SECOND REPORT BY CARMABI REGARDING THE JAN KOK OIL SPILL AUGUST 28TH 2012

II. EFFECTS ON CORAL REEFS

His report is solely intended to describe the effects and future ecological consequences of the oil spill that occurred in August 2012.

WHAT HAPPENED?

Since August 16th 2012, local authorities (Coastguard, Havendienst, Oil response coordinator etc) were warned that a large had occurred at the oil facility at Bullenbaai. The concerns were repeated but hardly any action was taken. Later in the week, while tropical storm Isaac, caused unusually strong south winds, much of the oil got trapped in the northwestern corner of Rif Marie where it entered the saliña of Jan Kok through a manmade canal. Serious responses to the ongoing disaster were started on Saturday, August 25th, almost a week after the spill had occurred.

CORAL REEFS IN THE AFFECTED AREA

The coral reefs of Curaçao represent one of the best reef systems left in the Caribbean at present. However, this does not mean that these reef systems are doing well. On the contrary: increased coastal development has resulted in pollution of near shore waters through the release of (untreated) sewage, nutrients and chemicals and overfishing represent some of the factors that have contributed to a near 20% decrease in the abundance of corals on the island in the last 25 years. Fish communities have been impacted similarly through uncontrolled fishing practices and

Curacao presently holds an intermediate rank among Caribbean nations in terms of fish abundance. Coral reef systems provide the foundation for the island's tourism and fishing industry and protect near shore developments against storms. Furthermore, healthy reefs prevent the rise of disease-causing bacteria in near shore waters preventing people, locals and visitors alike, from becoming ill. At the current rate of decline, coral reefs will have virtually disappeared around Curacao around the year 2060. Presently, it is estimated that Curaçaoan reefs bring in at least $1.6 million per kilometer per year through revenue from tourism, fishing and coastal protection alone. The decline of reefs will thus come with severe economic consequences for a recently formed country that finds itself still in a position to avert such catastrophe.

Coral reefs are an important aspect of Curaçao's identity. Coral reefs are traditionally used for fisheries, recreation, provide coastal protection, prevent beach erosion, support tourism based economies and prevent the emergence of waterborne diseases. Coral reefs are productive and biologically diverse ecosystems that, despite the fact that they globally cover only 0.2% of the ocean floor, support an estimated 25% of all marine life. In a way, coral reefs are like a bank account that when in "good shape" produces "more" through interest. A healthy system whether a reef or a bank account is simply more productive on the long term and should therefore be kept in such "healthy" (i.e., productive) state to ensure its long-term contribution to an island's economy and the ability of the system to renew itself.

Unfortunately, coral reefs face worldwide degradation, such that today we have already lost 27% of the world's reefs through a combination of natural and, more importantly, human impacts . If present rates of destruction are allowed to continue, 60% of the world's coral reefs will be destroyed over the next 30 years. Runoff, pollution, tourism overuse, destructive fishing and climate change are among others contributing synergistically to these trends and are, more and more also occurring on Curaçao.

Reefs provide a variety of goods and services, which create economic benefits to society. These economic benefits are often taken for granted, yet if these goods and services were taken away or destroyed, we would be forced to provide other methods to supply these benefits at significant costs. Presently, a kilometer of healthy Caribbean reef is estimated to generate approximately $1-1.5M annually through coastal protection, fisheries and tourism alone.

Curaçao is no exception to the trends outlined above and coral reefs, as well as the benefits they provide are in a state of decline. From a Caribbean wide perspective, Curaçao still harbors some of the best reefs in the region providing the island a unique opportunity to take advantage of the economic benefits coral reefs provide as well as to protect a unique ecosystem that is becoming increasingly rare elsewhere in the Caribbean.

The reef flat adjacent to Boka Sint Marie shelters luxurious coral communities which cover more than 50% of the bottom (MJA Vermeij & VF Chamberland, pers. obs.). Furthermore, the coral reefs included in this proposal shelter dense thickets of Elkhorn coral that sustain major ecological processes as gross community calcification and nitrogen fixation. Dense populations of this branching species dissipate wave energy and thus protect the coast (Mumby et *al.* 2008). Elkhorn coral also ensure healthy and productive reefs by providing shelter to an enormous amount of other reef organisms (Gladfelter & Gladfelter 1978), including both adult fish and their juveniles (Nagelkerken 1974). The deeper fore-reef near Boka Sint Marie is characterized by high coral cover and coral communities are dominated by species of the *Montastraea* species complex. *Montastraea* dominated fore-reefs provide shelter numerous other reef species, including herbivores, planktivores and predatory fish (Mumby et *al.* 2008) and are involved in biogeochemical and physical processes, such as community calcification, nitrogen fixation and wave energy dissipation.

THE ECONOMIC CONSEQUENCES OF REEF DEGRADATION

The dramatic future painted for coral reef is often dismissed and considered as “unrealistic” or “unlikely to occur”. However, several Caribbean locations have now experienced the consequences of sudden reef degradation (i.e., “collapse”) and found out three things. First, when reefs collapse, they often do so unexpectedly as factors till then believed to be unimportant, turn out to be crucially important to maintain the functioning of coral reef systems. A precautionary approach to reef protection is hence crucial. Secondly, once reefs degrade and one realizes what is lost, it is generally too late to reverse the downward spiral of reef degradation and lastly, the services provided by reefs (e.g., tourism, coastal protection) are lost and therefore reef degradation turns out to be costly as such services need somehow be replaced. Below are a few examples, of scenario’s that have occurred elsewhere and are not unlikely for Curaçao should the island’s reefs degrade further in the future.

The Dominican Republic depends on its beaches to attract tourists, but it's the reefs that keep the shoreline from eroding. Without reefs, the beaches disappear which has a huge impact on tourism. Researchers found that for each meter of beach a resort loses the average per-person hotel room rate drops by about $1.50 per night. So if beaches continue to erode at the current rate, the Dominican tourism industry stands to lose $52-100 million in revenue over the next decade.

A 2003 study found that overfishing at landing sites on Jamaica's north coast led to a 13 percent decline in total fish catch volume and a 17.3 percent decline in fish catch value between 1968 and 2001. Scaling this up to the national level suggests that Jamaica's failure to effectively manage its fisheries cost the country US$1.6 billion in lost revenues over the period from 1975 to 2000.

The fact that healthy ecosystems provide more substantial tourism revenue than other "tourism branches" (e.g., mass tourisms, cruise tourism) is probably best illustrated by a recent study from Belize. In 2007, reef- and mangrove-associated tourists spent an estimated US$176 to $265 million on accommodation, reef recreation (e.g., diving), and other expenses in Belize. Combined, these result in a total economic contribution of US$205–$299 million from coral reef- and mangrove-associated tourism in 2007 which corresponds to approximately US$1M per kilometer of reef per year. Belize's cruise industry, by comparison, brings a high volume of tourists—620,000 in 2007—but has a very small economic impact (i.e., US$5.3 to $6.4 million) compared to the overnight sector. Hence, while the negative impacts of cruise tourism affect coastal and marine areas disproportionately, these areas reap very little economic benefit from the industry.

Improvement in the collection and treatment of wastewater from coastal settlements benefits both reefs and people through improved water quality and reduced risk of bacterial infections, algal blooms, and toxic fish. Estimates show that for every US$1 invested in sanitation, the net benefit is US$3 to US$34 in economic, environmental, and social improvement for the nearby community.

There are many more examples of the associated costs and benefits that coral reef systems provide to small Caribbean islands. The ones above only show that what might happen once reefs degrade has become reality in localities where protection efforts were begun too late. It is also evident that a failure to protect one's marine resources comes with substantial economic losses.

PROTECTION STATUS

Rif-Sint Marie was given the "Conservation" status in the island's zoning plan locally known as the EOP ("Island Development Plan"; AB 1995 no. 36), which became effective on May 23, 1997. The conservation destination is attributed to areas with a scientific, historic, cultural or scenic value. The area was recently (August 2012) proposed as a RAMSAR area by the local government. RAMSAR is an international treaty to protect wetlands of special ecological value and is comparable to the UNESCO designation of Willemstad's historic center.

EFFECT OF OILSPILL ON CORAL REEFS

The negative effects of oil spills on coral reefs have been widely documented. Again, the reef in the affected area was in unusually good condition (one of the few on Curacao) and now faces severe degradation along (at least) 2.5 kilomers of coastline. The information to support this claim is widely available and some examples are given below:

Prior to the 1980's, large *Acropora palmata* (Elkhorn coral) colonies dominated coral communities in shallow reefs (> 4 m depth) across the Caribbean. Due to its abundance and branching morphology, *A. palmata* fulfills an essential role in the maintenance of healthy and productive reefs by providing shelter to an enormous amount of other reef organisms. Dense populations of this branching species also yield important physical benefit as they are known for their great wave energy dissipation capacity and thus protection of coastal areas. Due to a disease outbreak, the abundance of *A. palmata* has severely decreased throughout the Caribbean during the last 30 years and declines in abundance are estimated to more than 97%. As in the wider Caribbean, the shallow reefs of Curaçao have impoverished considerably in the past four decades. Data from 2011 indicate that the area affected by the oil spill still harbored continuous areas of *A. palmata*. Locally, it covers up to 75% of the shallow reef bottom and formed aggregations of large stands measuring more than 4 m^2. Preliminary results from other locations on Curacao indicate that the decline of *A. palmata* negatively affects local fish abundances. It was estimated that the shallow fish biomass was reduced by 67% and that one third of the species diversity was lost. The demise of this dominant structural framework builder has likely caused a corresponding reduction of their ecosystem functions, e.g., as a provider of habitat structure and complexity to other reef organisms.

The same coral mentioned above releases larvae only once a year and this happened approximately 2 weeks before the spill, meaning that larvae of this species (which is abundant at the affected site)

were present in the water column during the spill. Coral reproduction and early life stages are particularly sensitive to oil.

Sub-lethal detrimental effects of crude oil were studied on coral in a long term laboratory experiment. The experimental system consisted of four 1500 l. capacity tanks, two of which were periodically polluted. A significant decrease in the number of female gonads per polyp was recorded in 75% of the colonies in the polluted tanks. It is concluded that chronic-oil pollution damages the reproductive system of scleractinian corals (Rinkevich & Loya 1979).

Although conflicting reports continue to appear in the literature, growing evidence indicates a detrimental influence of oil pollution on coral-reef communities. Laboratory experiments and long-term field studies in the Red Sea witness detrimental effects of oil pollution on reef corals, such as complete lack of colonization by hermatypic corals in reef areas chronically polluted by oil, decrease in colony viability, damage to the reproductive system of corals (smaller number of breeding colonies, decrease in number of ovaria per polyp, fewer planulae per coral head and premature planulae shedding), lower life expectancy of planulae and abnormal behavioural responses of planulae and corals. Other detrimental effects on reef corals caused by crude oil, reported from the Caribbean, include lower growth rates, direct damage to tissues, thinning of cell layers and disruption of cell structure. damage to tactile stimuli and normal feeding mechanisms, excessive mucus secretion leading to enhanced bacterial growth and eventual coral destruction (Rinkevich and Loya 1980).,

In 1986 crude oil spilled into a complex region of mangroves, seagrasses, and coral reefs just east of the Caribbean entrance to the Panama Canal. Many populations of plants and animals in both oiled and unoiled sites had been studied previously, thereby providing an unprecedented measure of ecological variation before the spill. Intertidal mangroves, algae, and associated invertebrates were covered by oil and died soon after. More surprisingly, there was also extensive mortality of shallow subtidal reef corals and infauna of seagrass beds. After 1.5 years only some organisms in areas exposed to the open sea have recovered (Jackson et al. 1989). Numbers of corals, total coral cover, and species diversity based on cover decreased significantly with increased amounts of oiling. Cover of the large branching coral *Acropora palmata* decreased most. Frequency and size of recent injuries on massive corals increased with level of oiling, particularly for *Siderastrea siderea*. Growth of three massive species (*Porites astreoides, Diploria strigosa,* and *Montastraea annularis*, but not *S. siderea*) was less at oiled reefs in the year of the spill than during the 9 previous years. Subtidal

coral reefs, particularly those along protected coasts, suffered extensive damage from chronic exposure after major oil spills (Guzman et al. 1989). Oil that is now entrapped in sediments is expected to reappear during future storms.

Sublethal effects of oil pollution on coral reefs may not become manifest except over very long periods of time. Uniform reefs with an *Acropora palmata* belt (2 m depth) and a M*ontastrea annularis* community (4 m depth) were originally present along the coast near an oil refinery that has been in operation for more than 60 years in Aruba. Quantitative surveys of reef structure, coral cover, and numbers of juvenile corals along 15 km of the coast showed these reef characteristics to vary significantly in relation to the location of the refinery and the very persistent local current direction. The spatial structure of the reef has deteriorated, living coral cover is low, and less juveniles are present in front and downcurrent of the refinery. Some coral species, such *as A. palmata and M. annularis*, show a large gap in their distribution along the coast but a species such as Diploria strigosa is relatively abundant in the polluted area. The results of chronic oil pollution (such as spills, clean-ups, etc.) are, after 60 years, clearly discernible over a distance of 10 to 15 km along the reef.

WHAT TO DO?

Natural Recovery seems the only possibility here. C<u>lean-up activity will likely cause more environmental damage than the oil, so natural recovery should be considered</u>. Physical containment and collection of spilled oil on water using booms and skimmers is usually the primary cleanup method used at most spills. High current speeds, heavy wave action and/or shallow water limit the effectiveness of all these methods at the affected site. Skimming operations will most likely unsuccessful as they need to be conducted outside the reef in deeper waters. It is ridiculous to anchor collection booms on the reef slope because of the added damage to the remaining reefs. Booms should be anchored in a way that does not damage coral, and tended regularly to maintain effective positioning and avoid damaging shallow coral. Sorbent booms can be deployed to catch oil leaching from shorelines, but must be tended and changed frequently so they do not become a source of oiling themselves. Dispersants are chemicals containing surfactants, like those in soaps and detergents, which have both a water-soluble and an oil-soluble component. When applied to oil slicks, they reduce the surface tension of the oil and promote the formation small oil droplets that “disperse” throughout the water column. Dispersants are sprayed directly on floating oil as a fine mist, either from aircraft or boats. Oil also disperses naturally, especially lighter fuels and oils

spilled in areas with heavy wave action; however, the droplets are generally larger and can recoalesce and re-float. Regional contingency plans that pre-approve the use of dispersants generally place greater restrictions on their use in near shore waters (including Curacao) as these substances are sometimes even more toxic than the oil itself.

ONE THING TO CONSIDER IS THE IMMEDITAE INSTALLMENT OF THE ALREADY PROPOSED NO FISHING ZONES AS FISH, ESPECIALLY HERBIVORES, WHEN NOT FISHED, CONTRIBUTE TO REEF RECOVERY AS THEY REMOVE ALGAE THAT COMPETE FOR SPACE WITH CORALS (Mumby et al. 2006).

SEE ALSO:

http://www.researchstationcarmabi.org/images/stories/file/Mark%20PDFs/Vermeij%20MJA%20(2012)%20Curacao%20State%20of%20the%20reef%202012%20Carmabi%20(c)2012.pdf

DATA FROM: CARMABI, NOAA AND UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (EPA)

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