CoralWatch: education, monitoring, and sustainability through citizen science

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CoralWatch, launched in 2002, is a citizen-science program that seeks to integrate education and global reef monitoring by examining coral bleaching and uses a monitoring network to educate the public about reef biology, climate change, and environmental stewardship. The organization's development from research and monitoring to education and ecotourism has presented a number of challenges.

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Initiated in 2002 as a scientific research effort, CoralWatch is a global citizen-science program that now integrates education and global reef monitoring to examine coral bleaching. So far, CoralWatch has recruited volunteer participants ("CoralWatchers") from more than 60 countries, including Indonesia, one of many nations for which coral reefs provide vital ecosystem services.

The main tool for CoralWatch participants is a square of plastic that can be used like a color swatch card, to monitor coral bleaching and therefore coral health (Figure 1). CoralWatch participants match the chart colors to the coral color, record the codes, and enter the data on a chart ("Coral Health Chart") via the website www.coralwatch.org. Scientists developed the colors on the chart using intentionally bleached coral in temperature-controlled aquaria. Researchers used both spectrophotometric and photographic color quantification to produce a usable and accurate color series (Siebeck *et al.* 2006).

Students and recreational scuba-diving groups are the program's most frequent contributors, followed by environmental groups, tourists, and recreational sailboaters. CoralWatch also provides information designed for specific groups, including an "education package" for teachers (available in 10 languages) with lesson plans and a Virtual Reef for classroom use, and a "tourist package" that incorporates advice and suggestions. Likewise, *Coral Reefs and Climate Change: The Guide for Education and Awareness* – a CoralWatch-published book written by a school teacher, a graphic artist, an environmental educator, and a university professor – is specifically aimed at members of the public (Reid *et al.* 2009). Such diverse inputs have been a key aspect in CoralWatch's development.

Existing challenges

Achieving data validity

Data validity is a potential problem for many citizen-science programs (Foster-Smith and Evans 2003; Bell 2007), but our research indicates that volunteers are able to collect reliable data provided that the task is straightforward (Siebeck *et al.* 2006, 2010). CoralWatch data effectively discriminate bleaching events from normal color variation, and many scientists use the Coral Health Chart in their own research protocols; to date, this methodology has been applied in more than 25 published scientific papers (Fabricius *et al.* 2011). CoralWatch data gathered "on the ground" can also be used to validate remote-sensing techniques (Leiper *et al.* 2009).

Developing a simple and flexible data collection protocol

Many reef-monitoring programs use formal methods of data collection, requiring intensive training. In contrast, CoralWatch does not stipulate a specific method, although we are always happy to provide further guidance. We developed a flexible approach to accommodate the aims of different user groups, such as ecotourists, community groups, and research scientists. The Coral Health Chart (Figure 1) is used to achieve multiple objectives: to educate, to initiate and sustain participant engagement, and to acquire coral-bleaching data.

Initial investigations also indicated that adopting a flexible approach can increase participation rates, given that users vary in the amount of data they are willing to collect and in the frequency of participation. Some users have experience with formal survey methods, such as transects or quadrats, whereas others are more comfortable with simpler random survey techniques. Some volunteers take part on a one-off basis during vacations, whereas others provide regular data, monitoring change in their local area over several years. The Coral Health Chart can be used while diving, snorkeling, or reef walking (ie walking *around* corals), and at various depths.

New challenges

Engaging tourist communities

Many vacationers are aware of reef degradation and destruction, so "climate-change fatigue" may discour-

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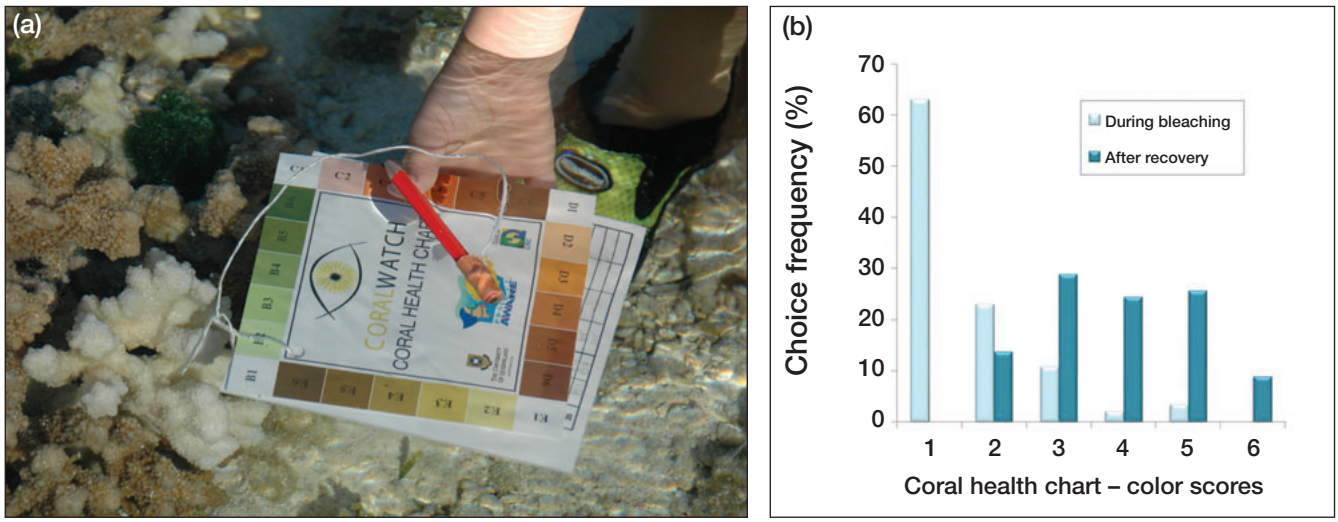

Figure 1. *(a) The Coral Health Chart enables CoralWatch volunteers to quantify coral bleaching by matching a pre-calibrated set of colors to observed coral color. (b) Sample data from a temperature-associated bleaching event on Heron Island, off the northeast coast of Australia, in 2002 and after recovery 6 weeks later. Data of this sort are plotted in real time as users enter their findings and can be compared with other data on the CoralWatch website.*

age participation in reef-monitoring efforts. However, by providing a sense of community and opportunities to participate in and learn about cutting-edge science, CoralWatch helps to facilitate and maintain engagement with its members, including tourists. Guests who return to reef resorts specifically to see how the surveys are going are a positive incentive for resort managers to organize specific events where marine biologists and reef tourists mingle and exchange ideas. Information updates, newsletters, website announcements, and interactions with resort staff, especially the activities managers, and being "on call" for guest questions also help to foster participation among tourists.

Promoting education

Clearly, "saving the reef" will require the involvement of all generations if the necessary reductions in atmospheric CO_2 emissions are to be achieved. Younger children are asking increasingly challenging questions about the future of reefs and the environment. Effective education about Earth stewardship, and predictions for an optimistic future if society's members work together as a team, will be key components in educating this age group, and CoralWatch is therefore currently engaged in simplifying its message through print and electronic media for primary schools.

Optimizing data return and accessibility

Improving data return optimizes scientific outcomes and provides more accurate information about participation. Although CoralWatch has distributed more than 20 000 Coral Health Charts worldwide since its inception, it is difficult to quantify how many charts have been used for field data collection and what proportion of collected data has been returned (Figure 2).

After the initial enthusiasm of volunteers to "get onto the reef" and collect data, there is not always the same impetus, time, or available technology to enter data online or return datasheets to our office. However, online support and communication with participants improves data return. The CoralWatch website now provides immediate graphic data summaries, enabling participants to compare their data to that of other users instantly. This "immediate gratification" is a vital component in motivating participants.

Although facilitating data return, emerging technologies (eg waterproof recording devices that automatically transmit data) will likely be limited to more affluent travelers or organizations, so paper and pencil will continue

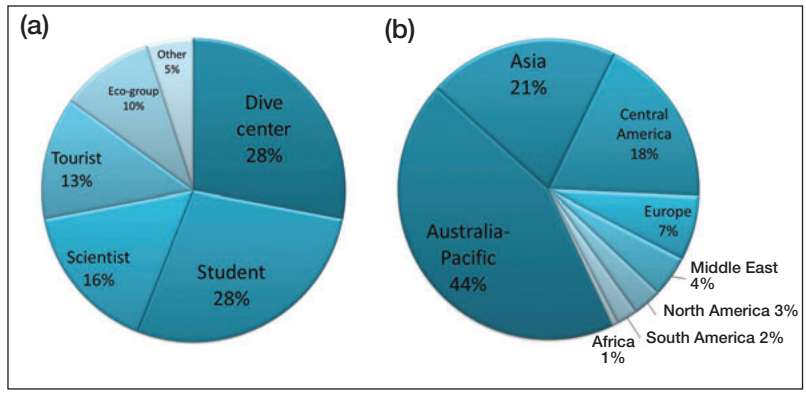

Figure 2. *(a) Of the 1174 CoralWatch user groups analyzed up to mid-2011, students and divers were the largest contributors. (b) The mid-2011 demographic analysis of CoralWatch use by country reflects the system's Australian origins and the distribution of reef systems worldwide.*

to be used in areas with limited resources. While developing e-book capability, CoralWatch will also maintain support for simpler, low-tech data gathering and analysis methods.

The future

Effective communication with participants through various media is key to continued engagement and motivation. CoralWatch has increased the frequency of newsletters, cultivated its social media presence, and explored new technologies. Our monitoring materials and data are available in many languages and we continue to develop new materials for specified target groups. Many CoralWatchers now organize their own workshops and dive activities all over the world. The main challenge for the future is to extend engagement through education and link this with improved outcomes for communities whose livelihoods depend on the presence of healthy coral reefs.

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