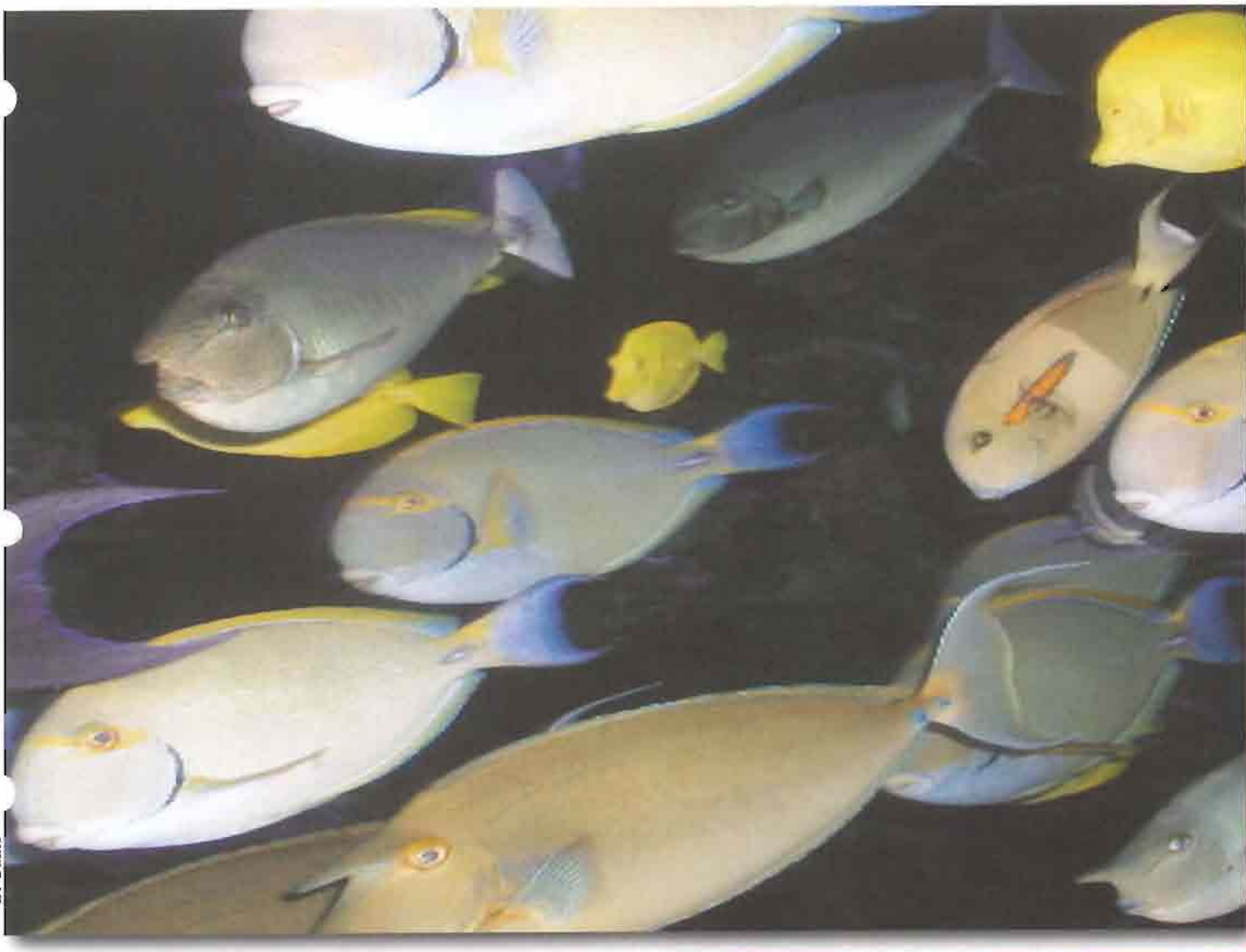


D. Gulko

Classifying Fish By How Mobile They Are...

Fish species can be categorized into site fidelity groups (mobility classes) based on Friedlander & Parrish (1998). The mobility classes are:

R - Species with limited movement and well-defined home ranges.

S1 - Species with daily movements on the order of tens of meters; may hold large territories or large home ranges.

S2 - Species that have daily movements on the scale of thousands of meters.

T - Species that move over great distances.

Fish Diver's Field Gear:

- 25 m Transect Cord Reels (2)
- Surface Safety Floats (2)
- Data Slate
- Fish Data Sheets
- Evidence Bags
- 2 Pelican-type Surface Floats
- Flagging Tape
- Underwater Camera

Fish densities are calculated using appropriate area estimates (e.g. 100 m^2 for fish greater than 20 cm; 50 m^2 for fish less than 20 cm). Fish numbers can be transformed into densities per hectare, with lengths used to calculate biomass using published length to weight conversions.

Surface Safety Floats are a critical piece of safety gear for submerged divers used to identify their location and serve as an emergency support platform upon surfacing. In an REA, the float also holds a working GPS and is used to time various aspects of the REA for both the surface support team and the benthic team.

The **Fish REA Team** deploys both surface safety floats. The 1st float is immediately anchored to the bottom at the beginning of the first 25 m transect line. The second float is carried by one member of the fish team (by way of a reel and line) until the fish team completes the first transect and begins to set the second 25 m transect. The second float is anchored at the beginning of the 2nd 25 m transect.

STOP HAZARD WARNING

As the team ascends the line, one of them reels in the float, until the group reaches its safety stop at 4 - 5 m. At this point, the surface support personnel may notice the first surface safety float moving away with the current. Care needs to be taken as the fish team may move considerable distance away from the benthic team while on their safety stop if there's strong current - this is one of the primary reasons for the two independent surface safety floats.

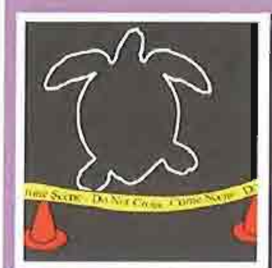
D. Gulko

D. Gulko

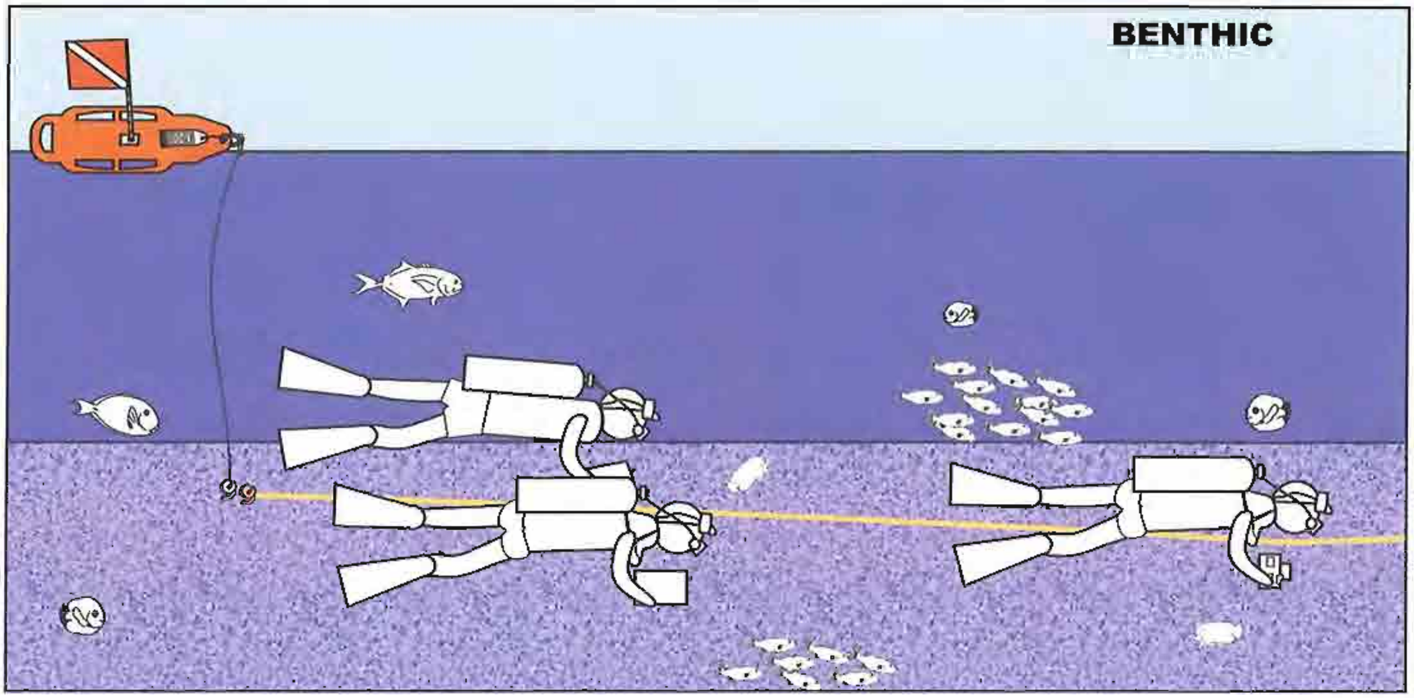
Larger, mobile fish are counted on the deployment or swim-out leg of the fish transect (*above*).

Cryptic and small fish are detected on each "swim-back" leg of the fish transect (*right*).

CORAL REEF CSI TIPS...



- **Immediately upon exiting the water onto the support platform, the fish team's photographer, the CROC, or one of the dedicated surface support personnel, should photograph all of the fish team's data sheets.**
- **In some cases, the fish team will surface without pulling up the first transect and dive safety float, in order to record the GPS off both floats. Under such circumstances, the benthic team will be responsible for pulling both transects and both dive safety floats. The team will surface at the location of the first surface safety float.**



THE REA BENTHIC TEAM

The benthic team is composed of three to four divers:

An Algal Ecologist or Algal Specialist. Focus on description of unique algal subhabitats, algal biodiversity and biomass, and descriptions of ecological function.

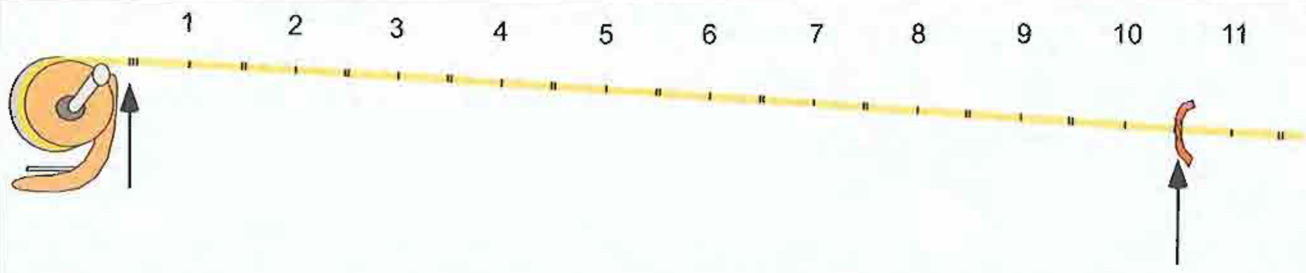
An Invertebrate Specialist. Focus on description of unique invertebrate-dominated subhabitats, macroinvertebrate biodiversity and biomass, density of urchins, and descriptions of ecological function.

One or Two Coral Ecologists or Coral Specialists. Focus on description of unique coral species-dominated subhabitats, coral biodiversity and biomass, and descriptions of ecological function.

Two 25 m transects are conducted per dive. After a wait of 10 to 15 minutes (using the position of the two surface safety floats as a guide to when the fish team is beginning the second transect), the benthic team enters the water, descends the line for the first anchored surface safety float, and begins taking data on the first 25 m transect line previously laid by the fish team. The delay by the the benthic team is warranted in order to minimize disturbance of fish populations being censused by the fish team. The benthic team surveys the first 10 meters and last 10 meters of each 25 meter transect line, resulting in a total of 4 transects per dive.

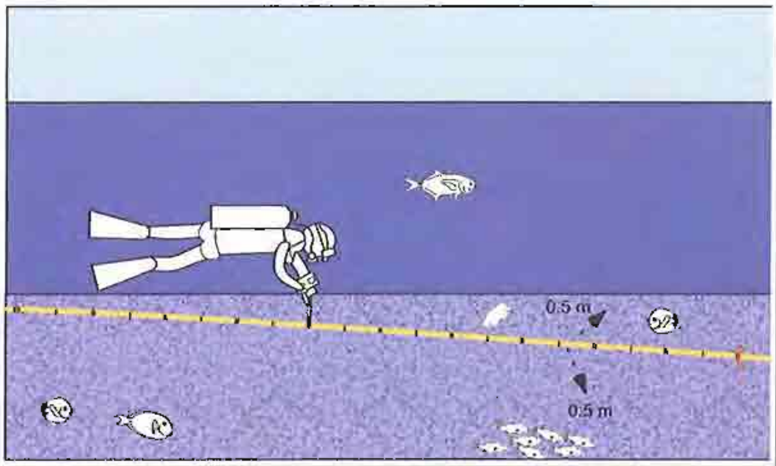
The algal person goes first and photographs the transect every 0.5 m at the meter or half meter marks. The algal diver is followed by the invertebrate specialist who quickly censuses the density of urchins and the coral biologist who conducts a point intercept every half meter along the line to determine bottom cover. On the return leg, each team member conducts in-depth surveys in each of their specialties as described on the following pages.

Depending on the type of injury event, the amount of coral cover, and the needs of the investigation, the fourth benthic diver (the 2nd coral diver) can be a ecotoxiciologist, a disease specialist, geologist, archeologist, or salvage expert.

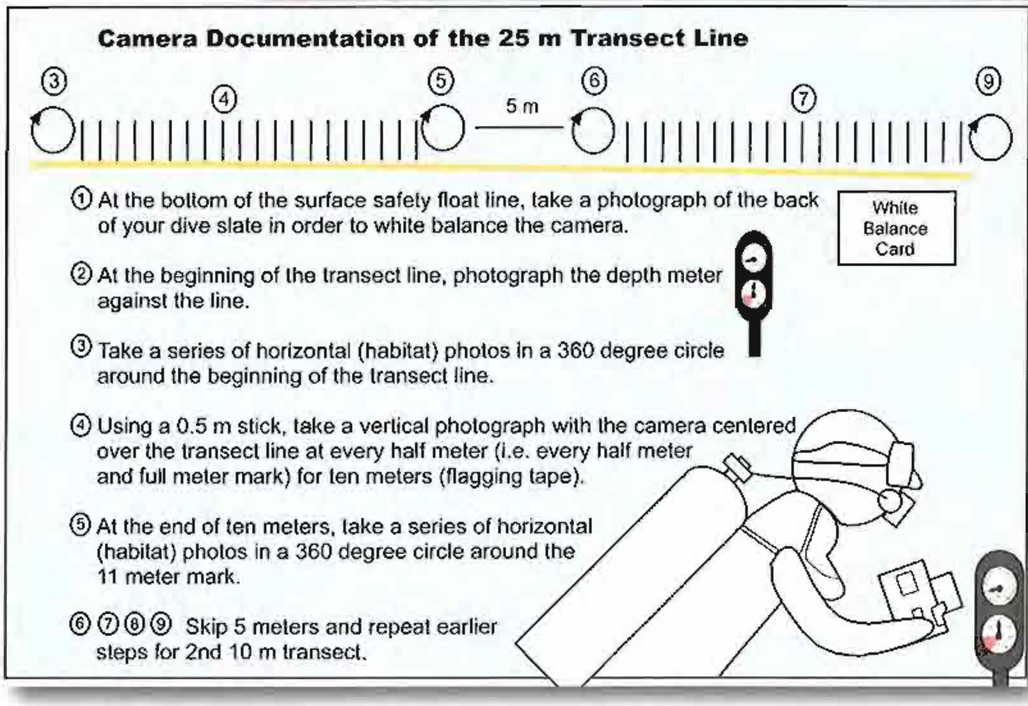


The 25 m REA Transect Line: The line itself is marked every meter with two dark bands, and every half meter with a single dark band. The beginning of the transect is approximately 0.5 - 1 meter in front of the reel (allowing room for anchoring if necessary) and is marked with three dark bands. At the end of 10 meters (and again at the end of 15 meters) the line is marked with attached red flagging tape to differentiate the two 10 m sub-sections used by the Benthic Team.

Photographing the Transect Line



The transect line is photo-documented prior to any disturbance by the benthic team in order to provide a visual record of what was surveyed, provide a back-up for analysis of benthic cover and habitat/ subhabitat descriptions, and to document the state of the injury (or the control) at the time of the surveys.



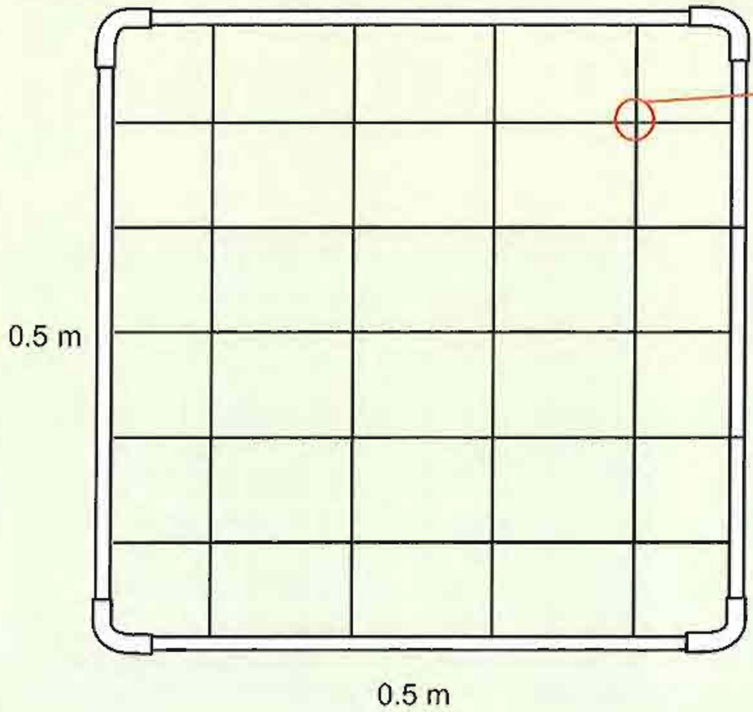
The first benthic team diver on the transect line following the protocol below. Photographs are taken along the transect line at 0.5 m above the center of the line, either horizontally or vertically depending upon geomorphology. This is accomplished by using a 0.5 m metal pole and placing the camera atop it as the diver works along the transect line taking shots every 0.5 m. At the beginning of the dive, the photographer

A quick shot of the photographer's depth gauge/dive computer at the beginning of each transect line documents the depth in with the other information.

photographs a data board with the site information on it, and then shoots 360 degrees at the beginning of the transect line to capture habitat information. At the end of 10 m, the photographer shoots 360 degrees again. The photographer will know when he/she reaches the end of 10 m by the presence of flagging tape on the transect line. The photographer then swims 5 m along the transect line to the next piece of flagging tape representing the beginning of the last 10 m of the transect. The photographer once again shoots 360 degrees and then photographs the transect line (and out 0.5 m to either side) every 0.5 m. At the end of the transect line (where the empty spool is anchored) the photographer shoots 360 degrees. This process will also be repeated when the team works on the second transect line. Upon surfacing, chain-of-custody protocols are followed as outlined elsewhere in this toolkit.

The Algal Component of the Benthic REA

During the benthic surveys, the algal team member will swim the two 25 m transects and collect samples of as many macroalgal species as possible. A 0.5 m band on either side of the transect line will be surveyed and assessed. The first time that the diver encounters an alga on the transect it will be photographed, collected (if necessary), and placed in a bag along with as much collection information as possible. For all subsequent encounters, the diver will note on his/her data sheet that the alga was seen again. Any and all rare or unknown species will be collected. All samples collected in these surveys will be deposited as voucher specimens with the resource trustee leading the investigation. Macroalgal taxa will be collected initially at each site and noted thereafter. All specimens will be pressed and dried on-site by the collecting diver, and a chain-of-custody form will follow all samples per site. Where appropriate, turf algae will be collected by chiseling small randomly selected pieces of dead coral/limestone substrate from the bottom that appear to support dense filamentous algal growth. These samples will be stored in 4% Formalin in seawater until they can be sorted using a



0.5 m^2 Quadrat

The intersection point created by the two lines is where you identify exactly what lies beneath (to species if possible). And then identify what lies underneath the other points on the quadrat (20 total).

microscope. Approximately 5 samples will be collected per transect line. Where appropriate, crustose coralline algae (CCA) will be collected by chiseling or breaking off pieces of the benthos where this alga is found. Samples of each species encountered will be collected per site. Specimens of CCA will either be dried or stored in 4% Formalin.

HI DLNR

(*Above*) Is dominance of a single species of seaweed a natural subhabitat or an invasive species outbreak?

Estimates of abundance and percent cover of various algal functional forms and dominant or keystone species on transect lines will be accomplished through use of a 0.5 m^2 quadrat, with 20 evenly-spaced points.

HI DLNR

(*Above*) Certain seaweeds (such as this *Lyngbya* sp.) can serve as an indicator of disturbance, weeks to months after an event.

Identification of algal or substrate type underneath the 20 points will be done for three fixed locations (0 m, 5 m & 10 m) along each 10 m segment of each of the two transects.

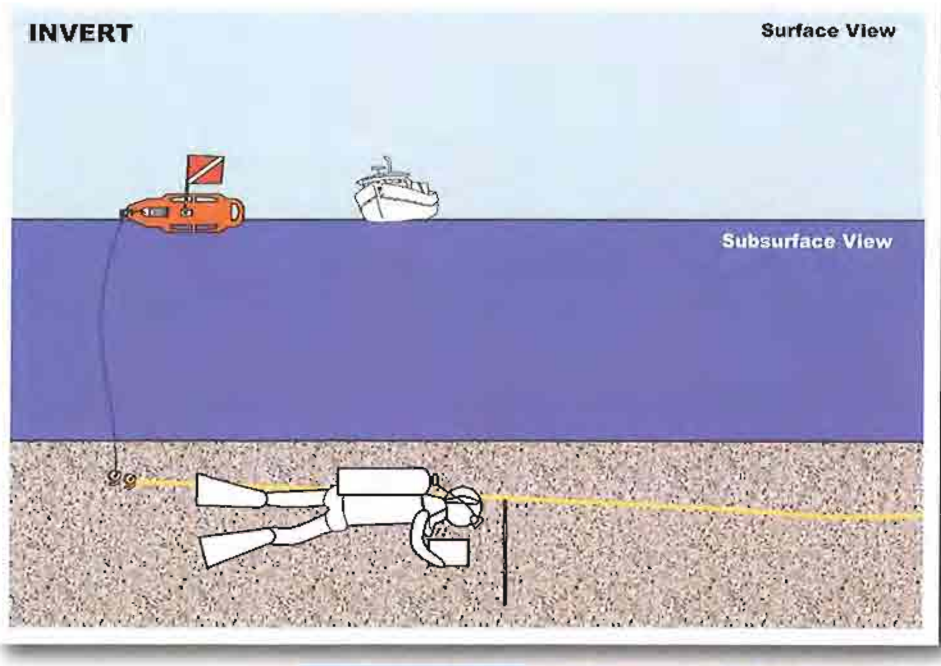
Algal Specialist Field Gear:
- 0.5 m Quadrat
- 15 m Measuring Tape
- 0.5 U/W Meter Stick
- Data Slate
- Algal Data Sheets
- Evidence Bags
- 2 Pelican-type Surface Floats
- Algae Collection Tool
- Flagging Tape
- Underwater Camera

THE MACRO-INVERTEBRATE COMPONENT OF THE BENTHIC REA

The invertebrate specialist samples invertebrates (both benthic and cryptic) along both benthic transect lines. A 0.5 meter band on either side of the transect line is surveyed and assessed. The first time that the invertebrate specialist encounters an unknown invertebrate on the transect line it will be collected

D. Gulko

and placed in a bag with as much collection information as possible. For all subsequent encounters the diver will note on his/her data sheet that the invertebrate was seen again. Any and all unknown species will be collected for later identification and analysis following appropriate chain-of-custody protocols. Cryptic species will be assessed through collection of substrate pieces and post-dive examination/ sorting of rubble.



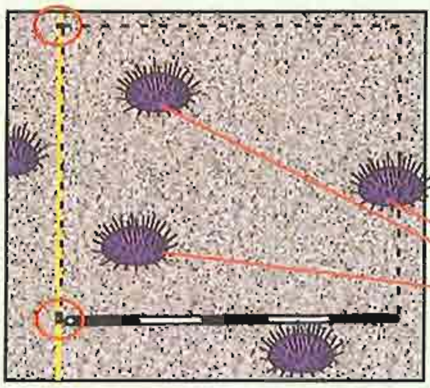
Unusual densities of urchins or other large macroinvertebrate target species will be documented as they occur either along the transect line or adjacent to it. This will be accomplished by enumerating five 0.25 m^2 quadrats for each 2 x 25 meter belt transect to determine the average percent cover. The reason urchins are targeted specifically for a density study, is that they serve as a keystone herbivore on many reef habitats and therefore represent an important indicator of overall reef condition. High concentrations could be indicative of a response to damaged CCA substrate resulting in a chemical signal which has attracted and concentrated urchins around an injury site. Unusually low concentrations could be

Invert Specialist Field Gear:

- 15 m Measuring Tape
- 0.5 U/W Meter Stick
- Data Slate
- Invert Data Sheets
- Evidence Bags
- 2 Pelican-type Surface Floats
- Invert Collection Tool
- Flagging Tape
- Underwater Camera

Dave Gulko

Assessing Urchin Densities



The invertebrate specialist uses the meter and half meter marks on the transect line to delineate a half meter along the vertical axis, thereby allowing the specialist to visualize a 0.5 m^2 quadrat. Any portion of an urchin that falls within the 0.5 m^2 quadrat is counted, and the totals used to determine average densities.

3 urchins per 0.5 m^2.

Beth Lumsden, NOAA

STOP **The invertebrate specialist is most likely of all the team members to come in contact with hazardous marine life as a result of his/her activities. Potential hazards include moray eels, stinging fire coral and hydroids, venomous sea urchins, mantis shrimps, sponge spicules, etc.**

indicative of a disease event, a trophic cascade, predator or prey displacement, or targeted extraction.

The Coral Component of the Benthic REA

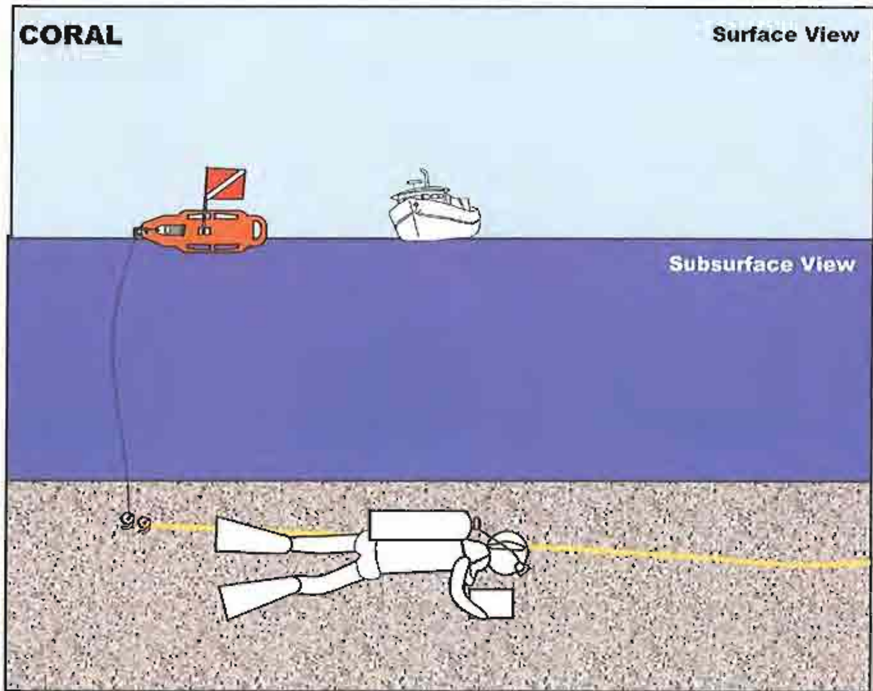
The coral specialist(s) census all colonies of corals found within 0.5 meters on each side of the two 10 m subsections of the 25 m transect line. The census involves estimating the longest diameter and species of each coral colony (or fragment) and recording the coral's assignment to one of eight long-diameter size classes listed below:

Coral Specialist Field Gear:
- 15 m Measuring Tape
- 0.5 U/W Meter Stick
- Data Slate
- Coral Data Sheets
- Evidence Bags
- 2 Pelican-type Surface Floats
- Coral Collection Tool
- Flagging Tape
- Underwater Camera

These size classes and protocols are adapted originally from Mundy (1996), who used them in American Samoa and Maragos (2003) who used them in the Northwestern Hawaiian Islands. The current technique has been developed and used by a variety of U.S. State and Federal coral reef biologists in Hawaii as a standard for conducting REAs and injury investigations (Gulko, 2006). Corals showing signs of disease, predation, abnormal growth, bleaching or direct human impact are tallied, described, photographed, and if necessary, collected. Loose coral fragments are also classed as above using a "f" instead of a tally mark. Colonies showing partial mortality, observable fission, or multiple incomplete re-colonization of the colony, will be tallied into size

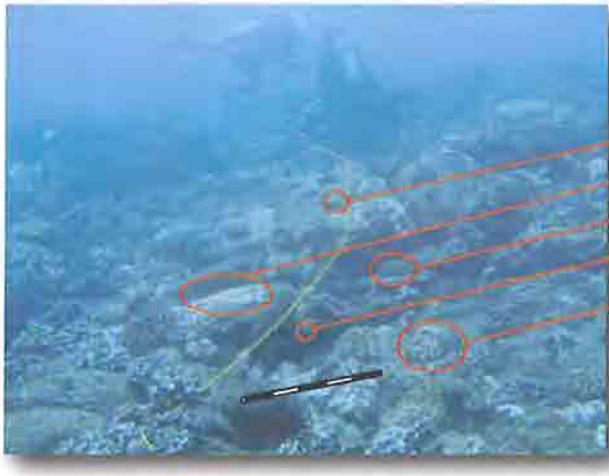
Coral Colony Size Classes

Data Code	Size Class
2	0.1 cm to 2 cm
5	> 2 cm to 5 cm
10	> 5 cm to 10 cm
20	> 10 cm to 20 cm
40	> 20 cm to 40 cm
80	> 40 cm to 80 cm
160	> 80 cm to 160 cm
+160	> 160 cm

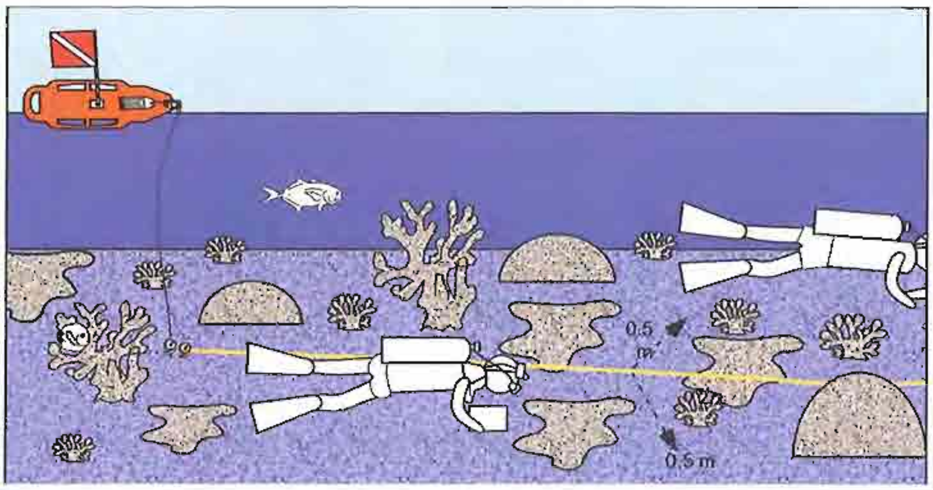


classes based on total original colony size, but with a flag as to either partial mortality or fission (using a "s" instead of a tally mark).

If available, two coral specialists are used as this is the most time-consuming of the REA activities. On each transect, the coral divers work as a dive pair with one diver responsible for the left side of all transects and the other responsible for the right side. In this way, error between survey divers is minimized relative to overall data to the greatest extent possible, and in a way that can be determined easier at a later time. Each diver will mark whether they are "left" or "right" on each coral data sheet. The two divers also lay down a rugosity chain for each 10 m subtransect after all other REA surveys have been accomplished (Note: if there is only one coral diver on the REA, then the rugosity measurement transfers over to the algal and invertebrate specialists, or to the fish team to conduct after they have finished both of their transects).



To assist the coral specialists in accurately sizing the colonies and to delineate the moving 0.5 m^2 area on either side of 10 m subsections of the transect line that they will size the coral colonies within, we use a standardized black and white meter stick (either custom-made or purchased (as a Archeological Meter Stick) from Forestry Suppliers, Inc.; www.forestry-suppliers.com). The meter stick is broken down into two independent 0.5 m segments which can be used by different members of the Benthic REA team. The 0.5 m stick can have the camera attached to one end with a "L"-shaped bracket to provide for exact measurement for camera placement 0.5 m above the transect line when the algal diver is recording the transect line (alternatively, the camera could be placed right on top of the 0.5 meter stick). This same 0.5 meter stick, with alternating 10 cm black and white bars, is used by all benthic divers to size specimens and for scale in evidence and impact photos. The coral diver(s) will use the 0.5 meter stick to specifically size colonies into the various size classes.



Unusual or unique coral formations (such as extremely large, solitary massive *Porites* colonies) are also documented following the subhabitat description process detailed below, including release of a numbered Pelican-type surface float for GPS data collection.

TAKING RUGOSITY MEASUREMENTS

To determine the three-dimensional nature of a surveyed area, one places a small-link chain of known length (10 m) directly alongside the transect line for each 10 m subsection. The chain will lay into the grooves and slopes of the bottom while the transect line will run over it. The result is that in an uneven (highly rugose or three-dimensional) habitat (i.e. a coral reef), the 10 m **rugosity** chain will end short of the 10 m mark on the transect line. The resulting fraction (Relative length (m)/Actual length (10 m)) is a representation of three-dimensionalness. As the fraction approaches "1", the habitat is primarily flat and featureless; as the fraction approaches "0", the habitat is highly three-dimensional.

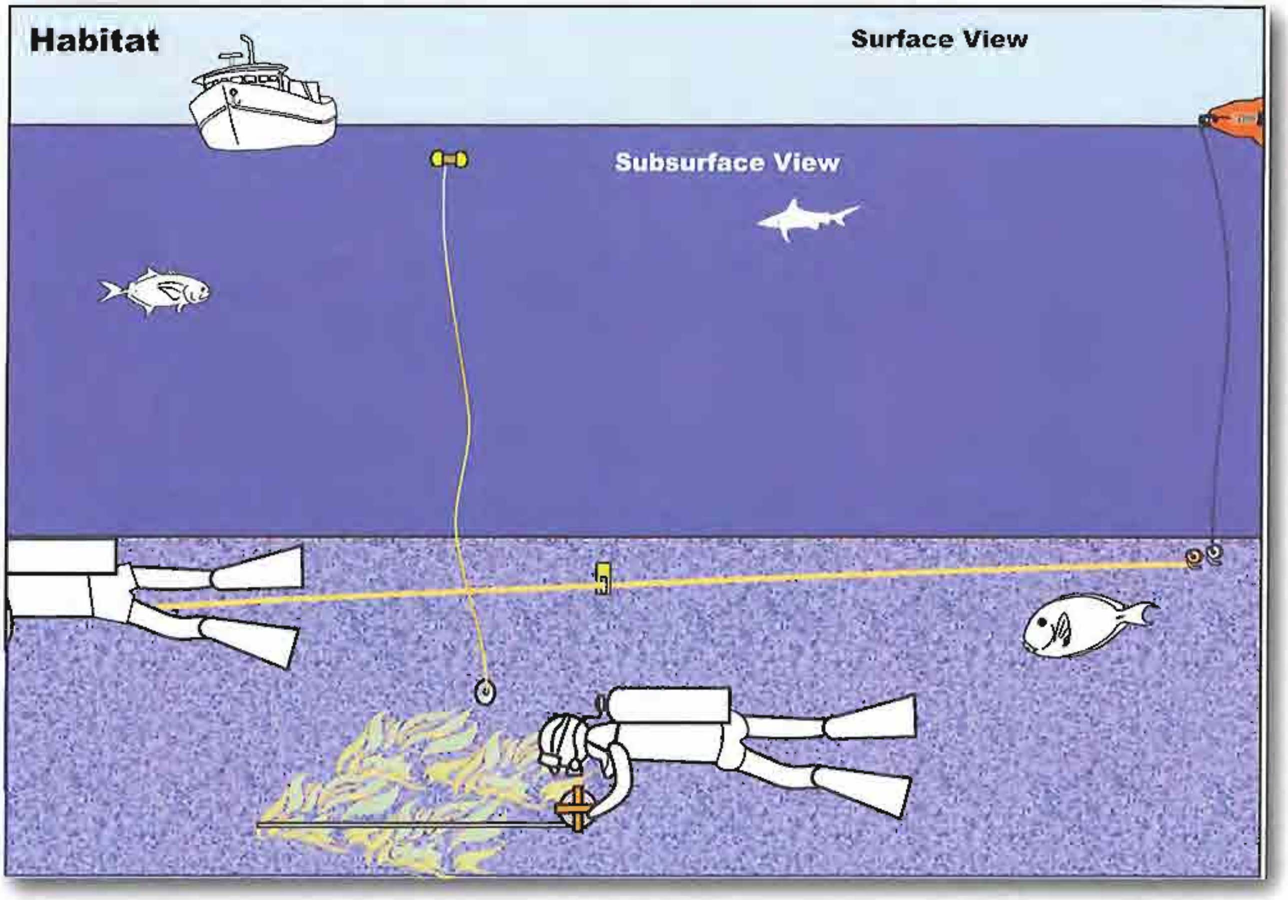
Rugosity is best used as a comparison between an impacted area and a reference or control area. Rugosity measurements should not be used independent of other habitat descriptions.

Identifying corals to species in the field under injury conditions requires recognized expertise. One could also classify corals into functional groups (often genera or families, or growth forms) if a coral expert is unavailable. If the person doing the coral surveys is an expert, size categories should be for every colony identified to species within a half meter to each side of the transect line for each 10 m segment assessed. If coral expertise is not available, identify each colony to growth form and place within one of the eight size classes

The Habitat & Subhabitat Protocol

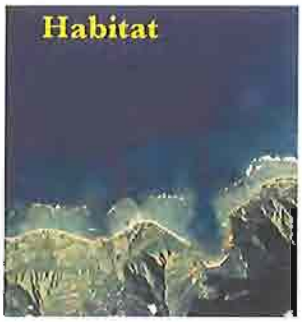
At any time during the transect, if a benthic diver spots a unique subhabitat adjacent to the transect line but outside of the transect area of coverage, the diver will attach a colored clip to the transect line to mark the point of suspension, swim over to the unique subhabitat and record characteristics of the subhabitat on the back of the data sheet along with the number of the diver's Pelican-style float, which will be released to rise to the surface where specific GPS information will be recorded by surface support personnel. Photo-documentation of the subhabitat should be accomplished following the digital photography protocol. The benthic diver uses their accessory 15 m metric tape reel to quickly get length versus width information for the unique subhabitat, and then returns the short distance to the transect line to resume the transect at the point where they had left the clip.

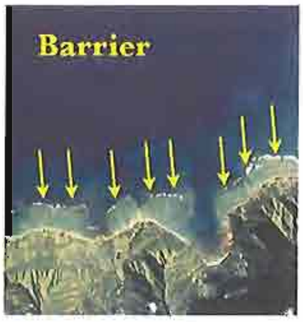
Benthic organisms will not be collected except species that are possibly new to science, or new records for the region or subregion, or warranting collection and cataloging relative to the event being investigated. The health of the corals or other benthos at each site will be assessed and photographed, including the extent of bleaching, disease, *Acanthaster planci* (or other) predation, alien species competition, entanglement in fishing gear, ship groundings (if any), anchor damage, and evidence of over-fishing or destructive fishing.

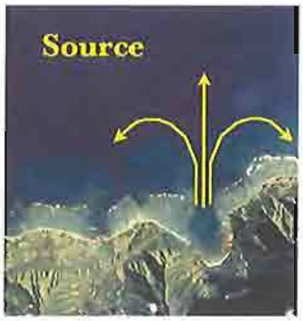


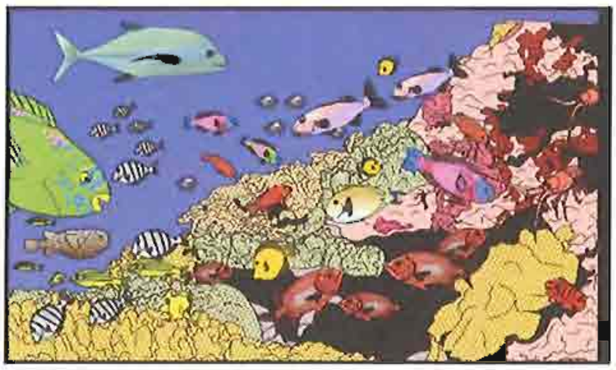
Broad-Scale Functions of Coral Reefs:

On a large scale reef structures can serve a variety of functions as relates to movement of water, larvae, adults, entire populations, etc. as shown below.









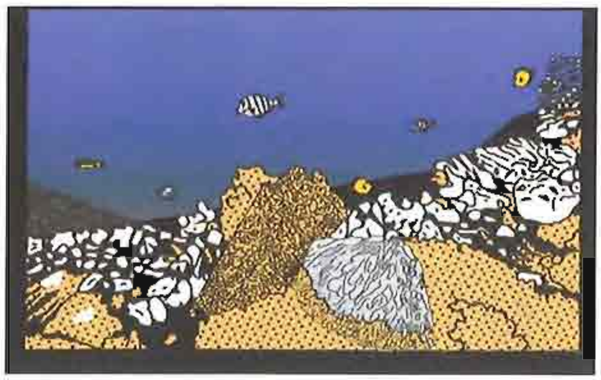
1980's View
"Wow, Look at all the fish!"

1990's View

Shifting Baselines:

Our view of what a coral reef should represent in terms of species assemblages, biodiversity, biomass, even reef health, is shaped by our experience with that reef. This has led to a perceptional view of what a specific reef should represent based entirely upon when one first experiences that reef. This changing view of what a reef first looks like leads to the concept of "Shifting Baselines" whereby as a reef degrades, new decision-makers use the degraded state as the optimal to strive for in restoration or other management strategies.

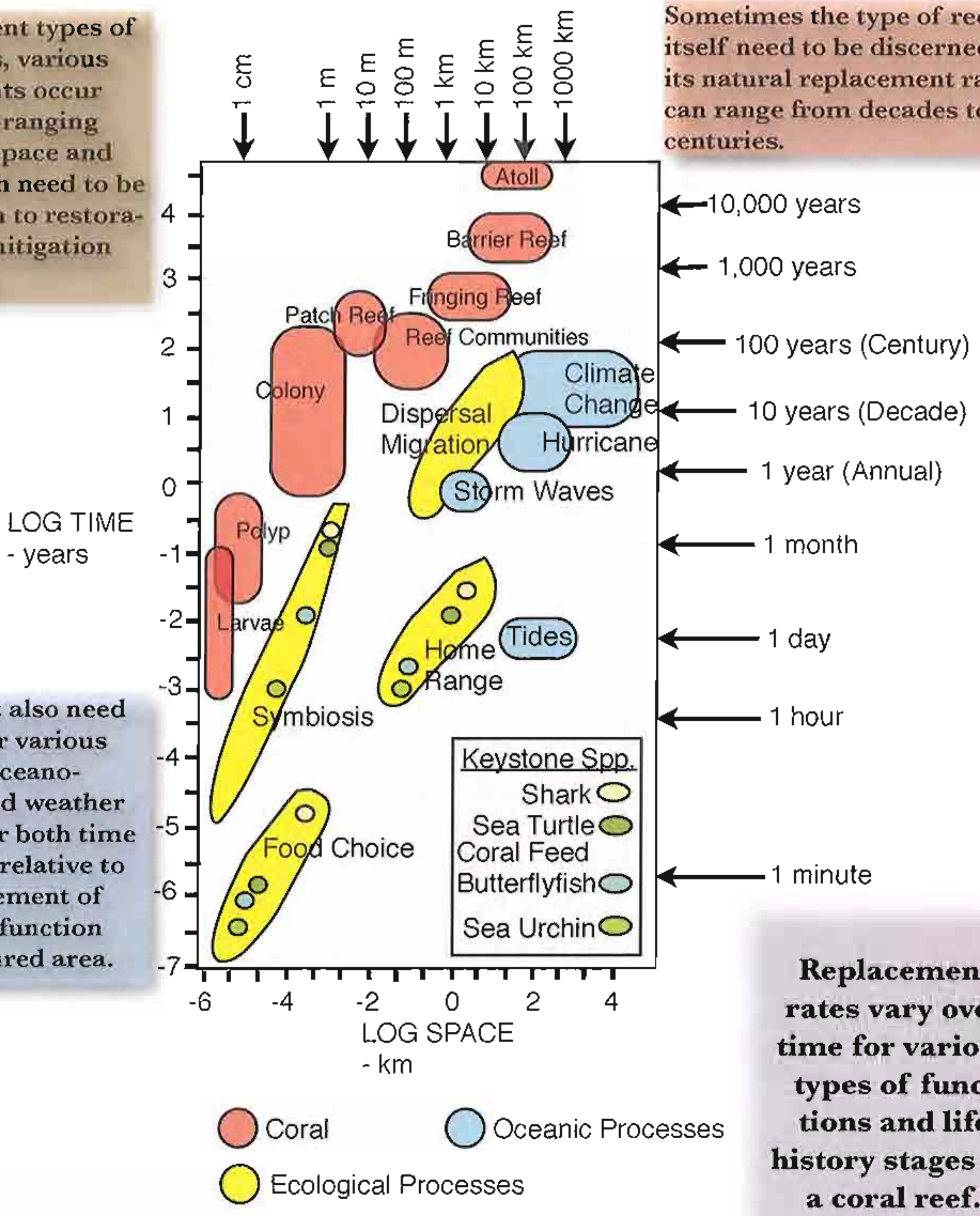
2000's View
"Wow, Look at all the fish!"



Ecological Function Over Space & Time

For different types of coral reefs, various components occur over wide-ranging scales of space and time which need to be factored in to restoration and mitigation activities.

Sometimes the type of reef itself need to be discerned as its natural replacement rate can range from decades to centuries.



One might also need to consider various geologic, oceanographic and weather events over both time and space relative to the replacement of ecological function within injured area.

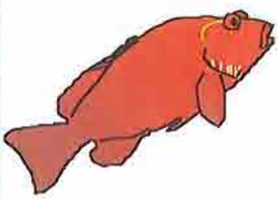
Replacement rates vary over time for various types of functions and life history stages on a coral reef.

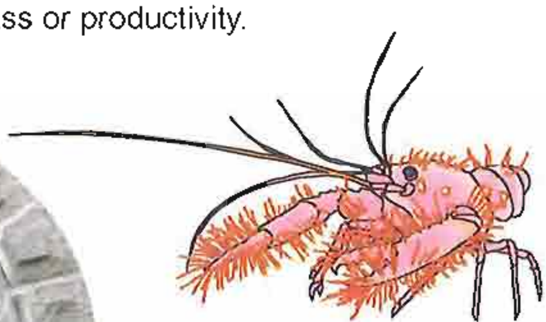
MEASURING ECOLOGICAL FUNCTION




The Concept of Keystone Species


A **keystone species** is a species that has a disproportionate effect on its environment relative to its abundance. Such an organism plays a role in its ecosystem that is similar to the role of a keystone in an arch. While the keystone feels the least pressure of any of the stones in an arch, the arch still collapses without it. Similarly, an ecosystem may experience a dramatic shift if a keystone species is removed, even though that species was a small part of the ecosystem by measures of biomass or productivity.



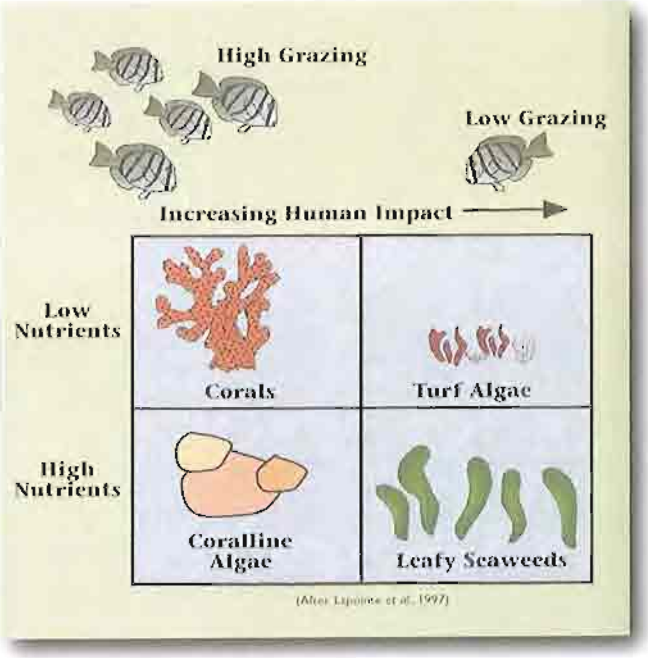
Sea Urchins as Keystone Species


USGS

The long-spined sea urchin (*Diadema antillarum*), a keystone Caribbean coral reef species that suffered a mass mortality in 1983, and resulted in a dramatic shift in overall cover of coral and algae on the reefs. The photo (*above*) taken before 1983, shows *Diadema* on dead portions of a coral head grazing on algae. Notice how the *Diadema* have kept the dead surfaces of this coral free of algae. That summer most of these urchins died throughout the Caribbean. In the years after 1983, without the browsing of these algae-eating urchins, dead coral surfaces such as this became coated with mats of fleshy alga which retarded the settlement of coral larvae, resulting in less coral on these reefs over time.

Algal Dominance

In areas with high impacts and various inputs from shore, coral dominance will be displaced by different forms of algae as shown below.



Key features that affect this process include the number and type of herbivores, and the sources and types of nutrients, balanced against the diversity (types)and biomass of seaweed.

Dave Gulko

Endemism

Endemic (or unique) organisms are only found in a limited area. From an ecological perspective, there is no replacement pool for these organisms.

Dave Gulko

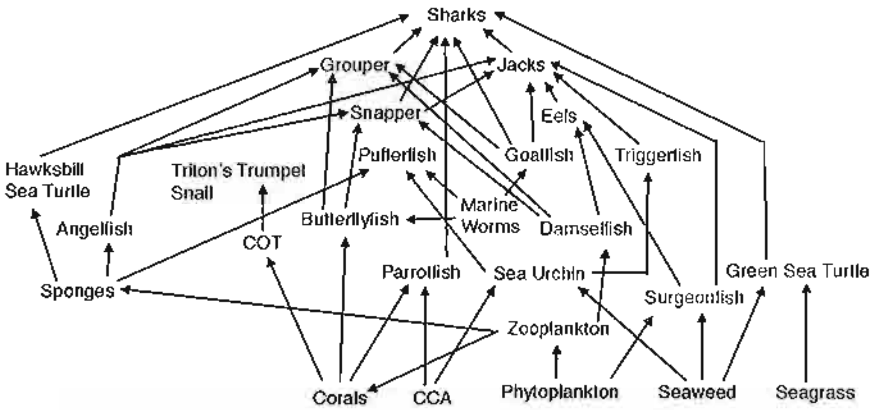
Protected Species

Species that are fully protected by law or statute may be impacted ecologically by an injury event through loss of foraging or prey habitat, loss of resting habitat, loss of mating habitat, interruption of cleaning interactions, disease, increased predation, harassment, interaction with human activities.

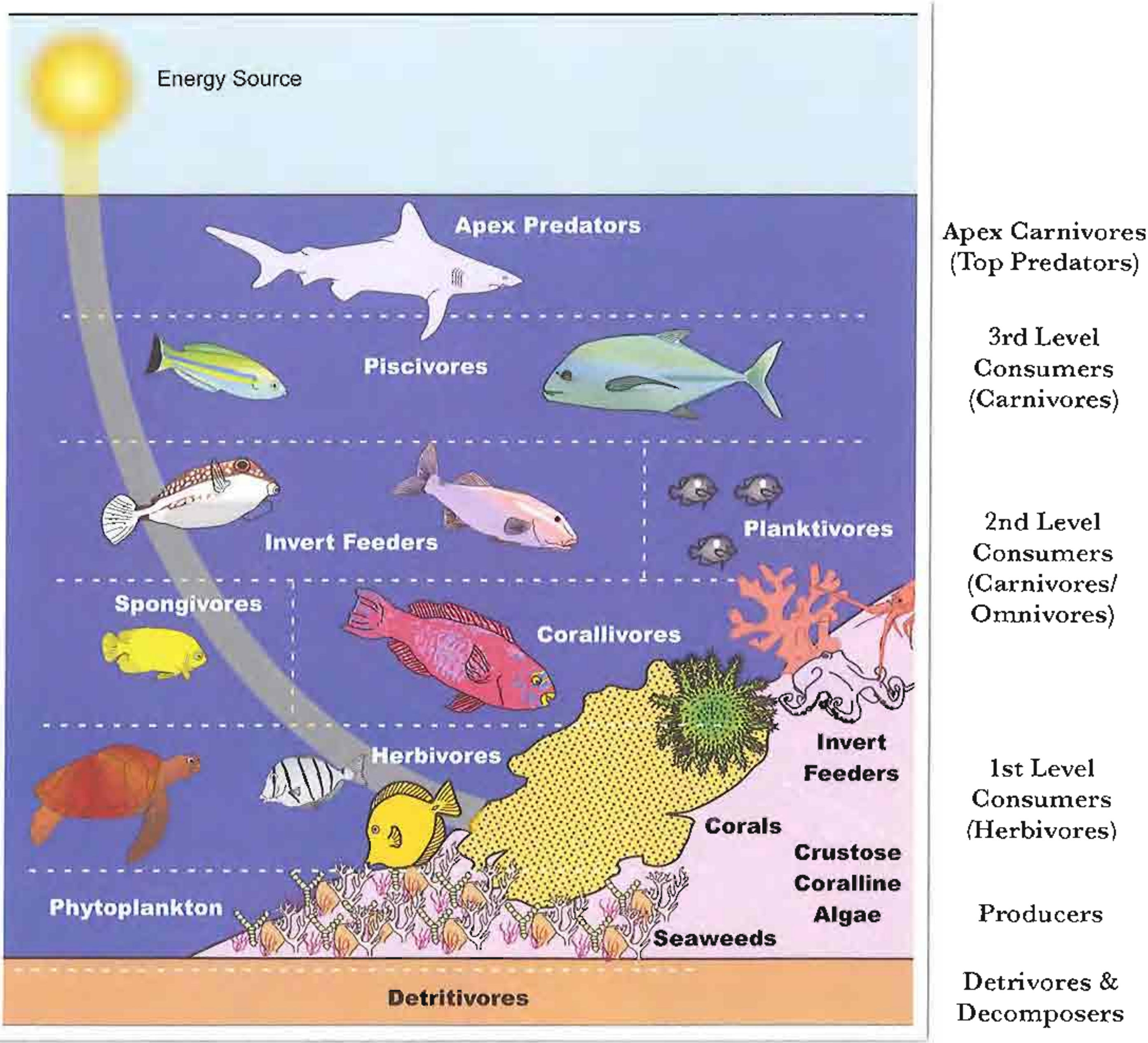
Dave Gulko

Trophic Ecology

Most coral reef animals are part of more than one food chain and eat more than one kind of food in order to meet their food and energy requirements. These interconnected predator-prey relationships form a complex food web (*above right*, note that the arrows go from prey to predator).

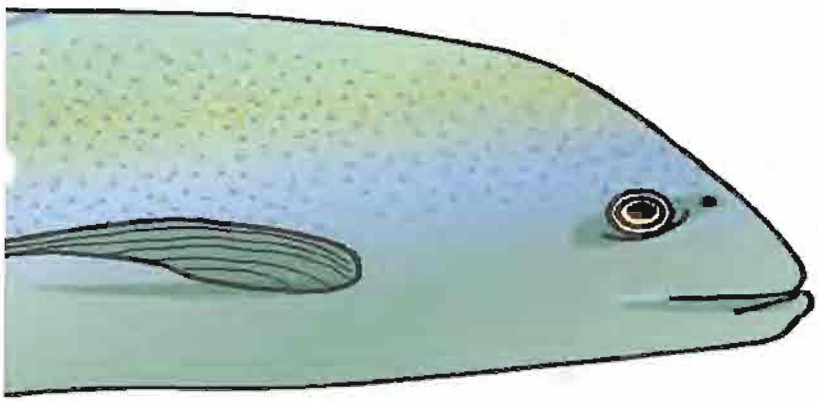


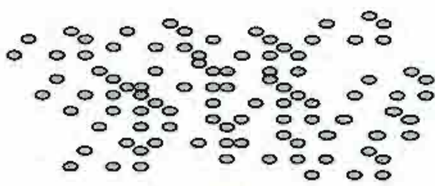
A SIMPLIFIED CORAL REEF FOOD WEB



A **trophic web** shows how each energy moves through an ecosystem. Plants are called **producers** because they use light energy from the Sun to produce food (sugar) from carbon dioxide and water (photosynthesis). Corals can fall in this category because of the single-celled photosynthetic organisms(**zooxanthellae**) living in their tissue. Most animals (**consumers**) cannot make their own food so they must eat plants and/or other animals. Animals that eat only plants are called **herbivores** (or primary consumers). **Carnivores** are animals that eat other animals. Carnivores that eat herbivores are called secondary consumers. Carnivores that eat other carnivores are called tertiary consumers. Some of these specialize in eating corals (**corallivores**), eating sponges (**spongivores**), or eating plankton (**planktivores**). Animals that eat both animals and plants are called **omnivores**. **Decomposers** are organisms (bacteria and fungi) which feed on decaying matter, while **detritivores** feed only on already broken-down matter. Decomposers speed up the process of decay, a process that releases mineral, salts & nutrients back into the food chain.

In a trophic web, energy is passed from one link to another. When a herbivore eats, only a fraction of the energy that it gets from the plant food becomes new body mass; the rest of the energy is lost as waste or used up by the herbivore to carry out its life processes (e.g. movement, digestion, reproduction). When the herbivore is then eaten by a carnivore, it passes only a small amount of the total energy it has received to the carnivore. Of that energy, some will be "wasted" or "used up" by the carnivore. The carnivore then has to eat many herbivores to get enough energy to grow. Because of the large amount of energy that is lost at each link (through metabolic processes and growth), the amount of energy that is transferred gets less at each level, resulting in fewer top trophic level animals versus the number of lower trophic level animals.

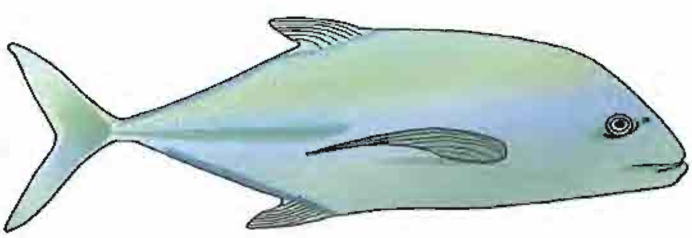




EGGS

Loss of Big Fish

A 0.70 m Jack produces 86 times more eggs than a 0.35 m Jack. The result is that adult big fish have a reproductive value far exceeding that of a smaller adult fish of the same species.



EGG

FINAL STEPS IN A RAPID ECOLOGICAL ASSESSMENT

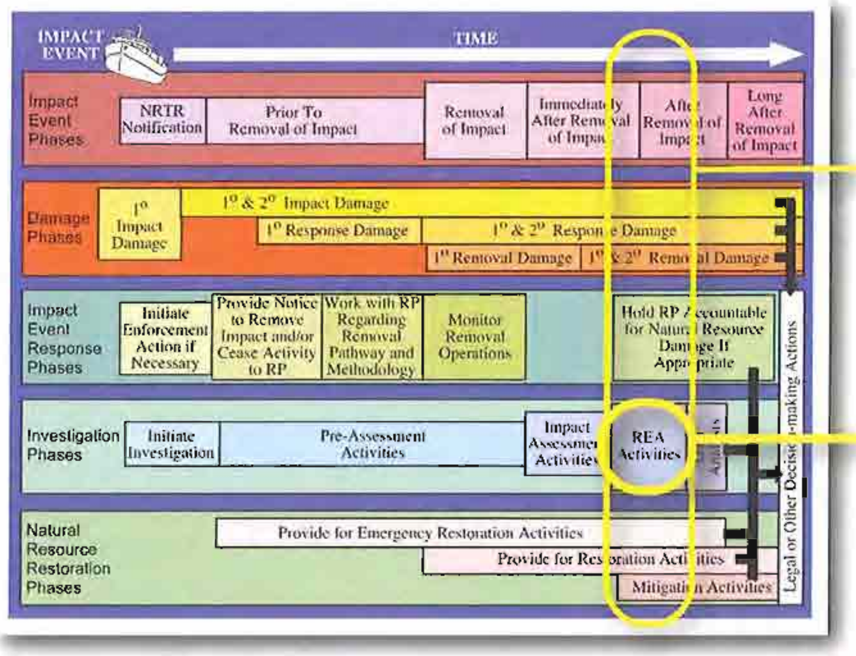
As the REA events in the field reach the final stages, it's critical that arrangements have been made to process and analyze the data, and that the data itself is maintained under a pre-existing set of chain-of-custody protocols for such information and samples.

At this point in the investigation, information should be kept internal until analyzed and presented to the NRTs. Media contacts should be limited and handled through a NRT Public Information Officer. Any safety or environmental concerns detected during these surveys should be passed on to the appropriate NRT or safety agency.

THE REA IS THE THIRD OF THREE IN-WATER COMPONENTS INVOLVED IN A MARINE IMPACT EVENT FIELD INVESTIGATION

Summary

During the Rapid Ecological Assessment, divers will focus on conducting a series of REA dives both within the impacted area and in appropriate reference (or control) sites. REA dives can be used to establish the lost resource values and help determine recovery rates through comparisons with appropriate reference sites.



This Module overlaps with these stages during an impact event and the investigation.

This Module represents this point in the timeline.

REVIEW SHEET

CONDUCTING A RAPID ECOLOGICAL ASSESSMENT

OUTLINE OF ACTIVITIES:

1. REA Team Arrives On-Site	Prepared	Conducted	Documented
a) CROC coordinates activities.			
b) All cameras synchronized to date and time, fresh batteries, housings checked.			
c) Photographer photographs all data sheets.			

Important Tools, Forms or Other Aids:

CROC Form

Initial Site Diagram

2. Fish Team On-Station	Prepared	Conducted	Documented
a) Anchor the first surface safety float at the beginning of the first transect; record the compass direction of the transect.			
b) Swim-out leg of first fish transect, swim back leg of first fish transect.			
c) Swim 5 m beyond first transect in same direction and set second transect, anchor second surface safety float.			
d) Swim-out leg of second fish transect, swim back leg of second fish transect.			
e) Conduct quick swim around transect lines searching for rare species and unusual fish habitat.			
f) Fish team retrieves first transect line (if benthic team finished), retrieves first surface safety float anchor and ascends first safety float line to safety stop.			

2. Fish Team On-Station	Prepared	Conducted	Documented
g) Photographer photographs all data sheets once back on-board support vessel.			

Important Tools, Forms or Other Aids:

Data Sheets

Transect Lines

Surface Safety Floats

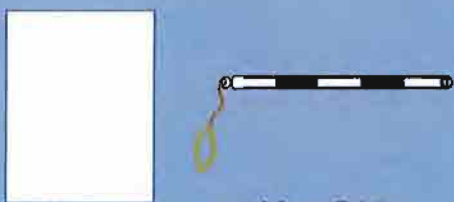
3. Algal Diver: Benthic Team On-Station	Prepared	Conducted	Documented
a) Algal diver photographs all data sheets and photographs 360 degrees at surface.			
b) Algal diver photographs 360 degrees at the start of the first transect line, photographs his/her depth gauge/dive computer, and then photographs every 0.5 m (using the 0.5 and 1 m marks) of the transect line using a 0.5 meter stick to position the camera exactly 0.5 m above the transect line for the first and last 10 meters of the line.			
c) Surveys 0.5 m to either side of the two 10 m subtransects, noting all species encountered and sampling as necessary.			
d) Uses a 20-point 0.5 m^2 quadrat to estimate abundance and percent cover along four randomly selected sections of each 10 m subtransect.			
e) Repeats procedure for second transect.			
f) Conduct quick swim around transect lines searching for rare species and unusual algal habitat.			
g) Helps retrieves second transect line, retrieves second surface safety float anchor and ascends second safety float line to safety stop.			
h) Photographs benthic team's data sheets immediately after team gets back on-board the surface support platform.			

Important Tools, Forms or Other Aids:

Quadrat Data Sheets 0.5 Meter Stick

4. Invert Diver: Benthic Team On-Station	Prepared	Conducted	Documented
a) Algal diver goes first to photograph the first transect line.			
b) Invert diver censuses density of urchins along the 10 m transects while the coral diver conducts a quick point intercept survey of bottom type to determine cover characteristics.			
c) Surveys 0.5 m to either side of the two 10 m subtransects, noting all species encountered and sampling as necessary.			
d) Focus on pre-determined keystone macroinvertebrate species.			
e) Repeats procedure for second transect.			
f) Conduct quick swim around transect lines searching for rare species and unusual invertebrate habitats.			
g) Helps retrieves second transect line, retrieves second surface safety float anchor and ascends second safety float line to safety stop.			

Important Tools, Forms or Other Aids:



Data Sheets 0.5 Meter Stick

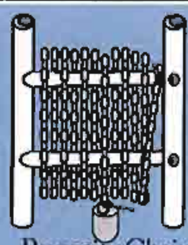
5. Coral Diver: Benthic Team On-Station	Prepared	Conducted	Documented
a) Algal diver goes first to photograph the first transect line.			
b) Coral diver conducts point intercept along each 0.5 m marking for each 10 m subtransect to determine cover characteristics.			

5. Coral Diver: Benthic Team On-Station	Prepared	Conducted	Documented
c) Coral diver(s) census all coral colonies within 0.5 m to each side of the transect line along each 10 m subtransect on the first 25 m transect line. Colonies are classified to one of eight size categories.			
d) Document fragments, partial mortality, disease, predation, abnormal growth, bleaching, other indirect human impacts.			
e) Conduct rugosity estimate using 10 m small link chain placed alongside transect line for each 10 m subtransect.			
f) Repeats procedure for second transect.			
g) Conduct quick swim around transect lines searching for rare species and unusual invertebrate habitats.			
h) Helps retrieves second transect line, retrieves second surface safety float anchor and ascends second safety float line to safety stop.			

Important Tools, Forms or Other Aids:

Data Sheets

0.5 Meter Stick



Rugosity Chain

The Role of the Coral Reef On-Scene Coordinator (The CROC)

Many investigations require a single person to coordinate the on-scene investigation and ensure that all necessary components are gathered in the correct order and maintained properly relative to standard evidence and data management for marine injury assessments. This person is referred to as the Coral Reef On-Scene Coordinator (the CROC).

While many NRT organizations will have various levels of administration, dive safety officers, safety officers, and medical personnel; a multi-agency field team often runs into issues associated with chain-of-command and chain-of-custody concerns (both within the team itself and between agencies) and interface with non-field team elements. Regardless of how the formal Incident Command System (ICS) is arranged to deal with these issues for the overall injury event and other response elements, in the field the injury assessment team has to have a single member on-site, who is overall in charge of the team in the field relative to:

1. Organization and Documentation.
2. Risk Management
3. Intelligence
4. Evidence and Data Chain-of-Custody

Organization and Documentation

The CROC is often the individual on a response team who takes the lead in making sure that prior to team deployment the team is organized and ready to deploy. This will involve the CROC being the focal point for information coming into the team and the lead for information emanating from the team. All formal documentation should go through the CROC.

Initial Investigation of the Incident

Once a CROC is established for an incident, it's going to be important for him/her to work with the NRT and other responding agencies to determine the appropriate level of response necessary. Often this will be leveraged against the type and scale of injury along with the potential risks that the injury vector poses to life, property and remaining natural resources in the immediate area. Primary roles to be accomplished include the following:

Overall Incident Risk Management

- File Boat, Dive, Mission Plans
- Arrange for Site Security

The Initial Investigation:

- Determine Level of Response
- Coordinate and Notify Interested Agencies & Parties
- Supervise Initial Investigative Response
- Ensure Proper Storage/Chain-of-Custody of Materials Gathered.

The Pre-Assessment:

- Determine Level of Response
- Pre-Dive & Post-Dive Briefings

The Impact Assessment:

- Determine Level of Response
- Pre-Dive & Post-Dive Briefings

The Rapid Ecological Assessment:

- Determine Level of Response
- Pre-Dive & Post-Dive Briefings

Risk Management

The CROC often has overall responsibility for risk management associated with staging and deploying the team on-site, conducting dive operations, extracting the team, and exiting the staging area after the dives are complete. Each of these elements has safety (and possibly security) issues associated relative to individual team members, support personnel and peripheral personnel involved. It is therefore important that the CROC be the NRT individual with the most safety and risk management training; in many areas CROCs are individuals who have gone through certification courses to be Divemasters, Assistant SCUBA Instructors, or SCUBA Instructors, where formal risk management field techniques are taught.

We strongly recommend that individuals seeking to serve as CROCs seek out and take advantage of public safety, risk management, rescue and rescue planning, and emergency response training. We also recommend that team's have assigned individuals responsible for gear maintenance, dive master (monitoring divers), safety diver (if necessary), communications, data and evidence storage, etc.

A key component of risk management is planning for contingencies and evaluating the risks associated with various proposed actions in order to maximize team safety and success of the mission. As such the CROC (with consultation of the team's (or NRT's) Diving or Field Safety Officer) should be responsible for planning the different dives, filing dive and mission plans, and conducting both the pre- and post-dive safety and mission briefings.

The Initial Investigation

Prior to putting a team in the field, the CROC will need to gather certain critical information or assign a team member to be responsible for his action:

Weather Forecast: Print out a three-day forecast from a reputable source. This forecast is used for planning field investigations, response activities, and projecting possible trajectories for oil or contaminant spills. Marine weather forecasts should include surface wind speeds and directions, wave heights, temperature range, sunrise and sunset times, humidity, and multi-day/long-range forecast.

Tidal Forecast: Printed tide charts or computer models of tidal changes for the next three days. Tidal information helps with logistical planning, turbidity estimates, spill trajectories, spawning concerns, etc.

The CROC should post weather and tidal conditions for the team and other NRTs.

Intelligence Officer

The CROC often has to serve as the team's intelligence officer, interfacing with terrestrial investigators, law enforcement, and other peripheral agencies prior to, during, and after the in-water phase of the investigation to gather information that may prove critical to both the safety of the team and the success of the investigation. That said, an experienced CROC will recognize that information derived from interviews by officers with individuals under arrest or threatened with prosecution should be viewed carefully; and terrestrial investigators often do not understand the hazards or difficulties involved with carrying out injury investigations underwater.

Pre-Assessment

During the Pre-Assessment, the CROC is responsible for coordinating amongst the site security, in-water assessment and field units, in addition to serving as the prime spokesperson for the team to the media (unless the team or the lead NRT has a Public Information Officer (PIO) who would take on this role) and to other involved government agencies. The CROC needs to make sure that all of the Pre-Assessment data elements are collected and properly handled and secured through the established chain-of-custody techniques in-use by the team.


CORAL REEF INCIDENT INITIAL REPORT FORM

Impact Assessment

It is critical that the CROC maintain control over all data elements and evidence collected during the Impact Assessment. Careful records (photographic and written) should be maintained at all stages of this assessment; and special care should be taken to ensure that proper chain-of-custody procedures are followed. Make sure you use the CROC form to track all elements.

REAs

The most important aspect of the REA for the CROC is making sure that the raw data is duplicated and stored with the previously gathered evidence in addition to a copy being used by the team's experts for analysis. Attention needs to be paid to designation of control or reference sites for the REAs, such that the controls represent the same type of habitat, are in close proximity (if possible) and at the same depth contour as the impact area.

Post Fieldwork

The CROC has primary responsibility to follow-up with all team elements to make sure that the data analysis is accomplished in a reasonable time frame, that data or evidence is not released to unauthorized parties, and that pre-agreed upon Standard Operating Procedures (SOPs) are followed relative to post-fieldwork actions once the various team members are back among their own NRT agencies. Usually it is the CROC who has the lead role for writing up the investigative report which is then reviewed by all of the active team members who participated in the fieldwork or data analysis.

Annual Training Exercises

The CROC should also take lessons learned from each injury investigation and incorporate these lessons into mandatory team training exercises which should be held at least once a year. The CROC, who functions much like the conductor in a symphony, or the director of a movie, is often the one individual who has seen all the angles of an injury investigation and therefore is in the best position to take the lessons learned and apply

them for the benefit of the team in future investigations. It should be noted that organizing Coral Reef CSI Training Scenarios may take up to a year to plan and develop. To be most effective, those who plan and organize the training scenario should serve as observers or referees, instead of participants in order to discern unanticipated issues and responses, and to maximize the learning potential from the exercise.

Other Coral Reef CSI Teams

Along these same lines, it is the CROC who should try to interface with other response teams in the region or with other Coral Reef CSI teams in other regions to share experiences, techniques and tools. It is the sharing of experiences and lessons learned from elsewhere that can be best incorporated into risk management planning for the next event to consider new threats, safer methods, or more complete investigations.

The CROC as Divemaster

Unless a Diving Safety Officer or a certified Divemaster is part of the dive team, the CROC will often have to take on the additional role of Divemaster for each of the assessment phases. In addition to logging each diver's dive parameters (depth, time, surface interval, etc.), the CROC will also need to have complete knowledge regarding each team member's abilities and inabilities relative to the diving environment, the type of marine injury being investigated, and the type of activity role each team member will be taking on for each type of assessment dive. The CROC needs to be constantly running risk-benefit analyses relative to the dive team's actions and the changing marine environment they are assessing. In addition to the Support Technician on board the dive platform, the CROC will need to also pay attention to the equipment used, it's condition, and the necessary decontamination, cleaning and servicing post-dive.

Impact Event Dive Activity Log

Event: Location: Dive Platform:

Dive	Divers	Role	Date	Time:in	Time:out	Max Depth	Surface Int.	Gas Mix	Note
Pre-Assessment/Impact Scene Perimeter									
Pre-Assessment/Impact Scene Perimeter									
Impact Assessment									
Impact Assessment/REA									
REA/Other									
Divemaster:									

Summary

The CROC is the on-site coordinator for most aspects of a field investigation. While seniority is an asset to a functional CROC, the most critical aspect is the level of training and experience in field risk management, emergency response planning and implementation, diving safety, etc. One of the most important roles for the CROC besides team safety, is to document that all necessary tasks have been completed, all data and evidence has been completed and accounted for (or secured), and that necessary chain-of-custody procedures were followed.

The CROC's Primary Responsibility is Team Safety

REVIEW SHEET

SERVING AS A CROC

OUTLINE OF ACTIVITIES:

1. Normal Readiness: Actions consist of developing & maintaining resources, planning, training and testing response capability.	Prepared	Conducted	Documented
a) Written SOPs will be maintained, and reviewed annually with all team members. It will also be presented as part of new team member orientation.			
b) A Copy of the SOP Will Be Kept With Each NRT. A Current Call-Down List WIll Be Present With Each Copy of the SOP and With Each CROC.			
c) The CROC Will Ensure That The Team's Technician(s) Maintain All Gear To Be Ready For Use.			

Important Tools, Forms or Other Aids:

SOP | Team Call-Down List | Gear Ready-To-Go List

2. Notification of an Injury Event	Prepared	Conducted	Documented
a) The CROC Will Notify Other NRTs and the ICS If Not Already Activated and of Large Scale.			
b) The CROC Will Activate the Team Using the Current Call-Down List.			
c) The CROC Will Gather/Receive Intelligence Regarding the Injury.			
d) The CROC Will Prepare Dive Plans, Safety Plans, Boat Plan, & Mission Plans as Necessary.			
e) The CROC Will Arrange For On-Site Enforcement or Security If Necessary.			
f) The CROC Will Meet With NRTs or ICS to Present Mission Plan & Get Approval Prior to Briefing Team.			

2. Notification of an Injury Event	Prepared	Conducted	Documented
g) The NRTs or ICS Will Inform All Field Agencies & Personnel Regarding The Team's Deployment and Field Activities.			
h) The CROC Will Brief All Field Team Members Completely.			

Important Tools, Forms or Other Aids:


Initial Contact Form


Dive Plan


Boat Plan

Mission Plan

3. Arrival On-Scene	Prepared	Conducted	Documented
a) The CROC Will Debrief Senior NRT Personnel At the Scene.			
b) The CROC Will Check-in With, & Update, Incident Command; Coordinate With Security/Public Safety Elements; And Serve As the Primary Media Spokesperson in the Field if No PIO Present.			
c) The CROC Will Arrange For Food/Rest Periods For Field Team Members.			
d) Oversee Establishment of Staging Area/Platform.			
e) Oversee Field Gear Set-up and Safety Gear Placement.			

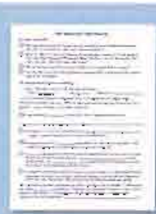
Important Tools, Forms or Other Aids:


Initial Contact Form


SCAT

Boat Plan

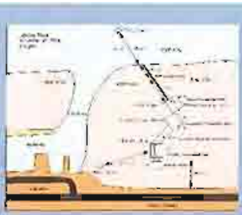
Mission Plan


Media Briefing Notes

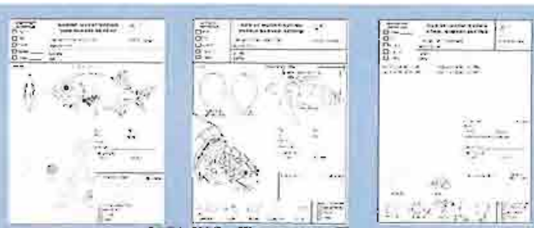
5. Impact Assessment	Prepared	Conducted	Documented
a) Brief Team Prior to Impact Assessment Dive.			
b) Oversee Proper Documentation & Chain-of-Custody During Activity.			

5. Impact Assessment	Prepared	Conducted	Documented
c) Monitor Dive Activity If Team Divemaster Not Available. Coordinate Communications With Other NRT/Public Safety Elements On-Scene.			
d) Debrief Team After Impact Assessment Dive.			
e) Brief Incident Command; Incorporate Results Into Revised Mission Plan; Brief Media If Authorized.			

Important Tools, Forms or Other Aids:


Damage Pathway Diagram


Impact Scene Diagram


Wildlife Damage Forms

Important Tools, Forms or Other Aids:


CROC Form


Chain-of-Custody Form


Dive Master Form

6. REA	Prepared	Conducted	Documented
a) Brief Team Prior to REA Dive.			
b) Oversee Proper Documentation & Chain-of-Custody During Activity.			
c) Monitor Dive Activity If Team Divemaster Not Available. Coordinate Communications With Other NRT/Public Safety Elements On-Scene.			
d) Prepare Incident Report.			
e) Brief Incident Command; Incorporate Results Into Revised Mission Plan; Brief Media If Authorized.			

Important Tools, Forms or Other Aids:

CROC Form

Chain-of-Custody Form

Dive Master Form Form

7. Post-Field Activity	Prepared	Conducted	Documented
a) CROC Will Oversee Recovery and Maintenance of All Gear.			
b) CROC Will Work With Incident Command To Plan Additional Field Activities If Necessary.			
c) Oversee That All Data Is Properly Analyzed; And That Data Security/ Evidence Chain-of-Custody Is Maintained.			
d) CROC Will Prepare The Investigation Report.			
e) CROC Will Review the Incident Response and Prepare An Evaluation for NRT Review.			

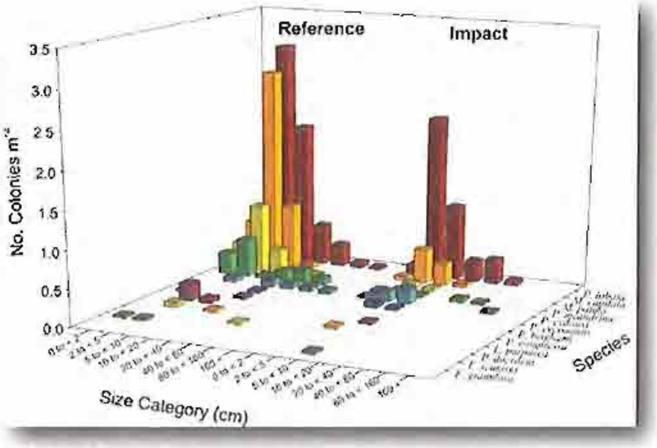
Important Tools, Forms or Other Aids:

Investigative Report (Sample)

Incident Response Evaluation

Media Briefing Notes

Analysis of Assessment Data



Often the weakest part of an in-water investigation is the post-fieldwork analysis of the biological evidence and REA data collected. The highly organized and coordinated assemblage of personnel and equipment involved in a field investigation often gives way to one or two individuals working independently over the following days (or weeks) to analyze what was collected. Often, these individuals, when not in the field, may get overwhelmed with other office duties and the analysis may get delayed. The real risk under such a scenario is a loss of chain-of-custody or degradation of the material collected such as to decrease its usefulness in the investigation.

STOP

The following requires a basic understanding regarding biological statistical analyses. For many jurisdictions, access to a biostatistician or professional marine biologists and ecologists with statistical analysis background is critical if such expertise is not available on staff.

Analyzing Biological Samples and REA Data

Analysis of biological samples and REA data involve different pathways in the injury investigation. Biological samples are often analyzed by experts in a laboratory setting; care must be taken at all steps to maintain chain-of-custody and to preserve the integrity of the biological samples. Analysis of REA data is basically number-crunching which can be done on a computer in an office or home by a trained expert with knowledge of basic data analysis and statistics. REAs focus on delineating the injury in such a way as to provide guidelines for what was lost in order to initiate mitigation or restoration. Note that both components (biological sample analysis and REA data analysis) vary from the type of analyses associated with most of the components of the Pre-Assessment and Impact Assessment. These function primarily to document the injury scene (i.e. create a narrative of the what's known to have happened) and analyze the evidence collected at the scene to allow for a reconstruction of the events and actions that led to the injury. It establishes a formal link between the injury and the responsible party while also delineating the damage caused to the natural resources.

While still on the boat, all data sheets should be photographed by the team photographer immediately after the divers exit the water. After the the field work is finished, all data sheets should be copied and the copies secured with other evidence prior to the individual team members being allowed to work on their data.

Regardless of specialty, all team members should enter their data into a pre-agreed upon spreadsheet from which anyone can analyze their data. While everyone has their favorites, Microsoft Excel is probably the most widespread and easily available. Metadata (information regarding the date, depth, location, time, tide, and other broad variables) should be included on a separate portion (or sheet) of the spreadsheet. Data should be entered into the spreadsheet at its lowest denominator - in other words, each cell should have the raw numbers first - exactly what was found on the data sheet - not averages, sums or fractions.

Graphics and charts in this section are presented in a number of styles and forms in order to expose you to different ways of presenting data analyses.

Injury Area Measurement Data

The specific injury measurements should be grouped by injury cause, location and habitat type. Total sums by category should be presented along with a total sum for the injury broken down into area measurements for direct and indirect amounts, and presented in amounts per meter square.

	Injury Site	Injury Area (m^2)
1	**Initial Impact Site**	**29.11 m^2**
2	**Debris Field**	**85.75 m^2**
3	**Dragging Scar**	**11.09 m^2**
4	**Secondary Impact Site**	**43.09 m^2**
5	**Tertiary Impact Site**	**22.12 m^2**
	Total Damaged Area	**192.06 m^2**

Example of measured damage to geological features, live coral and live rock from a single injury event.

REA Data Overview

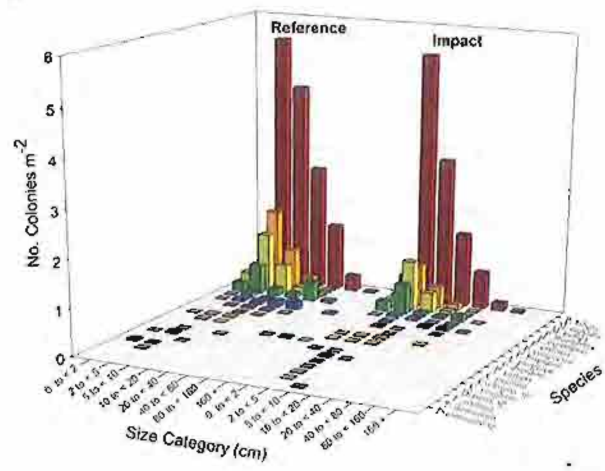
In most cases, the NRTs have little if any reliable data on what specific resources existed (and in what state) in the injured area immediately prior to the impact event. The use of multiple nearby areas for reference is a often-used approach for enhancing the probability of representing pre-incident communities fairly by accounting for ecosystem heterogeneity and reducing the potential for spatial differences. This reference data will often need to be sorted by common variables such as depth, habitat type, location, etc. and then averaged with standard error determined.

Rugosity Data

Rugosity data should be analyzed for each rugosity measurement by dividing the Relative length (measured in meters) resulting from use of the 10 m rugosity chain laid into the reef contours, by the Actual length of the transect section (fixed at 10 m). The resulting fraction is a representation of three-dimensionalness. As the fraction approaches "1", the habitat is primarily flat and featureless; as the fraction approaches "0", the habitat is highly three-dimensional. Data should be averaged across all transect subsections at each site for analyses. Primary comparison should be injured sites (broken down into habitat and/or depth) versus control sites (also broken down into habitat and/or depth).

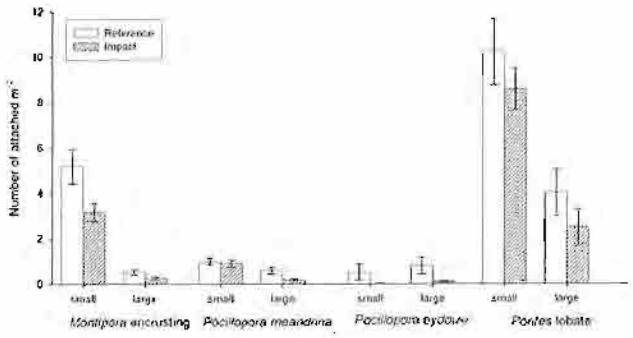
Coral Data

Biodiversity: An overall species list should be established based on presence absence at the controls versus injured area, and biodiversity comparisons made.



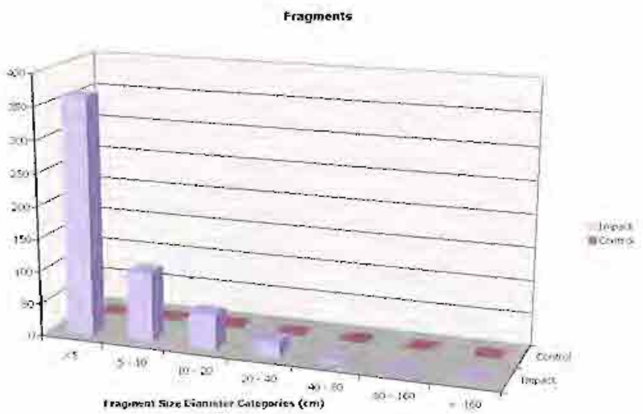
Biodiversity, colony size , and number of colonies from a injury site.

Abundance: You can plot species vs size category vs abundance as shown above, but in areas with lots of coral species this will become hard to visually interpret. In some cases you may wish to pool coral species data by classifying coral species into functional groups, growth forms, or lump all species within their respective genera. Data should be averaged across all transect subsections at each site for analyses; though each functional group should be analyzed separately. You may need to group attached coral size classes together in order to allow for standard parametric tests to be applied, especially in situations where small numbers of site replicates exist (very common in coral reef injury investigations). Groupings should be based on similarities such as age structure, suspected exposure to the injury, or relative habitat contribution.



Example of the Average (+ S.E.) Number of Colonies for Groupings of Coral Species from an Injury Event. Note the dominance of Porites lobata, a type of coral that is extremely long-lived and can form large massive colonies; this would be a flag for a resource manager to suggest that this injury would have a lengthy natural recovery.

Fragment Analysis: Loose fragments can be analyzed separately from the attached corals but using similar methods. You may need to group fragment size classes together. Fragment comparisons between reference and injury sites can be used as one measure of impact and pre-existing impact prior to the injury incident. Large numbers of fragments found within impact areas versus adjacent reference areas may suggest that the reef substrate was relatively intact immediately prior to the injury event, suggesting that the damage noted was due to this series of incidents by the RP.



Comparison of loose coral fragments documented within all impact areas (5) versus all control areas (12).

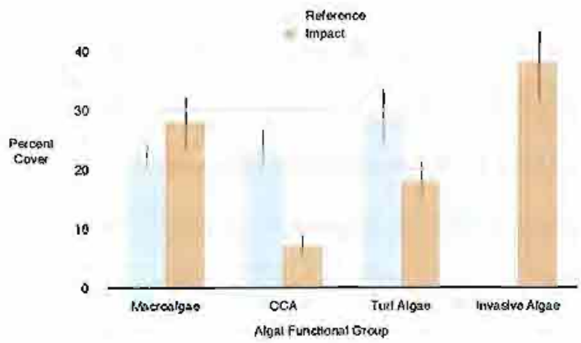
Algae Data

Biodiversity: An overall species list should be established based on presence absence at the controls versus injured area, and biodiversity comparisons made.

Abundance: Proportional cover should be determined for each species or functional group by dividing total number of relevant points by the total for each 10 m section of transect, this will result in a percentage cover representation. Data should be consolidated and analyzed by algal functional group (example: macroalgae, Crustose Coralline Algae (CCA), turf algae and invasive algae), and be averaged across all transect subsections at each site for analyses.

Functional Group	n	Reference	Impact
Macroalgae	6	21.76 ± 3.28	28.44 ± 6.05
Crustose Coralline Algae	6	23.33 ± 5.18	7.17 ± 3.44
Turf Algae	6	28.78 ± 6.44	18.21 ± 5.16
Invasive Algae	6	0	38.32 ± 6.90

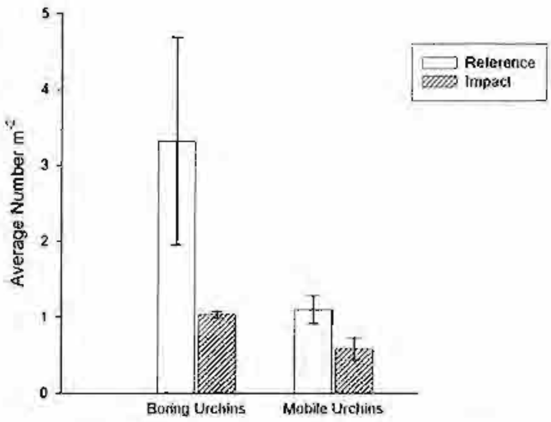
Example of Average (+ S.E.) Percent Cover of Algal Functional Groups from an Investigation of an Injury Event. Of the algal functional groups, turf algae had the highest cover at reference sites, while invasive algae had the highest cover at impact sites; however, invasive algae was not observed within measured quadrats in the reference areas.



Invertebrate Data

Biodiversity: An overall species list should be established based on presence absence at the controls versus injured area, and biodiversity comparisons made.

Abundance: Break data down at least by Phyla, and preferably by functional group (for example: mobile herbivorous sea urchins versus bioeroding boring herbivorous urchins) and/or susceptibility to the incident-related injuries. Data should be averaged across all transect subsections at each site for analyses; though each functional group should be analyzed separately.



Example of Average (+ S.E.) of Urchin Functional Groups Measured For A Coral Reef Injury Event.

Reef Fish Data

Biodiversity: An overall species list should be established based on presence/absence at the controls versus injured area, and biodiversity comparisons made.

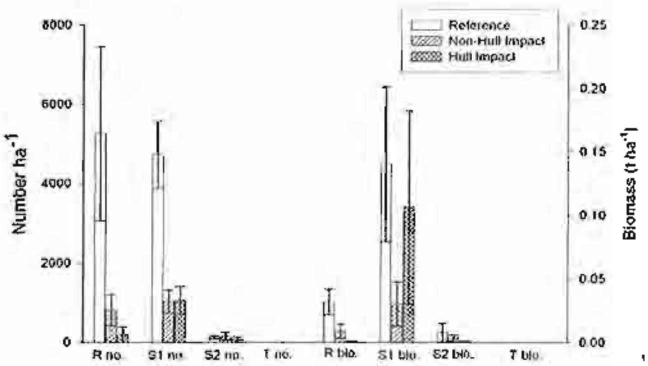
Abundance & Biomass: Fish densities can be calculated using appropriate area estimates (i.e. 100 m^2 for fish greater than 10 cm, and 50 m^2 for fish less than 10 cm). One way to translate fish numbers into densities per hectare is to calculate biomass per hectare using published length-to-weight conversions for the fish in your area.

Fish species can be categorized into mobility (or site fidelity) groups for your area by breaking down fish species as follows: **R** (species with limited movement and well-defined home ranges), **S1** (species that are mobile and have daily movements on the order of tens of meters), **S2** (species that move daily on the order of

Species	Mob.	Ref.	NHI	HI	Species	Mob.	Ref.	NHI	HI
Chromis vanderbilti	R	4or4	7	500	*Bodianus bilunulatus*	as	r4	o	o
Thalassoma duperrey	ab	r4 o	s o	o	*Coris gaimard*	ab	r4	s	o
Dascyllus albisella	ab	4r4	o	o	*Zebrasoma flavescens*	ab	r4	o	o
Paracirrhites arcatus	R	400	b, s	o	*Acanthurus olivaceus*	as	s.	o	o
Acanthurus nigrofuscus	ab	r. s	o	boo	*Caracanthus typicus*	R	s	o	o
Plectroglyphidodon johnstonianus	R	r. o	s	o	*Chromis ovalis*	R	s,	o	o
Sufflamen bursa	ab	sr4	o	soo	*Chlorurus sordidus*	as	s	o	o
Plectroglyphidodon imparipennis	R	as.	s.	o	*Cirrhitops fasciatus*	R	s.	s.	o
Canthigaster jactator	ab	b44	s, s	o	*Macropharyngodon geoffroy*	ab	s.	o	o
Chaetodon miliaris	ab	b44	o	o	*Naso hexacanthus*	ab	s.	o	o
Parupeneus multifasciatus	ab	b7.	bs.	o	*Ostracion meleagris*	ab	s.	o	b7
Plagiotremus goslinei	R	br4	o	o	*Paracirrhites forsteri*	R	s.	o	o
Chaetodon quadrimaculatus	ab	bbs	o	o	*Echidna nebulosa*	ab	bs	o	o
Scarus psittacus	as	44	o	o	*Gomphosus varius*	ab	bs	o	o
Chaetodon ornatissimus	ab	7.	o	o	*Canthigaster coronata*	ab	o	s.	o
Halichoeres ornatissimus	ab	7.	o	o	*Cantherhines dumerilii*	ab	o	s.	b7
Coris venusta	ab	o	7.	boo	*Melichthys vidua*	ab	o	o	b7
Parapercis schauinslandi	ab	o	boo	rb7	*Naso unicornis*	as	o	o	7
Pseudocheilinus octotaenia	ab	o	o	o	*Oxycheilinus unifasciatus*	ab	o	o	b7
Pseudocheilinus tetrataenia	ab	o	o	o	*Sufflamen fraenatus*	as	o	s.	o
Rhinecanthus rectangulus	ab	o	r4	s, 7					

thousands of meters), and **T** (species that move over great distances). Number and biomass of individuals in each mobility class can be summed for each transect, and the means of the two transects per site used in the follow-on analysis. For some incidents within defined areas, only fishes that are grouped into the two lowest mobility groups might be used for your analyses, because with many incidents the higher mobility and transient fishes were not likely to have been impacted by injury-effects that only represent a small portion of their total home ranges, and these groups tend to be unevenly sampled with this type of transect method. Conversely, less mobile fishes, with greater site fidelity, would be more likely impacted by the incident injuries within the defined area, which probably represents either all or the majority of their home ranges.

Data should be averaged across all transects at each site for analyses.



Example of Average (+ S.E.) Number and Biomass of Fish by Mobility Group For A Coral Reef Injury Event. Note the subdivision into direct injury by the grounded impact (hull impact) and the indirect injury caused by the response effort (non-hull impact).

DETERMINATION OF VARIANCE AMONGST MEASUREMENT FACTORS

In some cases, you may wish to explore running an Analysis of Variance (ANOVA) on specific data sets in order to compare the differences between field variables such as differences in depth, location, etc. As with many statistical tests, the data must meet certain conditions prior to running the ANOVA.

Source	DF	SS	MS	F	P	
Boring Urchins						
Depth	G	7i	7i			
LG: iiGi	G	GI i	GI i	G	G79	
nrrG	9	7 I 73	I 7G			
TG 1	CG	9 9CP				
Mobile Urchins						
Depth	G	G	G			
LG: iiCh	G	I G	I G	7	7	ci > Gnp
nrrG	9	G7 1	CP			
TG 1	CG	i 9				

Example of a Block Design ANOVA with Tukey HSD Comparison of 'Location' Urchin Densities and Depth. Note that the data were square-root transformed to meet model assumptions.

If done correctly, this will help to minimize suggestions by the RP or others regarding other explanations for your results.

STATISTICAL ANALYSIS FOR INJURY PROJECTIONS

At this point in the investigation, injury to a variety of coral reef resources has been observed and documented in pre-assessment and impact assessment activities. One of the purposes of the REA is to quantify the injuries relative to the natural resources that would have been there absent the incident, not determine whether injuries had in fact occurred. Statistical hypotheses thus tend, for most functional groups, to be one-sided. *A priori*, numbers of targeted organisms (corals, fish, invertebrates) for the different REA subgroups would be hypothesized to be less dense in injured areas compared to reference areas. Other organisms known to congregate in injured areas might be hypothesized to be at greater density after a major injury (for example Crown-of-Thorns Seastars feeding on damaged coral). When multiple factors (such as coral sizes, fish mobility classes) or impact types (for example, hull impacts versus non-hull impacts) are considered, two-sided ANOVAs (one-way, factorial, block) can not be used; factors can be independently evaluated with appropriate one- or two-sided tests. In most cases, transformation assumptions (square-root, log, arcsine square-root, etc.) can be used to meet model assumptions (Adapted from Kolinski *et al.*, 2006).

In many cases, data results should be presented with the standard error referenced against the results for Reference and Impact sites side-by-side for each biological variable analyzed.

DETERMINING ESTIMATED NUMBER, SIZE AND SPECIES OF CORAL COLONIES INJURED

One function of the rapid ecological assessments is to help establish average coral colony parameters that would have existed at the site prior to the injury. This is done by conducting multiple transects parallel, and adjacent, to each side of the injured areas at the same depth profile, whenever possible, to establish appropriate reference areas. This results in multiple, replicate 10 m transects for each injured area. The REA Coral transects classify every coral colony by species and size class out to 0.5 m to either side of the transect line resulting in a measurement of coral colony coverage within $10m^2$ for each of the parallel transects. Estimated number of coral colonies damaged within the impact area can be derived by multiplying the damage area measured (squared meters) times the average number of coral colonies (per species) in the reference transects divided by 10 square meters (the area of each reference transect surveyed). Confidence intervals at the 90% level are determined using the the standard deviation and the number of controls for each derived number of colonies damaged per species.

DETERMINING RECOVERY RATES

Use published growth rates or actively measure growth over time for one or more primary species of coral at the impact site. For example, *Porites lobata* from the

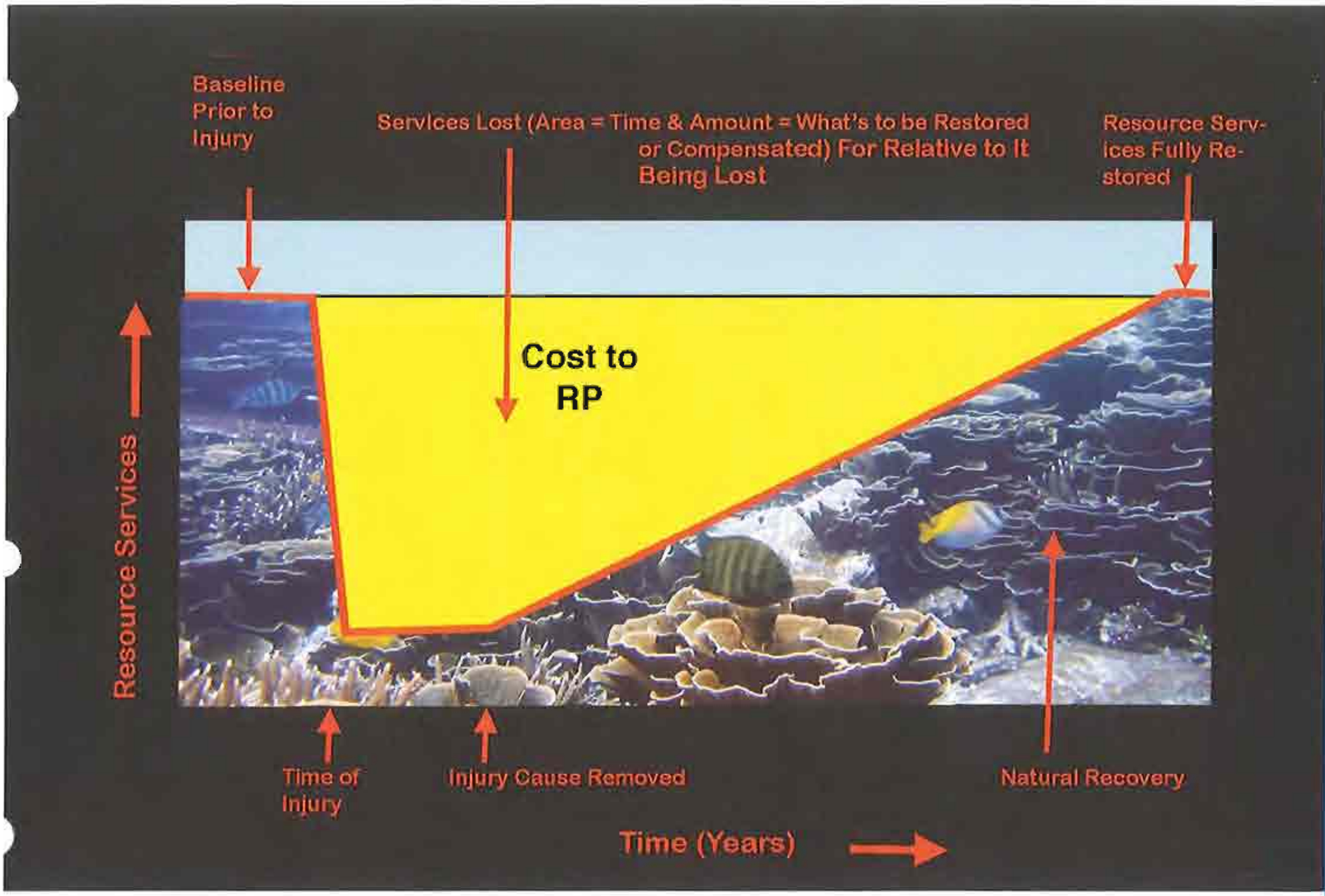
	Average # Colonies Reference Areas per 10m2	St. Dev	Impact Area (m2)	Estimated # Colonies Damaged Within Impact Area		90% Confidence Limits	Lower Range # Colonies Damaged	Higher Range # Colonies Damaged
Montipora patula	22.00	7.57	29.11	64		6.23	58	70
M. capitata	16.75	8.50	29.11	49		6.99	42	56
Pavona duerdeni	0.00	0.00	29.11	0		0.00	0	0
P. varians	0.00	0.00	29.11	0		0.00	0	0
Pocillopora eydouxi	0.75	1.50	29.11	2		1.23	1	3
P. meandrina	7.00	4.55	29.11	20		3.74	16	24
Porites lobata	0.50	0.58	29.11	1		0.47	1	1
P. compressa	22.75	10.87	29.11	66		8.94	57	75
				Total Estimated # Colonies Damaged	203		174	230

Example of a Derivation of Estimated Number of Coral Colonies by Species Damaged Within an Impact Area Based Upon Reference Area Measurements. Note that the estimated number of coral colonies damaged was derived by multiplying the damage area measured (squared meters) times the average number of coral colonies (per species) in the control (reference) transects divided by 10 square meters (the area of each control transect surveyed). Confidence intervals at the 90% level were determined using the the standard deviation and the number of controls for each derived number of colonies damaged per species.

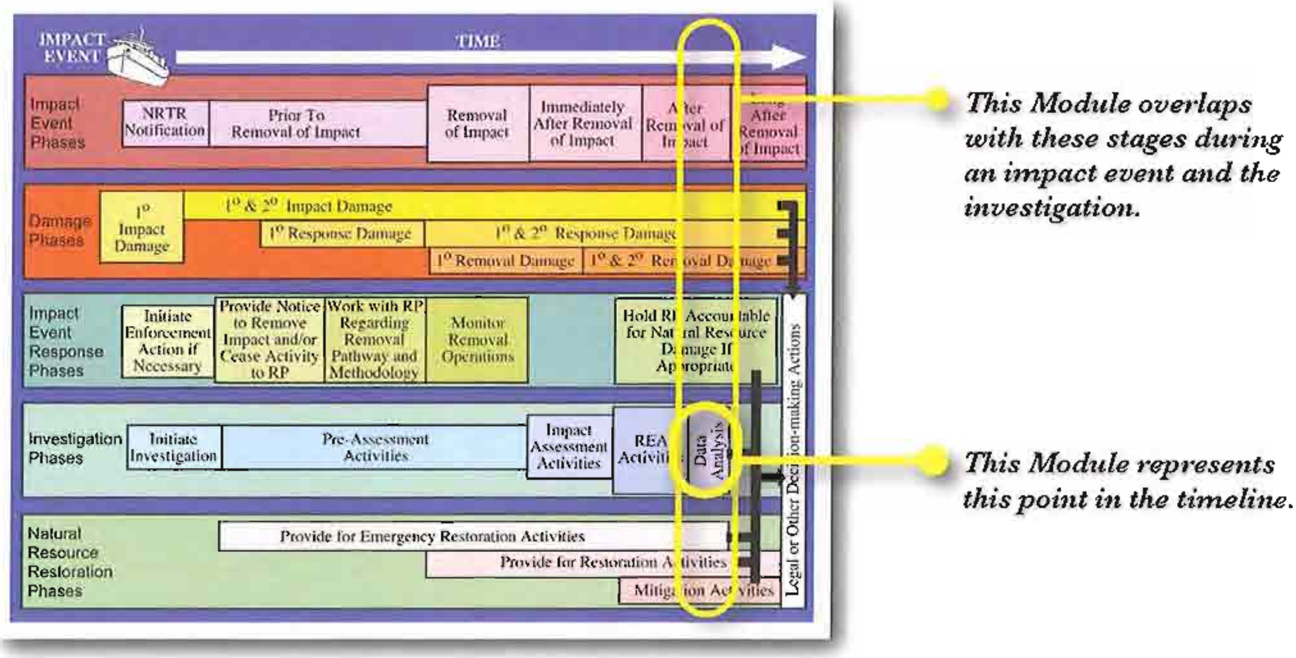
Main Hawaiian Islands might average around 1 cm/yr linear growth; we therefore could estimate that the recovery time for *Porites lobata* colonies (dominant coral on that type of reef) in the 80 cm - 160 cm range will take at least a minimum of 80 years. Use the dominant coral species or that with a predominant ecological function to base recovery of the reef itself on as the reef ecosystem would not be expected to fully recover until such time as the full assemblage of coral colonies in the size ranges that were present prior to injury event, re-establish themselves completely, and allow the full variety of associated reef fish, sea turtles, and invertebrates to make use of the ecological functions they provided prior to the impact injury; this often means the largest colonies impacted would take the longest time to fully recover.

Final Steps in Analysis of REA Data

After each team member has analyzed their respective data sets, a series of meetings should be held where the team members present their data to each other and work out or account for any inconsistencies in order to produce a unified account based on the data results and relative to the investigation. In general, the team should strive for data analysis that are clean and clear relative to their ability to be presented to a decision-,making body through either presentation or the written investigative report. Team members should carefully review each other's analyses to assure that the proper assumptions were met for each statistical test or analytical method used. Data and data analysis should be reviewed for inconsistencies or inaccuracies while in draft form, as the RP's experts



will be scrutinizing your analyses looking for any weak point or inaccuracy to strengthen their defense, minimize the injury amount, or lessen their responsibility for the injury.



Notes

Arrival & Preservation of the Scene


AVRAM (http://www.reefbase.org)

The initial steps taken at the beginning of an injury investigation are critical to the success of the follow-on in-water investigation elements, and ultimately, to the final decision-making and mitigative efforts.

The very first **Natural Resource Trustee (NRT)** representatives on the scene will need to evaluate the injury relative to the following issues:

1. **Safety** - Are the injury events still on-going in such a way as to pose a danger to life and property? Often these will involve government agencies that focus on public safety.
2. **Geographical Scale** - How large is the injury relative to distance? As this scale increases, usually additional NRTs become involved.
3. **Temporal Scale** - How long has the injury been on-going? How long is it expected to continue?

STOP Note: Coral Reef CSI Techniques as shown in this toolkit were developed for short-term, **not** continuous, human-caused injuries to coral reefs.

4. **Habitat Scale** - How many different habitats or subhabitats (marine, coastal or land) are currently being affected by the injury event?

The result of this quick evaluation by the NRT should be the basis for initializing a coordinated response by the NRT agency or if the scale is large enough a group of NRT and public safety agencies working together.

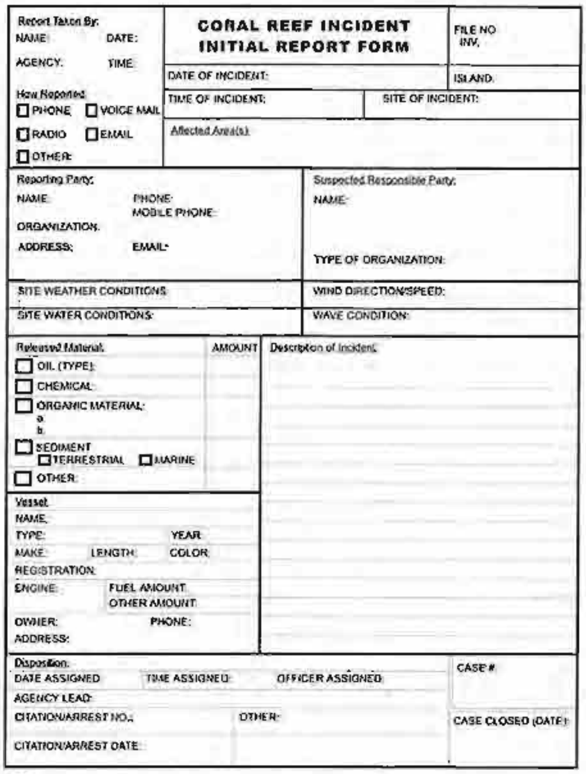
Who Should Report An Injury Event

Often the first people to notice a coral reef injury are not those well-trained to evaluate its scale and dangers. That said, most jursidictions should invest in educating the public and specific coral reef user groups regarding proper reporting procedures when they encounter a reef injury. With minimal background, any individual having knowledge of an incident can initiate a report to a NRT; these might include the RP, captains of commercial vessels and vessel- towing companies, boaters, divers, fishers, and other observers. It is important to emphasize the need for reporting the incident as early as possible, reporting specific location information, and reporting any potential dangers obvious at the scene. Additional information regarding specific identification of the cause of the injury, number of people involved and their status, etc. should also be solicited. The NRT representative who receives this information should also make sure to get the reportee's contact information. Efforts should be made by NRTs to have the ability to receive reports 24 hrs a day in a manner that is easily accessed by the target user groups (phone, radio, etc.).

What To Initially Report

In order to initiate a safe coral reef injury response with proper risk management, it is critical to get as much accurate information through the first reports as possible. The Florida Department of Environmental Protection (2007) has put together the following list of information to be reported that is useful to authorities regarding a coral reef injury incident:

- The type of incident that has occurred (vessel grounding, sinking, anchoring, oil spill, sediment event, etc.)?
- What is the specific location of the incident and the approximate size of the injured area? GPS coordinates is best, but a physical description of the area or location name may suffice if the description is specific enough to lead NRTs to the location of the incident.
- Is a vessel involved? If so, provide specifics such as the vessel name, registration numbers, type of vessel, make, model, color, size, and any other identifying characteristics.
- Are other environmental impacts associated with the reef injury, such as petroleum or other chemical releases?
- If the vessel involved is still on the scene, is the operator attempting to dislodge the vessel, take other corrective actions, or flee?
- Have any other NRT agencies been notified by the individual reporting the incident, or are there any NRT personnel or vessels at the scene?
- What is the contact information of the individual reporting the incident?
- Is there visual documentation of the incident (photos or video)?



CORAL REEF INCIDENT INITIAL REPORT FORM

Report Taken By:
NAME: DATE:
AGENCY: TIME:
How Reported:
☐ PHONE ☐ VOICE MAIL
☐ RADIO ☐ EMAIL
☐ OTHER:

FILE NO
INV.
DATE OF INCIDENT:
ISLAND:
TIME OF INCIDENT:
SITE OF INCIDENT:
Affected Area(s):

Reporting Party:
NAME: PHONE:
MOBILE PHONE:
ORGANIZATION:
ADDRESS: EMAIL:

Suspected Responsible Party:
NAME:
TYPE OF ORGANIZATION:

SITE WEATHER CONDITIONS:
WIND DIRECTION/SPEED:
SITE WATER CONDITIONS:
WAVE CONDITION:

Released Material: AMOUNT
☐ OIL (TYPE):
☐ CHEMICAL:
☐ ORGANIC MATERIAL:
a.
b.
☐ SEDIMENT
☐ TERRESTRIAL ☐ MARINE
☐ OTHER:

Description of Incident:

Vessel
NAME:
TYPE: YEAR
MAKE: LENGTH: COLOR:
REGISTRATION:
ENGINE: FUEL AMOUNT
OTHER AMOUNT
OWNER: PHONE:
ADDRESS:

Disposition:
DATE ASSIGNED TIME ASSIGNED: OFFICER ASSIGNED:
AGENCY LEAD:
CITATION/ARREST NO.: OTHER:
CITATION/ARREST DATE:
CASE #
CASE CLOSED (DATE):

The initial report form can be used to gather this information and relay it in a form that can be used by the various NRT agencies.

Essential Training for NRT Personnel Regarding Initial Reporting

NRT and other agency/government employees need to be made aware of their responsibility to report coral reef incidents through the normal course of business and other standard operating procedures (SOPs) such as interoffice/agency memoranda and email. It is important that all employees recognize that the official NRT agency(s) possess the overall responsibility, expertise, and resources to respond to these coral reef incidents. Notifying each NRT and public safety agency in a timely way facilitates an effective response to incidents causing coral reef injuries.

(Based on Florida Dept. of Environmental Protection, 2007)

The Incident Command System (ICS)

For large-scale injury incidents (either in regards to geographic scale, multiple habitat scale or multiple NRT scale), a multi-faceted response will probably occur. Many regions are using a **Incident Command System (ICS)** model to handle such events whereby all agencies agree that their personnel will follow a single layered command structure. The system is designed to grow and shrink along with the incident, allowing more resources to be smoothly added into the system when needed and released when no longer needed. Given large magnitude events, it's not usually possible for one agency alone to handle the management and resource needs. Partnerships are often required among various government agencies. These partners must work together in a smooth, coordinated effort under the same management system and under a single chain-of-command.

The **Chain of Command** is an essential part of being able to control incidents of all sizes. Every person involved in the incident response has a designated supervisor. As a result, there is a clear line of authority within the overall organization, with all lower levels connecting to higher levels, eventually leading solely back to the Incident Commander.

The principles of ICS clarify reporting relationships and eliminate the confusion caused by multiple, conflicting directives from multiple NRTs. Incident managers at all levels must be able to control the actions of all personnel under their supervision, regardless of agency. Note that these Chain-of-Command principles do not necessarily apply to the exchange of information in ICS, members of sections may directly communicate with each other to ask for, or share, information.

USCG (www.uscg.mil/d11/response/TRAIN.htm)

The ICS function may be carried out in two ways: as a **Single Command** in which the Incident Commander will have complete responsibility for

STOP

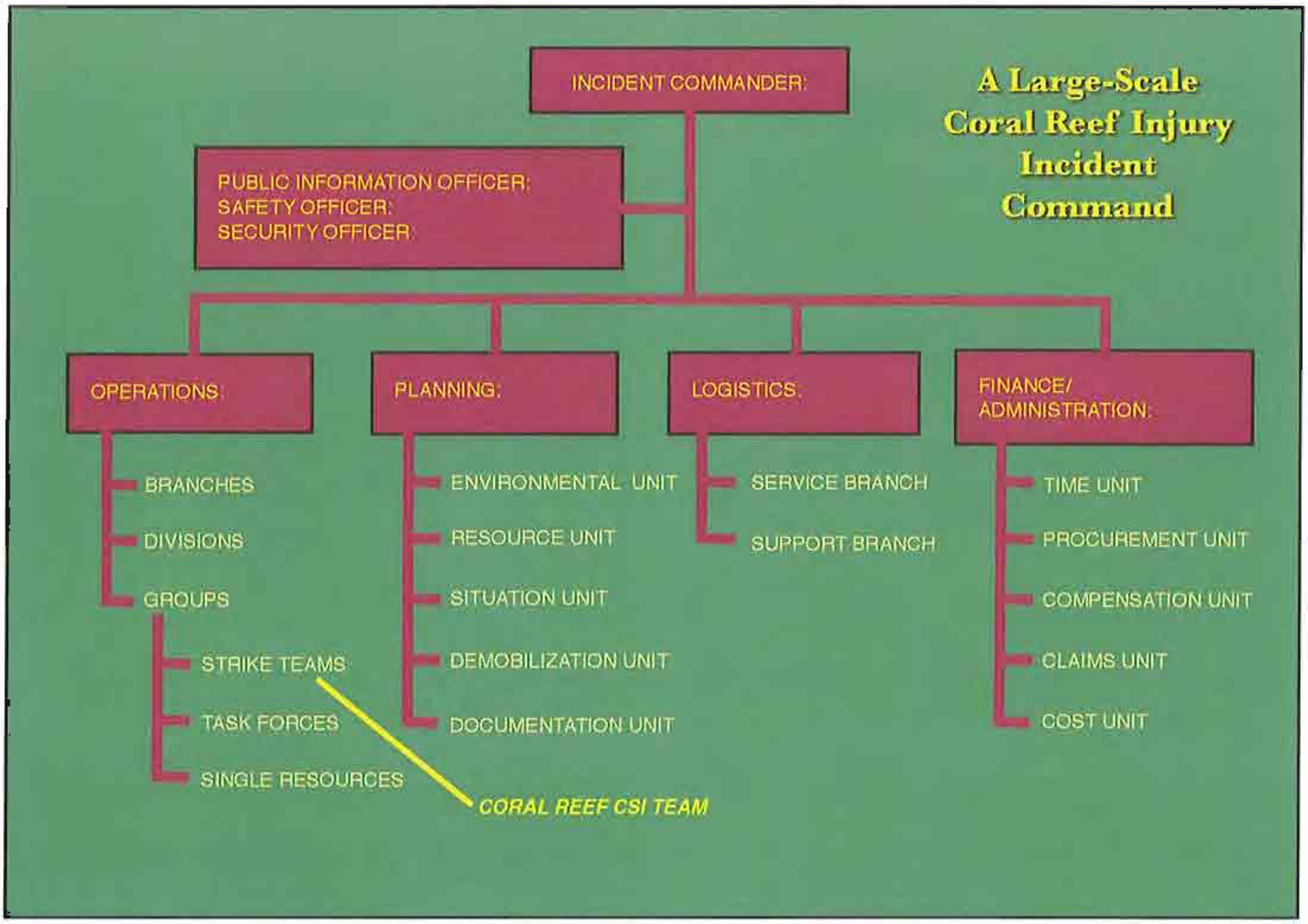
Note: In many injuries involving physical injury to coral reef resources, the response efforts can frequently cause greater damage than the original injury if not carefully controlled and planned.

Key Terms

- *Natural Resource Trustee (NRT)*
- *Incident Command System (ICS)*
- *Chain-of-Command*
- *Incident Commander*
- *Single Command*
- *Unified Command*
- *Ecological Triage*
- *Incident Action Plan*
- *Lightering*

incident management, or as a **Unified Command** in which responding agencies and/or jurisdictions with responsibility for the incident share incident management. A Unified Command may be needed for incidents involving multiple jurisdictions. A single jurisdiction with multiple NRT agencies sharing responsibility, or multiple jurisdictions with multi-NRT and/or public safety agency involvement.

If a Unified Command is needed, **Incident Commanders** representing lead NRT agencies or jurisdictions that share responsibility for the incident manage the response from a single Incident Command Post. A Unified Command allows various agencies with different legal, geographic, and functional authorities and responsibilities to work together effectively without affecting individual agency authority, responsibility, or accountability. Under a Unified Command, a single, coordinated **Incident Action Plan** will direct all activities. The Incident Commanders will supervise a single Command and General Staff organization and speak with one voice.



Personnel Notification System

Within the ICS and also within the Coral Reef CSI Team, a pre-existing personnel notification mechanism will be necessary in order to activate resources for an injury investigation. All staff with notification roles (either within the team or NRT's involved with the ICS) are responsible for maintaining current contact information for notification and activation purposes. Contacts should include both personal and business numbers for team members.

The Concept of Ecological Triage for Injury Events

In medicine, triage is the screening and sorting (classification) of a number of patients to determine the priority of need for treatment and transportation. Ecological triage is the idea of evaluating **immediate** natural resource injury response and emergency restoration needs based upon impaired or threatened ecological function and available resources at the habitat and subhabitat level. Effective real world ecological triage would require assessment of the biological, economic, and political realities relative to each proposed line of action.

This sorting generally results in reef injuries being placed into one of four general priority categories:

High Priority: Those that need immediate treatment and immediate transport in order to survive or which provide high ecological services.

Intermediate Priority: Those which will most likely survive but require treatment, or those which pose significant risk to other resources if left on-site in its current condition.

Low Priority: those who require little or no treatment or whose treatment and transportation can be delayed.

Lowest Priority: those injuries which cannot be expected to survive even with treatment or due to lack of needed resources, or those which pose no immediate threat to other natural resources if left on-site.

The chart below provides examples of some of the triage sorting that should occur with a major injury event. The actual sorting of habitat injury response or emergency restoration needs would be affected by the availability of response personnel, the qualifications of the personnel, resources available on-scene, the direct risks posed by the injury event, the environmental and weather considerations and the proximity of definitive support facilities and funding.

Coral Reef Injury Triage Summary	
High Priority (Red Priority)	**Intermediate Priority** (Yellow Priority)
• Fragmented/Overturned Branching Coral Colonies • Fragmented/Overturned Massive Coral Colonies • Injured Marine Mammals/ Sea Turtles • Oil or Chemicals in Water • Concentrated Organic Material	• Damaged Small Coral Colonies • Damaged Sea Fans/Soft Corals • Dead, Loose Corals or Large Rubble/Substrate If In Potential Wave Area • Marine Debris (Nets, Lines, Plastics, etc.) in Water
Low Priority (Green Priority)	**Lowest Priority** (Black Priority)
• Damaged Encrusting Coral • Dead Fish & Invertebrates • Damaged Seagrass • Metal or Concrete in Water	• Barren Substrate/Pavement • Dead Encrusting Coral

Example of a Triage Priority Chart for Coral Reef Injuries. You might want to rearrange these elements, or add new ones, to make this specific for your region.

General Coral Reef Ecological Triage Guidelines

- ❖ Triage should begin as part of the initial scene assessment.
- ❖ One of the senior responding NRT personnel should be in charge of the natural resource response and establish and remain in contact with the incident commander.
- ❖ A safety perimeter must be established.
- ❖ Personal protective equipment should be utilized as appropriate.
- ❖ Hazardous substance isolation techniques and equipment should be utilized as appropriate.
- ❖ All providers and bystanders should be protected from environmental hazards as appropriate.
- ❖ An estimate of the number and type of natural resource injuries should be performed.
- ❖ This information must be forwarded to the incident command center.
- ❖ The designated CROC should be informed of this information as well.
- ❖ Notify potential receiving marine animal care facilities of numbers and estimated severity of the injured organisms' condition(s).
- ❖ Call for additional assistance if required.
- ❖ Initiate Coral Reef CSI protocol, if the situation meets the local or regionally established criteria.
- ❖ The total number of natural resource injuries should be assessed and reassessed regularly.
- ❖ The decision to conduct immediate natural resource emergency restoration depends on
  - Distribution of natural resource injuries at the site.
  - Scene assessment/safety.
  - Available resources.
- ❖ Emergency restoration should occur for Red Priority injuries.
- ❖ If resources do not permit for this then initial treatment and stabilization must be performed to minimize additional damage in place in the field.
- ❖ Primary survey on all injuries.
- ❖ Rapid ecological assessment of all injury sites and adjacent reference sites.
- ❖ Tag and document all substrate injuries.
- ❖ If necessary, set-up a treatment area for injured wildlife.
- ❖ After initial triage designate substrate and wildlife injuries into smaller more workable groups by category.
- ❖ Conduct a secondary assessment on all injured natural resources.
- ❖ Correct other immediate habitat threatening conditions if resources permit.
- ❖ In a large-scale injury situation, prolonged effort in assessing and treating natural resource injuries in the low/lowest priority category is inappropriate if it delays the assessment and treatment of the remaining natural resource injuries.
- ❖ This delay may result in unnecessary habitat deterioration or wildlife death that might otherwise have been saved through basic interventions.
- ❖ As additional resources become available, low priority injuries should be reassessed and treated if appropriate.
- ❖ Treat and restore natural resource injuries as indicated by priority, equipment, and provider availability.

Note:

- Initial triage must be conducted rapidly and carefully ensuring no natural resource injuries are missed.
- One person (the CROC) must assume control to oversee assessments, delegate equipment and resources, and coordinate interaction with the incident command.
- This person must remain in charge until relieved by a suitably qualified individual.
- The incident command personnel or the NRT authority in charge should remain at the scene to direct additional units.
- Communications with the incident command facilities, other NRT units, rescue and safety personnel, and other responding agencies is paramount to the successful management of the incident and its response.

If resources are limited, injuries triaged into the Lowest Priority (black) category may be significantly delayed to enable available resources to be focused on "salvageable" injuries and especially those with the greatest ecological functions at risk.

Initial Response Perimeters

After receiving information about a coral reef injury and initiating response elements, a number of key issues will need to be addressed, depending on the cause of the injury and the availability of funding. The initial response personnel will need to ensure safety of the public, restrict natural resource damage, identify the Responsible Party (RP), take enforcement action against the RP, collect evidence, obtain any necessary authorizations for emergency restoration activities, carry out initial response activities, and develop and implement a restoration/mitigation plan.

Problems may arise with these issues as a result of overlapping NRT and/or public safety jurisdictions. As such, it is important in those injury events where ICS is not used, to identify clearly for all involved the primary NRT agency with enforcement authority who will take enforcement action, issue authorizations, and, if applicable, fund the required assessment and emergency restoration activities.

Pop Quiz: Initial Site Hazards

The first NRT personnel to arrive at a injury scene will have to quickly evaluate the impact site for potential hazards to response personnel and to nearby natural resources. If you were the first on scene and observed the vessel above, in murky water and partially submerged atop a reef flat as shown - how many of the following would be of concern in this case?

Site/Incident Response Concerns

☐ Fuel spill	☐ Solvents Onboard	☐ Sewage
☐ Fuel Tanks	☐ Lubricants	☐ Disease
☐ Hidden Fuel Tank	☐ Dispersents	☐ Corpses
☐ Refridgerents	☐ Cleaning Chemicals	☐ Currents
☐ Anchor Chain	☐ Rotting Food	☐ Depth
☐ Fishing Gear	☐ Scientific Gear	☐ Weather
☐ Fishing Line	☐ Scientific Chemicals	☐ Rope
☐ Rotting Fish	☐ Marine Life	☐ Munitions
☐ Broken Glass	☐ Sharp Metal	☐ Drugs

Initial Enforcement and Response Actions

The lead NRT with enforcement responsibility will need to establish the following regarding the injury scene and initiate the following actions which can occur concurrently with the activation and deployment of a Coral Reef CSI team to assess the injury and, where appropriate, to work with the lead NRT to assist in assessing the following (Modified after guidelines originally developed by the Florida Department of Environmental Protection, 2007).

1. Identification of the Cause of Injury

The lead NRT often is the final determinant in identifying the cause of the injury; which itself is critical to the team's assessment process. Direct observation of the incident is the most straightforward method of determining the cause of injury. As a result, NRTs must remain alert in natural resource monitoring, especially in areas where coral reef injuries have occurred in the past. The general public also can and should be encouraged to report incidents when observed.

For unobserved events, many human-caused injuries generally leave distinct scars or other signs indicating the cause of the injury. Such injuries are usually finite in area with distinct boundaries, characterized by straight lines or a specific directionality, distinctive grooves or markings, and bottom paint, debris, and/or significant localized structural injury. Compare this with storm injury, which is usually widespread across the affected area.

2. Identification of the Responsible Party (RP)

There are two basic types of RPs: those who are **known** and those who are **discovered**. **Known RPs** are those who have either reported an incident themselves, or who were witnessed in the act of injuring the reef resources and were reported to the NRT.

Discovered RPs are those whose identity is unknown at the time the initial injury report is received, but eventually becomes known through the investigative and forensic processes. Often a RP is suspected prior to being formally identified; under such circumstances the RP is referred to as a **Potential Responsible Party (PRP)**. Injury events where the RP remains unknown are often referred to as **orphan sites**.

3. Vessel Salvage

For injury events where a vessel (or other large, man-made object) is involved in a reef injury and is sunken or lodged, a government public safety organization is often the lead agency providing support for salvage operations (in the U.S. this is usually handled by the US Coast Guard). Salvage operations frequently result in additional (and sometimes extensive) damage to coral reef resources. These injuries often occur in the area immediately surrounding the grounded object but can be minimized with the use of salvage techniques developed to prevent injury to reef resources and through careful review prior to salvage by the NRTs. The principal causes of collateral injuries are dragging objects off the reef instead of floating them off; the use of steel towing cables that can drop on or drag across the substrate, impacting and dislodging resources (reef structure, corals, and sponges); the inappropriate lightering (lightering is defined as the process involving ship-to-ship transfer of oil, fuel, or loose cargo) of material off of the grounded vessel resulting in release to the environment; the anchoring of salvage equipment; and propwash and surge, generated by tugboat propellers, that displace sediment and dislodge organisms.

To avoid or minimize such collateral injuries, a reconnaissance survey should be conducted while the vessel is grounded to evaluate reef resources in the immediate area surrounding the vessel and determine an appropriate extraction route.

Other mechanisms to minimize response damage include proper lightering of fuels and other cargo, floating or use of buoyed towlines instead of steel cables, and towing activities should be conducted at or near high tide to facilitate floating the vessel. Before and during the extraction, global positioning system (GPS) coordinates at the bow and stern of the vessel should be recorded to assist with future injury assessment. GPS tracking should be operating on the grounded vessel during egress from the site and on all salvage vessels or tugboats involved with the salvage operation. The outbound path for vessel extraction may also need to be buoyed, to help avoid or identify injuries that may occur during the salvage operation.

4. Enforcement Action

Enforcement actions are the foundation for legal cases involving human-caused reef injuries. The issuance of a noncompliance letter, warning letter, or Notice of Violation (NOV) to an RP establishes the connection between the RP, the violation committed, and the NRT (usually a government agency). The issuance of such a notice also establishes the NRT's intent to pursue legal avenues for the restoration and/or mitigation of lost resources and ecological functions, the recuperation of costs associated with the investigation, and the possible imposition of penalties against the RP. In extreme cases of violations, enforcement action may involve seizure of the vessel or object causing the injury and/or arrest of the RP. Seizure of items or evidence, and powers of arrest should only be used by individuals properly trained in natural resource enforcement and through NRT agencies properly authorized by law.

5. Evidence Collection

The timely collection of evidence and the subsequent chain of custody are critical components to building a solid case if an RP is uncooperative, if criminal charges are levied against the RP, or if there are disputes regarding the need for, or the extent of, compensatory restoration/ mitigation. The NRTs seeking restitution must make a solid case that can only be built through proper Evidence Collection Processes. Proper evidence collection for reef injuries caused by anthropogenic activities consists of

(1) Knowledge of the types of evidence necessary to build a solid case;

(2) the use of divers who have been trained in accredited standards for the collection and maintenance of evidence; and

(3) the use of divers who operate with appropriate safety standards.

The Coral Reef CSI team, with its multi-disciplinary and multi-agency approach, including direct interaction with both enforcement and prosecutorial agencies, is well-suited for this role (Modified after Florida DEP, 2007).

B. Lumsden

Site Security Issues

For large field investigations, on-going response activities, natural resource injury events involving loss of human life, or injury events which pose a risk to public safety, one might need to have multiple zones of security surrounding an injured area.

- Zone 1: This zone surrounds the impact perimeter (and may also encompass all of the event perimeter). Obviously, this zone will expand and contract as conditions change and is designed to move with the operation. Enforcement or Public Safety personnel provide security (which often entails the use of vessels and public notices). Access is monitored. Only operational personnel are allowed within this zone; media, non-NRT/other agencies not allowed within Zone 1.
- Zone 2: This zone often serves as an equipment staging area, an area for support personnel (response, clean-up, medical) , briefings, and a mobile command center. Access is monitored. Media and non-NRT/other agencies allowed in for limited periods under escort, and with permission of Incident Commander.
- Zone 3: Area nearby where the media can operate or family members can gather if rescue or recovery operations are involved.

Decontamination Issues

In many impact investigations involving oil spills, sewage, sedimentation events, and other chemical or pollution release incidents (and to a lesser extent incidents involving fish kills or injured wildlife) it will be important for all divers to go through a decontamination procedure after exiting the water. In some cases this may not be possible aboard the dive platform and will need to be accomplished as soon as the team gets to shore. In any case, efforts should be made to immediately wash down divers in their gear with clean seawater or freshwater, then scrub down

Decontamination Gear For Injury Investigations

The following represents basic decontamination gear for dive platforms which can be used by surface support personnel to help decontaminate divers.

- Saltwater (or freshwater) rinse capability: hose and sprayer or buckets.
- Ear drops, disinfectant wipes.
- Freshwater scrub-down wash (antibacterial soap and light chlorine solution) and scrub brushes.

divers with a antibacterial chlorine wash and rinse again (Note: that this phase was should not be done near any natural areas where wash runoff (grey water) could introduce chlorine into contact with sensitive marine life). All dive gear should be removed (including suits) and placed into storage bins or bags (example; large, heavyweight plastic trash bags) where they can be further soaked prior to being rinsed again and dried out.

US EPA

After all divers have been

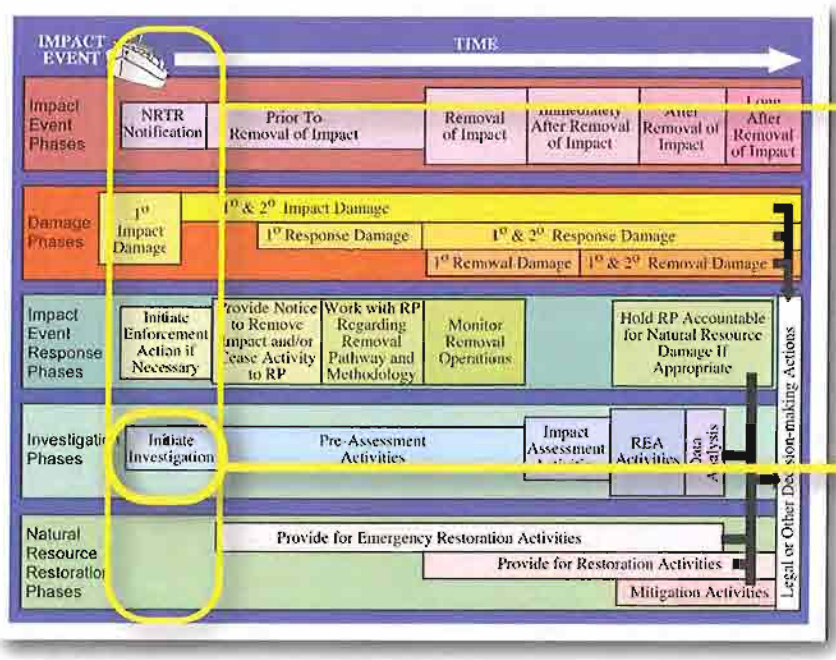
decontaminated, the surface technician (or others) who were decontaminating the divers need to be decontaminated themselves.

> **STOP** Note: In waters where there is clear evidence of pollution or chemical hazard, the team should use chemical dry suits, full face masks, and will need prior special training. If this is not available, the in-water investigation will need to wait until water conditions are clean enough to dive in.

Summary

The first NRTs at the scene need to assess safety issues and the scale of the incident relative to geography, habitats and time. In addition, a variety of details regarding the injury, cause and potential RP should be relayed to the responding NRT and public safety agencies. If the incident is of large scale or meets regional criteria, the Incident Command System (ICS) should be activated and control all response activities. Once again, if the incident is of large scale, affects a wide variety of resources, or meets regional criteria, ecological triage should be employed by the appropriate NRTs.

NRTs should endeavor to assist, where appropriate, enforcement actions resulting from the injury event, but only in a supportive and non-enforcement role, based upon training and legal authority.



This Module overlaps with these stages during an impact event and the investigation.

This Module represents this point in the timeline.

Initial Search for Evidence At Risk

Dave Gulko

Conducting successful searches underwater requires well-trained personnel, excellent surface support, and a focus on team safety.

What Is Evidence at Risk?

In many cases, field activities are conducted under conditions where specific items, victims, or injuries need to be determined through one or more dedicated searches. This is extremely time-sensitive as underwater certain materials often weather or are bio-eroded at fast rates, and habitats are in a constant state of change due to factors such as currents, tides, waves, surge, marine organisms, and impacts by other user groups. Spilled materials, organic materials, dead material (and bodies) will all quickly change underwater with conditions as listed above. Injured organisms will often leave the area or be consumed by predators. Damaged substrate will change as loose sediment and rubble are moved by surge or currents, and exposed substrate or damaged sessile organisms are overgrown by colonizing species. The result is a strong need for a well-conducted initial search early in the investigation and shortly after the injury event itself.

Organizing A Search

All available intelligence should be analyzed to narrow the search area prior to initiation. Search teams need to be experienced, having practiced the search type being used previously prior to going into the field. Prior to initiating the search, all personnel should go through a dry-run on land (or boat) and discuss contingency plans for various scenarios that might be encountered. Hand signals, documentation, and emergency procedures should all be discussed and agreed to by all parties involved prior to initiation.

STOP

Note: Conducting searches underwater requires advance training and coordination which few divers possess. Efforts should be made to use trained divers only.

Key Terms

- *Evidence at Risk*
- *Sweep Search*
- *Strip Search*
- *Grid Search*
- *Triangulation*
- *Diver Propulsion Vehicle (DPV)*
- *Remotely Operated Vehicle (ROV)*
- *Circle Board*

Risk Management During a Search

Conducting an underwater search is very different from most types of assessment dives in that the activities are often done under poor visibility conditions and often the areas to be searched are extensive. For most searches it is important to have enough trained personnel and/or enough time to cover a search area completely and in a methodical manner. The limitations of SCUBA diving should be used to pre-plan ALL search components; it is recommended that search dives involving free-swimming divers be limited to around **20 minutes** based on work load and stress levels (breathing effects) affecting most divers working in relatively shallow water reef environments.

Estimated Duration of a 80 cu. ft Aluminum Cylinder (Assumes 0.25 cu. ft/min)

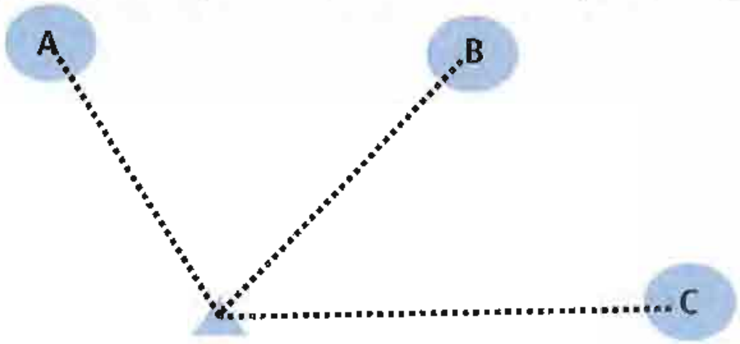
Depth (m)	Depth (ft)	Atmospheres ATA	At Rest (minutes)	Light Work (minutes)	Moderate Work (minutes)	Heavy Work (minutes)	Severe Work (minutes)
Surface	0	1.0	256	91	58	42	29
10	33	2.0	128	45	29	21	14
20	66	3.0	64	30	19	14	9
30	99	4.0	51	22	14	10	7

Consider that work loads, stress, cold and the ability of the diver to stay focused over time all lend towards minimizing individual diver bottom times. Add to this the realization that the slower rate of search is often more productive and less prone to missing the search object.

If the divers are going to be doing a bottom search or are conducting a search under low visibility or degraded water quality conditions, divers should be wearing protective gloves (taped to the wetsuit if possible). Under such conditions, each diver should have a small secondary air source (i.e. Pony Bottle).

Surface Aspects to a Search

In today's world of GPS, it might seem out of place to try and pin-point locations for searches the old-fashioned way, but if you only have one shot at an injury site and somehow your GPS isn't working correctly, wasn't calibrated properly, or your batteries die and you lose all your stored locations, using triangulation as a back-up makes a lot of sense and takes only a short amount of time to accomplish. **Triangulation** is the use of line-of-sight on three fixed points which all intersect at the spot which is your starting point.



Obviously, if one has a GPS you should ALSO record the latitude and longitude after you've calibrated the unit. Keep in mind that you might need to return to exact site of your search if field conditions worsen, you need more time, or to conduct other aspects of the investigation.

Organizing a Search

All available intelligence should be analyzed to narrow the search area prior to initiation. Search teams need to be experienced, having practiced the search type to be used previously before going into the field. Prior to initiating the search, all personnel should go through a dry-run on land (or boat) and discuss contingency plans for various scenarios that might be encountered. Hand signals, documentation, and emergency procedures should all be discussed and agreed to by all parties involved prior to initiation.

Various Options for Conducting Underwater Searches

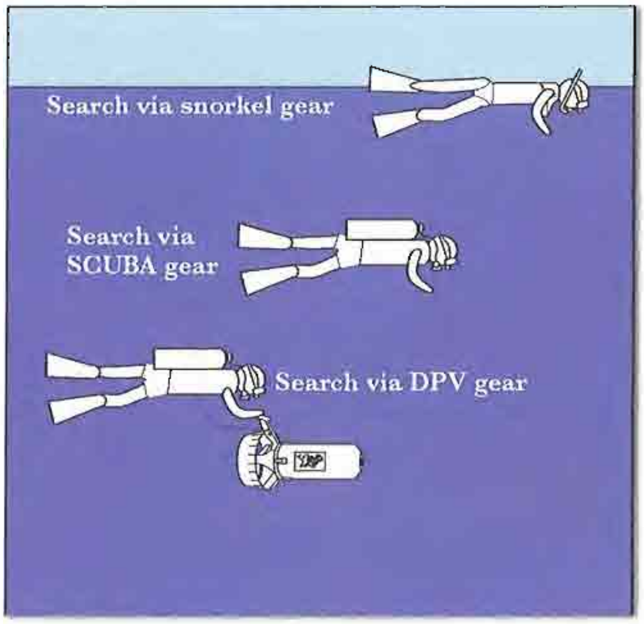
When conducting search operations on the ocean, prime consideration needs to be given for the safety of the in-water search team and the efficiency of the search method relative to the means, equipment and personnel available. When confronted with a large scale disturbance, initial efforts should be made to search the greater area from high elevation (helicopter, airplane, etc.) using visual (or hyperspectral) imagery if available.

From the air, large scale search items can be discerned if depth and water clarity are not an issue. Aerial surveys provide for searching extremely large areas (tens of kilometers).

Once the search moves to in-water activities, a variety of options are available ranging from a Remotely-Operated Vehicle (ROV) to the use of divers and snorkelers swimming via Diver Propulsion Vehicles (DPV), towboards, or on their own power.

In order to maximize best use of limited time, personnel, and equipment, along with providing for a documentable investigative approach, standardized search methods are utilized regardless of whether the search is being conducted by snorkeler or diver, swimming unassisted or with aid of DPV or towboard.

Remotely Operated Vehicles (ROVs) offer the ability to safely explore deep habitats repetitively. Initial costs are very expensive, though non-powered 'Drop Cameras' which can be slowly towed behind a boat may offer a lower-cost alternative. Both have limitations in regards to evidence retrieval.



There are a variety of search techniques that can be used in-water for finding physical evidence under a variety of environmental conditions [1]. In each case, specialized training and support is needed in order to safely conduct these activities; many of them require both specialized motorized equipment and specific safety gear.

Towboards can be used with both snorkelers and divers who, along with the boat operators, have undergone extensive training. Towboards offer a means to cover large areas in limited amounts of time and can be rigged to both record relative position through GPS and document the scene with video orientated forward or downward.

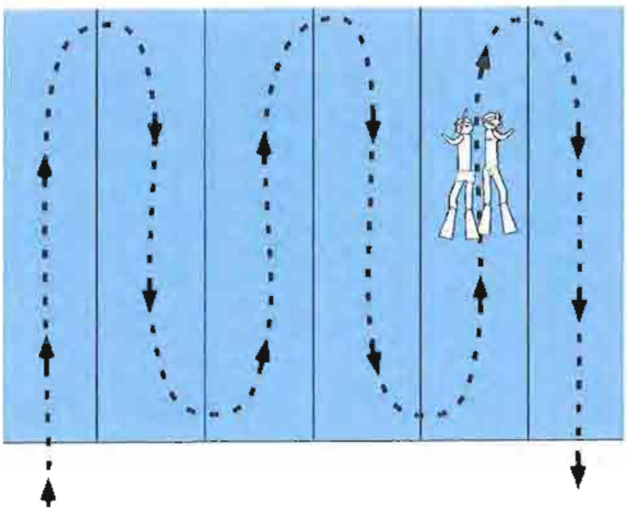
[1] Modified after Becker, 2006. Most of these are modified after established techniques developed for single divers operating under public safety diving conditions and parameters.

Sweep Searches

Sweep searches usually involve a single diver attached to a tether which is tended from shore by a tender operator. Both the tender and diver need to have undergone specific professional training in this technique. It works best immediately adjacent to a shoreline or structure. The diver is attached to a strong polypropylene line, starting from the shore and working outward in ever-broadening arcs. This method has the advantage of being usable under zero-visibility conditions with proper training.

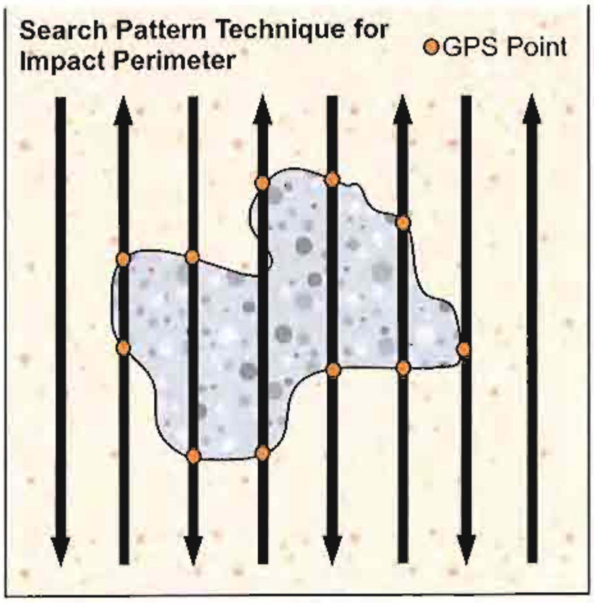
Strip Searches

One of the more common forms of searches conducted within coral reef habitats is the strip search. Team members use a pre-determined start point and compass heading and swim a pre-determined distance (either using fixed points, timed swims, or surface communication associated with a surface float). Divers swim side-by-side, with each diver searching off to the side (perpendicular) of the swimming direction. When they reach the end of one strip, they move to the next parallel strip and continue in the opposite direction. This is repeated until the search object is found, they reach the end of a predetermined distance or the limits of their dive time or safety conditions. If an object is found (or they need to stop the search for other reasons), they should pop a numbered float to get a GPS position on.



Note: It is critical to have a surface tender monitoring the search divers at all times. How this is accomplished will depend on the type of search and the type of equipment being used.

The most efficient way of delineating a large area to determine the impact perimeter is to use a modification of the Strip Search technique, whereby the overall area is searched starting at a point known to be outside of the impact area and moving in a set direction for a defined distance, marking each time one meets a impact edge. At the end of the prescribed distance, the team moves perpendicular to the first search transect and repeats in the return direction. At any point where the divers encounter the edge of a damaged area they release a numbered pop float that is used by a surface tender to take a GPS off of (*as shown on the right*). Divers and surface tenders both log the numbers associated with the floats; divers will produce

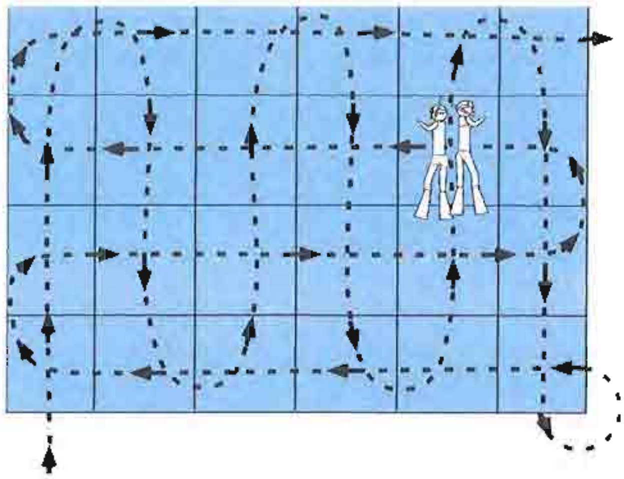


a damage area sketch with numbers for each float location, while the surface tender will associate each number with a GPS location.

Grid Searches

Grid searches can be done easily at two scales: for small items one can use the quadrat employed for the REA dives; while for large areas, one can use underwater transect reels, measuring tapes, or dive reels, along with some mechanism for securing the lines to the bottom and keeping them relatively straight.

For small items, lay the quadrat down atop the area to be searched and slowly start at one square of the quadrat (upper left for example). Carefully feel all areas within the bounded square for the object, then move horizontally to the next square and repeat. Once all the squares in the top row have been searched, repeat for the next row down, and so -on until all squares in the quadrat have been searched. At that point move the quadrat to the next search site and begin again.



Specific Gear for Search Activities

Aerial:

- Binoculars.
- Camera with Zoom.
- GPS.
- Notebook attached to leg so can write sitting down.

Surface Vessel:

- Same as above; substitute waterproof notebook.

Towboard:

- Communications.
- Pop-float or Safety Sausage.
- Attached Camera.

DPV:

- Same as above.
- Surface float with GPS.

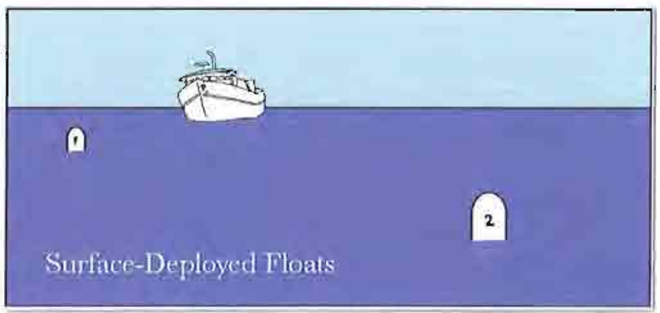
SCUBA Swim:

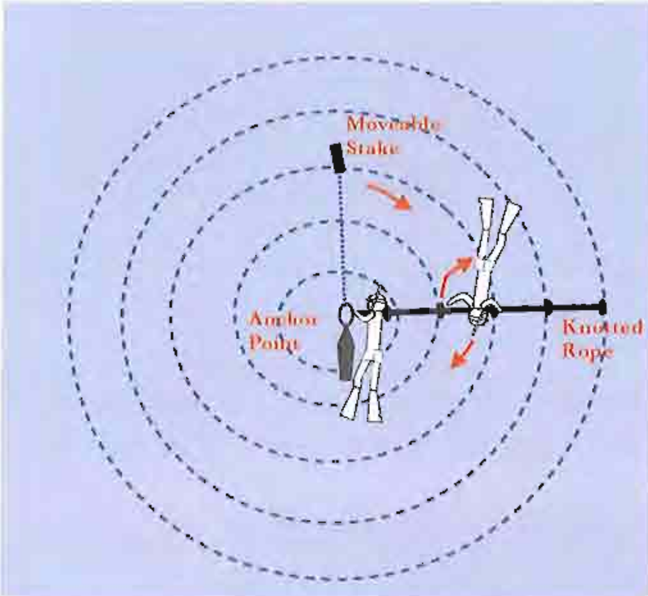
- Same as above.
- Underwater notebook.

For larger areas you will need multiple divers to lay down straight line transects along compass headings to form a large grid temporarily affixed to the bottom. The lines should cross at set intervals and create the equivalent of a large quadrat on the ocean bottom.

Circle Board

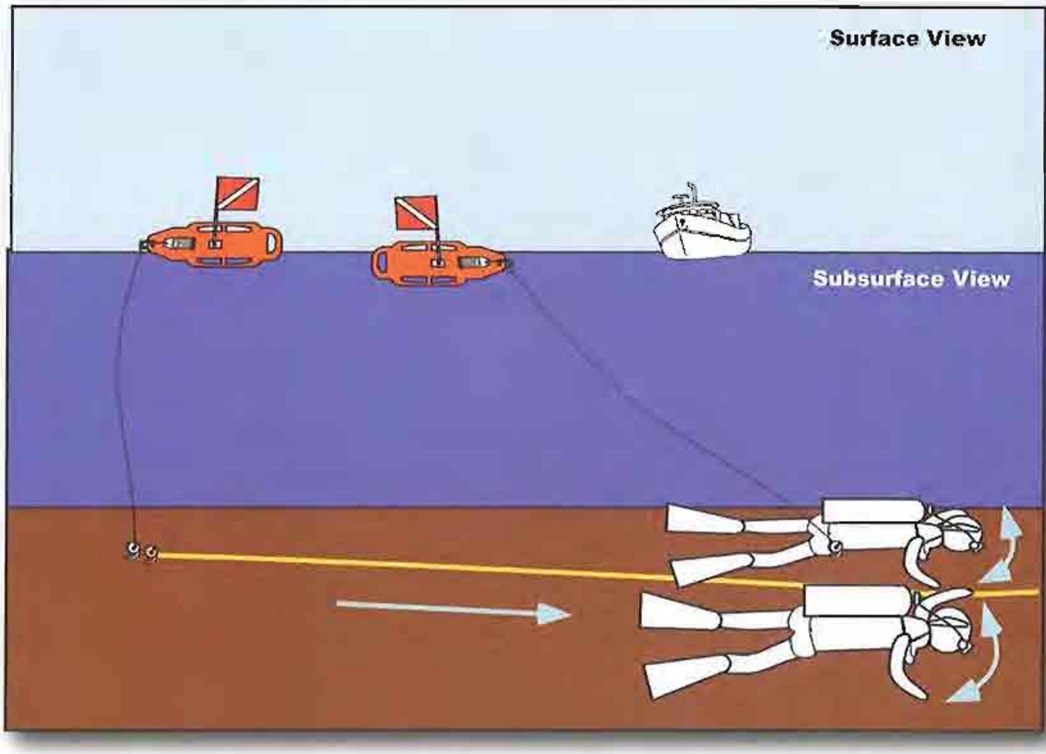
One of the easiest and most accurate ways of searching a limited area is to establish an anchor point with either a heavy object or by driving a stake or rod into the substrate. In either case, the anchor point needs to have either a swivel or eyelet on the free-end, to which is attached a knotted rope with knots placed every 1/4 or 1/2 meter. The submerged anchor point can be documented through the release of a numbered surface float that the surface support personnel will GPS. A second numbered surface float can be released at the exact site where the search object is discovered.





The search diver will begin at the knot closest to the anchor point and stick a pole into the substrate or place a heavy object onto the bottom at the stretched point of the knotted rope where the first knot is relative to the bottom substrate. The diver will then begin to swim in a clockwise direction, holding onto the first knot with his/her left hand. This will result in the diver slowly swimming in a 360 degree arc and ending up back at the pole or heavy object that was placed on the bottom. During this time the diver uses his/her right hand to continuously sweep inward towards the anchor point until he/she encounters the search object. Once a complete arc is achieved the diver slides his left hand down to the next outward knot, moves to pole or heavy object to directly beneath the stretched rope's second knot, and repeats the operation. This continues until the diver has reached the free end of the rope or the object is found.

A Few Final Words About Searches:



Because searches are one of the few investigative activities that often require divers to move over broad areas, they pose the greatest risk of separating the dive team from the surface support. Streams of bubbles and surface snorkelers can work to identify submerged divers locations in relatively calm, clear conditions, but often this is not the case. One suggestion is to use two surface support floats; the first is anchored to the start point of the search, the second moves with divers. This method has the advantage of providing a surface float for attachment of a GPS (or other gear) to document the search locations and tracks, and providing a support for the divers to conduct their safety stop or await pick-up if conditions (current, etc.) worsen.

Line Tender/Diver Hand Tug Signals

In situations of low visibility where a surface tender is controlling the movements of diver using a rope tether, the following hand tug signals between diver and line tender may be useful (once again, noting the need for specialized training in this type of diving).

Line Tender to Diver:

- 1 Tug: "Are you ok?"
- 2 Tugs: "Stop. Change direction. Take out line."
- 3 Tugs: "Come to surface."
- 4 Tugs: "Stop. Danger."

Diver to Line Tender:

- 1 Tug: "OK."
- 2 Tugs: "Need more line."
- 3 Tugs: "Have located object."
- 4 Tugs: "Need help."

Diver to Diver (requires hand to arm contact):

- 1 Tug: "OK."
- 2 Tugs: "Pattern completed."
- 3 Tugs: "Object found."
- 4 Tugs: "Help" or "Need Assistance".

Modified after: Professional Association of Diving Instructors, Underwater Investigator, Handout No. 12

Dave Gulko

Another critical aspect is the need to constantly practice coordinated search techniques both on land (*above*) and under controlled conditions underwater(*below*). Practice sessions should include direct monitoring of activities (note divemasters directly monitoring searching divers) and simulated difficulties such as low visibility (note taped masks) and underwater obstacles (having to cut through simulated seaweed to reach a search object).

Dave Gulko

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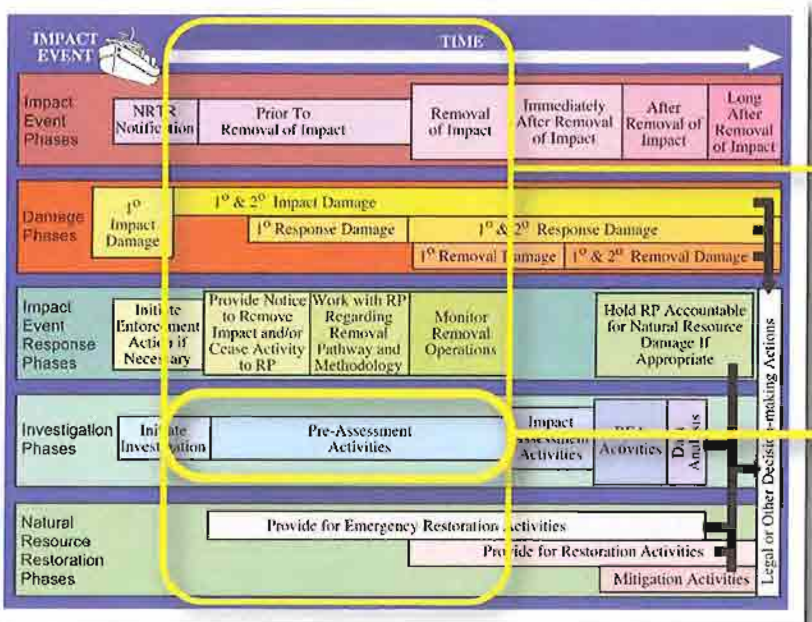

This Module overlaps with these stages during an impact event and the investigation.

This Module represents this point in the time-

Collection of Evidence Underwater

The marine environment, given its unique human physiological constraints, oceanographic processes and ecological interactions, poses unique challenges for an investigator seeking to collect evidence at an injury scene.

In general the concerns regarding collection of evidence underwater is similar to those concerns expressed regarding proper sampling techniques:

1. Follows a standardized collection/sampling protocol.
2. Fully document presence at site, collection, and transport/handling.
3. Processing of material follows proper and documented laboratory methods.
4. Proper interpretation of data/results.
5. Lack of "conflict-of-interest" on the part of the people collecting/transporting/analyzing evidence or samples.

One of the most critical features to the collection of evidence, samples, and possibly data, is following a standardized "chain-of-custody" procedure.

UNDERWATER EVIDENCE 101

If we think of a coral reef injury site as a crime scene, then there will be physical and other materials at the site that can assist in either identifying a potential RP or firmly connecting a potential RP to the injury itself. As such, the types of evidence that one might consider collecting underwater can be broken down into the following categories (depending upon the type and cause of injury):

- **Spilled Oil** (hydrocarbons)
- **Chemical Waste** (industrial)
- **Sewage** (enteric bacteria)

Dave Gulko

- **Fertilizers** (organophosphates)
- **Heavy Metals** (depleted uranium, etc)
- **Impact Fragments** (paint chips, hull scrapes, anchor pieces, etc)
- **'Stunning' Poisons** (cyanide, bleach, etc)
- **Affected Wildlife** (corals, algae, invertebrates, fish, sea turtles, sea birds, etc.)

In general, the specific materials that one collects underwater as evidence usually encompasses the following (once again, depending upon the type and cause of injury):

- **Water** (dissolved Oxygen, bacteria, chemicals, etc)
- **Silt** (chemicals, fertilizers, heavy metals, etc)
- **Freshly Broken Coral**
- **Dead Marine Organisms** (toxicology)
- **Oil Clumps and Samples** (hydrocarbon signatures)
- **Impact Fragments** (paint chips, hull scrapes, anchor pieces, etc)
- **Lost Tools** (dive tools, masks, etc)

Class & Individual Characteristics

Once evidence is collected, it usually needs to be analyzed at various levels through a process that maintains chain-of-custody at all times. At the broadest level each evidence item can be analyzed relative to its base characteristics:

- **Class Characteristics:** physical qualities **shared** by a group of like items. Examples of class characteristics include the chemical structure of a cyanide molecule, the tread patterns on a brand of new athletic shoes, the species source of a blood sample, the make and model of a firearm, etc.


USGS

- **Individual Characteristics:** physical qualities **unique** to an individual evidence item. This would be something that no other item in its class shares with it. Examples of individual characteristics include a fingerprint pattern, a pattern of cuts and wear marks on the tread patterns on a used pair of athletic shoes, the DNA code for a blood sample, the striation marks on a fired bullet, the pattern of ejector, extractor, breech and firing-pin marks on a fired cartridge.


USFWS


What's the marine resource equivalent of fingerprints relative to an injury or impact investigation?
USFWS

Key Terms

- *Class Characteristics*
- *Individual Characteristics*
- *Chain-of-Custody*
- *Splitting*
- *Unknown Sample*
- *Suspected Source*
- *Control*
- *Match*
- *Nonmatch*