CDHC Workshop Proceedings:

Guidance for Establishing a Disease Surveillance Network for Caribbean *Acropora palmata*

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St. Matthew's University
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About This Document

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About the CDHC

In response to the global decline in coral reefs, the U.S. Coral Reef Task Force's National Action Plan to Conserve Coral Reefs called for the creation of a *Coral Disease and Health Consortium (CDHC)* to organize and coordinate the scientific resources of the U.S. and its territories to meet the challenge of globally declining coral reefs. Its mission is to preserve and protect the health of coral reef ecosystems through an understanding of the effects of natural and anthropogenic stressors on reef-building communities. The CDHC serves to unify the coral health and disease research community, identify research priorities, and encourage a new generation of coral researchers through education and outreach. The biomedical perspective and innovative technologies developed from Consortium efforts is envisioned to give scientists, resource managers, and industry new tools to identify and alleviate hidden stresses before they become environmental health crises. Currently over 125 national & international partners, including federal agencies, NOAA, DOI, EPA, along with academia, non-profit and industry, contribute their time and expertise to the CDHC, while organizational infrastructure is supported by the congressionally funded NOAA Coral Reef Conservation Program.

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CDHC Workshop Report: Guidance for Establishing a Disease Surveillance Network for Caribbean *Acropora palmata*

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Table of Contents

EXECUTIVE SUMMARY

Acropora palmata was listed as Threatened under the Endangered Species Act in May 2006 and with continued declines in their population are being considered for uplisting to Endangered status. This coral exists only in the Caribbean where its existence is threatened by infectious pathogens, pollution, and human activities. There is a critical need to conserve remaining stocks of corals, but the status of this species is unknown in many regions in the Caribbean because the capacity to assess their condition and monitor reefs is lacking. This is particularly challenging in many Caribbean locations (e.g. small islands) with limited financial and personnel resources (e.g. small countries), and that lack access to a coordinated network of collaborators. The goal of this workshop was to provide methods that can assist coral reef managers, particularly those with limited resources, to assess and manage the health of their respective coral populations with a focus on *A. palmata* as a sentinel species. Specific aims of this workshop were as follows:

1) Develop survey methods based on the sound principles and theories of epidemiology that can:
    a. Provide demographic data directly comparable across regions.
    b. Be simple enough to apply for managers with limited means.
    c. Have sufficient sensitivity to detect adverse changes on reefs before it is too late to intervene.
2) Develop a means to analyze survey data to detect status and trends with the overarching goal to:
    a. Detect and report declines in populations or recruitment or increase in mortality on a real-time basis.
    b. Define trigger mechanisms that would merit the recruitment of outside experts to help investigate potential causes of unusual disease outbreaks, increases in mortality, or disease outbreaks.
3) Ensure that surveillance design and analyses are sound and appropriate for island biogeographic settings.
4) Design the surveillance methodology and networks targeted to small Marine Protected Areas with limited resources.
5) Develop a hierarchical structure, using the U.S. Centers for Disease Control and the World Health Organization as models, to develop an implementation strategy for methods in which surveillance is conducted and data analyzed, to detect anomalies. Resource managers are supplied inexpensive techniques to diagnose the change and then a means of accessing expertise when situations demand more specialized investigations.
6) Identify new methods or techniques from the available expertise to incorporate into the overall guidance document.

The format was a working meeting involving 12 recognized experts to develop a guidance document on disease surveillance and response. Each participant played a vital role in developing this methodology and guidance document with expertise in epidemiology, veterinary medicine, coral physiology, watershed characterization or resource management. The workshop was not a forum for presentations or discussion of policy issues.

I. Introduction

The health and continued existence of coral reef ecosystems are threatened by an increasing array of environmental and anthropogenic risk factors. Though the specific causes can vary from one location to another, coral health is being undermined by pollution, climate change, habitat destruction, and over-exploitation of marine resources. These and other environmental and anthropogenic factors result in increasing disease manifestations, mortality and reproductive failure across coral populations. The unprecedented loss and continued trajectory of failure of one of the most complex, biologically diverse, and economically valuable habitats on earth was recognized by the U.S. Federal government in 1998 by executive order. In an effort to form a cohesive national strategy to conserve and protect these ecosystems, President William Jefferson Clinton issued an executive order on June 11, 1998 that established the United States Coral Reef Taskforce (CRTF). A collective response from the U.S. resulted in an action plan for coral reef conservation efforts and legislation in Congress passing the Coral Reef Conservation Act of 2000 for implementation and appropriations. A decision for reauthorization of the Coral Reef Conservation Act is currently before the U. S. Congress.

Though these focused efforts of the U.S. have been in place for over 15 years, reports internationally continue to forecast coral reef loss with only a few localized examples emerging of recovery or healthy reefs. Caribbean reefs have suffered particularly significant loss. In 2006, two species, Elkhorn (*Acropora palmata*) and staghorn (*A. cervicornis*) corals were listed as threatened under the Endangered Species Act (ESA) of 1973, as amended on May 9, 2006 (71 FR 26852) in response to a 2004 listing petition from The Center for Biological Diversity and are currently being considered for uplisting to Endangered status. Because of their status, *Acropora palmata* was chosen as the subject of this workshop and to initiate surveillance efforts.

The genus *Acropora* is the most abundant and species-rich group of corals in the world. However *A. palmata* and *A. cervicornis* are two of only three acroporids that are found in the Atlantic/Caribbean, typically in shallow water. The third acroporid is a hybrid of elkhorn and staghorn corals, known as fused-staghorn coral *(A. prolifera)*. Historically elkhorn and staghorn corals were the dominant framework-building species on Atlantic/Caribbean coral reefs, and their high growth rates have allowed them to adapt to sea level changes. Both species, however, underwent precipitous declines in abundance in the early 1980s throughout their range, and this decline has continued (Aronson & Precht 2001). Although quantitative data on former distribution and abundance are scarce, in the few locations where quantitative data are available (e.g., Florida Keys, Dry Tortugas, Jamaica, and the U.S. Virgin Islands), declines in abundance are estimated at greater than 97 percent (Porter *et al.* 2002). Data suggested the decline in Atlantic *Acropora* abundance is primarily the result of disease (as a proximal cause of death); however, temperature-induced bleaching, human activities (e.g., construction, polluted run-off, degraded water quality) and physical damage (e.g., hurricanes, anchoring) have also been implicated. With exposures to these adverse conditions and the effects of disease, there have been significant population losses resulting in reductions in the corals' ability to successfully reproduce, both sexually and asexually (Quinn & Kojis 2006; Federal Register 2008).

To insure the species do not decline further, actions are needed to determine the causal and mechanistic aspects of these threats to both species. ***(Biological Status Review 2005)***

The challenge is to move away from a triage approach in dealing with coral reef decline (in this particular case, Caribbean *Acropora*), to a position of being able to identify and quantify factors driving these systems to fail and put into place practices to recover losses. This requires being able to detect change in coral health at the individual and population level before visible changes manifest at the community and ecosystem levels. Detecting change however requires establishing a baseline of coral health status at the beginning of a surveillance program, and then using standardized and accepted diagnostic methodologies to track changes in coral health.

Epidemiology is the study of disease in populations and of the factors that determine its occurrence ***(Thrusfield 2007)***

The principles and methodologies of epidemiology provide a systematic approach to identify and quantify risk factors that impact coral health (e.g., infectious agents, toxicants, unfavorable environmental conditions) and quantify the contribution of the various factors adversely affecting their health. Phase I involves quantifying populations at risk followed by detecting changes in morbidity, survivorship or recruitment at a level of sensitivity that permits intervention; Phase II involves identifying the most probable factors that could cause morbidity or declines in survivorship or recruitment; Phase III is demonstrating the etiology or probable cause for morbidity and mortality; Phase IV is translating this information into management actions and assessing their effectiveness in slowing declines in survivorship or recruitment.

Surveillance is gathering, recording and analysis of data, and dissemination of information to interested parties so that action can be taken to control disease ***(Thrusfield 2007)***

This report focuses on establishing a surveillance program for *Acropora palmata*—the first part of implementing an Epidemiological Strategy, realizing this methodology is applicable to any species of interest. The objectives of surveillance are three-fold:

1. **Collect baseline data for the population at risk**. In order to detect a change, you need to know what are the estimated numbers of animals, recruitment parameters, and background levels of morbidity and mortality.
2. **Determine relevant health parameters and appropriate trigger points** (i.e., the degree of change in a given parameter) that merit implementation of Phase II (further investigation of a perceived change). This may include documentation of new lesions not previously recorded, or documenting an X% decline in recruitment or Y% increase in mortality in recruitment over Z years.
3. **For surveillance of particular lesions, triage (prioritize) which lesions are most important**. In the case of *A. palmata*, tissue loss or white syndrome and bleaching are a

priority because they can kill rapidly and have been documented in the past to lead to important decreases in coral cover.

II. Surveillance Methodology

A. PHASE I: IS CHANGE OCCURRING ON THE REEF?

1. Selecting Study Sites and Collecting Baseline Data

When initiating a surveillance program it is important to first define the species and populations of interest and their geographic location, in this case, *Acropora palmata*. Gathering historical information for the site and species (mortality rate, recruitment rate, gross lesions, watershed assessments; hydrology) will assist in an assessment and should be obtained where available. Google Earth is a useful tool to define the geographic context and adjacencies of the populations of concern and to identify potential risk factors. Sentinel colonies should be tagged (depending on jurisdiction tagging is likely to be in adjacent substrate rather than on the colony), GPS mapped and an underwater map created to assist in locating colonies for repeated observations. Measures of change in morbidity and recruitment are recommended as two key factors related to the health of corals within the populations of concern. To detect these changes, appropriate sites must be selected, and specific baseline data must be collected for each site. Consider proceeding as follows:

1) Identify geographic regions with *A. palmata* at both local and Caribbean-wide levels.
2) Within each region, determine the areas with the largest aggregations or largest coverage of *A. palmata*. These should be the priority regions for surveillance because the priority objective is to save what is remaining, particularly given that resources are limited.
3) Establish standardized methods to survey demographics of these particular areas that are appropriate for the area. Many print and online resources are available describing methods for surveying corals, or contact the CDHC for help with locating an expert. Characteristics to quantify include the number and size of colonies (for quantifying recruitment), percent cover, substrate characteristics, lesion number and size, and percent live/dead tissue. Belt transects are a convenient and effective method of quantifying colonies. This method consists of stretching a measuring tape 25-50 m in length and quantifying numbers and sizes of colonies within a 0.5-2m swath on either side of the tape (this may be prohibited with Endangered species, check with permitting officials). To track individual colonies, tagging can be done with non-corrosive materials (e.g., cable ties and plastic cattle tags). For *A. palmata*, placing the tag on adjacent substrate is preferred to reduce the risk of damage to the colony. The point intercept method can be used to quantify/classify the substrate in the same area—this consists of recording the nature of the substrate at regular points (i.e., every 10 cm) directly beneath the tape (e.g., Woodley *et al*. 2008 for protocol)

2. Detecting and Quantifying Changes in Morbidity

Morbidity can be assessed in terms of living tissue on the colony, and it is therefore important to select colonies for surveillance that have some living tissue (i.e., at time point zero, mortality = zero) (Fig. 1). *Acropora palmata* populations can occur in densities that range from sparse with colonies found meters apart to dense thickets where individual colonies are difficult to distinguish. In some instances, patch reefs have very low *A. palmata* density making it logistically possible to sample all colonies within an area of reef. This is the preferred approach in cases with low species density.

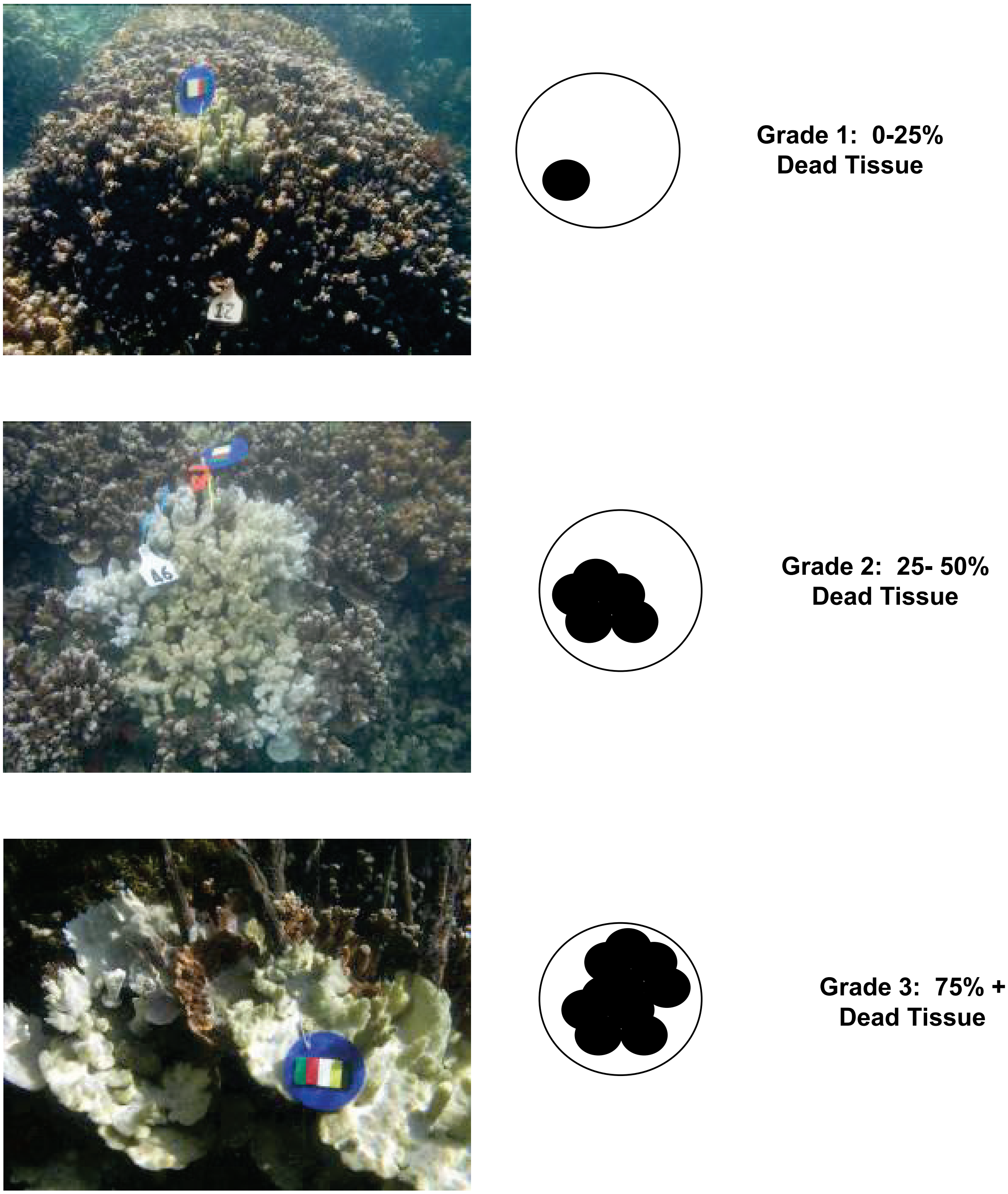


Figure 1 Above scheme is suggested to grade tissue loss on colonies for assessing individual colony condition.

In cases with dense networks or thickets of *A. palmata* (such that density does not sufficiently allow sampling of entire reef). The exact number of colonies will depend on the size of the thicket, however a reasonable sampling per strata would be 10 colonies.

RECOMMENDATIONS for INDICATORS: Once populations of concern are identified, select a sentinel coral or select group of sentinel corals (e.g., 5 colonies) to monitor for change. Triggers are based on a simple morbidity and recruitment matrix (Table 1).

3. Detecting and Qualifying Changes in Recruitment

Recruitment is measured at a predetermined frequency, with once per year recommended.

There are two types of recruitment with *A. palmata*—fragmentation and larval settlement. Both should be recorded, and the specific type should be noted. If a colony is fragmented, this should be photo-documented and the percent of fragments that form new colonies should be recorded. Recruitment due to sexual reproduction and settlement of coral larvae is typically documented by size class distribution.

Belt transect surveys are a simple and effective approach for quantifying recruitment and determining size class distribution. Sites suitable for larval recruitment typically consist of rubble or other solid substrate with coralline algae. Unsuitable sites are those with fleshy micro or macro algae, and/or where the bottom is composed of soft sediment such as sand or silt. The first step in performing a survey is to choose a location that is suitable for larval recruitment and then haphazardly (as randomly as possible while keeping the entire transect line within a suitable area) choose a location for the transect. *A. palmata* recruits (colonies less than 0.5cm in diameter) are then quantified using at least three belt-transects of length suitable to the area of interest (e.g., 20m, 30m, 40m, etc) and a minimum length of 20m. Recruits are counted and measured within a 1 meter wide band along the transect. Size classes can then be assigned (e.g., 1-10 cm, 11-20 cm, etc) for future comparisons. Colonies are only counted/measured if at least half of the entire colony falls within the 1m band.

4. Have changes occurred on the reef in terms of morbidity and/or recruitment and what is the nature of the change?

To determine if change is occurring on the reef a simple matrix can be constructed that compares mortality and recruitment and illustrates which parameters are increasing or decreasing (Table 1). The worst case is when both morbidity is increasing and recruitment is decreasing. If no change is detected, continue with regular Phase I surveillance. If a change is detected, begin Phase II to identify risk factors.

In practice, it is important to recognize that these metrics wax and wane over time and have their own inherent fluctuations. Therefore, it is important to establish reasonable triggers depending on the data and specific situation. For example, a reasonable trigger could be recruitment declines over at least three survey points or if a significant (e.g., 80%) drop in recruitment is detected. For mortality measures in Phase I, lesions will be document, therefore it is important to establish background levels of mortality in a given location. An appropriate trigger in this case may be an “outbreak” situation of new lesions at high prevalence occurs or an existing lesion increases from one survey to the next by 50% or more. Alternatively, for low-grade chronic lesions, consistent increases in tissue loss over three consecutive survey points can serve as a valid trigger to move to Phase II.

Table 1 Morbidity and recruitment matrix used to assist managers in determining if changes are occurring and the relative severity of the changes (i.e., increasing morbidity with decreasing recruitment would be the worst scenario).

Morbidity	Recruitment
Increasing	Increasing
Decreasing	Decreasing

B. PHASE II – IF CHANGE IS DETECTED, WHAT ARE THE POTENTIAL CAUSES OF THE CHANGE?

As long as the coral population is stable or showing positive changes then Phase I monitoring should continue. Once any adverse change (reduction in recruitment or increase in morbidity) in the survey population is identified Phase II should begin. Phase II is a more in-depth and targeted data collection effort to create a list of the most likely causative agents and what their impacts might be, also called a causal web.

1. Formulating a Causal Web

Most often in the case of coral disease, the causes are multifactorial and difficult to identify without extensive research. Some pathological conditions have many direct and indirect causes that represent a number of different pathways, with direct and indirect risk factors interplaying and culminating in a disease state. In Phase II of an epidemiological investigation, potential causative agents are identified and their interactions (or causative paths) developed into a Causation Web (Fig. 2) to illustrate the hypothesized relationship between

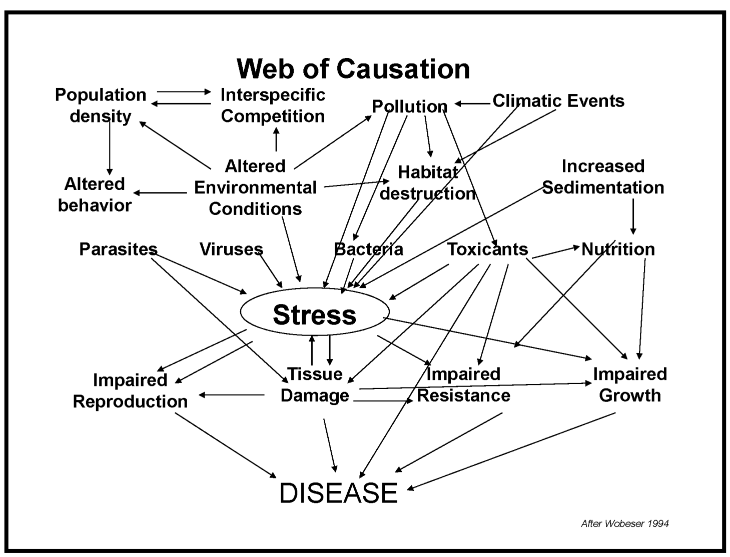


Figure 2 Web of Causation illustrating possible risk factors and their interactions.

direct and indirect risk factors. From these causal hypotheses, indicators of the risk factors are identified and measurements made to determine which potential causative agents are likely the most important contributors to the problem. These risk factors and the resulting causal web should be developed at a local level to provide the most refined picture of the possible causal factors and their linkages, in order to more effectively direct the investigation and diagnostic assays for identifying actual causes of the documented change and intervening with the most appropriate management actions.

The first step is to define the biological impairment that was detected during the Phase I monitoring. It is important to describe the impairment in specific terms and biological measures that are unambiguous, distinctive, relevant, informative, clear and unique to the specific case (e.g., Fig. 3). The second step is to develop a list of candidate causes. These must be potentially sufficient to cause the impairment and may include several causes that act together. This list may also identify known or suspected sources. To develop the list: a) make a map of area of affected coral colonies, the general and specific location highlighting proximities of possible sources, topology, land-water interfaces and other hydrographic or oceanographic features; b) gather existing information on potential sources, stressors and exposures potentially affecting the location; and develop a conceptual model, i.e., causal web (Fig. 4).

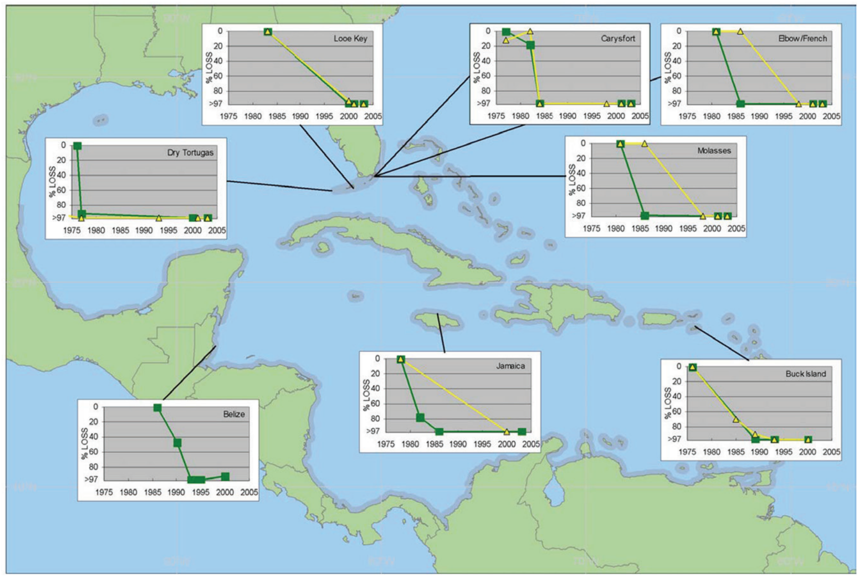


Figure 4 **Percent loss of *Acropora cervicornis* (green squares) and *A. palmata* (yellow triangles) throughout the Caribbean for all locations (n=8) where quantitative trend data exist. (*Acropora* Biological Review Team (2005).**

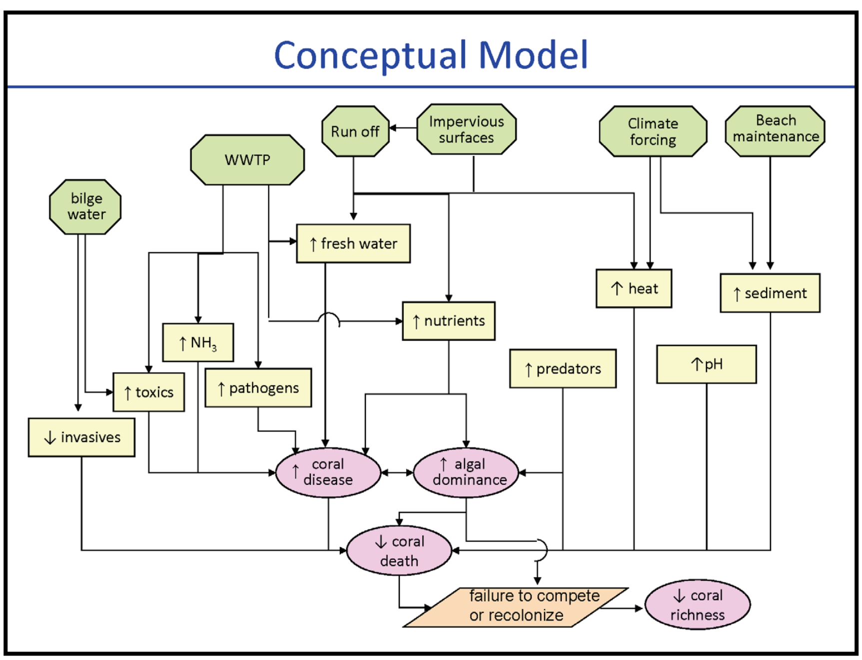


Figure 3 Example of a Conceptual Model consisting or candidate causes with known or suspected sources.

An ecological risk/threat assessment is one way of determining whether a candidate causal agent of a pathology is both relevant and probable.

2. Examples of Stressors and Indicators to Consider when Developing a Causal Web

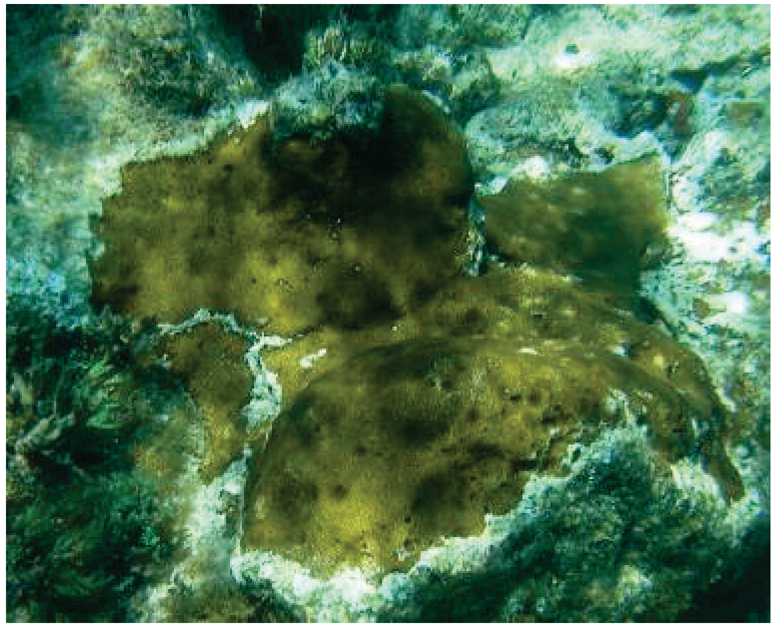


Figure 5 ***Cliona caribbaea*** **(aka:** ***C. viridis, C. langae, C. orientalis*****) a ubiquitous brown sponge found on coral reefs (red arrows).** ***Photo courtesy of Dr. Mike Risk*****.**

Eutrophication. Nutrient input can be an important stressor leading to increases in algal overgrowth, decreases in light availability to corals, and increases in potential pathogens being introduced to the reef. An indicator of an increase in nutrient input is an increase in fleshy algal growth. If nutrients are perceived as a potential risk factor in the area, high growth rates of certain boring sponges can be assessed as an indicator of high nutrient input. *Cliona* sponges are ubiquitous on tropical reefs. *Cliona caribbaea* are co-located with Caribbean *Acropora*, and excellent indicators of water quality. Expansion rates in high quality reef waters are approximately 4 cm/year; rates exceeding this nominal level are indicative of poor water quality and specifically eutrophication (see Acker and Risk 1985).

Sedimentation – an increase in sediment falling on a reef can be an important stress factor. Increased sediment might be visible on living coral tissue, and sediment traps of various designs can allow sedimentation to be measured and monitored (e.g., Storlazzi *et al.* 2011).

Suspended Solids – can affect the optical qualities of the water and lead to the accumulation of organic or inorganic material on the reef. As a general rule, suspended solids greater than 4g/L can be an indicator of a stress factor.

Presence/Absence of disease or predation – Although lesions are generally the effect and not the cause, the appearance, or nature, of the lesions can help to narrow down the list of possible causative factors. For example, small, round, white lesions could be indicators of white disease or fish predation. Closer observation might reveal gouges in the coral skeleton, an indication of predation.

Occurrence of major physical damage, e.g., storms, vessel grounding/anchoring, etc.

Absence of certain key non-coral invertebrates – certain invertebrates can be indicators of environmental problems (e.g. the absence of urchins might indicate the presence of toxicants or frequent hypo-salinity events), and can contribute to problems (e.g. the absence of urchins might lead to increased algal overgrowth).

3. Analyzing Data and Evidence from the Case and Elsewhere

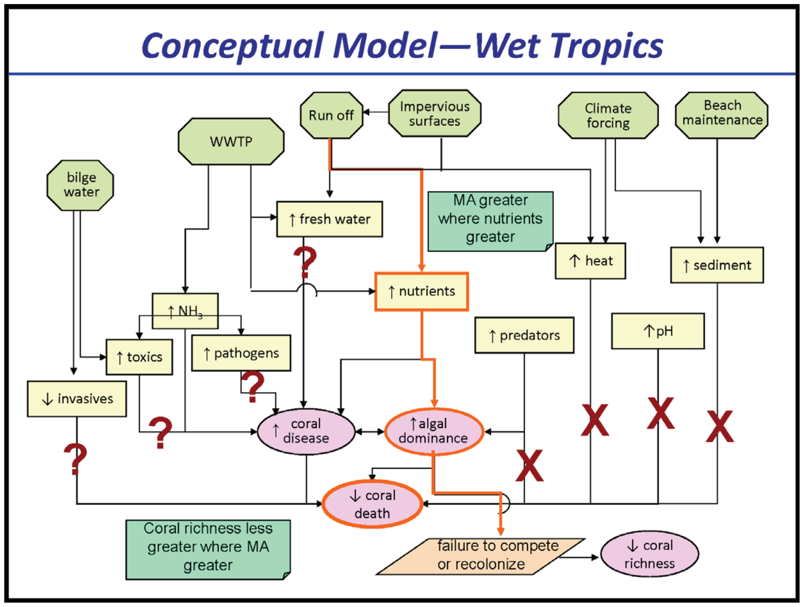


Figure 6 Example of a Conceptual Model showing causal links with some evidence (?), no supportive evidence (X) and the path with the quantity and quality of evidence that is credible (orange line).

Once a conceptual model is built from case specific (Fig. 6) and other available data, it is important to evaluate the evidence in terms of consistency, credibility, completeness and coherency. Meaning the evidence is internally consistent and does not contradict itself. The quantity and quality of the evidence is credible. The causal relationship(s) exhibits all of the causal characteristics and the causal relationship concurs with precepts of scientific theory. This process will allow you to logically eliminate candidates having weak evidence, and possibly identify alternative candidate causes and focus resources on investigating the most probable cause(s). Evaluations that warrant further investigation will trigger Phase III.

C. Phase III – Causal Investigation

The causal investigation will typically involve collaboration between local resource managers and outside experts that will help to determine which of the candidate causes in the causal web are actually responsible for the observed impairments. The Causal Web formed in Phase II of the investigation is a set of hypotheses created by local resource managers that can then be tested in Phase III to determine the causative agent(s) based on weight of evidence. This methodology can also provide measures of the relative contribution among several contributing agents. Because problems affecting corals are often multifactorial and affected by onshore human business and industry regulated by government, strong research-based evidence is often required to effect the necessary changes. Hypotheses generated from Phase II may not be sufficient to effect such change, hence the necessity for a formal, detailed investigation conducted by experts in Phase III.

D. PHASE IV – ENFORCEMENT AND INTERVENTION

In Phase IV of the investigation, corrective action is taken based on the results of the causal investigation. The nature of the action will depend on the cause and infraction, and on the laws and resources of the regulating agencies. It is imperative that Phase I surveillance be continued at all sites during the investigation and after the enforcement/intervention takes place so the effects of the corrective factors can be shown. Table 2 provides examples of possible management actions that could be explored based on the outcome of the Environmental Investigation.

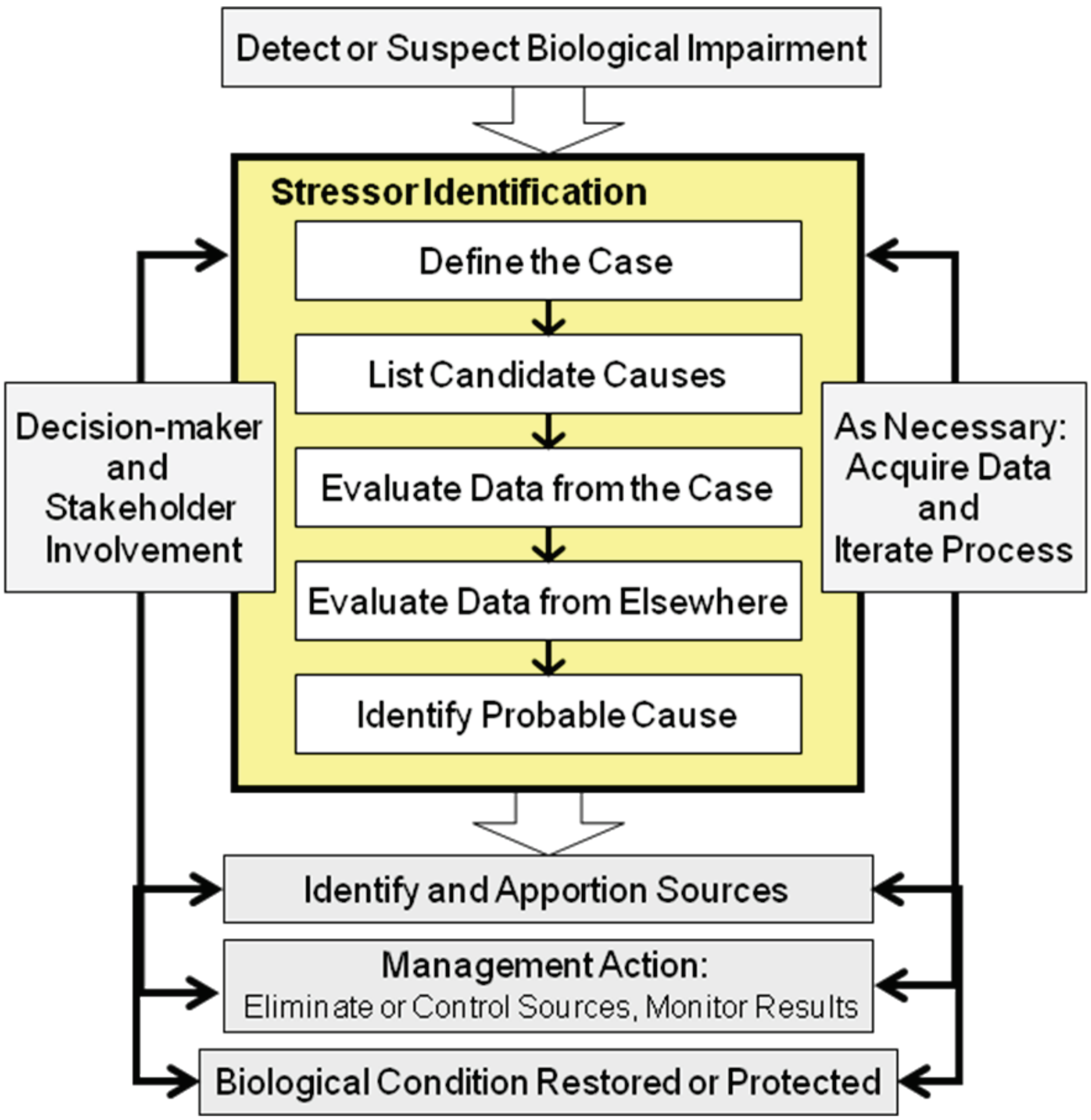
Table 2 Examples of Possible Interventions based on Causal Agent(s) Identification
(Courtesy of Dr. Susan Cormier, USEPA).

Causal Agent	**Sources**	**Options**
Sediment	Resuspension storms, props, etc, beach maintenance, construction, organic particles, dredging and spoil disposal, agriculture	• Restrict beach augmentation • Implement strict fines and controls for run-off • Implement development plan • Impose “windows” for dredging • Protect mangroves • Restrict and reroute boat and vessel traffic
Nutrients	Atmospheric deposition, waste water from homes and boats, fertilization, distant land sources, fires, spills	• Building permit revision to include composting toilets • Provide grants for composting toilets and small business start-ups. • Investigate nutrient sequestration options • Create carbon sequestration reefs as no fishing zones • Improve quality of turtle grass beds

Table 2 con't

Causal Agent	**Sources**	**Options**
Physical trauma	Storms (increased frequency and severity), boats and anchors, recreational activities	• Create carbon sequestration reefs as no fishing zones • Fund mooring buoy anchor program • Restrict boat access to certain areas. • Establish larger size of limited use areas and sanctuaries
Pathogens	Invasive introductions and opportunistic conditions	• See nutrients
Algae	Lack of herbivores, excess nutrients, increased heat	• Create carbon sequestration reefs as no fishing zones • See nutrients
Lack of herbivores	Overfishing	• Create carbon sequestration reefs as no fishing zones • Reintroduce *Diadema antillarum* and holothurians
Contaminants	Spills, waste, bilge water, cruise and other shipping, atmospheric deposition, agrichemicals; residential and urban run-off; personal care products; waste-water effluents	• Limit cruise lines to certain ports • See nutrients • Create retention ponds • Use of alternatives products • Improve waste-water treatment

E. Summary of the Causal Analysis Framework ***(Courtesy of Dr. Susan Cormier, USEPA)***



III. GLOSSARY OF TERMS

Causality (causation) – the relationship between cause and effect

Causal (causative) factor (agent) – a factor that causes disease

Disease – illness; sickness; interruption, cessation or disorder of an organism's normal functions

Disease in corals – any instance of abnormal pathological effects (e.g. loss of color, visible lesions) apparent in a coral colony or colonies

Environmental Forensics Investigation- providing data for a causal factor for use in the courts or public forum

Epidemiology – study of disease in populations and factors determining its occurrence

Eutrophication - an increase in the rate of supply of organic matter (nutrients, especially nitrates and phosphate) into an ecosystem, the sources can be artificial or natural and in marine systems often lead to excessive algal growth.

Population - all of the organisms that both belong to the same species and live in the same geographical area, for many marine species this may be referred to as a stock, for coral this may be reef

Metapopulation – a management term referring to a series of smaller populations that have some level of interaction. Bak & Meesters (1999) defines this as the largest spatial scale of a population which consists of the total grouping of all spatially separated, local populations or subpopulations. Within a metapopulation interactions and exchange between subpopulations are generally low.

Monitoring – routine collection of information, e.g., productivity or distribution or other characteristic of a population

Morbidity – A diseased condition or state.

Morbidity rate - An inexact term that can mean either the Incidence Rate or the Prevalence Rate

Recruitment - The measure of the number of young individuals (e.g., fish and coral larvae, algae propagules) entering the adult population, in other words, it is the supply of new individuals to a population.

Risk Web or Causal Web – an epidemiological model depicting the multifactorial nature of disease in a complex 'web' or network of interconnected risk and protective factors resulting in various pathways to define routes of risk or causation (for discussion see Krieger 1994; Thrusfeld 2007).

Sentinel Colony – a coral colony that is chosen as a prominent representative of a population such that it can be studied closely and regularly in order to detect change in the health of the population

Stress – reaction of an organism to deleterious forces that tend to disturb its normal equilibrium

Stressor – stimulus that induces stress

Subpopulation or local populations– groups of interacting individuals within a species distributed over a range of separate locations (Bak & Meesters 1999).

Syndrome – the aggregate of signs associated with a disease that provides a description of it

Surveillance – data gathering, recording, analysis and dissemination of information thus acquired to relevant parties so action can be taken to control disease

Syndromic surveillance- involves collecting and analyzing statistical data on health trends—i.e. high frequency of similar symptoms and signs, or surrogate data, e.g., flu medicine sales. Focusing on symptoms/signs rather than confirmed diagnoses provides earlier detection of nonspecific disease.

Threatened species - Defined by ESA as any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

IV. References

Acker KL & Risk MJ (1985) Substrate destruction and sediment production by the boring sponge *Cliona caribbaea* on Grand Cayman Island. *J. Sedimentary Petrology* 55: 705-711.

Acropora Biological Review Team (2005) Atlantic *Acropora* Status Review Document.
Report to National Marine Fisheries Service, Southeast Regional Office. March 3, 2005.
152 p + App. http://sero.nmfs.noaa.gov/pr/pdf/050303%20status%20review.pdf (accessed Nov 25 2013)

Aronson RB & Precht WF (2001) White-band disease and the changing face of Caribbean coral reefs. *Hydrobiologia* 460: 25-38.

Bak R & Meesters E (1999) Population structure as a response of coral communities to global change. *Amer. Zool.* 39: 56-65.

Federal Register (2008) Endangered and threatened species; critical habitat for threatened elkhorn and staghorn corals. 50 CFR Parts 223 and 226. 73(229): 72210-72240.

Krieger N (1994) Epidemiology and the web of causation: Has anyone seen the spider? *Soc. Sci. Med.* 39: 887-903.

Nixon SW (1995) Coastal marine eutrophication—A Definition, social causes, and future concerns. *Ophelia* 41: 199-219.

Porter J, Kosmynin V, Patterson K, Porter K, Jaap W, *et al.* (2002) Detection of coral reef change by the Florida Keys coral reef monitoring project. In: Porter J, Porter K, editors. *The everglades, Florida Bay, and coral reefs of the Florida Keys: An ecosystem sourcebook.* Boca Raton: CRC Press. pp. 749-769.

Quinn N & Kojis B (2006) Evaluating the potential of natural reproduction and artificial techniques to increase *Acropora cervicornis* populations at Discovery Bay, Jamaica. *Rev. Biol. Trop.* (Int. J. Trop. Biol.) 54 (Suppl. 3): 105-116.

Storlazzi C, Field M & Bothner M (2011) The use (and misuse) of sediment traps in coral reef environments: theory, observations, and suggested protocols. *Coral Reefs* 30: 23-38.

Thrusfield M (2007) *Veterinary Epidemiology,* 3rd ed. Blackwell Publishers, Singapore.

Woodley C, Bruckner A, McLenon A, Higgins J, Galloway S & Nicholson J (2008) *Field Manual for Investigating Coral Disease Outbreaks.* NOAA Technical Memorandum NOS NCCOS 80 and CRCP 6. National Oceanic and Atmospheric Administration, Silver Spring, MD 85pp. http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/1384/CDHC_CoralDiseaseOutbreak_2008FieldManual.pdf

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GUIDANCE FOR ESTABLISHING A DISEASE SURVEILLANCE NETWORK