24-2012) which will significantly reduce accidental washing of building materials into the ocean leading to the problems described above. It is possible that storms occurring during the construction process may result in wind, rain or wave erosion of stockpiles if they are not appropriately sited or protected.

No specifications are provided other than that "semi permeable silt screens" (description by Cashman Enterprises d.d. 03-24-2012) will be used during the construction process which potentially allows for excess spillage of concrete during the pier's construction phase, both during the filling of the pier's pilings as well as during the subsequent construction of the concrete cover of the pier itself. Furthermore, details and/ or specifications of the pump that will be used to fill the pier's pilings, the "connector" (to link the pump and the pilings' openings) designed by Cashman Enterprises and the scaffolding that will be used to hold the pump in place are missing from the information provided (letter from Cashman Enterprises d.d. 03-24-2012).

Consequently, damage to nearby marine communities is possible during this phase of the construction process from debris and/ or excess sedimentation. Other effects include disruption in the respiration of fishes and other aquatic organisms, reduction in filtering efficiencies and respiration of invertebrates, reduction of egg buoyancy, disruption of ichthyoplankton development, reduction of growth and survival of filter feeders, and decreased foraging efficiency of sight-feeders (Messieh et al. 1991; Wilber and Clarke 2001; USEPA 2005). Additionally, in their statement, Cashman Enterprises (their letter d.d. 03-24-2012) states that debris (from the kitchen and bar) is expected to end up in the ocean (page 2) and will be collected using the same "semi permeable siltscreens" mentioned above. In their letter to Rijkswaterstaat (d.d. 07-10-2012) Mr Visser mentions that the screen will only be present during the construction phase (6.6 Aanvulling op 6). Combining both statements leads one to conclude that debris from the kitchen and bar is expected to enter the ocean.

Conclusion: insufficient information is provided to determine whether the pooring of the concrete elements of the pier will result in unacceptable damage to the marine environment. Based on the information provided, some damage to nearby coral communities is expected to occur as building materials are transported by local currents to nearby coral communities.

CONCRETE FOUNDATION & PILINGS

Main concern: damage to marine life, alteration of local currents and sediment fluxes

Proposed mitigation measure(s): none

Structures placed in moving water have the capability to disrupt the water's flow and may cause increased flow and sediment rates immediately around their base leading to scour and erosion (Tyrrell 2005, Bozek and Burdick 2005). Altered hydrology and flood plain storage patterns around estuaries can effect water residence time, temperature, and salinity and increase vertical stratification of the water column, which inhibits the diffusion of oxygen into deeper water leading to reduced (hypoxic) or depleted (anoxic) dissolved oxygen concentrations (Kennedy et al. 2002).

Structures built in the ocean may also lead to a general slowing of flow (especially on their leeward side), resulting in settling out of sediments carried by the current See Figure 3 for an example). 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. Hence pier designs where piers are placed on pilings are generally preferred to allow the water to flow "trough" the structure. Nevertheless, it seems inevitable that a pier will change near shore currents and sediment regimes, especially massive, concrete designs as the one proposed here. Structures placed in moving water have the capability to disrupt the water's flow. Piles may cause increased flow rates immediately around the structure. These modifications in the flow of water may produce scour and erosion or increased deposition of sediments depending on the conditions and structure. Either of these may affect marine habitats. However, there appears to be very limited research results available on the impacts on sedimentation from pile supported structures. What research has been reported was done mostly focused on the morphological changes to adjacent shorelines and bottom topography and generally no information was provided on the nature of sediment type change, if any, over time in the

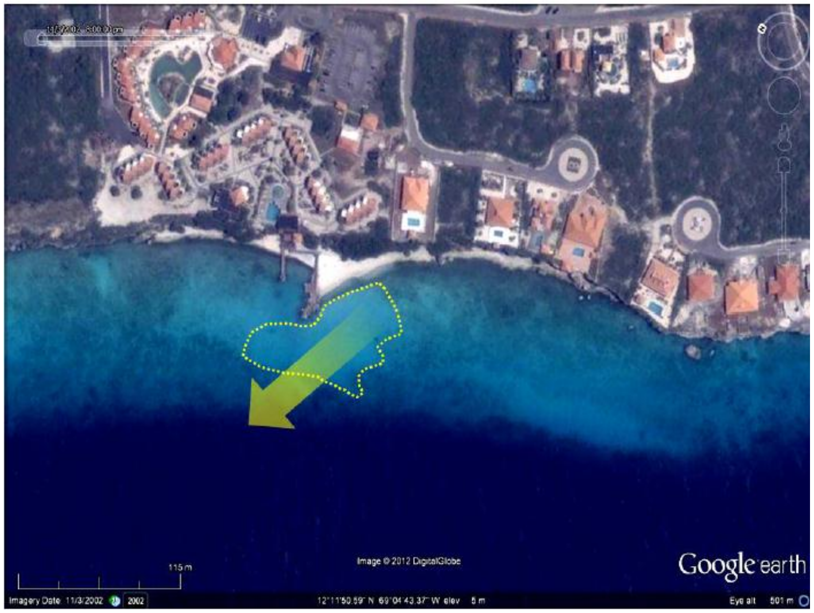

Figure 3. The dotted line indicates the location of an unusually thick sediment layer that formed upcurrent of massive breakwater that was built on Curacao. . The arrow shows the direction in which the sediment plume resulting from the aforementioned sediment layer moves toward the reef.

vicinity of pile-supported piers. Noble (1978) assessed the impacts of 20 piers that ranged from 625–2,500 feet in length and 15–300 feet in width that all had a pile spacing greater than 4 times the diameter of the piles. Noble concluded that these piers "had a negligible effect" on sedimentation and erosion of adjacent shorelines. He notes that his results support prior findings of Johnson (1973) and Evert and DeWall (1975).

While local sand scour around the pilings is expected to be low, major sand movement at the proposed location is however expected as a result of the interplay between (1) the change in local currents and sand movement caused by the construction of the concrete foundation for the bars, restaurant and dive shops and (2) the fact that the proposed design consists of a group of pilings that would (at least theoretically) affect local water movement patterns. Miller et al. (1983) showed that a "pile group scour effect" causes higher than expected scour rates than the sum of localized scour of individual piles. Currently, the pier extends 3 m into the ocean floor (specifications provided by Cashman Enterprises), but to unequivocally determine whether this is sufficient to ensure the structure remains in place (especially during storm events and/ or with excessive drag when 10 large ships are moored to the structure) additional information would be required on (1) the geotechnical characteristics of the bottom to determine if the pilings remain in place during severe weather events, (2) the local degree of sand scour caused by boats (prop wash), altered currents resulting from the construction of the concrete foundation near shore and (3) altered currents as a consequence of the size and location of the pilings themselves.

Conclusion: water currents and sediment fluxes will change resulting in increased sedimentation rates on nearby reefs and possibly accumulation of sediments in areas that can affect maritime operations in the area.

Coatings for rebar, deck and I-beams

Main concern: damage to marine life

Proposed mitigation measure(s): none

Kennish (2002) identified a number of contaminants associated with overwater structures that can be released into the aquatic environment, including detergents, petroleum products, and copper. Treated wood used for pilings and docks releases contaminants into the aquatic environment. Creosote-treated wood pilings and docks commonly release PAH and other chemicals, such as ammoniacal copper zinc arsenate (ACZA) and chromated copper arsenate (CCA), which are applied to preserve the wood (Poston 2001, Weis and Weis 2002). These chemicals can become available to marine organisms through uptake by wetland vegetation, adsorption by adjacent sediments, or directly through the water column (Weis and Weis 2002). The presence of CCA in the food chain can also cause a localized reduction in species richness and diversity (Weis and Weis 2002). These preservatives are known to leach into marine waters after installation, but the rate of leaching is highly variable and dependent on many factors, including the age of the treated wood. Concrete or steel, on the other hand, are relatively inert and do not leach contaminants into the water. Treated wood used for pilings and docks releases copper compounds that are applied to preserve the wood (Poston 2001, Weis and Weis 2002). These chemicals can become available to marine organisms through uptake by wetland vegetation, adsorption by adjacent sediments, or directly through the water column (Weis and Weis 2002). Urban stormwater runoff often contains metals from automobile and industrial facilities, such as mercury, lead (used in batteries), and nickel and cadmium (used in brake linings). At low concentrations, metals may initially inhibit reproduction and development of marine organisms, but at high concentrations, they can directly contaminate or kill fish and invertebrates. Shifts in phytoplankton species composition may occur because of metal accumulation and may lead to an alteration of community structure by replacing indigenous producers with species of lesser value as a food source for consumers (NEFMC 1998). Metals have been known to produce a number of toxic effects on marine fish species (e.g., Bodammer 1981, Klein-MacPhee et al. 1984, Lang and Dethlefsen 1987).

Conclusion: insufficient information is provided to determine which materials will be used to coat the proposed pier and facilities thereon. The same holds for the wood being used and how this is treated. Damage and accumulation of toxins/ heavy metals can be expected.

Severe weather events (storms, hurricanes)

Main concern: destruction of facility with resulting debris impacting nearby marine communities

Proposed mitigation measure(s): resistant design, removing elements during storm

Experiences from both Bonaire and Curacao have shown that facilities located on piers are generally too weak to withstand occasional severe weather events. In the recent past, tropical storms Lenny (1999) and Omar (2008) destroyed a significant number of piers and near shore facilities on both islands (Figure 4). Destruction of all or part of the proposed facilities by a storm similar to those mentioned above, will cause a large flux of debris to nearby marine and coastal environments. Therefore, concerns related to the effects of severe weather events go beyond structural aspects and also include precautionary measures to protect waste water systems etc. from being damaged during such events.

Similar constructions (or even stronger) were present on Bonaire and Curacao, but despite statements to contrary when designed and built, such structures have shown to be unable to withstand wave impacts associated with (tropical) storms such as Omar (2008), Lenny (1999) and Tomas (2010). Intense storms that cause significant destruction of near shore facilities “hit” the island approximately once every five years on average, but seem to have increased in frequency during the last decade (Meteorological Service of the Netherlands Antilles and Aruba, 2010). The most significant events in recent years were related to tropical storms Joan in 1988, Bret in 1993, Cesar in 1996 and hurricanes Ivan in 2004, Emily in 2005, Felix in 2007 and Omar in 2008.Tropical storm Joan, which passed just south of the islands on October 16, 1988, caused an estimated structural damage of approximately US$1.5 million to exposed harbor and beach facilities on Curaçao alone. Hurricane Ivan passed on September 7, 2004 and represents another good example of the destructive force associated with extreme weather events. This storm was so strong that a Hurricane Warning was issued on the ABC Islands. Its eye passed approximately 130 km north of these islands and although the destructive winds failed to impact the ABC Islands, the swells it generated were large enough to batter several constructions on its coasts at an estimated cost of $1.3M. Less than a year later, hurricane Emily passed the ABC at a distance of about 175 kilometers. Hurricane Felix (2007) was the first tropical cyclone in more than a hundred years whose center made a very close pass along the islands (< 100km). This system quickly became a category five hurricane and while its wind field was rather small but still resulted in rough seas leading to widespread destruction of near shore facilities. Tropical storm, later hurricane, Omar (2010) developed north of the ABC Islands and caused strong southwesterly winds with gusts to gale force over the islands and large waves from the same direction battering mainly south and west facing shores, which led to significant damage to some small vessels and coastal facilities and also caused significant beach erosion (Meteorological Service of the Netherlands Antilles and Aruba, 2010). To summarize, severe weather events resulting in strong near shore storm surge are common on the ABC Islands, including Bonaire and warrant serious attention as a factor contributing to coastal pollution through the destruction of near shore facilities, like the one proposed here.

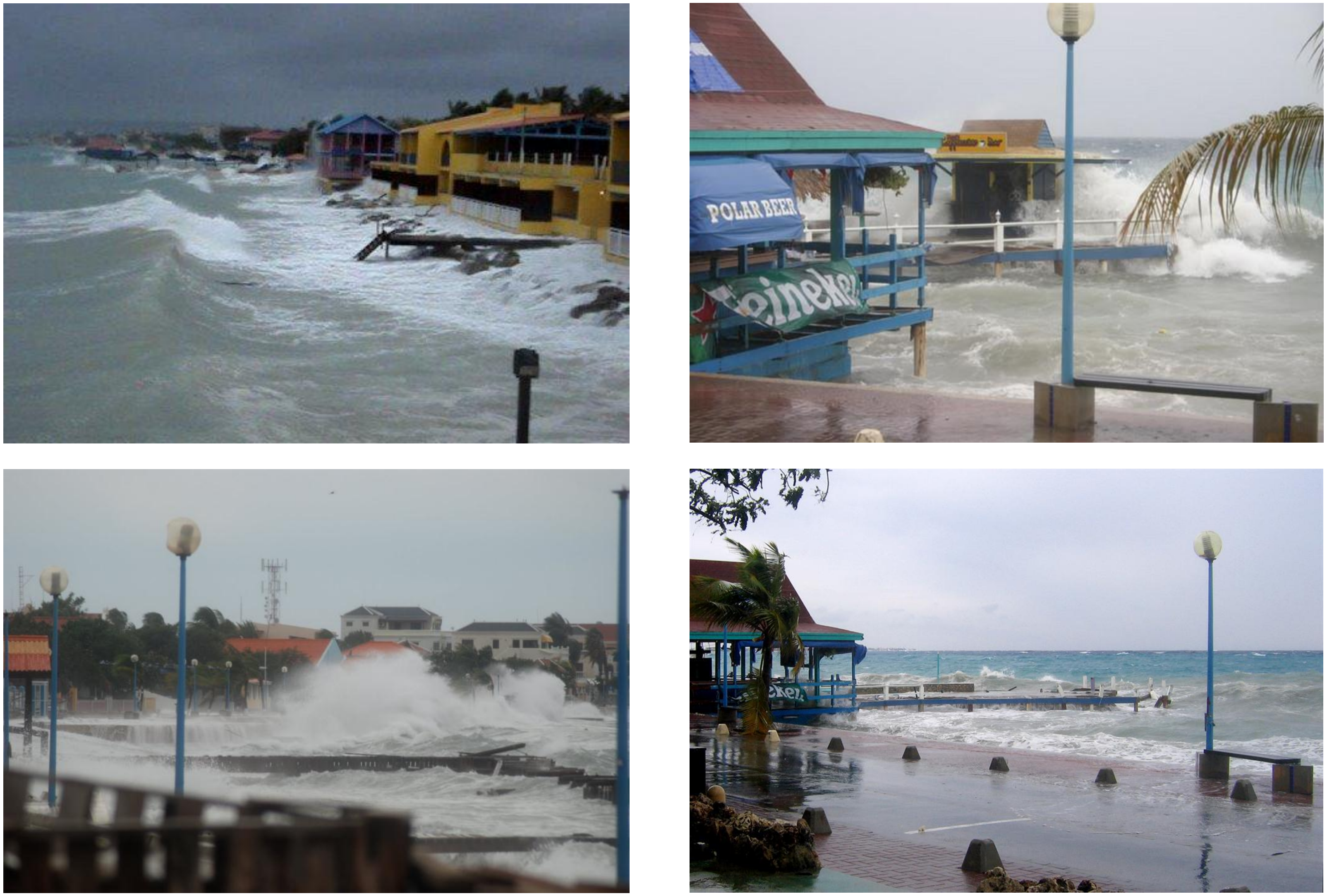

Figure 4. Impressions of the impact of storms on the coastal infrastructure of Bonaire (tropical storm Omar 2008). The pictures on the right show the impact of this storm on the facilities next to the location of the proposed facilities considered here, before (above) and after the storm (below). Clearly, the bar at the end of the pier was completely destroyed.

When selecting a pier design that is capable of withstanding the impacts of storm events, it is important (in addition to the adequate design of the above water section) to determine the elevation at which storm waves propagate. A geotechnical investigation with core borings is necessary for any pier construction in order to determine adequate pile penetration and breakout resistance based on local soil characteristics (Clark 2011). With a deck at approximately 1 m above the sea surface (specifications provided by Cashman Enterprises), storm waves that reach heights of 2-3 m (with maxima of around 5 m; Meteorological Service of the Netherlands Antilles and Aruba, 2010) will severely impact the structures on the pier as well as the pier itself. Mr. Visser has proposed to remove the planks of the pier as well as the mobile kitchen during storms which will help to reduce the amount of debris that will end up in the ocean. However, even with these measures, it can be expected that much (if not all of the structure other than maybe the steel pilings and the concrete foundation for the bars, restaurant and dive school) will be destroyed during severe weather. This expectation is largely based on experiences with similarly designed (or even sturdier) structures built near the shore line on Bonaire and Curaçao that were all largely destroyed during severe weather events in the last two decades (examples include: the Hilton hotel's concrete pier (1998), the Octopus Bar (1998, 2008), Karel's Beach Bar (2008), Habitat Piers (2008), houses along shore at St. Michiel (1998) etc.). Though mostly anecdotal, the fact that the destruction of such establishments caused a large amount of debris to become scattered across the sea bottom has been confirmed underwater by Debrot (2008) on Curacao after the passing of storm Omar: "In areas with coastal construction much fresh man-made material has been deposited on the reefs such as litter, bags, clothing and building debris".

Conclusion: A tropical storm will destroy part or the entire facility. Consequently, adverse weather events, common to Bonaire, will result in debris to become scattered across the sea floor nearby (e.g., the heavier elements such as the proposed glass wall), but also further away (e.g., wooden elements, waste present at the facility). Furthermore overloading of the proposed sewage/ drain water system during storms is expected.

Pollution resulting from proposed activities (kitchen, bathrooms, dive shop and bar)

Main concern: the facility will cause an unacceptable flow of waste/ debris to its surroundings

Proposed mitigation measure(s): sewage connection, storm water drain, use of degradable products

The future usages of the pier include a bar/restaurant and presently unknown functions related to the planned inclusion of the proposed pier and associated facilities in a nearby hotel-complex. Given the variety of usages associated with the pier and the large number of persons expected to participate in these activities, disposal of sewage and waste deserve the utmost attention to prevent them from entering the nearby reef waters. Mr Visser (as expressed in his letter d.d. 07-10-2012) states that 300 people will visit the planned facilities with an expected growth of 30% per year. During "special activities" that will be held twice a month, 700 to 1300 people will be present on the premises and again a 30% increase in this number per year is predicted.

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) 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). 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.

A septic system will be placed on land to receive the waste flux of the proposed facility. Septic systems consist of two key elements, a receiving tank and a leaching system or connection to a sewage treatment facility. A sewage line carries wastewater from the kitchen and bathrooms to the underground septic tank, where heavy particles settle out of the liquid, forming a layer of sludge on the bottom of the tank. Light materials float, forming a layer of scum on top of the water in the tank. Bacteria use the solid materials, liquefying these waste products. To allow sufficient time for particles to settle and for bacteria to break down the sludge, a septic tank should be large enough to hold at least one day's flow of wastewater and provide storage for sludge and scum.

Following the specifications provided by Mr Visser (letter d.d. 07-10-2012) a conservative estimate of the water usage of the proposed facility can be made. This estimate is provided below, including estimates of minimum and maximum water usage.

	Liter	Number of people/items (minimum)	Number of people/items (maximum)	Usage	Minimum	Maximum
Toilet flush	3.5	300	1300	2	2100	9100
Automatic washer	40	2	2	4	320	320
Showers	25	50	100	1	1250	2500
Cleaning	400	1	1	1	400	400
Boats	30	1	10	1	30	300
Rainfall	100	1	1	1	100	100
General water use	5	300	1300	1	1500	6500
				Total	5700	19220

Not included
Bar
Diveshop
Kitchen
Future increase in visitors
Storm water

Data from: http://inspectapedia.com/septic/wateruse.htm)

The specifications of the septic tank that is planned for the proposed facility were provided by Mr. Visser (Section A-A, Sewerage and Sanitation System Bonaire, BON-SEW-VAC010; December 2009). The proposed septic tank has a volume of 7065 liters rendering an effective volume of 5046 liters following recommendations from the Environmental Protection Agency (EPA, USA) stating that the total volume of a septic tank should be the daily volume of waste generated plus 40% to ensure sufficient residence time of the waste within the system. Clearly, the proposed septic tank is incapable of processing the waste flow generated by the proposed facilities and the activities that will take place thereon. The calculations above were made extremely conservatively and do not include various functions expected to use a lot of water (i.e., bar, dive shop). Nor do they include the expected growth in visitor numbers as described by Mr Visser (his letter d.d. 07-10-2012).

In a later conversation Mr. Visser (d.d. 08-20-2012) has clarified that the proposed septic tanks will merely be used as a storage tank for sewage as sewage will generally be pumped directly to the Bonairean sewage system. The tank is expected to gather sewage in case the pump connecting the septic/storage tank to the sewage system breaks down. Repairs are generally conducted within 6 hrs (according to Mr. Visser's information, d.d. 08-20-2012) so that the tank should be capable of holding at least 6 hrs of waste produced by the facility. Assuming maximum occupancy without additional growth, this equals 4805 liters (see table on page 16) which would be close to the tank's operational capacity of 5046 liters. While potential problems are unlikely directly after the commencement of the project's, the expected growth in visitor number (i.e., 30 % per year) and the various factors that are currently not included in the water budget (referred to on page 16) are likely to increase the volume of waste, potentially above the capacity of the proposed system in its currents form.

Additional issues that might compromise the efficient functioning of the proposed septic system are (1) problems associated with the excessive dumping of cooking oils and grease that can cause the inlet drains to block; (2) the flushing non-biodegradable items (e.g., cigarette butts, sanitary napkins, tampons etc.) can rapidly fill or clog a septic tank, and (3) high rainfall and flooding (during storms) can all cause the system to become backed up and stop the normal operation of the tank. A "storm water drainage" system is proposed, but specifications are missing. Therefore it is unclear if the system is sufficient to adequately transport storm water (and debris) to the septic tanks and what additional loading this system entails for the capacity of the septic system as a whole. Given that the decks of both the pier as the platform will be covered by planks (as stated in the permit application, undated and response by the Bestuurscollege d.d. 11-11-2011) it is unclear how the storm drainage (which will be located under the planks) will be kept free of debris piling up under the planks to ensure its effective functioning. The choice to cover both piers and the deck on which the bars, restaurant and diveshop will be placed with wooden planks is expected to hinder the effective collection of especially small debris that will fall through the spaces in between planks and gather underneath (in case of the bars, restaurant, dive shop area) or fall directly in the ocean in case of the pier. Since no information is provided as to how far the planks will be separated from another, the issues outlined above could cause a large flux of debris into the ocean directly (on the pier) or during storms when the piled up debris underneath the planks of the bar, restaurant and dive shop sections will be washed away.

Septic systems or sewage holding tanks will operate effectively if, and only if, they are designed properly, situated in areas that allow proper operation, used only for the purposes for which they were designed, and given periodic maintenance. The US EPA estimates that 10-25% of all individual sewage systems are failing at any one time, introducing feces, detergents, endocrine disruptors, and chlorine into the environment (Hanson et al. 2003). Even a properly operating system will discharge nutrients (phosphates and nitrates) and some bacteria or viruses to the ground and nearby ocean water according to a variety of studies and findings of the Environmental Protection Agency (EPA 2001). An improperly maintained or failing system will discharge even more contaminants to the surrounding. When nutrients such as nitrogen and phosphorus are discharged from septic systems into the surrounding water, they contaminate drinking water supplies, and also represent a potentially important nonpoint source of pollution. Nowhere is information provided on how the potential malfunctioning of the septic tank will be monitored so that problems mentioned above could occur without being noticed.

Conclusion: The proposed sewage system might be too small for the proposed facility in time. While its capacity seems sufficient to support the facility during the beginning of the project, expected increases in visitor numbers as well as various functions currently not included in the waste water budget might render the holding tank too small during times when the sewage pump itself it out of commission or cannot be repaired within 6 hrs Based on experiences elsewhere (see above), this system, when not maintained properly, could eventually introduce a certain amount of pathogens (associated with sewage), nutrients and chemicals into the environment leading to potential occurrences of diseases, algal proliferation and general deterioration of the marine habitat.

DIVESHOP

Main concern: divers and dive-operations negatively impact local reefs

Proposed mitigation measure(s): none

The owner has expressed his intention to start a diveshop/ -school on the proposed premises (see: permit application, undated and response by the Bestuurscollege d.d. 11-11-2011), but no information is included as to where this diveshop will be located, how many divers/ students are expected to use the facilities and whether dives will be conducted in front of the proposed facility.

In short, new information has become available that diving and the infrastructure to support it are not as harmless to the environment as previously assumed. For example, recreational divers “hit” the bottom between 35 and 304 times per half hour dive time (Hariott et al. 1997). Most divers damaged no coral (0.6 per dive to 1.9 per dive), but a small minority of divers broke between 10 and 15 corals each per 30 minute dive. Therefore at intensively dived, coral-dominated sites (which are common in Bonaire), the potential exists for considerable environmental impact as the number of recreational divers increases beyond present levels, i.e., by the addition of yet another dive school. Another study, conducted on Bonaire, reports that diving pressures on Bonaire were already unsustainable > 10 yrs ago (Hawkins et al. 1999). Diver-related rates of abrasion rendered corals on Bonaire more susceptible to disease, thus mediating their decline. The Hawkins et al. study (1999) shows that even relatively low levels of diving can have pronounced effects manifested in shifts in dominance patterns and loss of overall coral cover. Bonaire's reefs have among the highest coral cover and greatest representation of ancient coral colonies of reefs anywhere in the Caribbean. Conserving the character of these reefs may require tighter controls on diving intensity (Hawkins et al. 1999). These expectations (i.e., that high numbers of divers have detrimental effects on Bonairean reefs) were confirmed in an island-wide study on the island (IUCN 2011). Clearly, Bonairean reef communities experience unsustainable damage from the high number of divers and consequently the assumed increase in their number (expected as a result of the opening of the proposed dive shop) will further impact the island’s reefs.

In addition, the dive shop will largely increase the volume of water used by the facility as a whole and add to the volume of waste water that needs to be processed by the under capacitated waste water system (see: previous page). While information has not been provided, the following general impacts are expected from the proposed dive shop: (1) dangers resulting from the operation of a dive shop and a pier where boats can moor within the same complex; information on how the potential routes used by divers and boats are spatially separated are not provided (in case diving takes place directly at the facility); (2) the use of cleaning products related to gear maintenance, how will these be prevented from ending up in the ocean?; (3) all other environmental effects of running a maritime operation such as a dive school (e.g., oil leakage of boats, cleaning of boats with chemicals etc.).

Conclusion: Insufficient details were provided by Mr. Visser to assess what impact the future establishment of a dive school on the proposed location will have, but various issues discussed above could be expected to damage coral reefs near and away from the facility to some degree depending on its final design and visitor numbers.

BOATS: YACHTS, BOATRENTAL AND WATERTAXI

Main concern: boat related activities negatively impact local reefs

Proposed mitigation measure(s): none

Information on the future use of the proposed pier by boats is primarily provided by an overview drawing referred to as "Situatie" (Designed by: Cashman E, Drawn by: Karel Visser; PR-ST). The pier is expected to provide room for ten boats measuring approximately 7 (l) x 2 (w) Environmental impacts of recreational nautical activities (including those of boats this size) were recently evaluated by a European team of consultants (European Commision 2007). These broadly concluded that 6 main environmental impacts by boats exist that should be considered in impacts assessments such as this one: (1) Hydrocarbon releases and other substances: though releases by fishing, shipping and passenger small vessels represent only a small share (2%) of overall hydrocarbon releases from land-based activities, maritime transport and other sea-based activities, and natural deposition. (2) Oily and bilge water: unburnt or incompletely burnt fuel, particulates and traces of oil are released into the environment. These might accumulate locally, especially when boats are stationary, which results in an oil film on the surrounding water. (3) Noise disturbance: when operated at speed close to the shore, engine noise is perceived as a nuisance in sensitive areas such as beaches or natural protected areas. (4) Sewage and grey water: grey water (washing waters) from recreational craft contains a wide range of chemicals and fats and is often released into the sea. (5) Antifouling paints: The biocide agents they contain might be toxic for the environment but their use is (generally) regulated. (6) Physical damage to the environment (anchorage and prop wash).

Vessels operating in shallow water to access docks may cause a resuspension of bottom sediments and may physically disrupt aquatic habitats, such as bank and shoreline (Barr 1993) and SAV through "prop dredging" (Burdick and Short 1999). Barr (1993) identified a number of potential impacts to aquatic ecosystems from resuspension of sediments caused by vessel activity, including reductions in primary productivity (e.g., phytoplankton and SAV), alteration of temperature, dissolved oxygen and pH of the water, abrasion and clogging of fishes gill filaments, and reductions in egg development and the growth of some fishes and invertebrates.

Outboard motors associated with boating have long been associated with contamination of waterways. Milliken and Lee (1990) provide a good summary of the early literature. Petroleum products consist of thousands of chemical compounds that can be toxic to marine life including polycyclic aromatic hydrocarbons (PAH), which can be particularly damaging to marine biota because of their extreme toxicity, rapid uptake, and persistence in the environment (Kennish 1998). PAH have been found to be significantly higher in urbanized watersheds when compared to nonurbanized watersheds (Fulton et al. 1993). By far, the largest amount of petroleum released through human activity comes from the use of petroleum products (e.g., cars, boats, paved urban areas, and two-stroke engines) (ASMFC 2004).Two-cycle engines release up to 20% unburned fuel along with exhaust gases (Moore, 1998). Moore (1998) compared the PAH output from a two-cycle outboard engine with that from a four-cycle engine. Discharge from the two-cycle contained five times as much PAH from a four-cycle engine, and generally considered acutely toxic. Albers

(2002) notes that PAH concentrations in the water column are "usually several orders of magnitude below levels that are acutely toxic", but those in sediments may be much higher. PAHs related to boating activities probably accumulate in bottom sediments (Sanger et al. 1999) where they may be stirred up by boat traffic (Albers 2002).

Conclusion: Based on the expected boating impacts overviewed in a comprehensive study ordered by the European Union, it becomes obvious that the environmental impacts associated with nautical activities, such as those proposed by Mr. Karel Visser, could in theory be many. Specific information on boat use is currently lacking (other than the proposed scenario's whereby boats are allowed to moor at the pier during the night or not) which makes it difficult to assess to which degree all the concerns listed above are relevant to the proposed facility. Nevertheless, given the relatively large number and size of the boats, the following issues are expected to occur: (1) gradual built up of hydrocarbons and chemicals in the sands at the location through spillage of oil- and bilgewater as well as chemicals used for boat cleaning; (2) prop wash whereby the sands on the bottom are stirred up by the propellers of moving boats resulting in undesirable sediment plumes that could affect downstream marine communities; (3) potential risks associated with conducting both dive- and boat operations in a relatively small area and (4) structural concerns related to way the boats are tied up. Currently, boats are connected to the pier by a set of simple ropes attached to their stern. It seems unlikely that such system is sufficient to keep the boats in place when wakes pass resulting from passing boats or boats trying to dock at the same pier.

CONTAMINANTS: DEBRIS, CLEANING PRODUCTS AND LIQUID WASTE

Main concern: damage to marine life

Proposed mitigation measure(s): use of biodegradable materials, glass fence and ridge on pier to prevent debris from entering the ocean, clean ups using divers

Contaminants of concern from discharges are nutrients, heavy metals and specific organic compounds. The constituents of sewage are human pathogens, nutrients, organic carbon and - if the source of the sewage is combined oils, greases and chemicals that enter the sewage stream both from household use and storm water runoff. Local experience has shown that when a bar is located on or near a pier (e.g., Karel's Bar, the Octopus Bar, Waterfront Arches, Pirate Bay, Kokomo, Seaside Terrace) trash ends up in the water as a result of recreational activities on the pier. Hence, and despite presumed efforts to minimize the flow of waste towards the ocean, the fact that piers and the activities thereon increase the amount of waste entering the water is undeniable.

The large number of people (up to 1300 d^{-1}; as expressed in Mr. Visser's letter d.d. 07-10-2012) 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. It is presently unclear how the proposed facilities aim to address this concern other than by installing a glass fence (1.4 m high) around the perimeter of the facility's "plateau", i.e., the area where the bars, restaurant and dive shop are planned (as described in the letter of Mr. Visser, d.d. 07-10-2012). This fence will likely reduce some of the waste that will enter the ocean, but the greatest potential for debris entering the ocean likely exists at the pier itself that will only be equipped with a 4 to 6 cm high "wall" to prevent waste from entering the ocean. This is for sure not sufficient to retain waste (examples described above) and prevent it from being blown into the ocean given the wind gusts typical for Bonaire which generally exceed 18.6 m/s (climate summary Bonaire, from: www.meteo.an). Much of the waste entering the ocean will be transported down current and hence reach areas that represent greater ecological values than those surrounding the proposed facility at present (IUCN 2011). Litter has become more and more serious problems in recent times. It consists mostly of plastic waste discarded from centers of dense human population and fishing vessels. Another, more localized, source is tourism which is increasing worldwide particularly in tropical countries. Litter accumulates on beaches and in shallow water habitats. The thousands of tons of plastics discharged into the marine environment constitute a considerable source of marine contaminants that affect marine wildlife, particularly turtles, mammals and birds, through entanglement and ingestion (GESAMP 2001). Entanglement and ingestion of marine debris by marine species is known to affect individuals of at least 267 species worldwide, including 86% of all sea turtle species, 44% of all seabird species, and 43% of all marine mammal species (Laist 1997). Plastic debris may be ingested by seabirds, fish and invertebrates, sea turtles, and marine mammals, which can obstruct the animal's intestinal tract and cause infections and death (Cottingham 1988). A study of marine debris ingestion by seabirds in the southern Atlantic Ocean found that 73% of all birds sampled had ingested some type of marine debris, and plastics composed 66% of all debris occurrences (Copello and Quintana 2003).

Litter also has repercussions on coastal economic activities, particularly tourism (GESAMP 2001). Plastics, notably polyethylene and polypropylene, account for the major part because of their poor degradability. A comparison of the accumulation of marine debris among locations is however complicated by differences in the intensities and periods of study and the methods of classifying debris and beach substrate. Nevertheless, it is obvious that marine contamination by buoyant and neutrally-buoyant debris is ubiquitous. Even pristine environments located far from man-made sources, such as the Southern Ocean and the bathyal plain, are no longer free of marine debris (GESAMP 2001). Given that much of the debris will float and become dispersed by currents, diver led clean-ups are not considered to control or remove all of the trash and debris that enters the ocean. Such mitigation actions are foremost effective at the removal of trash and debris that sinks which is expected to be a minute fraction of the total amount of trash/ debris that is expected to end up in the ocean.

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 (but probably also dive gear/ the dive shop and boats that will moor at the facility), which is to some degree largely open structure (i.e., most of the substances used will pass through the openings separating the planks that make up both the deck of the pier as well as those covering the area in which the bars, restaurant and dive shop are planned) that facilitates the leaching of chemicals, will cause the input of cleaning products as well as nutrients (e.g. phosphates), to the water.

The influx of untreated sewage and other house-hold derived waste fluxes is presently already alarmingly high and advances in waste water systems to prevent waste water from coastal developments entering the ocean are poor at best at a regional scale. Around 80% of the waste water discharged into the Caribbean Sea is untreated (UNEP 2006). An estimated US$ 56 billion is needed annually to address this enormous waste water problem at a global scale. However, the costs to coral reefs, tourism and losses in fisheries and human health risks may be far more expensive. Waste water treatment is also one of the areas where least progress is being made globally. Many marine species are highly sensitive to temperature changes and dissolved oxygen, making them highly vulnerable to climate change and pollution (Dodds et al. 2007). This, in turn, makes them vulnerable to diseases (Hall-Spencer et al. 2007). The poor management of sewage not only presents a dire threat to health and ecosystems services, it may also increase poverty, malnutrition and insecurity for the people that depend on coastal resources (UNEP 2006). Nutrient exports to the marine environment are projected to increase at least 14% globally by 2030 (UNEP 2006) and are expected to increase equally or even higher on Bonaire given the strong increase in population density over the last decades. Generally, an increased influx of nutrients/ sewage to the island's near shore habitats will have serious effects on the islands marine resources and severely exacerbate the effects of extreme weather, the ability of coral reefs to resist and recover from climate change and reduce the productivity of coastal ecosystems.

Though all the above holds for Bonaire as a whole and is not specifically referring to the proposed facility, it is expected that, given the number of people that will visit the proposed facility, the large number of functions it will fulfill in combination with the fact that much of the above will occur above the water (i.e., on the pier), the proposed activities will significantly contribute to an undesirable increase in waste, chemicals and nutrients to the waters around Bonaire. These reefs are currently in decline (see: Steneck and Arnold 1999, IUCN 2011) and the proposed facility is hence not solely responsible for the ongoing degradation of Bonaire's marine resources, but simply adds to the existing suite of stressors that synergistically contribute to the rapid decline of the island's coral reef systems

The problems that will follow from nutrient pollution from phosphates (as expected here from the many types of cleaning activities) are particular reasons for concern as shown in a recent study (on Bonaire) by Den Haan (unpubl. data). In short, anthropogenic eutrophication from sewage and land runoff results in increased nutrient loading on coral reefs, notably in the form of nitrogen and phosphorus. Testing the effects of increased nitrogen and phosphorus availability on the growth of 6 commonly found algal species on Bonaire, Den Haan and colleagues observed that algal growth was foremost limited by the availability of phosphates in the overlying water column. In other words, while nitrogen is widely available in Bonairean water (and also a sign of nutrient pollution), the amount of phosphate is currently limiting (explosive) growth of algae on Bonairean reef systems. Hence, even small additions (as expected to occur at the proposed facilities) are not only expected to favor algal growth in the water column (phytoplankton) and on the reef bottom (i.e., benthic algae) near the proposed facility, but also further downstream where better developed coral communities are currently present, hence further degrading the coral reefs on Bonaire by increasing algal abundance. There is evidence that eutrophication has led to increased incidence, extent, and persistence of blooms of nuisance and noxious or toxic species of phytoplankton; increased frequency, severity, spatial extent, and persistence of hypoxia; alterations in the dominant phytoplankton species and size compositions; and greatly increased turbidity of surface waters from planktonic algae (O'Reilly 1994). Heavily developed watersheds tend to have reduced storm water storage capacity, and the various sources of nutrient input can increase the incidence, extent, and persistence of harmful algal blooms (O'Reilly 1994). Interestingly, the detrimental effect of anthropogenic additions of phosphorus to the near shore marine environment has gained attention of policy makers in the Wider Caribbean who acknowledged its detrimental effect in a Draft protocol on Land Based Activities (LBA) being negotiated under the Cartagena Convention by the Regional Coordinating Unit for the Caribbean Environment Programme which was adopted on Aruba in 1999.

Conclusion: Due to the fact that much of the proposed facility will be located above the water in combination with the large number of people expected to visit the establishment, the expected influx of nutrients and chemicals (largely from cleaning activities) and trash will be large. Both contaminants will be moved by local currents to downstream marine communities that will be negatively impacted through increased algal growth (resulting from euthrophication) and increased mortality of turtles, mammals and birds through entanglement and ingestion of plastics.

UNDERWATERLIGHTS

Main concern: disturbance to (behaviour of) marine life

Proposed mitigation measure(s): none

Fish use visual cues for spatial orientation, prey capture, schooling, predator avoidance, and migration. The reduced-light conditions found under an overwater structure limit the ability of fish, especially juveniles and larvae, to perform these essential activities (Hanson et al. 2003). In addition, the use of artificial lighting on docks and piers creates unnatural nighttime conditions that can (1) increase the susceptibility of some fish to predation, (2) interfere with predator/prey interactions, (3) disrupt the behavior of sea turtles that will avoid such areas for nesting and (4) disorient the navigation capabilities of recently hatched sea turtles (Witherington et al. 2000, Nightingale and Simenstad 2001).

Conclusion: The proposed underwater lights are expected to severely disrupt the natural behavior of a large number of marine organisms that occur in the area.

SOUND POLLUTION RESULTING FROM BOATS

Main concern: disruption of natural behaviour of local marine life

Proposed mitigation measure(s): none

Even small boats with large outboard motors can produce sound pressure levels in excess of 175 dB (WSDOT 2006). Exposure to low levels of sound for a relatively long period of time, or exposure to higher levels of sound for shorter periods of time, may result in auditory tissue damage in fish, though recovery is generally possible within 24 hrs (Popper et al. 2005). Compared to data for the effects of exposure to sound on fish hearing capabilities and the ear, there are even fewer peer-reviewed data regarding effects on other aspects of fish anatomy and physiology, though oscillations induced by high sound pressure levels can cause swim bladders in fishes to tear or rupture (Hastings and Popper 2005). Whereas it is possible that some (although not all) species of fish would swim away from a sound source, thereby decreasing exposure to sound, larvae and eggs of fish (and also corals) are often at the mercy of currents or move very slowly. Data are limited concerning the effects of sound on developing eggs and larvae for nearly all marine taxa and effects differ enormously among species (Banner and Hyatt 1973). In conclusion, because sound plays a role in the ecology and physiology of various marine taxa (e.g., Simpson et al. 2004; Simpson et al. 2005; Vermeij et al. 2010), the disruption of the native sound spectrum in an area may have an impact on local marine communities. Similarly, the sound associated with the "special activities" (mentioned in Mr. Visser's letter d.d. 07-10-2012) where up to 1300 people will be present on the pier during parties or other festivities, is likely to have a similar disruptive effect on local marine communities.

Conclusion: The potential (though likely) negative effects of the sound produced by the increased local boat traffic will add to already existing sound pollution due to the many boating activities in the area (including nearby recreational and fishing harbors, waterskiing, general boat traffic, the presence of a nearby cruise boat terminal and a commercial harbor).

BEACH CONSTRUCTION

Main concern: disruption of natural currents and sediment regimes

Proposed mitigation measure(s): none

East 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. Alongshore sediment transport may also be affected in the near shore environment if material placed on the beach is not compatible with natural or historic material. In addition, near shore rock groins are sometimes constructed in order to reduce erosion of the nourished beach, which alters the down drift of sediment and may starve adjacent beaches of sand. It should be noted that the interactions of seawalls (such as the proposed concrete foundation) and beaches are not completely understood at this time (e.g., Kraus et al. 1995). The expected impacts were therefore assessed based on the best available information.

Conclusion: not enough information is provided to adequately assess the environmental effects of the construction and/ or formation of a beach next to the proposed facilities.

Archaeological aspects

Main concern: destruction of historically important artefacts

Proposed mitigation measure(s): none

The area has been intensively used in the past. Near shore development and former anchorage by boats have modified the environment to such degree that historic artefacts are longer expected to be present.

Conclusion: The proposed facility is unlikely to result in any form of destruction to historically important resources.

CONCLUSIONS

This document should be viewed as an expert judgment that evaluates current knowledge given a very short period of time for this advice. It strives to present a comprehensive overview of what impacts can be expected from the proposed facility by Mr. Visser. No assessment is made as to judge whether the considerable impact that is associated with the proposed facility and its future functions can be considered acceptable or not. This needs to be decided based on locally applicable laws and regulations. Furthermore, based on the information provided, it is often difficult to provide a realistic assessment of the impact that the proposed facility and its future usages will have on the environment. Nevertheless, various elements of the proposed facility are considered particularly detrimental to the marine environments and organisms therein. While their individual effect might be considered minimal, the fact that many stressors occur in one area causes a multiplicative effect resulting in a wide variety of stressors at one particular location. Of particular concern are:

(1) The fact that the proposed structures are largely incapable of withstanding severe storm events.
(2) The fact that the proposed septic system might not be capable of processing the expected flux of waste products which potentially leads to an increase of pathogens and nutrients in the waters bordering the proposed facility.
(3) The fact that the large number of people, expected to be present at the pier above the water, will cause an uncontrollable flux of debris that will partly sink, but also float to reef communities further away. Especially plastics are expected to cause birds and turtles to become entangled or die after they ingest these items.
(4) The use of cleaning products above the water in combination with what seems like a suboptimal drainage system will cause an influx of phosphates into the water leading to uncontrolled algal growth near and away from the facility.

Not considered, but potentially adding to the negative impact that the proposed facility will have on the marine environment are (1) the fact that the pier will likely be used by fishermen resulting in a local increase in fishing pressure and (2) the possibility that the place could accidentally burn down resulting in a large flux of various forms of waste to the water.

Special notion should also be given to the local water quality that is expected to be poor. Especially, the misting of water might cause a health risk as waterborne pathogens could now easily be inhaled.

It also needs to be stressed that the concerns outlined in this document are often also applicable to other facilities that are already present on Bonaire.

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