Lac Bonaire – Restoration Action Spear Points, September 2010

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IMARES Wageningen UR

Institute for Marine Resources & Ecosystem Studies

Bonaire Marine Park (STINAPA)

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Summary

Lac Bay, Bonaire is the most important mangrove and seagrass area of Bonaire and has been undergoing steady ecological decline in the last decades. Based on an initial assessment of conservation management issue and potential solutions, as, conducted by IMARES in June 2010, the Dutch Ministry of Agriculture, Nature and Food Quality (LNV) asked IMARES to return to Bonaire to work with Stinapa Bonaire to choose narrower priorities and jointly make a short-list of topics as a working document for cooperation and action. In the beginning of September, site visits and discussions were held in Bonaire with the manager of Lac Bay and various stakeholders to identify and agree on priority issues for action. This working report gives the results of that visit.

Four action spear point projects were identified, based on urgency and feasibility based on local Bonaire and Dutch IMARES expertise. The projects are as follows:

a) Mangrove restoration demonstration pilot study
b) Baseline ecological study of the zonation of aquatic communities
c) Recreational and land use survey for Lac Bay and its catchment area
d) Study of avifaunal habitat use of Lac Bay

A project plan is presented by which all four projects can be delivered by December 2012. These projects can count on government and broad community support. In this all, Stinapa indicated to be willing to provide basic free lodging to interns and scientists at their science accommodations at the entrance of Washington-Slagbaai National Park. The ability and willingness of IMARES to recruit and guide students and interns for these projects was an important selection criterion to help restrain total project costs. The action spear points will, nevertheless, require funding as well as permits from the Island Government of Bonaire. With LNV various funding options were reviewed and discussed, and the need for permits was discussed with DROB (Dienst Ruimtelijke Ontwikkeling en Beheer) Bonaire. DROB envisioned few problems with the required permits. The visit was concluded by the joint resolve to work out ways to maintain momentum and proceed towards the implementation phase.

A fifth project for implementation by Stinapa and Dienst LVV (Bonaire Agriculture, Animal Husbandry and Fishery Service) was also identified and this relates to:

e) re-establishing water flow from the Bakuna dam to Lac using a pipe system.

The Lac mangrove channel clearing project of Stinapa was reviewed and judged to be valuable and important. The baseline study of zonation of aquatic communities (project b) is urgently needed in this respect to allow short and long-term evaluation of this project which need to become a structural part of Lac Bay management. Routine mangrove channel maintenance was identified as ideal work for involvement of Bonaire youths and volunteers, to rekindle public involvement in caring for Lac and its rich natural and cultural-historical heritage.

Terms of Reference

The mangrove and seagrass lagoon of Lac Bay on Bonaire covers an area of roughly 700 ha. It is home to rare and endangered sea turtles and the Caribbean queen conch, *Strombus gigas*, and is an important roosting site for birds. Other endangered species include the threatened corals *Acropora palmata* and *A. cervicornis* and *A. prolifera* as well as the rainbow parrotfish *Scarus guacamaya* and some IUCN vulnerable species. Based on its nature values this 7 km^2 bay has been designated as a legally protected RAMSAR site (Stinapa Bonaire 2003) and identified as a IUCN IBA (Important Bird Area) (Wells and Debrot 2008). The area is managed by the National Parks Foundation of Bonaire STINAPA Bonaire based on their recent management plan in which several issues are addressed. Nevertheless, Lac Bay is under increasing development pressure for recreational use and has been in long-term decline (e.g. Lott 2001).

Based on these concerns, the Ministry of LNV, The Netherlands, commissioned IMARES to assess the situation and come with recommendations for action. The resulting report (Debrot et al. 2010) identified a total of 18 different issues to tackle by means of action points. For an overview of the 18 action points, see Appendix 2. As a follow-up IMARES was asked to visit Bonaire again (Appendix 1) to discuss the findings with key parties and to jointly shortlist priorities into a working document for more immediate implementation.

It needs to be kept in mind that this is only a working document and that the four short list priorities should not be interpreted or used to limit or exclude possibilities, only as an aid to help focus attention and effort. In other words, only as an aid to move from idea and paper report to actual implementation. Because of the many potential and often unpredictable limiting factors at play and opportunities which may appear unexpectedly, a flexible, opportunistic approach is essential, nevertheless operating from within a framework of chosen priorities.

We like to thank the following people for their assistance, information and cooperation:

Mr. N. Oleana, Bonaire Commissioner of Agriculture and Fisheries, Frank van Slobbe from the Department of Environment and Natural Resources (DROB). Dr. Rita Peachy from CIEE Bonaire, Ton Akkerman and Hayo Haanstra from the Dutch Ministry of Agriculture, Nature and Food Quality (LNV), the Lac fishermen Dòi and Stanley, and from Stinapa: Washington Park Manager Juny Janga, the mangrove channel clearing team as led by Ton and Lac Bay-enforcement officer Papa).

Figure 1.Commissioner N. Oleana (center) answering questions on historical-cultural significance of Isla di Pedro. (Left: T. Akkerman, right: R. de León)

1 Introduction

Starting point for this exercise was the list of 18 action points from the June 2010 Lac Bay assessment by Debrot et al 2010 (IMARES Report C066.10). From these, 8 projects were identified in which students and interns were judged able to participate, given proper preparation and both academic and local guidance and support. The advantage to LNV and other parties of the involvement of students and interns for field aspects is that total project costs can be kept lower (than for projects in which students can only play a minor role). In this Stinapa is essentially willing to provide basic free lodging to interns and scientists at their science accommodations at the entrance of Washington Slagbaai National Park. The action spear points will require funding and various permits from the Island government of Bonaire. With LNV various funding options were reviewed and the need for permits was discussed with DROB Bonaire. DROB envisioned few problems with the required permits for the key action points proposed and would cooperate in providing the forms needed for permit requests, and full assistance in processing these. Other local parties spoken to and who were ready to assist or participate in various ways are Jerry Ligon (birds), Dr. Peachey of CIEE (Council on International Educational Exchange) (corals and seagrass) and Dr. S. Engel (corals and seagrass general).

Figure 2. Kas sientifiko science accommodations at Washington-Slagbaai National Park.

Figure 3. Interior view of science accommodations at Washington-Slagbaai National Park.

2 Lac Bay Action Plan Spear Point Projects

2.1 Mangrove Restoration Demonstration Pilot Study

Mangrove zonation in Lac (Figure 5) shows the same basic pattern as portrayed in the diagram presented by Lewis (2005) (Figure 4)

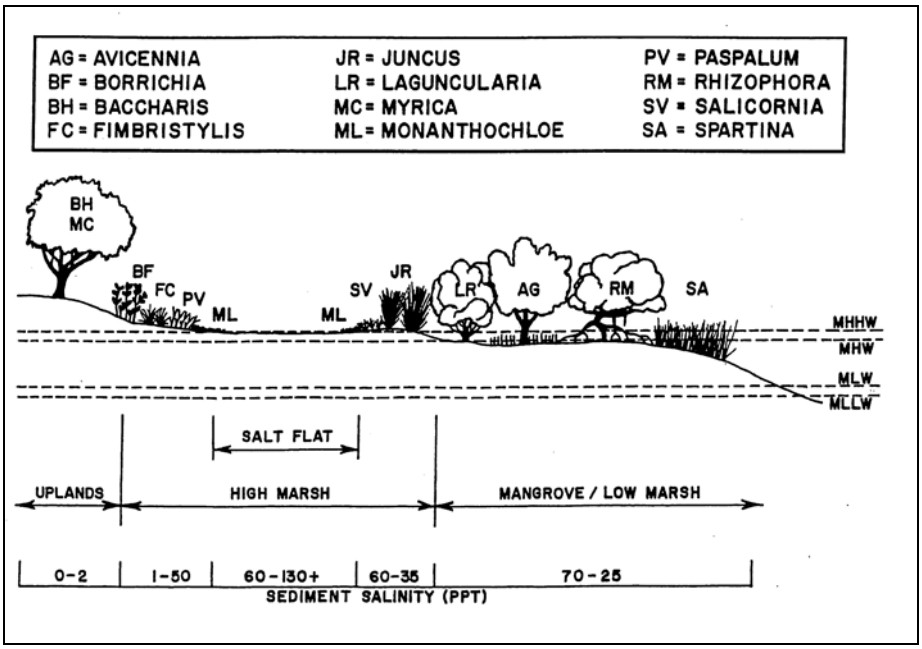

Figure 4. Zonation diagram of the mangrove ecosystem, and as found at Lac (Lewis 2005).

Figure 5. Mangrove zonation in Awa di Lodo di San Hose Lac, near one pilot study site. Left: dying Conocarpus erectus, center: dry high marsh flats; right: Avicennia germinans, the mangrove tree best capable of surviving in hypersalinity. Missing is the red mangrove, which is found under suitable conditions further towards the right, but outside the picture (in Figure 7).

2.1.1 Objectives and guidelines

At Lac the basic objective of the pilot demonstration rehabilitation project will be to reestablish water depth and tidal connection in high marsh salt areas that have resulted from infilling with sediment, and restore them as effective mangrove and low marsh fish nursery habitats. To this end areas of approximately 15 m by 50 m will be excavated to restore water depth and tidal conditions identical to nearby reference mangrove sough habitat. The areas will be fenced to exclude destruction by grazers, Along the shores of the excavated zone red mangrove propagules will be planted by schoolchildren under guidance by STINAPA. The restoration principles outlined by Lewis and Streever (2000) and Lewis (2005) are used to guide the process.

Many mangrove restoration projects cannot be appropriately assessed due to failure of experimental design (Lewis and Gilmore 2007). To this end, using "BACI" design (before, after, control, impact), a quantitative baseline study of the physical parameters, fauna and flora of the experimental, and adjacent control and reference sites will be conducted prior to all restoration activities. After restoration activities have been done, these areas will be subsequently monitored quantitatively to assess ecological change and project success. With local guidance, the field aspects of the baseline study and monitoring and basic reporting can be done by students.

2.1.2 Selection of restoration sites

Two sites were chosen for the pilot demonstration study for red mangrove reforestation and revitalization of fish nursery habitat. One lies on the land side of Kreek di Koko (Figure 6) and the other at Awa di Wanapa (Figures 7). In addition, two restoration sites were also chosen for restoration of the *Avicennia germinans* forest in a area where the main problem is overgrazing by feral livestock (goats, sheep, donkeys) (Figure 8).

Figure 6. Dr. Erik Meester and Dr. Diana Slijkerman at the Kreek di Koko red mangrove restoration site (foreground). Re-establishing productive fish nursery waters and mangrove vegetation will be based on re-establishing water depth in the sediment-filled area in the fore ground. The "reference" mangrove habitat area is located just outside the picture frame to the left.

Figure 7. Red mangrove restoration site at Awa di Wanapa. View facing figures 5 and 8 . The reference red mangrove and aquatic seagrass habitat is to the left center of the picture. The restoration area is in the foreground stretching towards the mangrove slough in the background. In-filled sediments will be removed to establish depth and tidal hydrology identical to that of the reference mangroves.

Figure 8. Reforestation demonstration pilot project area of high marsh salt flats and Avicennia germinans mangrove forest fringe. Grazing is intense in this area. Exclusion of grazer should be sufficient for the intensively trimmed Avicennia bushes (upper center) to grow out to tree stature.

By collecting baseline data before the restoration activities take place, it will be possible to monitor and compare and assess changes in fauna and flora at the restoration sites and hence evaluate the effectiveness of the measures implemented. This project can be done by IMARES students as guided on site by STINAPA.

2.2 Baseline ecological study of the zonation of aquatic communities

Based on IUCN funding for conch restoration, in the last three months, the Marine Park of Bonaire, managing organization for Lac Bay, has started restoring water flow in the former mangrove channels which have been choked shut with mangrove overgrowth (Figure 9). A four-man mangrove team is doing the initial clearing. A site visit was guided by commissioner N. Oleana. He was able to show how this work is reestablishing the ecological connection between the Lac main open water area and backwater mangrove areas which formerly had served as fish nursery areas but which had become shut-off. Once the heavy work is done, keeping the channels clear with shears and clippers is an adventurous outdoor activity ideal for volunteers. It was recommended that Papa, as part of his program of involving young people could develop such a group and take them out routinely for mangrove channel maintenance.

The Lac area is an area clearly in high and growing demand by visitors and water sporters. It is also an area of exceptional historical and cultural significance to native Bonaireans, possibly exceeded in significance only by the plantations of Slagbaai and Washington. However, while non-intrusive traditional recreational use of Lac by Bonaireans has become gradually limited, this has been replaced by touristic use that has increased dramatically to high levels, and which probably regularly exceeds local carrying capacity in both ecological and social sense (cruise tourist swimmers at Sorobon, R. de León, pers. obs). Involvement of scouts and youth rangers in activities such as mangrove channel exploration and traditional maintenance by trimming mangroves (which used to be done by fishermen) provides a possible new vehicle by which the youth can stay involved in this part of their cultural heritage. In Papiamentu this concept can be captured succinctly by the expression “biba bo kultura” (literally “live your culture”).

Figure 9. Former mangrove channels which have been grown shut for years have recently been hacked open to re-establish their nursery function.

During the site visit a clear zonation of habitats from the clear water, central seagrass area of the Bay back through the newly cleared mangrove channels was evident. The aquatic habitats of Lac (from central seagrass zone to shore) showed four principal zones.

These are:

<u>*Central clear water area of Lac.*</u>

This is the principal area of Lac with various seagrass and algal benthic communities (as well as two areas with rare shoreside coral communities dominated by the coral *Siderastrea siderea*). These areas are of key importance to the endangered queen conch (*Strombus gigas*) and green turtle, (*Chelonia mydas*), the latter of which was very numerous. The seagrasses of Lac Bay have been floristically described by van den Hoek et al 1972) and monitored (Lott 2000, 2001, Engel 2008) in recent years, but communities have not been described quantitatively. Studies on nearby Curacao show that within this

central zone, various zoned benthic seagrass and algal communities can be expected (Keunen and Debrot 1995).

The shallow-water coral areas (bay sides of isla di Rancho and isla di Pedro) were referred to the fishermen as areas of the “butishi”. This word stands for the old Dutch Jenever pottery crocks which are reddish brown in color: the same color as that of healthy *Siderastrea*. While the corals were not being overgrown, they were evidently pale and stressed. The fishermen pointed to the traditional importance of these areas in the bay to aggregations of young fish (grunts and snappers).

Eutrofied green mangrove-fringe waters

These are parts of the central lagoon areas up to about 100 meters from the mangrove fringe. The water and bentic zones were clearly greenish. Fish community composition differed obviously with the open-water areas (many more Atherinidae, different Gerridae) and juvenile fish densities were higher (also schools of juvenile “masbangu”: *Decapturus*). The aquatic and benthic algae were evidently serving the important role of converting the (coral-toxic) nutrients from the inner mangrove areas into food for the Lac fauna.

Figure 10. Greenish water and bottom growth of filamentous algae on the seaward margins of the mangrove fringe (Boka di Pos area). Juvenile fish school densities were higher than in the clear open water of Lac Bay.

Eutrofied (back-water) brown mangrove waters

These areas were accessed through the newly hacked channels and are only recently becoming more freely connected to the outer Lac Bay. The water and benthic algal communities are brown and smell strongly of H_2S which is toxic to fish (and corals). This H_2S results from the decay of organic material. Gross observation indicates that the benthic algal communities were quite different from the open water zones. Fish densities were very low (due to the poor connection with the open bay areas and probably the adverse water quality) and grossly different in species composition. Now that these areas are being reconnected, the mangrove channel team indicated that fish abundance has been improving rapidly (N. Oleana, pers. comm.).

Figure 11. Brownish mangrove tannin and H^2S-odorous waters of the interior mangroves (interior Boka di Koko).

Hypersaline mud waters of the supratidal high marsh areas

Behind the dying mangroves in the rear areas of Lac (Awa di Lodo di Bakua and Awa di Lodo di San Jose) and seawards of the areas fully filled in with terriginous sediments lie areas subject to intense annual salinity changes. These areas become hypersaline during the dry season and constitute a fourth aquatic habitat of Lac. These areas formerly formed part of the fish nursery areas of Lac but have now degraded to habitats dominated by impoverished seagrass and algal communities and impoverished fish communities dominated by *Poecilia* and *Cyprinodon*. These are food of the flamingo. As indicated elsewhere, Bonaire has no shortage of flamingo habitats around the island but does have a shortage of mangrove and seagrass habitats. In light of this and towards active measures for greater ecological resilience, for Lac the key goal for the future is to restore its coral reef fish nursery function. Now that actions are being planned to restore the mangroves and their nursery function, it is critical at this point is to establish good, quantitative baseline descriptions of these four principal zoned aquatic communities as a basis on which to be able to evaluate the long-term success and effects of the mangrove channel clearing by Stinapa.

While the channel clearing activities of Stinapa will likely yield significant benefit on relatively short term, without a baseline study, the success and effectivity of this program will always remain undocumented and in doubt. Therefore, a scientific study is needed to provide a quantitative description of aquatic community zonation as it exists at landscape level today in Lac. This will provide the framework against which large-scale community change and effectiveness of mitigation measures can be monitored and evaluated, and is one of the four spear points for action.

2.3 Recreational and land use survey for Lac Bay and its catchment area

The current use of Lac Bay has changed dramatically from about 50 years ago. Particularly in the last decade since introduction of large cruise ships to the island, recreational use of Lac and pressures on the ecosystem in terms of disturbance, pollution, and direct impacts to flora and fauna are growing rapidly and there are currently no limits set to this growth. Based on the conversations held and documented declines in seagrass bed coverage, it appears that Lac may already be at its environmental and social carrying capacities.

A baseline survey is urgently needed to map and quantify current uses, interactions with flora and fauna and potential pressures. This holds not only for activities taking place on or immediately surrounding the bay but also for land-use and agricultural practices elsewhere in the whole catchment area surrounding Lac. Such a baseline study will involve

a. field surveys to quantify and map actual use, and actual and potential interactions as related to the distribution of species and ecosystems.
b. surveys of stakeholders to assess their awareness of issues, their views and preferences for various scenarios for Lac and their willingness to contribute, comply with various management options.
c. quantification of land-use practices (bulldozing, water extraction, planting, obstruction of water flow, dumping of urban waste, livestock densities, -ownership and –distribution) in the hinterlands of the total rainfall catchment area feeding water, nutrients and contaminants into Lac.

These will help define current user pressures, key issues and options for dealing with any identified problems.

2.4 Study of avifaunal habitat use of Lac Bay.

Lac Bay is one of the five Ramsar wetland areas of Bonaire. Based on the available habitats, (especially mangroves and shallow shore areas) it is of clear importance to many migratory shore and insectivorous birds (mosquitoes breed in the mangroves). Nevertheless, the avifauna of Lac Bay and how the birds use the different available habitats remain poorly known. Only a few casual bird lists are available for the bay and its shores. Casual observations on September 2 (at the beginning of the boreal migratory season) showed the bay to be of value to hundreds of migrating barn swallows (*Hirundo rustica*) that were feeding on the leeward side of the bay on the insects emanating from the mangroves. Also during a short period of observation at one site at the end of the afternoon a total of nine fork-tailed flycatchers (*Tyrannus savana*) were observed flying overhead into the Lac mangroves (AOD, pers. obs.). This was a highly remarkable observation as confirmed by local expert birder Jerry Ligon (pers. comm.). Many pigeons, and parakeets (*Aratinga pertinax*) including several hundred palomba pretu (*Columba squamosa*) flew over head to use the mangroves as roosting habitat (e.g. Harms and Eberhardt 2003). The area is of clear local importance to both resident and migratory birds but not even orientative semiquantitative studies are available. Therefore, such work was identified as a priority for management.

3 Project Plan

Start date: 02-01-2011
End date: 30-12-2012

Team members

Name	Organization	Role
Dr. Dolfi Debrot	IMARES	Projects coordinator, local expert
Ramon de Leon	STINAPA	local expert, logistic support
Dr. Erik Meesters	IMARES	Coral reef ecologist, biostatistician
Dr. Sabine Engel	STINAPA	Sea grass ecologist
Jerry Ligon	Resident naturalist	Local bird expert
Hans Verdaat	IMARES	Quantitative bird survey expert
Peter Hofman	v Hal Larenstein	Student counsellor
Dr. Martin Pastoors	Centre for Marine Policy, IMARES	Expert marine policy
Students		Field assist. and analysis

3.1.1 Target Group and Information Needs

Dutch Ministry of Agriculture, Fisheries and Food Quality (formerly LNV), insular government, nature managers, NGOs.

3.1.2 Deliverables

In this project four studies will be conducted and reported on:

a) The minimum ecological conditions for mangrove recovery in four small areas of Lac will be re-established. Prior to this, baseline data will be taken of biotic and abiotic variables so that the effects of the interventions can be quantified and assessed. On the basis of that evaluation it can be decided if and how the results may be applied on a larger scale within Lac.
b) A scientific description will be done of aquatic community zonation as it exists at landscape level today in Lac. This will provide the framework against which large-scale community change and effectiveness of mitigation measures can be monitored and evaluated.
c) User density and pressures in Lac will be mapped and assessed and problems and potential solutions will be identified.
d) Habitat use of Lac by birds during the migratory season will be assessed: potential problems and solutions will be identified.

3.1.3 Relevancy of the project to the Ministry of LNV

High relevancy. These projects create a framework for nature restoration within Lac and implement a pilot restoration project. Prior research has shown that management intervention is required to restore and protect critical ecosystem values and services in Lac.

3.1.4 Approach and project breakdown

1. preparation, among which acquiring materials, placing fences, request permits by STINAPA
2. field visit Bonaire mangrove restoration baseline and collect community zonation data
3. working out results together with students IMARES.
4. preparation for second field visit
5. field visit Bonaire to monitor restoration, work in students survey and bird study.
6. working out results together with students IMARES.
7. Visit Bonaire to discuss and jointly with STINAPA present four reports to stakeholders.

3.1.5 Planning

Activity	months	completion
Preparation 1st field visit	1	Feb 2011
First field visit IMARES mangrove restoration baseline and community zonation data	1.5	Mar 2011
Working out results	2	Jun 2011
Preparation 2nd field visit	1	Jan 2012
Field visit IMARES to monitor restoration, work in students survey and bird study	1.5	Sep 2012
Working out results and reporting	3	Nov 2012
Visit Bonaire to discuss and present four reports to stakeholders	0.5	Dec 2012

4 Conclusions

LNV requested IMARES to visit Bonaire to help Stinapa Bonaire, manager of the Lac Bay, to shortlist priority projects for implementation towards key management objectives for Lac Bay. Based on site visits, discussions with key government officials, LNV, and the main regulatory agency (DROB), four spear points for implementation were chosen as the first follow-up from the IMARES Lac Bay Assessment of June 2010.
These projects were as follows:

The scientific and nature conservation community of Bonaire is clearly ready to support the adaptive management approach. According to commissioner Oleana, he has witnessed that in recent months the traditional and engrained views that nature protection meant that no active measures should or could be undertaken, has been supplanted by the realization that, especially in the case of Lac, active measures for restoration are essential and urgently needed. Field (1998) has before criticised mangrove ecologists for their generally intrinsic focus on research instead of using research findings in management and rehabilitation.

More and more, especially in light of inexorable global climatic change and the existence of alternate ecosystem states, traditional conservation paradigms based on assumptions of stability and stasis and past climatic conditions, have proven inadequate and insufficient (West et al. 2009). In the future, successful management of natural resources will require managers and decisions makers to think differently than in the past and abandon old paradigms and objectives in order to preserve ecosystem function (Baron et al. 2009). This transformation in insight is an encouraging development and is essential to effectively deal with the Lac issue. But the same holds for other critical issues as well, like the grazing issue which has now become of decisive urgency with a large portion of the plant diversity of Bonaire facing total extirpation within the near future unless effective measures are taken (e.g., Amigoe 2009).

Based on this visit, which included site evaluations and discussions with various stakeholders, officials and regulatory agencies, four joint projects for follow-up have been identified and agreed. These are briefly stated, as follows:

a) Mangrove restoration demonstration pilot study
b) Baseline ecological study of the zonation of aquatic communities
c) Recreational and land use survey for Lac Bay and its catchment area
d) Study of avifaunal habitat use of Lac Bay

A project plan is presented by which all four projects can be delivered by December 2012.

A site visit was also made to the water catchment dam of Bakuna. This dam was constructed by government in the 1950s for agricultural purposes. However, the water has long not served any such purpose. While theoretically such dams should foster rainwater influx into the groundwater, in practice, due to the often high clay contents in the soils in dams and poor dam maintenance, groundwater penetration may be minimal (C. Winkel, Dienst LVV Curacao, pers. comm.) . In practice then, most water held behind dams is lost through evaporation. Such massive “impenetrable” dams obstruct natural water flows prevent upstream migration of a diverse amphidromous freshwater fish and shrimp fauna (Debrot 2003a,b), and destroy the nursery function of coastal wetlands like Lac for native freshwater fauna. R. de León has a design for a simple and effective way to permit water flows, using a pipe system, without damaging the dam or preventing use of the water for agriculture, should this be desired. We recommend Stinapa and the island agricultural service (Dienst LVV) to take the measures to correct the situation accordingly.

Figure 12. The big water catchment dam at Bacuna prevents essential freshwater inflow into Lac and cuts off the ecological connection for freshwater fauna to a large hinterland catchment area. The water in the dam is from downpours the night before and would have been of great value to Lac mangroves and freshwater shrimps and fishes, were it not for its obstruction by the dam.

Figure 13. Lac Bay Action Spear Points decided (September 7, 2010). From left to right. R. de León (Manager Bonaire Marine Park and Lac), F. van Slobbe (DROB), T. Akkerman (LNV quartermaster), A. Debrot (IMARES).

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Quality assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 57846-2009-AQ-NLD-RvA). This certificate is valid until 15 December 2012. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

Justification

Rapport C131/10
Project Number: 430.82010.38

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Dr. M. de Graaf
Researcher

Signature: 

Date: 10-11-2010

Approved: Drs. F.C. Groenendijk
Head of Department Ecosystems

Signature: 

Date: 10-11-2010

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Number of appendix attachments: 2

Appendix 1: Realized schedule of Lac Meetings and Site Visits

THU 2 Sept: arrival in Bonaire KL 753, 3:25 am

a) 8:00 am, briefing (Marine park manager R. de León, LNV quarter master T. Akkerman, H. Haanstra, A. Debrot)

b) 2:00-3:00 and 5:30-7:30 pm, Lac site visit (by A. Debrot), preliminary restoration site evaluation, and migratory and roosting bird assessment

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FRI 3 Sept:

c) brainstorming at park headquarters (R. de León, Papa, Dr. R. Peachey, Dr. S. Engel, A.Debrot)

d) restoration site visit and assessment (Dr. R. Peachey, A. Debrot)

SAT 4 Sept:

e) 7 am-10 am; Lac mangrove excursion (Commissioner Oleana, R. de León, T. Akkerman and STINAPA's Lac mangrove channel restoration team leader, Ton, A. Debrot)

f) 10-11 am: mangrove restoration site visit (R. de León, T. Akkerman, A. Debrot)

g) 11-12 am: field visit to the Bakuna dam (R. de León, T. Akkerman, A. Debrot)

h) lunch meeting with (T. Akkerman, R. de León, A. Debrot)

TUE 7 Sept:

i) 9:30-11:30 meeting with Dienst Ruimtelijke Ontwikkeling en Beleid (DROB) and final decision on action restoration pilot study sites and action spear points (F. v. Slobbe, T. Akkerman, R. de León, A. Debrot)

j) 12:30- 1:30 pm: lunch meeting assessment (R. de León, A. Debrot)

afternoon, 2:00 pm departure KL 754 to Holland

THU 17 Sept:

11-12 am Den Haag: meeting with LNV to outline and discuss Lac Bay action spear points (Haanstra, Meesters, Debrot)

Wrap-up: After return to Holland, in consultation with LNV, Dolfi and Ramon finalize visit report and conclusions, and initiate implementation of processes.

Appendix 2. Overview 18 Lac Bay action points from IMARES Lac Report C066.10

Infilling and water circulation

1) The ultimate cause of the accelerated infilling of Lac is the over-grazing of the vegetation by feral live stock and detrimental land-use practices that destroy the top soil of Bonaire enhancing erosion (Coblentz 1980). A start should be made as soon as possible to tackle the livestock overgrazing problem in the whole watershed and reduce sediment runoff both inside and outside the bay. This would reduce the rate of infilling, re-vitalize the surrounding vegetation, improve bottom hydrology and likely also reduce the sediment impacts on the reefs. Ideally an integrated watershed approach should be applied.

2) Regularly open up the former channels to the rear areas of the mangroves and reestablish circulation and water quality, as recommended in the Lac Bay management plan. A project for this has already been designed. This needs to be done after thorough planning is conducted based on historical data regarding former channels and current hydrology (K. Kats, pers. comm.). The BNMP have been opening several channels at least every 2 years (at least for the last 6 years) and are currently opening them again (R. de León, pers. comm.). Simple monitoring of the project should be conducted to evaluate the results, in terms of both exacted damage to mangroves and effectiveness in terms of water circulation.

3) Design and implement a pilot project to remove filled-in sediments and reforest with red mangroves in the rear stagnant areas of Lac so as to re-establish mangrove and fish nursery habitat. This should preferably be done in a small scale, in such a way as to cause little sediment transport to the outer, open sections of Lac. Simple monitoring of the project should be conducted to evaluate the results before proceeding on a larger scale. In Curaçao and Bonaire, several successful reforestation projects have been conducted in recent years based on the most simple concepts and methods (Debrot 2009).

4) A pilot project on how to rehabilitate the recovered topsoil (efficiently remove the salt) for use in sustainable agriculture elsewhere on the island.

Seagrass degradation

5) Upper limits should be set for the various users, and public access to seagrass areas should be strictly limited using a combination of zoning, demarcation and enforcement, as recommended in the current management plan.

6) Visitor facilities designed to limit or steer user impact towards low sensitivity areas need to be upgraded and kept up.

7) Conduct a quantitative baseline description of the seagrass meadows of Lac to determine coverage using GIS and aerial photography and start monitoring a number of permanent quadrats to be revisited every year to asses long term trends in seagrass community development and health (e.g. fouling species, rate of fouling.

Disturbance

8) A survey of current bird use of the Lac area and an assessment of their vulnerability to disturbance.

9) Monitoring of human use of the bay, identification and prioritization of threats.

Contamination

10) Conduct regular cleanups with volunteers and monitor litter densities.

11) Clean submarine gullies of abandoned fishing lines and limit and regulate fishing inside of Lac.

12) Conduct PAH (polyaromatic hydrocarbon) studies of the water in Lac

Reef status and algal blooms

13) Periodic annual monitoring of enteric bacterial presence at high risk locations.

14) Install a monitoring program to assess the nutrient situation in Lac at several locations.

15) Continue monitoring of coral overgrowth by *Ramicrusta* sp. and conduct more research on the biology of this alga, as already initiated by CIEE.

Legal tools

16) Analyse the various legal options available for the protection of Lac and its inhabitants and evaluate the legality of current activities.

17) Evaluate and enforce property lines and adherence to building plans and permits. (map property lines, plus lease conditions, plus control on adherence.

18) Adapt the Verordening Marien Milieu (VMM) to accommodate the threats from development and human disturbance. The by laws of the Nature law waiting at this moment to be approved by the BC contain several regulations that will improve the situation in Lac.