Using Reef Check For Long-term Coral Reef Monitoring in Hawaii

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Abstract

A major goal of a government coral reef monitoring program is to provide the data required for management. But management programs will fail without community support. Involving the community in monitoring builds public support for management initiatives. The Reef Check coral reef survey program is carried out by volunteers from the community, particularly recreational divers. It was initially designed as a one-time assessment of coral reef health on a global scale. During 1997 and 1998, the Hawaiian environmental group, "Save Our Seas" coordinated Reef Check training and surveys at seven sites on Maui, Kauai, and the Big Island, providing the first standardized coral reef survey results from these three islands and demonstrating that the local community is interested in helping to monitor coral reefs. Internationally, Reef Check also grew quickly and spread to 40 countries. A formal link was established between Reef Check and the Global Coral Reef Monitoring Network (GCRMN) to serve its community-based monitoring needs. This led to a demand to broaden Reef Check objectives to include long-term monitoring. In the future, it is expected that most countries with coral reefs will belong to the GCRMN/Reef Check network and will have long-term monitoring programs including at least two levels: a community-based level using localized versions of Reef Check, and a higher resolution level. The State of Hawaii could benefit greatly from formally incorporating Reef Check into its planned monitoring program, and should provide seed funding for environmental groups to coordinate these surveys on all islands. A number of issues must be considered when using Reef Check methods for long-term monitoring. The most important are taxonomic specificity, temporal and spatial replication.

Introduction

The scope of the Reef Check program has changed as it has grown. The program was initially designed as a one-time assessment of coral reef health **on a global scale** using teams of recreational divers trained and led by a marine scientist (Hodgson, in press). The original concept was for teams to be deployed at the same time at many sites around the world and to use a common survey method to check on the status of coral reefs. In 1997, the “window” for surveys was specified to be 2.5 months, while in 1998, the open period was expanded to 6 months. Beginning in 1999, surveys can be carried out at any time. By the end of 1998, well over 400 reefs had been surveyed in 40 countries and territories around the world by hundreds of recreational divers, villagers, and scientists. The methods were successfully adopted by a wide variety of users including government and non-government monitoring and management programs in both developing and developed countries. Also in 1998, the Global Coral Reef Monitoring Network (GCRMN) was formally linked with Reef Check, and GCRMN chose the Reef Check methods for its community-based monitoring work. Thus the desired application of the Reef Check methods has been broadened, and some adjustments are needed to meet these new uses.

There will never be an “off-the-shelf” long-term monitoring program. Each location has specific needs and resources that will require a custom design. The need for governments to carry out long-term monitoring of coral reefs has been slow to be realized, even in developed countries. However, as more individual projects and governments have decided to set up coral reef monitoring programs, a “preferred design framework” has emerged (Hodgson, this proceeding). In locations such as Western Australia and the Florida Keys, where coral reef monitoring programs are well developed, it is becoming clear that the ideal model will involve at least two levels of monitoring: a community-based, relatively broad-brush monitoring program carried out by teams of scientists and community members e.g. Reef Check, and a high resolution program carried out by pure scientific teams. In the above two locations, and many others, Reef Check has become part of a well-thought-out, well-developed, multilevel monitoring program that is useful at local, regional and global scales. The program has worked well with divers from local communities and with the international community of tourist divers.

In a multilevel monitoring program Reef Check has several roles. First, it is a relatively fast method, that allows a team to gather a snapshot of the health of reef corals, other invertebrates and fish at up to two sites per day. As more sites are surveyed in a particular area, the resolution of the snapshot is increased. Because Reef Check is based on major inputs from volunteers, with modest government and NGO support, Reef Check teams can be mobilized to survey many more sites than is possible with more intensive methods which are much more costly in time, staff and funding. Thus, the “ideal” two-level monitoring program would have a few high resolution sites using methods such as English et al., and a larger number of lower resolution Reef Check sites (Fig. 1). In addition, the Reef Check sites can be resurveyed more frequently than the high resolution sites. Typically, high resolution scientific surveys are carried out once, or at most, twice per year. If Reef Check surveys are repeated at quarterly intervals, they can then act as an early warning system for major anthropogenic changes such as bleaching, blast or poison fishing, overfishing, eutrophication and sedimentation.

The second role of Reef Check is to build up community support for a coral reef monitoring and management program in each area. Without such support, even wellfunded government-led management efforts will fail. By participating in Reef Check training, fund raising, and surveys, community members develop a sense of stewardship towards the reefs they are monitoring. What is particularly important about this ideological transformation is that it may involve businessmen, politicians, artists etc. These are people who may not originally have had a particularly strong interest in conservation, and who can then spread their educational experience throughout society. There also are large rewards for scientists who volunteer to help train the survey teams. By taking the time to explain to members of the public why coral reefs are important, scientists are able to show why coral reef science and ecology in general, are important pursuits. While many scientists are already involved in some form of community education, others are not. This type of interaction generates public support for coral reef science and for scientists who carry out basic research.

Reef Check Methods Used in Hawaii

A full description of the Reef Check methods is given at the website: http://www.ust.hk/~webrc/ReefCheck/reef.html. A summary is given below.

Site selection

Site selection is important to determine the geographic distribution of human impacts on reefs. For this reason, Reef Check teams that can only survey one site are asked to survey the "best" site they have access to in terms of least likely to have been affected by human impacts, fishing, pollution etc. with high living hard coral cover and dense fish and mobile invertebrate populations. For groups willing and able to survey multiple sites, then they should choose two or more additional sites representative of moderate and heavy human impacts. By describing these sites in the Site Description sheet, later during the analysis, it is possible to compare like with like. To standardise comparisons, surveys of reefs predominantly located in caves or underhangs are not accepted. Reef sites should be moderately to fully exposed reefs with a reef crest and outer slope. The transects can then be placed seaward of the reef crest on the outer slope.

Basic design

The goal is to survey two depth contours, 3 m and 10 m below chart datum (lowest low water). However, on many reefs, the highest coral cover will not be found at these exact depths. Therefore, choose the depth contour with the highest coral cover within the following ranges: Shallow (2 - 6 m depth), Mid-reef (>6 - 12 m depth). Note that particularly for the shallow transect, the tide should be taken into account. Along each contour, four 20 m long line transects will be deployed and surveyed. The transects should follow the designated depth contour one after the other, however, transect start and end points should be separated by a 5 m space. The distance between the start of the first transect and end of the last transect will be 20 + 5 + 20 + 5 + 20 + 5 + 20 = 95 m. The depth contours were chosen for practical reasons of time and safety. Reefs in many areas are not suitable for survey at both depths. In this case, just survey one depth contour. A single 100 m fiberglass measuring tape available from hardware and survey equipment supply stores is recommended. In locations where reefs are broken into patches with large areas of sand/rock in between, it may be necessary to separate the transect into 20 m segments.

There are four types of data that will be recorded. The three transect surveys will be made along the same transect line.

1) Site Description: Anecdotal, observational, historical, locational and other data should be recorded on the Site Description sheet.
2) Fish Belt Transect: Four 5 m wide (centered on the transect line) by 20 m long transects will be sampled for fish typically targeted by spearfishermen, aquarium collectors, dynamite and cyanide fishermen. The fish transect should be carried out first.
3) Invertebrate Belt Transect: Same four 5 m wide (centered on the transect line) by 20 m long transects as above will be sampled for invertebrate species typically targeted as food species or collected as curios.
4) Line Transect for Substrate: Same four 20 m long line transects, but this time, point sampled at 0.5 m intervals to determine the substrate types on the reef.

The Hawaiian Reef Check fish indicators are: Butterfly fish, Taape Blueline snapper, Roi (Peacock grouper), Ulua (Jacks), Wekeá (Yellow goatfish), Uhu (Parrotfish) >20cm, Lau'ipala (Yellow tang), Puhi (Moray eel), Umaumalei *Naso literatus*. The invertebrates are: Banded coral shrimp (*Stenopus hispidus*), Black urchin (*Echinothrix diadema*), Pencil urchin (*Heterocentrotus mammilatus*), Sea cucumber (edible only), Crown-of-thorns seastar (*Acanthaster*), Triton shell (*Charonia tritonis*), Lobster, Cowry shells, Collector urchin *Tripneustes*. In addition, the percentage of the reef covered by the following living and non-living substrate types is recorded along a line transect: Hard coral, Soft coral, Dead coral, Fleshy seaweed, Sponge, Rock, Rubble, Sand, Silt/clay, Other.

Pre-dive Preparation

The training needed for each team will depend on their experience and knowledge level. A half-day training on land prior to the dive day is recommended, so that the training can be absorbed and there is sufficient time for questions and discussion. This can be supplemented with a brief review on the dive day. The Team Leader/Team Scientist (TL/TS) are responsible for making a presentation that includes:

1) An explanation of the goals of Reef Check;
2) A review of the sampling design and rationale of the indicator organisms;
3) Field identification training for all organisms and Reef Check definitions for substrata;
4) An introduction to the data recording format, and preparation of slates;
5) An explanation of the difference between work diving and pleasure diving and how to avoid smashing reef corals by proper buoyancy control;
6) Explanation of the post-dive data entry, checking and submission procedures.

There are three field data sheets (pro-forma) for the core protocols, the Site Description, Line Transect and Belt Transect sheets. The Belt Transect sheets are divided into a section for invertebrates and a section for fish.Teams may use either underwater paper or a plastic writing slate. Photos of the indicators can be downloaded from the Reef Check website and printed in color and either laminated or placed inside a plastic "zip-lock" bag and then carried underwater for reference.

One buddy pair should lay out a 100 m transect line along the specified contour (2-6 or >6-12 m). Estimated time to deploy the transect is 30 minutes. After deployment, the entire length of the transect should be examined to ensure it is not snagged or floating too high off the bottom. Small marker floats should be attached to the start and end points and (optional) permanent stakes can be installed so that the site can be located next time. A GPS (Global Positioning System) reading should be obtained from one end, and the compass bearing to the end marker buoy recorded (only those teams with precision navigation systems such as differential GPS need record the coordinates of both ends). Visual line-ups with landmarks should also be recorded in case the GPS has given false readings. Teams without a GPS should obtain the most detailed chart of the area available and record the coordinates of
the location of the transect.

Fish Belt Transect Instructions

The fish belt transect should be the first work done after the transect line is deployed. Try to begin the fish transect at about 10:00 AM. Work can be started after a 15 minute period during which no divers disturb the area. Estimated time to completion is 1 hour. The maximum height above the transect to record fish is restricted to 5 m. Data should be recorded on a slate following the Belt Transect Sheet format.

The diver(s) assigned to count fish will swim slowly along the transect and then will stop to count target fish every 5 m, and then wait 3 minutes for target fish to come out of hiding, before proceeding to the next stop point. This is a combination timed and area restriction survey, four sections x 20 m long x 5 m wide = 400 m². At each depth contour, there are sixteen "stop-and-count" points, and the goal is to complete the entire 400 m² belt transect in 1 hour.

Target fish: The target fish have been selected as some of the top fish typically removed from reefs by spear or line fishing or other methods. Given the magnifying effect of water, divers should practice estimating sizes using the transect line or measured sticks (hand-held or floating tethered to a small weight) before attempting the fish surveys. A note should be made of any sightings of rare animals such as large manta rays, sharks and turtles, and if these are off-transect records, they should be written at the bottom of the slate under “Comments".

In poor visibility, or when there are large numbers of fish, we suggest that each diver survey half the 5m wide belt. One diver can cover one side of the transect line and record fish in a 2.5 m wide strip with the buddy recording the other side (together the 5m wide belt will be surveyed). A measured 2.5 m colored wire or rod can be used to help estimate the 5 m belt transect width.

During the fish transect work, the other team members should be gathering descriptive site data and one should be responsible for filling out the Site Description form. Only one form is filled out per site.

Invertebrate Belt Transect Instructions

When the fish belt transect is complete, Divers 3 and 4 can carry out the belt transect survey for invertebrates. The same transect line is used and, like the fish belt, the invertebrate belt transect is 5m wide with 2.5 m on either side of the transect line. It is best to split the work again, with each diver recording data along one 2.5 m wide strip. Estimated time to complete this work is 1 hour. Total survey area will be 20 m x 5 m = 100 m^2 for each transect, for a grand total of 400 m^2 for each depth contour. In addition to recording indicator organisms, each group should note the presence of coral bleaching or unusual conditions (eg. that might be diseases) along the transects. Team members should be encouraged to look in holes and under overhangs to detect species, such as lobster, that may be hiding

Line Transect Instructions

When the invertebrate belt transect is almost completed, the next designated buddy pair can begin point sampling the line transect (the same transect used for the previous work). The estimated time to complete this work is 30 minutes.

The method chosen for Reef Check sampling of substrata is "point sampling." Point sampling was chosen because it is the least ambiguous and fastest method of survey and is easily learned by recreational divers. In use, the diver can simply look at a series of points where the transect tape touches the reef and note down what lies under those points. In cases where the tape is hanging above the substratum, it is useful to carry a 5 mm diameter nut or other heavy metal object tied onto a 2 m long cotton or nylon string for use as a plumb-line. The object is dropped at each designated point and it touches only one substrate type which can be recorded. For Reef Check, substrate type will be recorded at 0.5 m intervals along the line, i.e. at: 0.0 m, 0.5 m, 1.0 m, 1.5 m etc. up to 19.5 m (40 data points/20 m transect). This procedure will be repeated for the remaining three transects at 3 m and the remaining four at 10 m depth. The substratum categories are: hard coral, soft coral, dead coral, fleshy seaweed, sponge, rock, rubble, sand, silt/clay, other. It is important for each group to document the transect location, survey results and findings using a combination of still photos and videography both on land and in the water.

Post Dive Tasks

The team scientist is responsible for gathering the slates and data together as soon as the survey is completed and reviewing them immediately with the team members. The purpose is to make a quick assessment of the data to determine if some error has been made that can be corrected while the team is still on site, and the transect is in place. Typical errors that could be corrected would be "double-counting" of fish, mis-identification of organisms or mis-labelling the slate. When an error is suspected, a re-survey should be made to check or to correct it. Before departing from the site, the team scientist is responsible for ensuring that all required data have been collected, and that the slates have been filled out properly, in particular with each individual's work identified. As soon as possible after the dive, the data should be entered into the automated Excel Spreadsheets which have been sent to all participants, and these spreadsheets emailed to Reef Check headquarters <reefchck@ust.hk>.

How Reef Check has been implemented in Hawaii

The environmental group, “Save Our Seas” (SOS) has acted as the Hawaii coordinator for Reef Check since 1997. The first formal Reef Check surveys in the world were carried out as part of a large International Year of The Reef event organized by SOS called CLEAN OCEANS '97 during June 13-15, 1997 at the Princeville Hotel, Hanalei Bay, Kauai. The activity involved over 100 recreational divers, supported by dive companies (Hanalei Divers and Bubbles Below), the University of Hawaii Marine Option Program, Sierra Club, and Hanalei Canoe Club. Drs. Alan Friedlander and Cindy Hunter led the training and surveys, assisted by many other Hawaii-based marine scientists. Based on this success, a plan was formulated for a volunteer coral reef monitoring group in Kauai. Since then Reef Check has grown and spread to other islands.

Reef Check Hawaii was started in an attempt to help state agencies monitor reefs, gather baseline information about the reefs, and bridge the gap between the scientific community and people who are actually using the reefs. SOS advertised the concept by articles in the newspaper, posters and brochure mailings, community access television, as well as by word of mouth through local community networking. Many divemasters were also contacted, and in turn donated tanks and other support for the volunteer operations. As the program has grown, training has been arranged with the help of local scientists, university professors and coral reef experts. The training consists of a three-hour classroom session given on one evening including lectures about coral reef ecology. This is followed by a slide show of the indicator organisms, discussion of the survey methods, and the use of the computerized data sheets, as well as a dry land simulation of Reef Check monitoring. Local marine biologists, science teachers and other experts are invited as guest speakers to discuss the significance of the area to be monitored.

A survey is normally scheduled on a Saturday or Sunday following the training, and additional on site and in water training are provided at that time as needed. The dive buddy teams are made up of one person who has done Reef Check and a new trainee. In this way the new people gain experience. One of the objectives of the program is to get as many people involved as possible, while collecting good data. For this reason, SOS also invites interested people to snorkel and observe the coral reef monitoring procedure. Some of these people become data collectors at a later date, while others just learn about coral reefs and monitoring.

So far, survey sites have been chosen because of their importance to the community, or because some environmental problems were noted. Altogether, seven sites (Fig. 2) have been surveyed on Kauai, Maui and the Big Island (Big Island work was coordinated by S. Peck of Sea Grant Extension Service). In the future, the State of Hawaii can provide a priority list of its sites that can be added to the target list. This highlights the importance of collaboration between Reef Check and a number of groups and government agencies. The project has succeeded because of the support of the State of Hawaii Department of Land and Natural Resources (Division of Aquatic Resources), University of Hawaii Marine Option Program, Sea Grant, Save Our Seas, and the local dive and community groups. More, however, can be done. In particular, seed money is needed to encourage more communities to get involved and to pay for minor training expenses. The State could reap large rewards by investing in this program, and providing financial support for a coordinator.

Despite a lack of core funding and a reliance on 100% volunteers, Reef Check has been successful in raising public awareness about coral reefs as well as collecting useful data in Hawaii. Following the surveys, Reef Check television programs have been shown on community access television on most major islands. Positive changes can be observed. For example, local high schools on Kauai have decided to participate and to adopt reefs. More volunteer monitoring groups are being established on a number of islands. Data continue to be collected, sent to Reef Check headquarters, and forwarded to the global database on reefs called "ReefBase." Local scientists and dive shops are working together with community members in reef monitoring, and support has increased for the State DLNR's reef management programs. Direct community involvement is a very important factor in this process.

So far, Reef Check has been used in Hawaii to serve the original purpose of a snapshot assessment. If some adjustments are made, the methods can easily be improved for use in long-term monitoring that would complement the planned intensive monitoring program (CRAMP).

Considerations When Using Reef Check for Long-term Monitoring

It is important for all potential Reef Check users to recognize that the core methods are meant to be flexible, and can be changed to meet local needs, within certain boundaries, and still be useful for the annual global assessment. While the methods were designed for use by volunteer recreational divers, they have been used in many parts of the world by teams of scientists. The point is that the methods can and should be adjusted to match the ability level of the team members and management needs. When major changes are made in the Reef Check methods, the team has two choices: either the team can extract the core data and submit them to Reef Check for inclusion in the global database and annual report (which is then provided to ReefBase), or the team can simply use them for their own analysis and management purposes. While one goal of Reef Check continues to be to obtain annual reports on as many reef sites as possible, the latter option is reasonable when more than one survey is made per year at a given site.

The three most important considerations for using Reef Check for long-term monitoring are taxonomic specificity, temporal and spatial replication. Team scientists are encouraged to add indicator organisms that may be of particular importance in their area. Adding taxonomic specificity, i.e. requiring species level identification of some organisms may also be useful. As more parameters and/or specificity are added to the core Reef Check methods, the designer must try to strike a balance between the need to obtain "useful" data, the ability of the volunteer team members, and the potential to bore or burn them out. If more than a few additional species level identifications are added, pre-testing should be used to ensure that the volunteers are capable of identifying all organisms accurately. The success of Reef Check depends on it remaining an enjoyable experience for volunteers.

The original Reef Check methods were designed to be carried out once per year at each site. This level of temporal replication is typically sufficient to characterize changes in reef corals and other sessile invertebrates. If there is sufficient manpower, this may be increased to twice per year to get a more frequent update. For mobile invertebrates and reef fish, however, this frequency of replication is generally considered too low for a meaningful stock assessment at one site (but when repeated at many sites, the snapshot becomes very meaningful). It is important to recognize that the sample size used in one Reef Check survey is robust with respect to the parameters measured. What allows the survey to be carried out quickly is that there are relatively few parameters measured and no temporal replicates. To use Reef Check methods for long-term monitoring of fish and mobile invertebrates, additional temporal replicates should be made of the fish and invertebrate belt transects. A pilot study could be carried out to determine the variability of fish and invertebrate populations at a given location. A suggested rule of thumb would be to carry out three replicate surveys at each site (i.e. three repeat surveys of one transect deployment), and then to resurvey each site at quarterly intervals. If the taxonomic requirements are not increased too much, this higher intensity survey could still be accomplished by recreational divers.

The core methods include four spatial replicates along the transect line. Given the low taxonomic specificity in the methods (typically family level), these replicates are sufficient to capture variability within one site, and the overall 100 m length of the sample is robust. However, it is desirable to measure variability at several sites within "the area of interest." Thus for long-term monitoring within a 1 km wide bay, a set of three to five sites might be used.

The core methods include two transects with the deepest located at a maximum allowable depth of 12 m. The Reef Check program does not accept data obtained from deeper areas for two reasons: safety considerations and the fact that reefs do not extend below this depth in many parts of the world making regional and global comparisons difficult. However, in areas where it is important to record information at greater depths, a third or forth transect could of course be surveyed and the information used locally. Although these data will not be included in the annual Reef Check report, they could be submitted directly to ReefBase (www.reefbase.org).

The Future for Reef Check in Hawaii and the Pacific

The coral reefs of Hawaii have been the subject of studies for more than 100 years (Maragos, 1977). It is well known that Hawaii's reefs have a high socioeconomic and cultural value. The marine recreation industry alone generates over $700 million annually (Grigg, 1997). Given its location and its academic strengths, the state of Hawaii should be a leader in the design and implementation of coral reef monitoring and management programs throughout the Pacific. Unfortunately, Hawaii has fallen far behind other developed locations such as Australia, Florida, Guam and even French Polynesia and in terms of planning for sustainable monitoring and management of coral reefs. Thus there is little monitoring data available for most Hawaiian reefs, particularly those on Lanai, Molokai, Niihau and Kahoolawe. This Workshop and the recent CRAMP work are a hopeful sign that Hawaii's potential will soon be realized.

If a combination of state and federal funding were provided as seed money for Hawaiian community groups to coordinate Reef Check training and surveys, the number of volunteers and the number of surveys could be increased dramatically. Reef Check works well even in impoverished villages in Indonesia where people cannot afford a scuba tank. How much better it could work in a state which boasts one of the highest densities of recreational ocean users in the world. If Hawaii follows the model for a monitoring program that has been successful around the world, it will provide for a two-tiered system involving many dozens of Reef Check sites, interspersed with a handful of high resolution sites. The data from all of these sites would be submitted to the state at regular intervals, processed and analyzed. This network of sites, and particularly those involving Reef Check, would provide an early warning system of ecosystem problems.

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Figure 1. The "ideal" monitoring system would include two or more levels: many low resolution stations (X) that can be surveyed frequently using methods such as Reef Check, and a few high resolution stations that would be surveyed less frequently. The specific locations and ratios are indicative only.

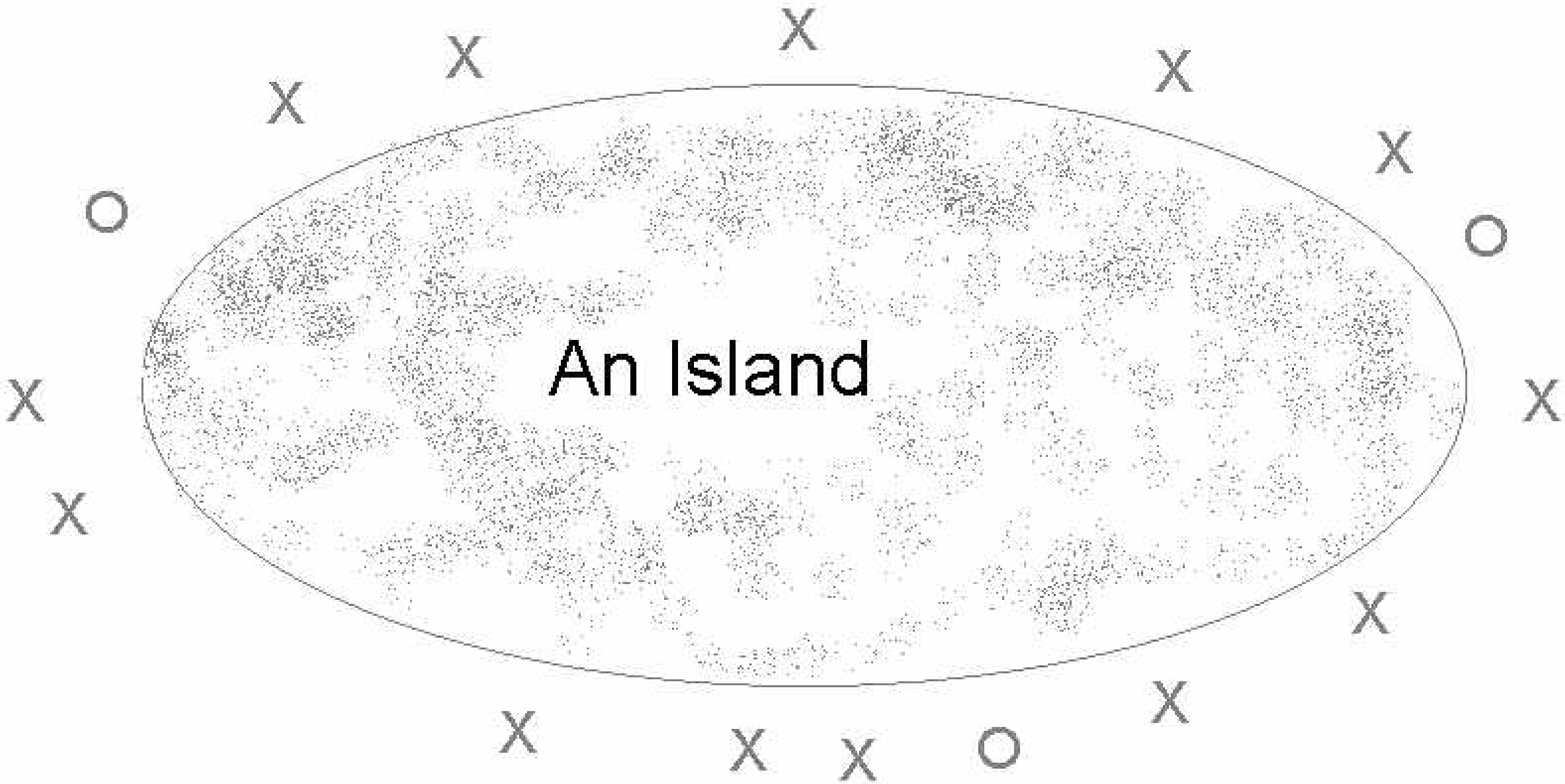

Figure 2. Reef Check survey sites in Hawaii (1977-8)