Generic ecological assessment framework for coastal ecosystems in the Caribbean Netherlands

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Healthy reef- Bonaire

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Summary

The aim of this study was to draft a generic ecological assessment framework for coastal systems in Caribbean Netherlands (CN) that offers guidance in the process of license-applications of planned activities that could impact coastal systems, as well as a general guidance towards environmental and ecological monitoring related to proposed projects and existing activities. The study was limited to the review of (inter)national ecological assessment frameworks and monitoring initiatives; peer-reviewed academic literature was not consulted. Though this draft framework provides guidance, it limits itself to standard practice and general regulations. Further fine-tuning of the framework is required to be applicable to the specific situation in CN. Furthermore, it is the responsibility of the individual initiators to customize an adequate and comprehensive ecological impact assessment and monitoring-plan adjusted to the spatial and temporal scale relevant of the type of activities and possible impact resulting from the project.

Fundamental to the draft framework is a network approach in which the impact chain between the activity and ecosystem components is specified by a suit of pressures. The broad strategy of the ecological assessment framework consists of three major phases:

1. Establishing the context in which the project will take place.
2. Scoping of the project activities, their pressures and the environmental descriptors relevant to the projected area.
3. Assessment and evaluation of the pressures on the environmental descriptors.

For each phase practical guidance is provided in the form of questions. While answering these questions an overview is established of all relevant activities, pressures, and environmental descriptors. Each phase is further elaborated upon in the report. An adaptive and interactive management approach is required for the processes of the three phases. Informative environmental descriptors groups were identified based on international monitoring initiatives (Benthic diversity, Coral health, Species requiring special attention, Fish diversity, Chemical water quality, Physical structure) and for each descriptor indicators are proposed. Further study is required into which indicators are most appropriate for CN.

Threshold levels are not commonly available for each of the environmental descriptors. Significance testing in the absence of threshold levels is discussed in de report. A practical guidance is proposed to evaluate and categorize the significance of an impact by listing questions related to the nature, magnitude and intensity of the (expected) impacts. Reference is made to relevant (inter) national treaties or ordinances in which qualitative goals are reported.

This report provides practical guidance and considerations on how to establish appropriate reference situations in a changing environment. The reference situations must be chosen using best available information about the physical and biological characteristics of the environment to ensure that they represent suitable reference conditions. Important factors to consider are summed up in this report. A well set-up monitoring design should include multiple reference sites (spread across space and time) to allow the authorities and the initiator to tease apart natural variability and general trends in decline (e.g. due to climate change) from changes caused by the initiated project.

The proposed framework has not yet been tested with pilot situations or cross-referenced with the legal framework in CN, nor has it been evaluated with stakeholders. It is highly recommended to evaluate this framework by applying it to pilot or actual cases, and to adapt were necessary.

Contents

1 Introduction

1.1 Background and aim of the study

The Caribbean Netherlands (CN) is in a transition process since October 10, 2010. The law WET MARITIEM BES, introduced new regulations regarding initiatives in the coastal zone of Caribbean Netherlands. As a result all planned projects and initiatives in Bonaire, Sint Eustatius and Saba have to comply to WET MARITIEM BES. Under this law, the permitting-procedure of new initiatives as well as existing constructions in CN is in need of a generic assessment framework. A generic ecological assessment framework for coastal systems in CN should be applicable as a guide for license-applications of planned activities that could impact biodiversity, water quality, and the physical structure of coastal systems. This framework should also be applicable in re-evaluation of existing activities.

Ministry of Infrastructure and the Environment (I&M), Dienst Noordzee, responsible for the implementation of the law Maritiem BES, has requested the Ministry of Ministry of Economic Affairs, Agriculture and Innovation (EL&I) to set up a generic ecological framework and where possible, provide ecological assessment criteria. Subsequently, EL&I has asked IMARES to fulfil this task.

The aim of this report was to draft an generic ecological assessment framework that can be used as guidance in the process of applying or granting a permit. Where possible, local details on criteria were included, based e.g. on local nature ordinances. Furthermore, the framework provides a generic guidance towards environmental and ecological monitoring related to the project/initiative. The assessment of the framework relate to ecological and environmental criteria; social-economic or cultural aspects were not included.

Special attention was requested by I&M and EL&I on the following aspects:

- How to deal with the lack of quantitative criteria or threshold levels;
- How to define a reference state in a changing environment;
- How to determine significance of impacts resulting from large or small scale initiatives;
- How to design a monitoring plan related to the project/initiative;
- How to integrate specific mitigation options in relation to monitoring design. This aspect was not elaborated upon. Mitigation options are a result of the assessment, and cannot be specified in a generic framework

1.2 Outline of the report

In chapter 2 the methodology for the development of the framework is described. In chapter 3, the generic framework is drafted into three phases, and guidance per phase is provided. Chapter 4 clarifies specific ecological aspects of the framework, whereas chapter 5 clarifies the assessment and evaluation aspects. Chapter 6 is an overall discussion and concludes with recommendations for the further development and application of the generic ecological assessment framework.

2 Methods

2.1 Introduction

In order to set up a generic ecological framework for the CN, existing frameworks and assessment studies for similar ecological regions were reviewed. This comprised (generic) ecological assessment frameworks, and environmental impact assessment studies on local, regional and global scale. Particularly studies and framework of the United States and Australia were studied, two nations that have coral reefs within their national territories. French National generic frameworks (such as Natura 2000, applicable to the French Caribbean Islands) were also searched for, but no comprehensive documents were retrieved. In addition to frameworks, monitoring schemes of international multi-party initiatives were reviewed to establish relevant environmental indicators. Due to limitation in time, this report does not include a comprehensive review of the academic literature.

2.2 Frameworks reviewed

The generic frameworks of the following national agencies were consulted:

- MER: The Netherlands Commission for Environmental Assessment (Commissie M.E.R.) http://www.commissiemer.nl/
- Rijkswaterstaat: http://www.rijkswaterstaat.nl
- AIMS : Australia's tropical marine research agency http://www.aims.gov.au/
- GBRMPA: Australian Government Great Barrier reef Marine Park Authority http://www.gbrmpa.gov.au/
- ANZECC: Australian and New Zealand Environment and Conservation Council (ANZECC & ARMCANZ (2000)
- ARMCANZ: Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ 2000)
- EPA: United States Environmental Protection Agency: http://www.epa.gov/
- NOAA: National Oceanic and Atmospheric Administration (U.S.A.) http://www.nmfs.noaa.gov/

For indicators in coral reef environments we consulted the following international initiatives:

The Atlantic and Gulf Rapid Reef Assessment (AGRRA) http://www.agrra.org/
The AGRRA Program is an international collaboration of scientists and managers aimed at determining the regional condition of reefs in the Western Atlantic and Gulf of Mexico. AGRRA is the first and only program that has developed an extensive regional database on Caribbean coral reef condition. Using an innovative regional approach to examine the condition of reef-building corals, algae and fishes, over 800 reef areas at 39 sites are assessed throughout the Caribbean region. Preliminary findings have provided valuable baseline data for scientists and government.

The Healthy Reefs Initiative (HRI) http://www.healthyreefs.org
HRI is an international, multi-institutional effort that tracks the health of the Meso-American Reefs. The Initiative was launched in early 2004 as a catalyst to improve our collective conservation impact in the Meso-American Reef Ecosystem. The founding members are the World Wildlife Fund (WWF), the Meso-American Barrier Reef System Project (MBRS), the World Bank, the Summit Foundation and Perigee Environmental.

Mesoamerican BRS of The Coral Reef Targeted Research (CRTR) : http://www.gefcoral.org
The CRTR Program is seeking to fill the critical gaps in our global understanding of what determines coral reef ecosystem vulnerability and resilience to a range of key stressors – from localized human stress to climate change – and to inform policies and management interventions on behalf of the coral reefs and the communities that depend on them.

Hawaii Coral Reef Assessment and Monitoring Program (CRAMP) http://cramp.wcc.hawaii.edu/
CRAMP was created during 1997-98 by leading coral reef researchers, managers and educators in Hawai'i. The initial task was to develop a state-wide network consisting of over 30 long-term coral reef monitoring sites and associated data base. Based on the monitoring network, quantitative assessment tools were developed. Today the emphasis is on using these tools to understand the ecology of Hawaiian coral reefs in relation to other geographic areas.

MAR Coral Reef Watch http://www.marcoralwatch.net/en/home.php
The Mesoamerican Coral Reef Watch Program is a regional initiative that operates in the Caribbean Coast of Mexico, Belize and Honduras, integrated by several national and international organizations working for the conservation of these valuable marine resources.

Caribbean Coastal Marine Productivity Program (CARICOMP)
http://www.unesco.org/csi/act/caricomp/summary14.htm
CARICOMP of UNESCO is a regional scientific programme to study coastal ecosystem productivity. The goal of CARICOMP is to contribute to integrated coastal management by: determining the factors that regulate productivity of the three main coastal ecosystems in the Caribbean region - mangroves, seagrasses, and coral reefs; and assessing the nature and influence of land-sea interactions. The network consists of 29 sites in 22 countries and territories: Bahamas, Barbados, Belize, Bermuda, Bonaire, Cayman, Colombia, Costa Rica, Cuba, Curacao, Dominican Republic, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Puerto Rico, Saba, Trinidad and Tobago, U.S.A., Venezuela.

ReefCheck http://reefcheck.org
The Reef Check Foundation is an international non-profit organization dedicated to conservation of two ecosystems: tropical coral reefs and California rocky reefs. Reef Check works to create partnerships among community volunteers, government agencies, businesses, universities and other non-profits. Reef Check goals are: to educate the public about the value of reef ecosystems and the current crisis affecting marine life; to create a global network of volunteer teams trained in Reef Check's scientific methods who regularly monitor and report on reef health; to facilitate collaboration that produces ecologically sound and economically sustainable solutions; and to stimulate local community action to protect remaining pristine reefs and rehabilitate damaged reefs worldwide.

In addition, international treaties, local and regional nature ordinances have been studied to retrieve normative ecological criteria or assessment levels. The results of this review are provided in chapter 4.

3 Generic Framework

In this chapter, the results of the reviewed frameworks are integrated in a draft framework for the Caribbean Netherlands.

3.1 What are generic ecological assessment frameworks?

The generic ecological assessment framework for coastal systems in CN is meant as a guide for license-applications of planned activities that could have consequences on biodiversity, water quality, and the physical structure of coastal ecosystems. This framework can also be used as a re-evaluation of existing activities. Though this framework provides guidance, it limits itself to standard practice and general regulations. It is the responsibility of the individual initiators to customize an adequate and comprehensive ecological impact assessment and monitoring-plan, which should subsequently be evaluated by the relevant authorities.

The principle functions of an ecological assessment framework are to (adapted from EPA 2003):

- Establish baseline data on the condition of tropical coastal ecosystems;
- Establish the extent and patterns of decline in key ecosystem components: e.g. corals, fish, seagrass, mangroves;
- Identify any undesirable condition within the radius of an action;
- Measure the impacts of an action;
- Allow evaluation of effectiveness of various management strategies.

Generic assessment frameworks could have several additional uses (adapted from EPA 2003):

- Complying with legal requirements;
- Improving the consistency of ecological impact assessment and management;
- Serving as models for site-, action-, or region-specific criteria;
- Providing clear direction for the development of methods and models;
- Facilitating communication with stakeholders by creating a set of familiar and clear generic criteria;
- Reducing the time and effort required to conduct monitoring.

3.2 Proposed framework

Based on the reviewed frameworks and integration of ideas we identified 3 common phases.

Fundamental to the proposed framework is the network approach as described by Karman and Jongbloed (2008). In this network approach, the impact chain between the activity and ecosystem components is specified by a suit of pressures. Via several assessment steps, these impact chains can be evaluated and prioritized, and pressures can even cumulated. This framework is key to our proposal. Besides Karman and Jongbloed, (2008), elements of ANZECC & ARMCANZ (2000), EPA (2003), and GBRMPA (2009) are fitted into this generic framework.

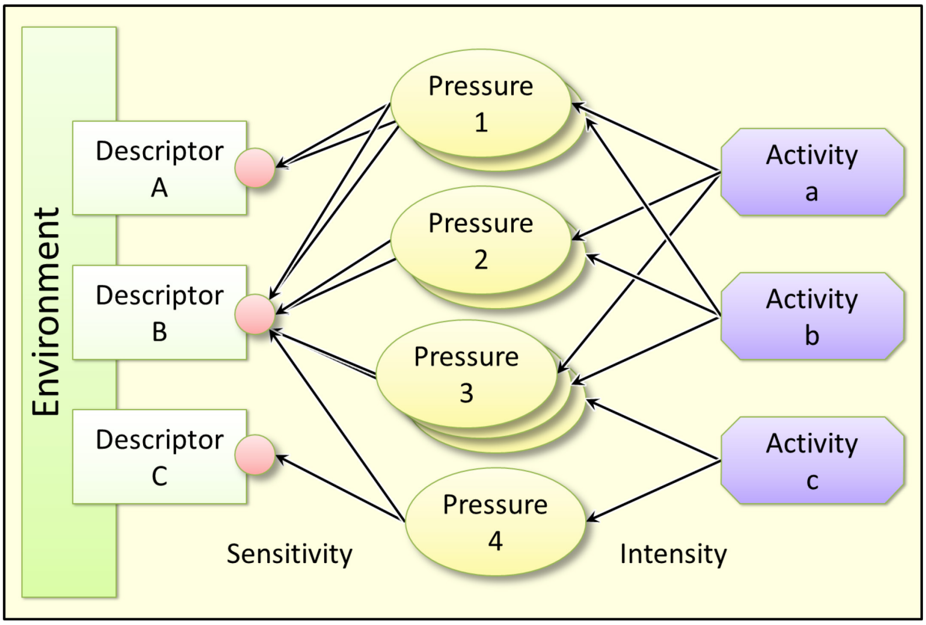

Figure 1. Impact chain approach in which ecosystem descriptors are linked to activities via a suit of pressures. Relations are defined by "intensity and sensitivity. More information is provided in this report. Image based on Karman & Jongbloed (2008).

The broad strategy of the ecological assessment framework consists of three major steps:

1. Context phase: establishing the context in which the project will take place.
2. Scoping phase: scoping of the project activities, their pressures and the environmental descriptors relevant to the projected area.
3. Assessment and evaluation phase: in this phase the pressures on the environmental descriptors are assessed and evaluated.

In general, the context and scoping phases are a process of problem formulation, planning, and scoping to establish the goals, breadth, and focus of the project. They allow the characterization of the ecosystems in which the activity and pressures may occur as well as the biota that may be exposed in a spatio-temporal scale. The last phase develops profiles of the effects of the project-activities on the environmental descriptors by assessing the degree of impact of the pressures resulting from the activities, as well as identifying key issues of concern at an early stage in the planning process. Impact can be estimated using a variety of techniques including the comparison of individual exposure and effects values, the comparison of the distributions of exposure and effects, or the use simulation models. The impact can be expressed as a qualitative or quantitative estimate, depending on the available data. New data are frequently required to conduct analyses that are performed during the assessment. Data from verification studies can be used to validate the predictions of a specific assessment. Ecological effects or exposure monitoring can aid in the verification process and suggest additional data, methods, or analyses that could improve future assessments (below, guidance is provided to go through each of the phases. Consequently the assessment process should be an iterative one. The key questions provided in the following three phases are based on a compilation of MER, Rijkswaterstaat, ANZECC, ARMCANZ, EPA, GBRMPA, and our own judgment. For each phase it is necessary to evaluate the quality of information and/or data available.

1. **Context phase**
- Define the project/initiative.
- Who are the stakeholders?
- What (inter)national regulations apply?
- What treaties apply?
- What local or regional nature ordinances apply?
- What is the current monitoring or management which may respectively detect or prevent potential or undesirable risks?
- What are the requirements related to the use of the area during the construction and operation of the project?
- What are suitable sites that represent reference conditions?
- Is there baseline biological and environmental data available for the area?
- What problems have been identified in previous cases?

The context phase results in a first overview of all relevant stakes. In the scoping phase the relevant aspects are further defined.

2. **Scoping phase**

Activity
- What are specific activities, including those of alternative scenarios?
- Where and when is the activity?
  - Define all sub-activities related to the construction and operation of the project.
  - Define the duration and intensity of each activity.

Pressures
- What are identified pressures of each of the (sub-)activities?
  - Use Table 12 of chapter 5.1 as guidance.
- What are the temporal and spatial scales of the pressures?
- With what frequency and intensity can or will the pressure occur?
  - The list of pressure indicators in chapter 5 can be used as guidance.

Environmental descriptors
- What environmental descriptors are relevant to the project?
  - Use the suit of environmental descriptors in chapter 4.1 as guidance.
- Is there baseline biological and environmental data available for the descriptors?
  - If not, define current situation with monitoring.
  - Use the tables in chapter 4.1 as guidance.
- What are the narrative and quantitative thresholds?
  - If not available, compare situation in projected area with a suitable reference situation (in time and space).
  - Use the thresholds (Table 7, Table 8, Table 9, Table 10) in chapter 4 as guidance, and species lists in annex 1.
- What is the vulnerability of the descriptor to each of the pressure?
- What are the gaps in knowledge that require further research?
- What are suitable references?
  - Use chapter 4.3 as guidance.

The scoping phase results in an overview of all relevant activities, pressures, and environmental descriptors. In the subsequent assessment and evaluation phase the relevance and significance is evaluated by taking into account the spatio-temporal co-occurrence of the pressures and environmental descriptors.

3. Assessment & evaluation phase

- How does each pressure influence each environmental descriptor?
  - Construct the relevant impact chains such as in Table 12.
- What is the level of impact of each of the pressures on the environmental descriptors?
  - use questions in the Box 1 as guidance to define and quantify.
  - Use Table 13 in chapter 5.
- How likely is it that the impact will occur?
  - Use Table 14 from risk assessment in chapter 5.
- What is the priority of each of the impact-relationships?
- Is the impact acceptable or unacceptable?
  - If single impacts are assessed as insignificant, elaborate on the possible cumulative impact.
- Evaluation during construction and operation: What is the status of the environmental descriptors in the projected area relative to reference conditions?

The assessment and evaluation phase results in the prioritization of the impact-relationships. All significant impact-relationships should be monitored and evaluated.

The overall result is a conceptual model that identifies the environmental values to be protected, the data the analyses need, and monitoring scheme to be used. This end result should include a detailed and comprehensive version of Table 12 with all relevant activities, pressures, and environmental descriptors for the proposed activity. The initiator has to tailor the guidelines for local conditions and specific aspects of its project/initiative.

The monitoring aspects identified in phase 3 should be maintained during and after implementation of the agreed management response(s), to evaluate their performance in achieving the objectives and hence the management goals. This process should be iterative and on-going to ensure the environmental values continue to be sustained (after ANZECC & ARMCANZ 2000).

4 Scoping of environmental descriptors

4.1 Environmental descriptors for coral reef ecosystems

In order to assess the impacts of current or planned activities on the marine environment, the ecological status of impacted and reference situations need to be monitored. These monitoring plans must ensure that information is gathered in enough detail to monitor whether or not degradation of the marine environment occurs and if so, if this differs from the autonomic trend in the surrounding areas. The ecological status of the environment can be assessed by using indicators. An indicator can be a measure, an index of measures, or a model that characterizes some critical component of the system (EPA 2010). Indicators are signs or signals that relay a complex message in a simplified, useful manner.

Based on a review of the studies mentioned in chapter 2, we suggest that the ecological assessment of coastal systems in the Caribbean Netherlands should consist of at least six environmental descriptors:

- Benthic diversity
- Coral health
- Species requiring special attention
- Fish diversity
- Chemical water quality
- Physical structure

4.1.1 Benthic diversity, coral health, species requiring special attention, fish diversity

The descriptors "Benthic diversity", "Coral health", "Fish diversity", and "Species requiring special attention" allow the evaluation of the biological condition using biological surveys and other direct measurements of resident biota (EPA 2009). Indicators related to these descriptors offer an understanding of the desired natural community based on the numbers and kinds of organisms expected to be present in the environment (Jameson et al. 1998 & 2003, EPA 2011). Because biota are constantly exposed to the impact of various pressures, these communities reflect not only current conditions, but also changes in conditions over time and their cumulative impacts (EPA 2011). Impairment of the environment is judged by its departure from the reference situations (Jameson et al. 1998 & 2003, EPA 2002).

Table 1, Table 2, Table 3, and Table 4 provide lists of key indicators relevant to the environmental descriptors "Benthic diversity", "Coral health", "Fish diversity", and "Species requiring special attention", that should be included in assessment and monitoring plans for tropical coastal systems in the islands. These lists are by no means exhaustive, but represents a minimum; the initiator is required to assess all indicators that are relevant to the proposed activity.

Table 1 Benthic diversity indicators for tropical coastal systems. This list is not exhaustive, but represents a minimum; the initiator is required to assess (change in) all indicators relevant to the specific proposed activity.

Benthic diversity	**Rationale**	**Reference**
Coral (soft & hard) species, abundance, cover	universal reef condition indicator; interpretation case by case	AGGRA; CRAMP; EPA; CRTR; English et al. 1997
Seagrass species, abundance, cover	universal seagrass condition indicator	
Mangrove species, abundance, cover	Universal mangrove condition indicator	
Sponge species, abundance, cover	general biodiversity indicator; in severely disturbed reefs sponge cover/number increases; some sponge species aggressive bioeroders	AGGRA; MAR; CARICOMP; Reef Check; CRTR
Diadema abundance	key algae grazer; low abundance could be risk for coral	AGGRA; HRI; MAR
Major invertebrate species and abundance	shifts in community composition and dominance of certain species may indicate altered reef conditions	Jameson et al. 1998 & 2003; English et al. 1997
Crustose corraline algae cover	constructs/cements reef framework; may indicate good conditions for coral larval recruitment	AGGRA; MAR; CARICOMP; CRTR; English et al. 1997
Fleshy macroalgae and truf algae cover	may indicate altered reef conditions (e.g. increased nutrients, temperature, few herbivores) ; may inhibit coral larvae recruitment; overgrows coral	AGGRA; HRI; MBRS; MAR; CARICOMP; Reef Check; CRTR; English et al. 1997
Cyanobacteria cover	may indicate altered reef conditions (e.g. increased nutrients, temperature, few herbivores) ; may inhibit coral larvae recruitment; overgrows coral	AGGRA; English et al. 1997
Non-indigenous (benthic) species	could potentially become invasive and cause regime shifts;	International treaties; MARPOL

Table 2 Coral health indicators for assessment and monitoring plans for tropical coastal systems. This list is not exhaustive, but represents a minimum; the initiator is required to assess all indicators relevant to the specific proposed activity.

Coral health	**Rationale**	**Reference**
Live coral cover	universal reef condition indicator; high cover indicates healthy reef	AGGRA; HRI; MBRS; MAR; Reef Check; EPA; English et al. 1997
Newly dead coral (by species)	indicates ongoing disease, bleaching, predation, competition of other perturbation	AGGRA; CRAMP; MAR; EPA; CRTR; English et al. 1997
Coral bleaching (by species)	indicates altered reef conditions (often thermal stress)	AGGRA; CRTR
Coral disease (by species)	indicates climate change and/or human impact	AGGRA; HRI; Reef Check; CRTR
Coral recruitment	indicates natural resilience	AGGRA; HRI; CRAMP; CRTR

Table 3 *Fish diversity indicators for assessment and monitoring plans for tropical coastal systems. This list is not exhaustive, but represents a minimum; the initiator is required to assess all indicators relevant to the specific proposed activity.*

Fish diversity	**Rationale**	**Reference**
Fish species abundance and size	universal reef condition indicator; high diversity indicates healthy reef	AGGRA; HRI; CRAMP; MAR; Reef Check; CRTR
Herbivorous fish species abundance and size	graze algae; low abundance could be risk for coral	AGGRA; HRI; CRTR

Table 4 *Species types for assessment and monitoring plans for tropical coastal systems. This list is not exhaustive, but represents a minimum; the initiator is required to assess all indicators relevant to the specific proposed activity.*

Species requiring special attention	**Rationale**	**Reference**
Threatened and endangered species and abundance	biodiversity loss	SPAW; CITES; IUCN
Migratory species		SPAW; IUCN

4.1.2 Water quality descriptor

Water quality steers the ecosystem and its biota which means that alterations in water quality can directly and indirectly affect the ecosystem. Water quality aspects are both natural/general (e.g. nutrients, turbidity, and organic matter), but as well anthropogenic e.g. pesticides and oil. The latter is always a result of human activity. The first (nutrients, turbidity, and organic matter) can have natural dynamics and fluctuations, but might be elevated by human activity as well.

Altered water quality can adversely affect the ecosystem by causing an undesirable change in the population structure of a species by affecting rates of mortality, reproduction, or growth and development (EPA 2003). The toxicity of chemicals should always be measured as concentration and exposure duration (Rijkswaterstaat 2010a,b). Threshold values are concentrations that, if exceeded, would indicate a potential environmental problem, and so trigger a management response, e.g. further investigation and subsequent refinement of the guidelines according to local conditions (ANZECC & ARMCANZ 2000). For chemical substances threshold values can be found in literature (so called PNEC values- Predicted No Effect Concentrations) for multiple species (Ecotox database EPA- http://cfpub.epa.gov/ecotox/). For general water quality aspects environmental threshold values are reported in “Werkgroep Milieunormen Bonaire”, and provided in 4.4.

Table 5 provides a list of key water quality descriptors that should be included in assessment and monitoring plans for tropical coastal systems in the CN-islands. This list is not exhaustive, but represents a minimum; the initiator is required to assess all relevant indicators to the specific proposed activity.

Table 5 Water quality indicators for assessment and monitoring plans for tropical coastal systems. This list is not exhaustive, but represents a minimum; the initiator is required to assess all relevant indicators to the specific proposed activity.

Water quality	**Rationale**	**Reference**
Salinity	salinity can be altered by e.g. emissions of production water	
Temperature	temperature can be altered by e.g. emissions of production water, but also by natural changes (e.g. in climate)	
Nutrients	concentration in combination with threshold levels NH4, NO3, DIN, PO4 indicate eutrophication	e.g. Lapointe 1997, Milieunormen Bonaire
pH: Acidity	indicates acidification (pH ↓) and eutrophication (pH↑). Threshold levels for effluents available	Lapointe, Milieunormen Bonaire
Oxygen concentration (O_2)	can indicate eutrophication (O2↓) and healthy reef condition. Threshold levels available for surface waters and effluents	Milieunormen Bonaire
Pathogens	pathogens can be introduced by e.g. shipping emissions of sewage, or agriculture run off, and can lead to deceases in e.g. corals	
Sedimentation rate	indicates natural fluctuation vs. impacted, and increased rate (in combination with quality) indicates risk for coral health	MAR
Contaminants (e.g. oil, pollutants, metals)	indicates spills or emissions from human activities	MBRS
Marine debris	indicator for human activities, but not always good point-source relation due to diffuse input from sea	MBRS

4.1.3 Physical structure criteria

Physical structure comprises the physical attributes or characteristics of reefs, including reef rugosity, hydrological characteristics, bathymetry, bank form, sinuosity, bank and channel vegetation, and substrate type and composition (EPA 2003, 2010). There are several physical factors critical to aquatic life, such as habitat structure, flow patterns, and energy sources. The impacts of many actions on the physical structure of the coast and the bottom of water bodies can be readily predicted (e.g. mooring, sealing, anchoring). Other effects (such as hydrology changes due to land use changes) are more difficult, but still possible, to model (EPA 2003). Physical characteristics often are readily observed or measured at sites being assessed and are usually recorded in biological surveys.

Table 6 provides a list of key physical structure indicators that should be included in assessment and monitoring plans for tropical coastal systems in the BES-islands. This list is not exhaustive, but represents a minimum; the initiator is required to assess all relevant indicators to the specific proposed activity

Table 6 Physical structure indicators that should be included in assessment and monitoring plans for tropical coastal systems in the CN-islands. This list is not exhaustive, but represents a minimum; the initiator is required to assess all relevant indicators to the specific proposed activity

Physical structure	**Rationale**	**Reference**
Physical damage to reef	as an indicator of overuse though exact cause of physical damage may not always be clear	MBRS
Rugosity; reef topographic complexity	change in complexity affects the biodiversity; rugosity is a component of habitat quality for reef fishes	AGGRA; CRAMP; EPA
Sediment	increase in sediment can affect coral reef health	AGGRA; CRAMP
Rubble	increase in rubble cover reduces potential of recruits	AGGRA; CRTR
Habitat area (reef, seagrass, mangrove)	indicates natural resilience	

4.2 International treaties

In this section an overview is presented of policy frameworks and conventions, providing guidance in setting normative assessment criteria to some of the descriptors described in chapter 4.

4.2.1 Treaties and conventions relevant to Caribbean Netherlands.

When countries join a convention or treaty, they are enlisting in an international effort for a common objective. Parties to the treaty agree on a number of commitments. Compliance with the commitments is mostly voluntary and there are neither regulatory regimes nor punitive sanctions for violations of or defaulting upon treaty commitments. International treaties are, however, binding in international law in that sense. The whole edifice is based upon an expectation of common and equitably shared transparent accountability. Failure to live up to that expectation could lead to political and diplomatic discomfort in high-profile international fora or in the media, and would prevent any Party concerned from getting the most out of what would otherwise be a robust and coherent system of checks and balances and mutual support frameworks. Failure to meet the treaty's commitments may also impact upon success in other ways, for example, in efforts to secure international funding. In addition, national jurisdictions should embody international obligations in national law and/or policy with direct effect in their own court systems (Meesters et al 2010).

Relevant treaties and conventions applying directly to marine biological resources in the Caribbean region and applying (normative) objectives and targets are (not exclusive):

- Cartagena / SPAW protocol
- Convention on Biological Diversity
- Convention for Migratory Species
- Inter- American Convention for the Protection and conservation of Sea Turtles (IAC)
- RAMSAR
- UNCLOS
- MARPOL

Cartagena Convention (1983) and SPAW protocol (1990)

The Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (the Cartagena Convention, 1983, www.cep.unep.org/cartagena-convention) is a legally binding environmental treaty for the Wider Caribbean Region. The Convention and its Protocols constitute a legal commitment by the participating governments to protect, develop and manage their coastal and marine resources individually or jointly.

The SPAW Protocol (Protocol concerning Specially Protected Areas and Wildlife, 1990, entering into force 2000), is part of the Cartagena Convention and is signed by the Kingdom of the Netherlands to apply to the Netherlands Antilles. The SPAW Protocol has been internationally recognised as the most comprehensive treaty of its kind, and concerns the Marine and Terrestrial environment.

The objective of the Protocol is to protect rare and fragile ecosystems and habitats, thereby protecting the endangered and threatened species residing therein. The Caribbean Regional Co-ordinating Unit pursues this objective by assisting with the establishment and proper management of protected areas, by promoting sustainable management (and use) of species to prevent their endangerment and by providing assistance to the governments of the region in conserving their coastal ecosystems.

The protocol is in many ways a precursor to the Convention on Biological Diversity (CBD). It is therefore now also described as a regional vehicle for the Convention on Biological Diversity. The protocol calls on parties to take the necessary measures, in accordance with its laws and regulations and the terms of the Protocol, to protect, preserve and manage in a sustainable way, within areas of the Wider Caribbean Region in which it exercises sovereignty, or sovereign rights or jurisdiction:

a) areas that require protection to safeguard their special value; and
b) threatened or endangered species of flora and fauna.

SPAW aims to protect rare and fragile ecosystems and habitats, thereby protecting the endangered and threatened species, it is recommended to take into account the intention of this convention during assessment (with respect to descriptor "*species requiring special attention*"), and to assess at least the threatened and endangered species list. This list can be found in annex 1.

For proper management of these areas the SPAW protocol calls on parties to adopt and implement planning, management and enforcement measures for protected areas including among others:

- Scientific research and monitoring of impact of users, ecological processes, habitats, species and populations, aimed at optimizing the management.

In order to ensure that the objectives of the protected area are achieved the Protocol directs the Parties to take the following specific measures as appropriate:

a) the regulation or prohibition of the dumping or discharge of wastes and other substances that may endanger protected areas;
b) the regulation or prohibition of coastal disposal or discharges causing pollution, emanating from coastal establishments and developments, outfall structures or any other sources within their territories;
c) the regulation of the passage of ships, of any stopping or anchoring, and of other ship activities, that would have significant adverse environmental effects on the protected area, without prejudice to the rights of innocent passage, transit passage, archipelagic sea lanes passage and freedom of navigation, in accordance with international law;
d) the regulation or prohibition of fishing, hunting, taking or harvesting of endangered or threatened species of fauna and flora and their parts or products;
e) the prohibition of activities that result in the destruction of endangered or threatened species of fauna or flora and their parts and products, and the regulation of any other activity likely to harm or disturb such species, their habitats or associated ecosystems;

f) the regulation or prohibition of the introduction of non-indigenous species;
g) the regulation or prohibition of any activity involving the exploration or exploitation of the sea-bed or its subsoil or a modification of the sea-bed profile;
h) the regulation or prohibition of any activity involving a modification of the profile of the soil that could affect watersheds, denudation and other forms of degradation of watersheds, or the exploration or exploitation of the subsoil of the land part of a marine protected area;
i) the regulation of any archaeological activity and of the removal or damage of any object which may be considered as an archaeological object;
j) the regulation or prohibition of trade in, and import and export of threatened or endangered species of fauna or their parts, products, or eggs, and of threatened or endangered species of flora or their parts or products, and archaeological objects that originate in protected areas;
k) the regulation or prohibition of industrial activities and of other activities which are not compatible with the uses that have been envisaged for the area by national measures and/or environmental impact assessments pursuant to Article 13;
l) The regulation of tourist and recreational activities that might endanger the ecosystems of protected areas or the survival of threatened or endangered species of flora and fauna; and any other measure aimed at conserving, protecting or restoring natural processes, ecosystems or populations for which the protected areas were established

Convention on Biological Diversity (CBD, 1992)
The Convention on Biological Diversity (www.cbd.int) entered into force on 29 December 1993. The CBD has 193 parties and 168 signatures, including The Netherlands. As such it constitutes one of the most important environmental treaties. The CBD has 3 main objectives:

1. The conservation of biological diversity,
2. The sustainable use of the components of biological diversity, and
3. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

It is often seen as the key convention regarding sustainable development. The Convention also offers guidance based on the precautionary principle: that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat. The Convention is legally binding; countries that join it are obliged to implement its provisions. Marine and coastal biodiversity have been a priority since the first Conference of Parties (COP 1, 1995). Other include coral bleaching, physical degradation and destruction of coral reefs, mariculture, high seas biodiversity, deep seabed genetic resources beyond the limits of national jurisdiction, and the development of a network of marine protected areas.

Most of the Parties have established National Biodiversity Strategies and Action Plans (NBSAP) to implement the convention. These NBSAP’s should be used during the assessment, phase 1 and 2.

Convention for Migratory Species (CMS, 1985)
The Convention on Migratory species (www.cms.int) was agreed upon in 2005 and ratified by the Netherlands. A migratory species under the Convention can be an entire population of a species or a geographically distinct part of the species. The term migratory is partly political, partly biologically defined. In any case, a significant proportion of the population of the species must cross national borders on a cyclical basis or migrate.

There are no specific agreements under the CMS for the Caribbean, but as it is a region where cetaceans, dolphins and turtles are found and as it is part of the flyway of the eastern U.S. migratory range, the islands are dealing with endangered migratory species (e.g. Voous 1983, Wells and Debrot 2008, Brown et al. 2009, Prins et al. 2009). The CMS has two appendices listing species in need of protection. In CMS Appendix I, the migratory species in danger of extinction throughout all or a significant proportion of their range are listed. In Appendix II species with an "unfavorable conservation status"are listed. This is meant as an additional stimulus to international, and sometimes regional protection agreements.

For the Dutch Caribbean there are 9 Annex I CMS species - four whales and five turtles -. The Annex CITES II listed 14 species that also occur on the CMS Annex II list, nine dolphins and five birds (see annex 1 of this report).

Although no specific goals are set within the CMS, it is recommended to take into account the intention of this convention, and to assess the CMS species list.

Inter- American Convention for the Protection and Conservation of Sea Turtles (IAC, 1996)
The Inter-American Convention for the Protection and Conservation of Sea Turtles is the only international treaty dedicated exclusively to sea turtles, setting standards for the conservation of these endangered animals and their habitats. Because individual sea turtles migrate and disperse over vast distances, they are resources shared by the peoples of many nations. The Netherlands has ratified the Convention.

The measures proposed in the Inter-American Convention, promote regional management plans and agreements, such as the International Agreement for the Conservation of Caribbean Sea Turtles (Tripartite Agreement), a recently completed pact which deals specifically with the Caribbean coasts of Costa Rica, Nicaragua and Panama. The Inter-American Convention places great importance on environmental conservation, as well as the reduction of bycatch by developing more selective fisheries gear and practices, for example through the use of Trawling Efficiency Devices (also called Turtle Excluder Devices - TEDs).

RAMSAR convention on wetlands
The RAMSAR convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
Bonaire comprises five RAMSAR sites (Lac, Pekelmeer, Klein Bonaire, Gotomeer, Slagbaai), of which some could be in the range of influence of (future) maritime or coastal activities. It is recommended to take into account the RAMSAR sites and its ecological components during the scoping phase of the assessment.

UNCLOS
The United Nations Convention on the Law of the Sea (UNCLOS), also called the Law of the Sea Convention or the Law of the Sea treaty, is the international agreement that resulted from the third United Nations Conference on the Law of the Sea (UNCLOS III).

The convention comprises over 300 articles governing all aspects of ocean space, including protection and preservation of the marine environment. Under part XII on the protection and Preservation of the marine environment, States have an obligation to protect and preserve the marine environment and are required to take all measures necessary to prevent, reduce and control pollution of the marine environment from any source. The Netherlands have ratified this convention.

MARPOL
The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL regulates pollution by oil spills, ballast water, sewage, garbage

and air pollution, all of which are severe threats to coral reefs, particularly in heavily trafficked and/or vulnerable areas.

It sets criteria for e.g. discharges, and noxious substances.

The MARPOL Convention was adopted on 2 November 1973 at IMO. MARPOL has been updated by amendments through the years. On 14 May 2005 Annex IV to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto entered into force for the Netherlands Antilles.

The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes.

4.2.2 Nature Policy Plan 2012-2017

The goal of the Nature Policy Plan 2012-2017 is whilst promoting sustainable use, to preserve, protect, study and where necessary restore the rich and extraordinary nature of the Caribbean Netherlands to a level consistent with its ecological role and ecosystem services (draft NBP, August 2012). Concrete nature goals, thresholds and limits are not provided in the NBP.

More specific are the Island ordinances. These ordinances specify what to protect, and provides more information on which species to protect. This list can be used during the scoping phase of the assessment, and helps to identify what species to take into account during assessment and if applicable, monitoring.

Bonaire adopted an Island Ordinance in 2010, specifying a list of protected species at the insular level. Although St. Eustatius also has a list of legally protected species this list needs to be updated and linked to the National Nature Ordinance. Saba has a draft list of species that should be protected but has not yet adopted the necessary legislation. The National Nature Ordinance and now the "Nature Conservation Law BES" provides the option for all islands to have a list of protected species, beyond those protected by international agreements such as SPAW and CMS. Species listed under CITES appendix I, SPAW annex I and II and CMS are also granted full protection under the Nature Conservation Law BES.

During assessment of a project/initiative one should check the latest status with each of the treaties.

4.3 Reference situation

In order to assess relative impact of an activity, it is important to know how to define a reference situation. In this section a definition of the reference situation is provided, including a practical guidance on how to establish a reference.

4.3.1 Reference definition

Commissie MER (Dutch EIA procedure) defines the reference situation as the future situation without the execution of the perceived activity (Commissie MER , 2011).

EPA definition:
The chemical, physical and biological condition expected to be found in unimpaired waterbodies of a similar type as the impacted area. This can be determined by sampling at unimpaired or minimally impaired reference sites, from historical data and information, or through modelling and estimations. The

reference site can set thresholds that define whether action should be aborted or altered. The reference condition is derived from samples collected from a set of regional locations or reference sites with minimal human influence.

ANZECC & NWQMS definition:
Reference condition that provides both a target for management actions to aim for and a meaningful comparison for use in a monitoring or assessment program. The reference condition for sites that may or may not be disturbed at present can be defined in terms of these sources of information: historical data collected from the site being assessed; spatial data collected from sites or areas nearby that are uninfluenced (or not as influenced) by the disturbance being assessed; or data derived from other sources. For modified ecosystems, 'best-available' reference sites may provide the only choice for the reference condition.

> In summary, the reference situations must be chosen using best available information about the physical and biological characteristics of the environment to ensure that they represents suitable reference conditions.

4.3.2 Establishing a reference

There can be large differences from one reef to the next, as well as one site to the next on the same reef. Coral communities occur in different locations and are composed of many different organisms living in a variety of physical and chemical environments. Responses to changes in water quality varies spatially and temporally (Cooper et al. 2009). Similarly, reef conditions are generally changing over time (e.g. Hughes et al. 2003, Hoegh-Guldberg et al. 2007). All these factors need to be considered when establishing reference conditions. We therefore recommend to always take into account:

- Spatial aspects : select appropriate reference sites outside of the projected area and, if applicable, also along a human disturbance gradient
- Temporal aspects: long-term monitoring of the projected sites and the reference sites is required to detect trends and delayed responses (the duration will depend on the proposed project and associated pressures).

Furthermore the following important factors should be considered when selecting reference sites (based on a compilation from GBRMPA, ANZECC, EPA):

- Where possible, pre-disturbance data should be collected from appropriate control or reference sites as well as from the site(s) subjected to the disturbance.
- The definition of a reference condition must be consistent with the level of protection proposed for the ecosystem in question — unimpacted, or slightly modified or relatively degraded (where the general aim is not to rehabilitate a degraded ecosystem to such a high level).
- Sites should be from the same biogeographic and climatic region.
- Where applicable monitoring should be conducted along a human disturbance gradient
- Reference sites should have similar geology, topography, and dominant physical processes (e.g. currents, wave energy, depth) as the impacted sites.
- Reference sites should contain a range of habitat types (e.g. reef crest, fore, back, patch reef) similar to those at the impacted sites.
- Downstream or downwind impacts must be considered.
- Whether a disturbance gradient is detected depends strongly on the indicators used.

Effective environmental management requires monitoring programmes that provide specific links between changes in environmental conditions, ecosystem health, and pressures related to an activity/project. The response of indicators to pressures may differ in time; some responses may be rapid (minutes-hours) and some may only become apparent after long-term monitoring (years) (e.g. Cooper et al 2009). The duration of response will depend on the indicators as well as the stressors (See Figure 2 for an example).

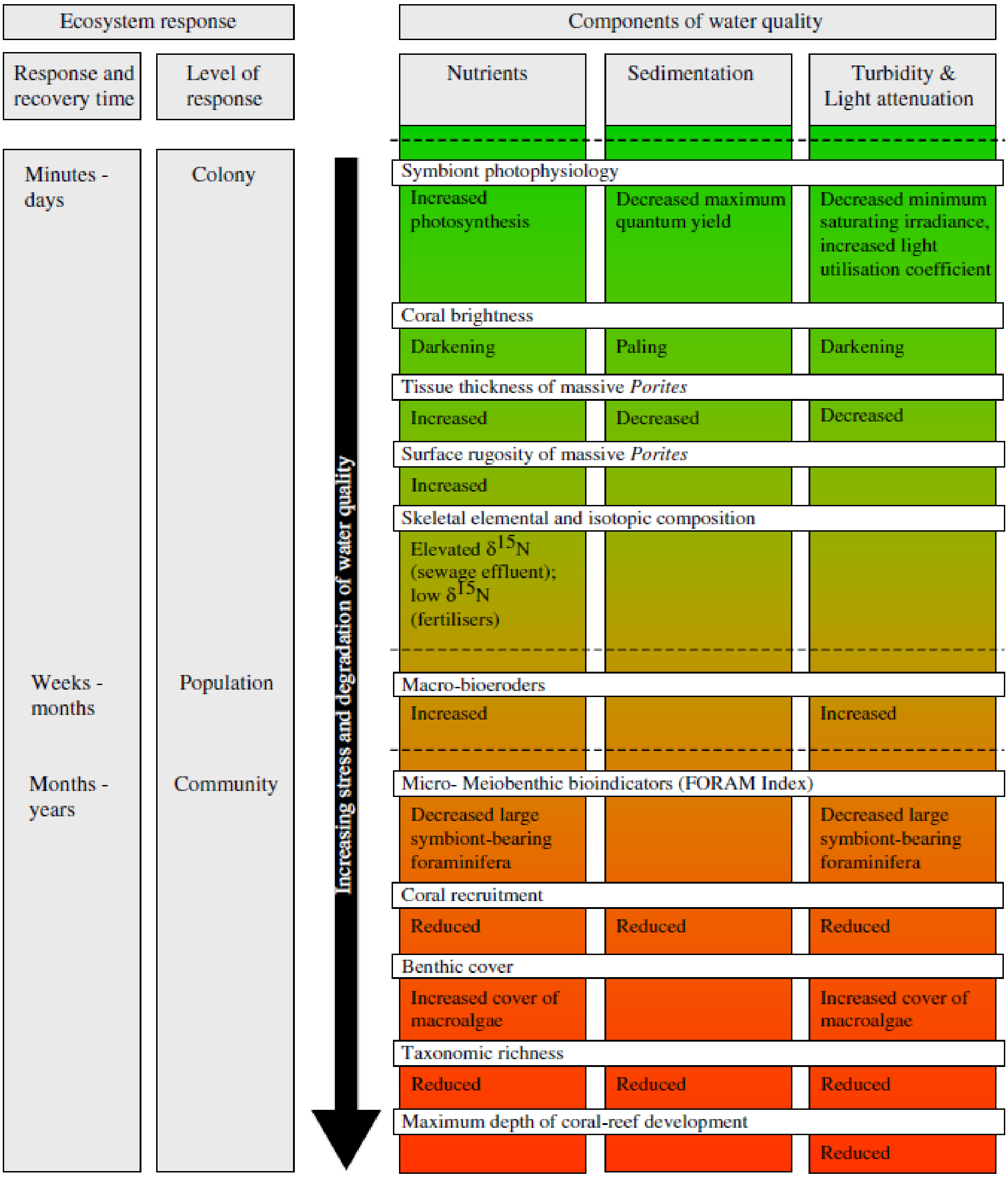

Figure 2 *Conceptual model of coral bioindicators to indicate increasing exposure to the key components of water quality. Responses are presented in increasing order of effect from stress to mortality resulting from increasing levels of stressors. Responses will depend on both the magnitude and duration of changes in the levels of stressors. All the responses will first be evident at the genetic/colony level and then in the wider community. Sublethal responses, therefore, may pre-empt more severe effects at the population and community level and can be used to describe shifts in ecosystem condition from healthy (green) to degraded (red) conditions from (Cooper et al. 2009)*

4.3.3 Addressing climate change variability

Coral reefs are dynamic systems and even reefs that are remote from direct human influence still show cycles of disturbance and recovery that can involve major disturbances from natural causes. Furthermore, coral reefs are under stress of climate change (e.g. Hughes et al. 2003, Hoegh-Guldberg et al. 2007). A recent inventory of Bonaire's Coral Reefs (Carmabi 2011) shows that the reef is in general decline in terms of coral and fish abundance. The question is how to define a reference state in a changing environment. A well set-up monitoring design including multiple reference sites should allow the initiator to tease apart natural variability from general trends (e.g. decline) invariability caused by the initiated project. A steeper decline in environmental indicators in the project area compared to the the reference sites would be an indication that the pressures of the actions are having a significant impact on the ecosystem (See for a conceptual model Figure 3). If adequate and appropriate reference sites are selected, climate change does not have to be considered separately in the monitoring design.

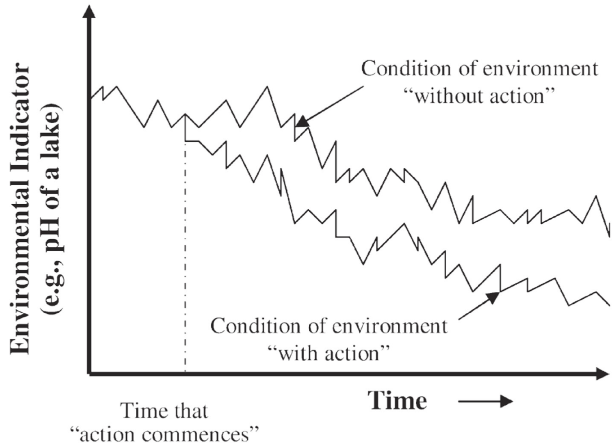

Figure 3 *Conceptual framework for assessing environmental changes. The reference condition is the without-action condition and, because of naturally occurring changes, is not necessarily equal to the condition at the start of the monitoring, yet has consistently more favourable levels of environmental indicators than the condition 'with action' (From Kassim & Simoneit 2005). Note that more than one reference site is required for appropriate assessment.*

4.4 Threshold values

As far as the general normative thresholds are concerned, the CN Nature Policy Plan states: "In order to maintain and cultivate the intrinsic, economic and health benefits this special nature provides, it needs to be preserved, protected, and where necessary restored."

The ecological assessment framework of the "Kader Richtlijn Water" (Waterkwaliteit) upholds the 'stand still' principle and also requires the principle of 'no degradation', a principle which can be found in 'Milieunormen Bonaire' as well. The Marine Strategy Framework Directive prescribes the pre-cautionary approach in ecosystem based management. Although these European frameworks do not apply to CN, the essence of these frameworks forms the basis for Dutch nature policy in the Netherlands and much valuable experience has been gained. The application of its is something to consider.

There are no agreed thresholds of concern for most of the commonly recorded variables relating to the health of coral reefs (Jameson et al. 1998 & 2003, Sweatman et al. 2004). As there are few narrative or quantitative thresholds, we need to work with the relative status of reefs; i.e. the status of impacted area relative in time and relative to a reference situation outside of the impacted area.

In the absence of thresholds, Sweatman et al. (2004) and Sweatman (2007) suggest that thresholds should be based on extreme values (for instance, 90th percentiles) of the distribution of recorded indicator values (suitably regionalized). However, this approach does not take into account subtle changes, which do not relate to any (extreme) threshold, but can lead to structural ecosystem changes (e.g. alternative stable states). Scheduled reviews by a panel of reef scientists who should also identify opportunities for experimental work to assist setting thresholds of concern or with interpreting monitoring results in other formats should be part of the protocol. As there is no best practice yet in establishing thresholds, we recommend a general rule of thumb that as soon as any sign of a difference, degradation, or decrease is seen in the impacted site relative to the reference, further investigation is required. The observed difference does not necessarily have to be statistically significant. Subtle changes might be hard to detect with statistics, and could require a high resolution (in time and space) and longterm monitoring. Even then, it is not definite that statistically significant changes can be detected. This does not mean that the changes in the ecosystem are not significant, or may become significant on the longer term.

The Healthy Reefs for Healthy People Initiative (http://www.healthyreefs.org/index.php/en/healthy-reef-indicators/indicator-framework) proposed a number of quantitative indicators to evaluate reef health in the MesoAmerican Reefs (Table 7). These data-ranges are based on the experience, data, and perspectives of a scientific review committee, as well as data from the Atlantic and Gulf Rapid Reef Assessment (AGRRA) database of over 800 Caribbean reef sites. Representativeness for the CN-islands should be assessed first.

Table 7 Quantitative indicators to evaluate reef health in the MesoAmerican Reef proposed by The Healthy Reefs for Healthy People Initiative (http://www.healthyreefs.org/index.php/en/healthy-reef-indicators/indicator-framework).

	Very good	Good	Fair	Poor	Critical
Coral cover (%)	> 40	20.0-39.9	10.0-19.9	5.0-9.9	<5
Coral disease prevalence (%)	<1	1.1.-1.9	2.0-3.9	4.0-6.0	>6
Coral recruitment (m-2)	>10	5.0-9.9	3.0-4.9	2-2.9	<2
Fleshy Macroalgae Index	<10	10.-19	20-39	40-59	>60
Fleshy macroalgae % cover	0-0.9	1.0-5.0	5.5-12.0	12.1-25	>25.0
herbivorous fish abundance (g/100m2)	>3480	2880-3479	1920-2879	960-1919	<960
commercial fish abundance (g/100m2)	>1680	1260-1679	840-1259	420-839	<420
Diadema abundance (m3)	2.5-7	1.1-2.5	0.5-1	0.25-0.49	<0.25

Table 8, 9, and 10 give threshold levels for water emissions, and surface water based on "Milieunormen Nederlandse Antillen, 2007". These standards have been proposed, but not yet implemented in policy and environmental management. The report of Milieunormen Nederlandse Antillen (2007) proposed to use these environmental standards while also taking into account a "stand still" principle. This means no deterioration of any kind is allowed.

Table 8 Emission standards World Bank and Dutch Antilles (Milieunormen Nederlandse Antillen, 2007)

Emission standards µg m-3		
	Antilles 2010-2020	**World bank**
TSP year avg	75 - -	80
PM10 year avg	50 - 20	50
PM10 24 hr.	150 - 50	200
SO2 year avg.	80 - 50	80
SO2 24 hr.	365 – 20	300
NOx year avg	100 – 40 (NO2)	100
NOx 24 hr	300 – 200 (NO2)	200

Table 9 Quality standards effluents (Milieunormen Nederlandse Antillen, 2007)

Existing standards	**Oil/fat/ grease** (mg/l)	**BOD5** (mg O2/l)	**COD**	**N** (mg N/l)	**P** (mg P/l)	**Feacal Coli** (x/100ml	**Suspended Solid** (mg/l)
LBS-protocol (Class I- II)	15-30	30-150				200	30-150
Other (Ant =Neth. Antilles) (Bonaire: concept eilands-verord. Afvalwater 2007)	20-200 (Ant.) 200 (Bonaire: discharge to sewer	5-60 (Ant; <20 (Ant-irrigation) 20-25 (Texas/ Barbados) 30-45 (Guam; avg resp. 30-7 days) 50 (Ant. Irrigation Bonaire)	<100 (Ant; irrigation) 125 (Ant. Irrigation Bonaire)	10/30/60-120 (Ant/Jamaica/ Texas/Japan <30 (Kj-N Ant; irrigation) 5 (Australia; Great Barrier Reef) 5-28 (Ant: irrigation Bonaire)	1-2 (Ant.) <2-16 (ned-Japan 1 (Australia; Great Barrier Reef) 5 (Ant: irrigation Bonaire)	400-1000 (Bar-bados-Texas) 200-400 (Guam; avg resp. 30 and 7 days) 23-240/2,2-23 (California resp. mediaan 7 dgn en 30 dagen > 1 monster <1000 (Ant;irr.)	10-60 (Ant.) 30-200 (Barbados-Japan) 30-45 (Guam, avg resp. 30 and 7 days) 5 (Ant. irrigation Bonaire)

Table 10 Overview of surface water quality levels in the world (Milieunormen Nederlandse Antillen, 2007)

	Oil/fat/ grease (mg/l)	**Diss. Oxygen** (mg/l)	**N** (mg N/l)	**P** (mg P/l)	**Feacal Coli** (x/100ml	**Suspended Solid** (mg/l)
Min-max values	**0-5** (Florida) **Not visible/ no odour** (EU + Blue Flag)	**>0.3 - >5.0** (Florida; resp. industrial and shellfish water) **>4- >5** (Puerto Rico, resp. swimming water, nature+ , fishing, boating	**0.1-0.5 NO3 (**US,Guam**)** **0.014 DIN** (Lapointe) **0.1 – 1.2 TN** Australia **0,010-0,20 Puerto Rico** (NO3 + NO2 as N)	**0.025-0.10 PO4-P (**anorg.; (US**,**Guam) **0.003 TF** (Lapointe) **0.01-0.02** (Aus TF) **1 TP** (Puerto Rico)	**Entero: 35** (mean 5 in 30 days)**; max. 104/276** (US,Guam) **250-500** (EC in cfu): EU bath **100** (beach criteria Blue Flag Caribbean, max 20% hoger) **200-2000** (Puerto Rico; resp. max. 20% boven 400 of 4000)	**5-40** (US, Guam) **3. 85** (Great Barrier reef tolerance level)

Table 11 Surface water threshold values for Bonaire (Milieunormen Nederlandse antillen, 2007)

Watertypes	**Oxygen (DO) [mg/l]**	**N [mg N/l]**	**P [mg P/l]**	**Feacal Coli [n/100 ml]**	**Oil/Fat [mg/l]***	**transparency [m]**
Recreation	>5	0.10	0.02	5	0.5	5-25
Nature	>5	0.014	0.003	100	0.1	25
Industry	>0.8	1.27	0.10	100	3	5
Rest (lagunes, lakes, estuaria)	>4	0.15	0.02	200	0.5	5-25

5 Assessment and evaluation

5.1 Linking activities, pressures to environmental descriptors

In assessment and evaluation phase the relevance and significance is evaluated by taking into account the spatio-temporal co-occurrence of the pressures and environmental descriptors. An indication of pressures and the relevance of those pressures in terms of the proposed environmental descriptors is given in Table 12. The table presents a qualitative assessment of relevant linkages that can be used as guidance during the scoping phase. During the assessment phase the linkages can be made more specific by giving relative weight to each relevant linkage. A guide to determining the significance of an impact is provided in Chapter 5.2.

It is important to gain more insight into the trends of activities and the associated pressures on the ecosystem. Information that is already available from various sources could easily be used to develop indicators of human pressures. The list below gives examples of indicators that could be applied to monitoring plans either at the level of a human activity as a proxy for pressures, or as a pressure itself. It should be added that not all indicators attribute evenly to a pressure descriptor (for example, ships will add more to background noise than platforms).

- Risk of introduction of NIS by shipping (IMO Ballast Water Convention G7 guideline on environmental risk analysis)
- Number of mariculture units
- Area impacted by human activities (extent and frequency)
- Volume of sand extraction
- Volume of coastal nourishments
- Number of ship movements
- Surface area of anchorage
- Emissions at sea of nutrients, synthetic and non-synthetic substances
- Atmospheric deposition of nutrients, synthetic and non-synthetic substances
- Surface discharges of nutrients, synthetic and non-synthetic substances
- Amount of litter collected

The initiator is required to check these relationships in addition to others that are relevant to the specific proposed activity.

Table 12 A qualitative indication of links between human activities, pressures and relationship with environmental descriptors in CN

Pressure	Activity	Coastal development	Cruise tourism	Dive Tourism	Dredging	Fishing	Inland clearing/agriculture	Oil refineries	Piers/jetties (e.g. restaurants, diving, yachting)	Harbours (municipal)	Shipping (maritime transport)	Aquaculture	Desalination of water	**Environmental descriptors**	Benthic diversity	Coral health	Species requiring special attention	Fish diversity	Physical stature	Chemical water quality
Biological disturbance	Introduction of new habitats	×							×	×		×		→	×		×	×	×	
	Selective extraction of species (incl. non-target catches)				×	×						×		→	×		×	×		
	Introduction of non-indigenous species and translocations		×					×		×	×	×		→	×			×		
	Introduction of microbial pathogens		×				×		×	×	×	×		→	×	×	×	×		×
Nutrient,carbon and organic matter enrichment	Inputs of organic matter	×			×	×	×	×	×	×	×	×	×	→	×	×		×		×
	Inputs of fertilisers and other nutrient-rich substances	×			×	×	×	×	×	×	×	×	×	→	×	×				×
Contamination by hazardous substances	Introduction of substances and compounds	×			×			×	×	×	×	×	×	→	×	×	×	×		×
Interference with hydrological processes	Other hydrological changes	×			×				×	×				→	×		×	×	×	×
	Significant changes in thermal or salinity regime												×	→	×	×	×	×		×
Other physical disturbance	Electrmagnetic changes													→			×			
	Marine litter/debris	×	×			×		×	×	×	×	×		→	×		×	×		×
	Underwater noise		×		×	×			×	×	×			→			×	×		
Physical damage	Selective extraction of sediment				×				×	×				→	×				×	×
	Abrasion				×	×		×	×	×	×	×		→	×	×			×	
	Changes in siltation, sedimentation	×	×	×	×		×	×	×	×	×	×	×	→	×	×	×	×	×	×
Physical loss	Sealing	×						×	×	×		×		→	×	×	×	×	×	
	Smothering	×			×		×			×		×		→	×	×	×	×	×	

5.2 Significant impact

5.2.1 Determining significant impact

In the assessment and evaluation phase the significance of impact of the pressures of the proposed activity on the surrounding environment is determined. In Chapter 4.4 we have seen that distinctive threshold values are still missing for the majority of environmental descriptors of tropical coastal ecosystems. Even without threshold values, however, the significance of an impact can be assessed.

ANZECC & ARMCANZ (2000) define a significant impact as an impact which is important, notable, or of consequence, having regard for its context or intensity.

In determining the nature and magnitude of an action's impacts, it is important to consider matters such as:

- the sensitivity of the environment which will be impacted;
- the timing, duration and frequency of the action and its impacts;
- all on-site and off-site impacts;
- all direct and indirect impacts;
- the total impact which can be attributed to the action over the entire geographic area affected, and over time;
- existing levels of impact from other sources, and the degree of confidence with which the impacts of the action are known and understood.

Once all the potential impacts of an action have been identified, the next step is to consider how severe those impacts are likely to be. The following criteria are relevant:

- What is the scale of the action and its impacts?
- What is the intensity of the action and its impacts?
- What is the duration and frequency of the action and its impacts?

In the box below, a checklist is provided as a guide to evaluate the significance of impact. These questions are based on a compilation of ecological impact and risk assessments published by ANZECC, ARMCANZ, GBRMP, and EPA.

BOX 1 Significance guide

There will be a significant impact of a pressure if the answer is 'yes' to one or more of the following questions.
Will the action:

- Modify, destroy, fragment, isolate or disturb an important, substantial, sensitive or vulnerable area of habitat or ecosystem component?
- Have an adverse effect on health, functioning or integrity of coastal ecosystem?
- Have an adverse effect on a population of a species including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution?
- Result in a substantial change in air quality or water quality which may adversely impact on biodiversity, ecological health or integrity or social amenity or human health?
- Result in a known or potential pest species being introduced or becoming established in the coastal ecosystems?
- Permanently alter tidal patterns, water flows or water quality in coastal ecosystems?
- Reduce biological diversity or change species composition in coastal ecosystems?
- Extract large volumes of sand/sediment or substantially destabilise coast?
- Adversely affect (inter)nationally threatened species and ecological communities?
- Adversely affect migratory species protected under international agreements?
- Adversely affect RAMSAR wetlands of international importance?

5.2.2 Categorize/prioritize significance

In order to set priorities in deciding whether an impact of a pressure on the environment is acceptable or unacceptable, the degree of the consequences and their likelihood should be assessed. Table 13 and Table 14 provide guidance in prioritization.

Table 13 Degrees of consequences of impact from pressures on Environment –Ecosystem level taken from the Great Barrier Reef Marine Park Authority (GBRMPA) Environmental Assessment and Management (EAM) Risk Management Framework (2009).

DESCRIPTION	DEFINITION
CATASTROPHIC	Impact is clearly affecting the nature of the ecosystem over a wide area OR impact is catastrophic and possibly irreversible over a small area or to a sensitive population or community Recovery periods of greater than 20 years likely OR condition of an affected part of the ecosystem irretrievably compromised.
MAJOR	Impact is significant at either a local or wider level or to a sensitive population or community. Recovery periods of 10 - 20 years are likely.
MODERATE	Impact is present at either a local or wider level. Recovery periods of 5 - 10 years anticipated.
MINOR	Impact is present but not to the extent that it would impair the overall condition of the ecosystem, sensitive population or community in the long term.
INSIGNIFICANT	No impact or, if impact is present, then not to an extent that would draw concern from a reasonable person. No impact on the overall condition of the ecosystem.

Table 14 Levels of likelihood of impact taken from the Great Barrier Reef Marine Park Authority (GBRMPA) Environmental Assessment and Management (EAM) Risk Management Framework (2009).

DESCRIPTION	FREQUENCY	PROBABILITY
Almost certain	Expected to occur more or less continuously throughout a year (e.g. more than 250 days per year)	95-100% chance of occurring
Likely	Expected to occur once or many times in a year (e.g. 1 to 250 days per year)	71-95% chance of occurring
Possible	Expected to occur once or more in the period of 1 to 10 years	31-70% chance of occurring
Unlikely	Expected to occur once or more in the period of 10 to 100 years	5-30% chance of occurring
Rare	Expected to occur once or more over a timeframe greater than 100 years	0-5% chance of occurring

6 Discussion and recommendations

In this report a generic ecological framework was drafted for the Caribbean Netherlands (CN). The purpose of a generic ecological framework is to offer guidance during licensing of planned activities which could have consequences on the biodiversity, water quality, and physical environment of coastal systems. The framework may also be used as a re-evaluation of existing activities. This draft framework was constructed based on a review of existing frameworks primarily from Australia and U.S.A, two nations with tropical coastal ecosystems within their territories. The proposed framework is, however, not bound to a specific geographic region and is therefore applicable to tropical coastal ecosystems within the overall geographic area of the CN, including both the Windward and Leeward islands.

We propose three generic phases to assess the impacts of proposed activities on coastal ecosystems (1. establishing context of the proposed activity, 2. scoping of activities, pressures and environmental descriptors, 3. assessment and evaluation of pressures on environmental descriptors).

An adaptive and interactive management approach is needed, based on a pre-cautionary principle towards the environment given that the consequences for the local economies could be great should a negative impact occur. Though this draft framework provides guidance, it limits itself to standard practice and general regulations. It is the responsibility of the individual initiators to customize an adequate and comprehensive ecological impact assessment and monitoring-plan adjusted to the spatial and temporal scale relevant of the type of activities and possible impact resulting from the project. This impact assessment and monitoring plan should subsequently be evaluated and approved by the relevant authorities.

An area of concern is that specific assessment criteria in local policy plans are lacking and no quantitative goals have been set which is standard practice in the Netherlands (e.g. in Nature 2000 policy and policy plans). The few normative/qualitative goals are set in local nature ordinances (e.g. derived from international treaties). In view of this general lack of observation goals, or other quantitative criteria, and accepted thresholds, we recommend to require each project to monitor the projected area that may be impacted as well as reference areas both in time and space (thus multiple sites within multiple areas over multiple time periods). Models alone will not suffice. Reference situations (both in space and time) can represent target conditions during the monitoring. Considering the size of the islands of CN, it should be feasible to select a suit of reference sites per island that have the "best available" ecological conditions. These sites should remain unharmed, be regularly monitored and can indicate the general transition of the coastal ecosystems due to natural or larger scale causes. By incorporating multiple reference sites in the monitoring scheme, the effects of an activity can easily be separated from general climate change effects.

Significant impact on the environment can be qualitatively evaluated by using the schemes in chapter 5 of this report. However, a legal review on these schemes and their application is required.

This study was limited to the review of (inter)national frameworks and monitoring initiatives. What became apparent in this review was that only state indicators are used in the frameworks and monitoring schemes. As described in chapter 4, state indicators (such as biota) are constantly exposed to the impact of various pressures, these indicators reflect not only current conditions, but also changes in conditions over time and their cumulative impacts. As such, state indicators are important and highly informative. However, relevant process indicators remain underexposed in the evaluated protocols. It is therefore recommended to review process indicators (e.g. calcification, bio-erosion, fleshy algal growth, grazing intensity) in peer reviewed literature, and to evaluate their practical applicability in relation to this assessment framework. Furthermore, it should be recognized that frameworks and protocols can be made more applied to CN by incorporating indicators specific to the region/island. This specificity was beyond the scope of the present project, given the limited time available, but is highly recommended for an upcoming version of the framework.

We would like to stress that this report describes a first concept of a generic ecological assessment framework. As such, this report and its content has not been tested with pilot situations or the relevant legal framework, nor evaluated with stakeholders. It is highly recommended to evaluate the proposed framework with pilot or actual cases, and to adapt were necessary. The eventual framework should be made more specific to the legal and environmental context of CN.

To conclude, there are a number of significant knowledge gaps that require further study in order to set-up an adequate general ecological assessment framework that can be applied for the coastal ecosystems of CN. To summarize the following next steps are required:

- Consider to establish quantitative and/or narrative thresholds for environmental descriptors and indicators in the CN, related to the Nature Policy Plan. This should be based on a thorough review of academic peer-reviewed literature as well as field surveys.
- Determine appropriate locations for permanent reference sites for each island in the Caribbean Netherlands.
- Review relevant process indicators and their applicability into the framework and protocols for monitoring state changes.
- Run pilot studies (e.g. small scale versus larger scale projects; different environments/ecology) to evaluate the applicability of the framework.
- Determine whether all aspects of the ecological framework comply within legal context of CN.

7 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.

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Justification

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

Approved: Dr. Erik H.W.G. Meesters
Senior researcher

Signature:

Date: 25 October, 2012

Approved: F.C. Groenendijk, MSc.
Head of Department

Signature:

Date: 25 October, 2012

Annex A. Species lists

National nature Ordinance- species list

Species listed under CITES appendix I, SPAW annex I and II and CMS are also granted full protection under the Nature Conservation Law BES. During assessment check latest status with each of the treaties.

Latijnse naam	Papiamentse naam	Nederlandse naam	Engelse naam	
Zeezoogdieren				
Balaenoptera acutorostrata	bayena	dwergvinvis	minke whale	▲
Balaenoptera edeni	bayena tompoes, topo	Brydevinvis Brydewalvis	Bryde's whale	▲
Balaenoptera physalis	bayena	vinvis	fin whale	▲
Delphinus delphis	dòlfein	gewone dolfijn	common dolphin	▲
Globicephala macrorhynchus	kabes di keshi	Indische griend kortflippergriend	shortfin pilot whale	▲
Grampus griseus		grijze dolfijn gramper	grey dolphin	▲
Kogia breviceps		dwergpotvis	pygmy sperm whale	▲
Kogia simus		kleinste potvis	dwarf sperm whale	▲
Lagenodelphis hosei		sarawakdolfijn dolfijn van Fraser	Fraser's dolphin	▲
Megaptera novaeangliae	bayena	bultrug	humpback whale	▲
Mesoplodon europaeus		spitssnuitdolfijn van Ger-vais	Gervais's beaked whale	▲
Orcinus orca		orka zwaardwalvis	orca, killer whale	▲
Peponocephala electra		witlipdolfijn, witlipgriend, veeltandgriend, elektra-dolfijn	melon-headed whale	▲
Physeter catodon	kachalote	potvis	great sperm whale	▲
Pseudorca crassidens		zwarte zwaardwalvis	false killer whale	▲
Stenella attenuata	dòlfein	slanke dolfijn, pantropi-sche gevlekte dolfijn	pantropical spotted dolphin	▲
Stenella clymene		clymenedolfijn	Atlantic spinner dolphin	▲
Stenella coeruleoalba		gestreepte dolfijn	striped dolphin	▲
Stenella frontalis		Atlantische vlekdolfijn	Atlantic spotted dolphin	▲
Stenella longirostris	toniwa	langsnuitdolfijn, spinner-dolfijn	spinner dolphin	▲
Tursiops truncatus	dòlfein	grote tuimelaar	bottlenose dolphin	▲
Ziphius cavirostris		dolfijn van Cuvier	Cuvier's beaked whale	▲
Haaiachtigen				
Aetobatus narinari	chuchu águila	gevlekte adelaarsrog	spotted eagle ray	•
Dasyatis Americana	chuchu ròk	Amerikaanse pijlstaart-rog	southern stingray	•
Manta birostris	manta	mantarog	manta ray	•
Selachimorpha (Euselachii)	tribon	haaien	sharks	•
Zeereptielen				
Caretta caretta	kawama	dikkopzeeschildpad	loggerhead	▲
Chelonia mydas	tortuga blanku	groene zeeschildpad	green seaturtle	▲
Dermochelys coriacea	drikil	lederrugzeeschildpad	leatherback	▲
Eretmochelys imbricata	karet	karetschildpad	hawksbill	▲
Lepidochelys olivacea (kempi)	bastardo	warana	olive ridley	▲
Zeevissen				
Balistes vetula	pishiporko rabu di gai	koningstrekkervis	queen triggerfish	•
Dermatolepis inermis	olitu		marbled grouper	•
Epinephelus itajara	djukvis	itajara	Goliath grouper, jewfish	•
Epinephelus striatus	jakupepu	Nassau tandbaars	Nassau grouper	•
Lachnolaimus maximus	hokfis	everlipvis	hogfish	•
Lutjanus analis	kapitán	snapper	mutton snapper	•

Latijnse naam	Papiamentse naam	Nederlandse naam	Engelse naam	
Lutjanus cyanopterus	karaña pretu	cubera snapper	cubera snapper	●
Pagrus pagrus	djent'i maishi	rode zeebrasem	red porgy	●
Scaridae	gutu	papegaaivissen	parrotfishes	●
Thunnus obesus	buni wowo grandi	grootoogtonijn	bigeye tuna	●
Ongewervelde zeedieren				
Panulirus argus	kref	kreeft	Caribbean spiny lobster	■
Panulirus guttatus	kref	gevlekte kreeft	spotted spiny lobster	■
Panulirus laevicauda	kref	kreeft	smoothtail spiny lobster	■
Koraalachtigen				
Antipatharia	koral pretu	zwarte koralen	black corals	●○
Gorgoniacea		waaierkoralen	gorgonians	●
Milleporidae		brandkoralen	fire corals	●○
Scleractinia		steenkoralen	stony corals	●○
Stylasteridae		kantkoralen	lace corals	●○
Zeeschelpdieren				
Strombus gigas	karkó	roze vleugelhoorn grote kroonslak	queen conch	●■○
Zeegrassen				
Syringodium filiforme (Cymodocea manitorum)		zeegras	manatee grass	●
Thalassia testudinum	yerba di kaña	zeegras	turtle grass	●
Zoogdieren				
Chiroptera	raton di anochi	vleermuizen	bats	●
Vogels				
Amazona barbadensis	lora	geelvleugelamazone	yellow-shouldered amazon	▲
Aratinga pertinax xanthogenius	prikichi	West Indische parkiet	brown-throated parakeet	●○
Buteo albicaudatus	gabilan di seru, falki	witstaartbuizerd	white tailed hawk	●○
Caracara cheriway	warawara	kuifcaracara	crested caracara	▲
Falco peregrinus	falki peregrino	slechtvalk	peregrine falcon	▲
Margarops fuscates bonairensis	chuchubi Spaño palabrua boka duru	witoogspotlijster	pearly eyed trasher	●
Pandion haliaetus	gabilan piskadó	visarend	osprey	●○
Pelecanus occidentalis	ganshi	bruine pelikaan	brown pelican	▲
Phoenicopterus ruber	chogogo	Caribische flamingo	Caribbean flamingo	●○
Tryngites subruficollis		blonde ruiter	buff-breasted sandpiper	▲
Tyto alba	palabrua	kerkuil	barn owl	●○
Reptielen				
Iguana iguana	yuana	groene leguaan	green iguana	○
Zoetwaterdieren				
Typhlatya monae		blinde garnaal	Mona cave shrimp	●
Mangrovesoorten				
Avicennia germinans	mangel blanku	witte mangrove	black mangrove	■
Conocarpus erectus	mangel, mangel blan-ku	grijze mangrove	buttonwood	■
Laguncularia racemosa	mangel blanku	mangrove	white mangrove	■
Rhizophora mangle	mangel tan	rode mangrove	mangrove	■

●= protected species bases on Eilandverordening Natuurbeheer, article 11, 2e lid.

□= protected species based on Eilandverordening Natuurbeheer, article 11, 2e lid.including measures

□= protected species based on international treaties

○ = protected species according to Cites annex 2.

<u>CITES and CMS species lists</u>
Appendix I species and CMS appendix number. Only marine species are included.

Scientific name	English	Papiamentu	CMS
Cetaceans (whales, dolphins)			
Physeter catodon	Great Sperm Whale	Kachalote	I/II
Balaenoptera acutorostrata	Minke Whale	Bayena	
Balaenoptera edeni	Bryde's Whale	Topo	II
Balaenoptera physalis	Fin Whale	Bayena	I/II
Megaptera novaeangliae	Humpback Whale	Bayena	I
Sea turtles			
Chelonia mydas	Green Turtle	Tortuga blanku	I/II
Eretmochelys imbricata	Hawksbill Turtle	Karèt	I/II
Caretta caretta	Loggerhead Turtle	Kawama	I/II
Lepidochelys olivacea	Olive Ridley	Tortuga bastiá	I/II
Dermochelys coriacea	Leatherback Turtle	Drikil	I/II

CITES Appendix II species and CMS appendix number.

Scientific name	English	Papiamentu	CMS
Cetaceans (Whales, dolphins)			
Tursiops truncatus	Bottlenose Dolphin	Toníu	II
Lagenodelphis hosei	Fraser's Dolphin		II
Delphinus delphis	Common Dolphin	Toníu	II
Stenella attenuata	Pantropical Spotted Dolphin	Toníu	
Stenella frontalis	Atlantic Spotted Dolphin		
Stenella longirostris	Spinner Dolphin		II
Stenella coeruleoalba	Striped Dolphin		II
Stenella clymene	Clymene Dolphin		II
Grampus griseus	Risso's Dolphin		II
Ziphius cavirostris	Cuvier's Whale		
Mesoplodon europaeus	Gervais's Beaked Whale		
Pseudorca crassidens	False Killer Whale		
Orcinus orca	Orca - Killer Whale		II
Kogia breviceps	Pygmy Sperm Whale		
Kogia simus	Dwarf Sperm Whale		
Peponocephala electra	Melon-headed Whale		
Globicephala macrorhynchus	Shortfin Pilot Whale	Kabe'i keshi	
Gastropods (snails)			
Strombus gigas	Queen Conch	Karkó	
Black corals			
Antipathes americana			
Antipathes atlantica			
Antipathes dichotoma	Black Coral	Koral pretu	
Antipathes pennacea			
Antipathes tanacetum			
Antipathes hirta			
Antipathes furcata			
Antipathes caribbeana			
Stichopathes lutkeni			
Stichopathes gracilis			

Scientific name	English	Papiamentu	CMS
Stony corals			
Acropora cervicornis	Staghorn Coral	Koral Kachu di Biná	
Acropora palmata	Elkhorn Coral	Koral Kachu grandi	
Acropora prolifera	Fused Staghorn Coral		
Agaricia agaricites	Leaf Coral		
Agaricia humilis			
Agaricia tenuifolia	Ribbon Coral		
Agaricia fragilis	Fragile Saucer Coral		
Agaicia lamarcki	Leaf Coral		
Agaricia grahamae	Leaf Coral		
Agaricia undulata	Scroll Coral		
Montastrea annularis (s.l.)	Mountainous Star Coral		
Montastrea cavernosa	Cavernous Star Coral		
Dichocoenia stokesii	Elliptical Star Coral		
Colpophyllia natans	Floating Brain Coral		
Diploria labyrinthiformis	Brain Coral		
Diploria strigosa	Brain Coral		
Diploria clivosa	Brain Coral		
Porites asteroides	Mustard Hill Coral		
Porites porites	Club Finger Coral		
Porites branneri			
Porites furcata			
Madracis mirabilis	Yellow Pencil Coral		
Madracis decactis	Green Cactus Coral		
Madracis carmabi			
Madracis senaria			
Siderastrea sidereal			
Siderastrea radians			
Scolymia cubensis	Solitary Disk Coral		
Scolymia lacera			
Mycetophyllia aliciae			
Mycetophyllia daniana			
Mycetophyllia ferox			
Mycetophyllia lamarckiana			
Mycetophyllia reesi			
Mussa angulosa	Large Flower Coral		
Stephanocoenia michelinii	Blushing Star Coral		
Leptoseris cucculata			
Eusmilia fastigiata	Flower Coral		
Favia fragum	Golfball Coral		
Meandrina meandrites			
Dendrogyra cylindrus	Pillar Coral		
Millepora alcicornis	Fire Coral		
Millepora complanata			
Millepora squarrosa			
Stylaster roseus	Lace Coral		

IUCN Red List species found in the Dutch Caribbean EEZ.

Scientific name	Popular name	Red List Status
Acropora cervicornis	staghorn coral	Critically Endangered
Acropora palmata	elkhorn coral	Critically Endangered
Agaricia lamarcki	lamarck's sheet coral	Vulnerable
Carcharhinus longimanus	oceanic whitetip shark	Vulnerable
Dendrogyra cylindrus	pillar coral	Vulnerable
Dichocoenia stokesii	elliptical star coral	Vulnerable
Millepora striata	fire coral	Endangered
Montastraea annularis	boulder star coral	Endangered
Montastraea faveolata		Endangered
Montastraea franksi		Vulnerable
Mycetophyllia ferox	rough cactus coral	Vulnerable
Oculina varicosa	large ivory coral	Vulnerable
Megaptera novaeangliae	humpback whale	Vulnerable
Physeter macrocephalus	sperm whale	Vulnerable
Trichechus manatus	west indian manatee	Vulnerable
Lutjanus analis	mutton snapper	Vulnerable
Lutjanus cyanopterus	cubera snapper	Vulnerable
Mycteroperca interstitialis	yellowmouth grouper	Vulnerable
Mycteroperca venenosa	yellowfin grouper	Near Threatened
Epinephelus flavolimbatus	yellowfinned grouper	Vulnerable
Epinephelus itajara	goliath grouper	Critically Endangered
Epinephelus morio	red grouper	Near Threatened
Epinephelus niveatus	snowy grouper	Vulnerable
Epinephelus striatus	nassau grouper	Endangered
Balistes vetula	queen triggerfish/moonfish	Vulnerable
Scarus guacamaia	rainbow parrotfish	Vulnerable
Lachnolaimus maximus	hogfish	Vulnerable
Pristis pectinata	wide sawfish	Critically Endangered
Carcharhinus perezi	caribbean reef shark	Near Threatened
Carcharhinus leucas	bull shark	Lower Risk, Near Threatened
EIsurus oxyrinchus	shortfin mako	Vulnerable
Galeocerdo cuvier	tiger shark	Lower Risk, Near Threatened
Sphyrna lewini	scalloped hammerhead	Endangered
Sphyrna mokarran	squat-headed hammerhead shark	Endangered
Caretta caretta	loggerhead turtle	Endangered
Chelonia mydas	green turtle	Endangered
Eretmochelys imbricata	hawksbill turtle	Critically endangered
Dermochelys coriacea	leatherback turtle	Critically endangered
Lepidochelys olivacea	olive ridley rurtle	Vulnerable
Pterodroma hasitata	black-capped petrel	Endangered

SPAW species list

SPAW protected species list taken from Jongman et al 2010. Green = present, red= rare.
B= Bonaire, c= Curacao S= Saba, E= St. Eustatius, M= St. Maarten.

Scientific name	*English name*	*B*	*C*	*S*	*E*	*M*
Zeeschildpadden						
Caretta caretta	Loggerhead	🟢	🟢	🟢	🟢	🟢
Chelonia mydas	Green turtle	🟢	🟢	🟢	🟢	🟢
Eretmochelys imbricata	Hawksbill turtle	🟢	🟢	🟢	🟢	🟢
Lepidochelys olivacea	Olive Ridley	🔴	🔴	🔴	🔴	🔴
Dermochelys coriacea	Leatherback	🔴	🔴	🟢	🟢	🟢
Vogels						
Puffinus lherminieri	Audubon's shearwater	🟢	🟢	🟢	🟢	🟢
Pelecanus occidentalis	Brown pelican	🟢	🟢	🟢	🟢	🟢
Falco peregrinus	Peregrine falcon	🔴	🔴	🔴	🔴	🔴
Polyborus plancus	Caracara	🟢	🟢			
Charadrius melodus	Piping plover	🔴				
Sterna antillarum antillarum	Least tern	🟢	🟢	🟢	🟢	🟢
Sterna dougallii dougallii	Roseate tern	🟢	🟢	🟢	🟢	🟢
Amazona barbadensis	Lora	🟢				
Zeezoogdieren						
All Cetacea	all whales and dolphins	🟢	🟢	🟢	🟢	🟢
All Sirenia	all manatees		🔴			
Tadarida brasiliensis	Mexican free-tailed bat	🟢	🟢	🟢	🟢	🟢