Reefs = Barrels
The Quiksilver Crossing Reef Check Expedition

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ABSTRACT

The Quiksilver Crossing is a global expedition embarking on its sixth year to travel the world's remote oceans in search of new surf breaks while simultaneously supporting coral reef conservation. The Quiksilver Corporation sponsors a berth for scientists so that they can survey coral reefs using the Reef Check rapid assessment method. Survey results show that Crossing sites are more remote than non-Crossing sites monitored by Reef Check. There were no obvious patterns in the abundance of five key indicators (lobster, grouper, butterfly fish, Haemulids, and hard coral) at Crossing and non-Crossing sites. These results suggest that anthropogenic impacts, particularly long-distance fishing, are affecting remote reefs in a similar manner to reefs near towns and cities. The Quiksilver Crossing is an example of successful involvement of the private sector in marine science and conservation.

INTRODUCTION

In 1997, Reef Check carried out the first global survey of coral reefs using a standardized, comparable scientific protocol. The results demonstrated that coral reefs in over 30 countries around the world were in decline due to the effects of human activities including over fishing, pollution, global warming and sedimentation, and that the coral reef crisis was global in extent (HODGSON, 1999). One limitation of the sampling design was that the survey teams tended to survey coral reefs in relatively close proximity to dive resorts or marine laboratories. A question that remained unanswered was whether more remote coral reefs had escaped these anthropogenic impacts.

In 1999, The Crossing expedition was launched by the Quiksilver Corporation to discover never-before surfed waves, perform Reef Checks, and share information with other cultures. As part of the marine conservation component, Quiksilver sponsored one berth on the Crossing vessel, the "Indies Trader," for a Reef Check scientist to carry out coral reef surveys on a continuous basis. After initial success in the Indo-Pacific, the original Crossing expedition was extended to five years. So far, the Indies Trader has covered over 177,000 miles and continues to traverse the globe in search of new waves (Figure 1). The Indies Trader has provided an excellent floating platform for assessing the status of coral reefs using the Reef Check rapid survey protocol and has helped to promote awareness of the coral reef crisis (HODGSON and LIEBLER, 2002) and marine conservation among the surfing community.

Most of the best, most hollow waves in the world break over shallow, living coral reefs. The extreme power of breaking waves constantly erodes and alters the bottom topography. Many surf breaks that border continental land masses rely on sediments transported by rivers and ocean currents to maintain the surf break. In contrast, coral reef breaks rely on the continual growth of corals to maintain the bottom topography required for perfect surf. Noting the link between healthy coral reef communities and perfect surf, Quiksilver has embarked on a mission to help increase the state of knowledge of the health of coral reefs on a global scale in an effort to actively assist in conservation of these valuable ecosystems.

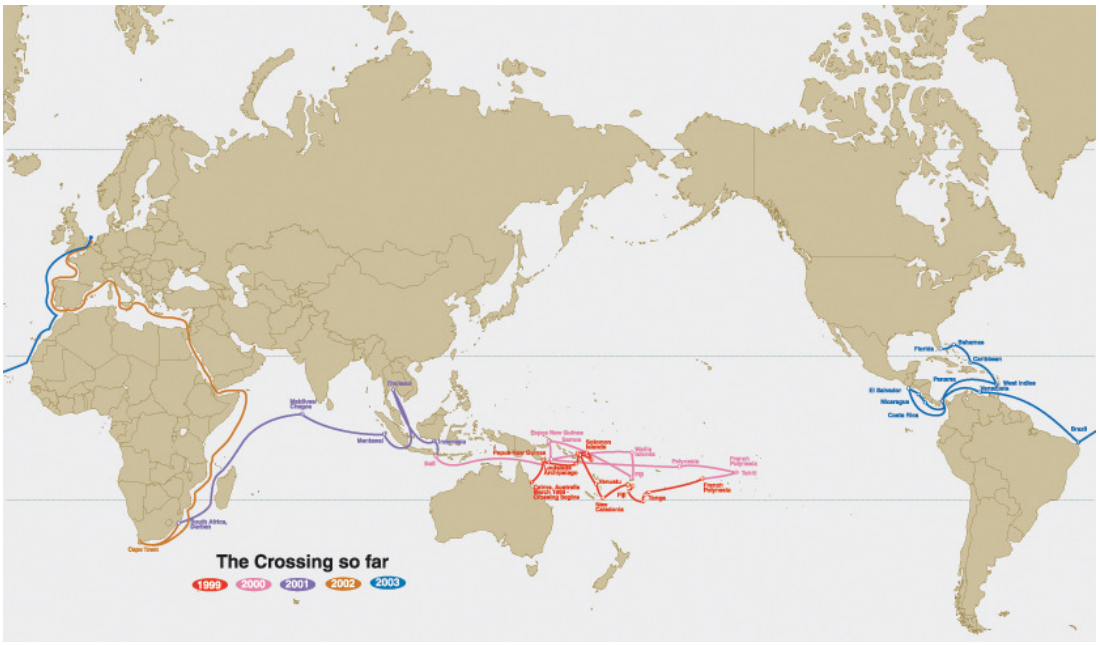

Figure 1. Route of the Indies Trader on the Crossing

METHODS

The research carried out as part of the Crossing is opportunistic and the location and timing of reef surveys are therefore dependent entirely on the schedule of the Indies Trader with respect to finding surf. At a macro-scale, the Crossing targets ocean areas typically exposed to long-period waves, thus there is a bias towards reefs located near high-wave environments. At the local scale, the reefs selected for survey were typically within 1 km of a reef regularly exposed to high surf, but were relatively sheltered to permit surveys to be completed in a safe and efficient manner.

The Reef Check survey methods are described in detail in HODGSON *et al.* (2004). In summary, the survey has four basic parts: a site description including some 30 parameters about geography, perceived impacts and socioeconomics of the nearest town, a belt transect survey for selected fish and then repeated for invertebrate indicators, and a line transect survey for substrata. All transects are comprised of four 20 m long replicates with 5 m gaps in between. The belt transect is 5 m wide (and 5 m high for fish) and the line transect is point sampled at 0.5 m intervals. The belt transect is surveyed with respect to a set of selected fish and then again for invertebrate indicators. Each indicator was chosen to demonstrate at least one human impact such as spear fishing or elevated nutrients. The results are recorded on underwater slates and transferred to standard spreadsheets and transmitted by email to the data administrator for QA and input.

For this study, only the results of five key reef health indicators were considered (spiny lobster, grouper, butterfly fish, fish of the family Haemulidae, and hard coral). All five are globally distributed on coral reefs and there is an international food market for the highly sought-after spiny lobster and grouper. The haemulids include food fish such as sweetlips, margates and grunts which are a prime target for spearfishers. Butterfly fish are closely tied to coral reefs due to their feeding habits and about 30 species are collected for the marine aquarium trade (SHUMAN *et al.* in press). Hard corals represent the basic building blocks of coral reef communities and have been shown to be susceptible to temperature increases, possibly caused by global warming (HODGSON and LIEBELER, 2002), destructive fishing practices (PET-SOEDE *et al*., 1999; McMANUS *et al*., 1997), direct and indirect impacts from the aquarium trade (SHUMAN *et al*., in press; SHUMAN 2003), sedimentation resulting from poor land use management practices (HODGSON, 1997), and indirect impacts induced by anthropogenic fishing activities that disrupt the delicate ecological balance of the coral reef community (HUGHES, 1994).

A Distance/Population Index (DPI) was calculated as a way of integrating two parameters recorded for each Reef Check survey, "Distance to Population Center" and "Size of Population." The DPI was calculated by creating size and distance classes (HODGSON, 1999) wherein Population 0 – 10,000 = 0; 10,000 to 50,000 = 1; 50,000 – 100,000 = 3. Distance >50 km = 0; 25 - 49 km = 1; 10 – 24 km = 2; 0 - 9 km = 3. The DPI was then calculated as the sum of the distance to population center and population scores and has a maximum value of six when population is high and distance to the nearest town is small. The DPI was compared between Crossing and non-Crossing sites in the Indian, Pacific and Atlantic oceans using a t-test (SOKAL and ROHLF, 1995).

Given the relatively low numbers of indicator organisms, the results from the four replicates per transect were summed to produce a single estimate of indicator organism abundance or substrate percent cover for each transect. Five important indicators (lobster, butterflyfish, grouper, Haemulids and hard coral cover) were selected for comparison between Crossing and regular Reef Check survey sites to test the hypothesis that the more remote Crossing sites generally support more "healthy" reef communities that are less impacted by human activities than regular Reef Check survey sites. All surveys were separated into ocean region (Indian, Pacific, and Atlantic) to control for spatial difference between differing geographic regions. Non-Crossing Reef Check surveys were selected to correspond to the year that Crossing Surveys were performed in each of the ocean regions (Indian 2001, Atlantic 2003-2004, Pacific 1999). Crossing surveys in the Pacific were only conducted in 2 countries, Fiji and French Polynesia. Therefore, only Reef Check surveys from these two countries were used in analyses and were performed in 2000 and 2001 because no Non-Crossing surveys were performed in this region of the world in 1999. The mean of the selected indicators was then compared between Crossing and Reef Check surveys in each ocean region using the Mann-Whitney Rank Sum Test (SOKAL and ROHLF, 1995). This non-parametric analytical test was used because assumptions for traditional parametric statistical tests were not met.

RESULTS

Between 1999 and 2004, 70 sites were surveyed in 17 counties or territories in the Pacific, Indian and Atlantic Oceans by 11 Reef Check scientists on board the Indies Trader including the first author. Following quality assurance, 53 surveys were selected for analysis (Table 1). The majority of Crossing surveys that were rejected did not contain sufficient information to

calculate the DPI. The number of Reef Check surveys included in the analyses were more numerous than Crossing surveys in each ocean region and are shown in Table 1.

Table 1. Number of Crossing and Non-Crossing surveys included in analyses.

	Pacific (1999*)	Indian (2001*)	Atlantic (2003-2004)
Crossing Surveys	8	21	24
Non-Crossing Surveys	19	71	135

*One Crossing Indian Ocean survey was conducted in early 2002. Reef Check surveys in the Pacific Ocean were performed in 2000 and 2001 as only Crossing surveys were performed in Fiji and French Polynesia in 1999.

The mean DPI was higher at Non-Crossing than Crossing sites in all three oceans (Figure 2) with this difference being significant in the Atlantic and Indian oceans (t-test, $p < 0.01$). These results support our hypothesis that Crossing reefs are more generally more remote from human population centers than Non-Crossing reefs.

Figure 2

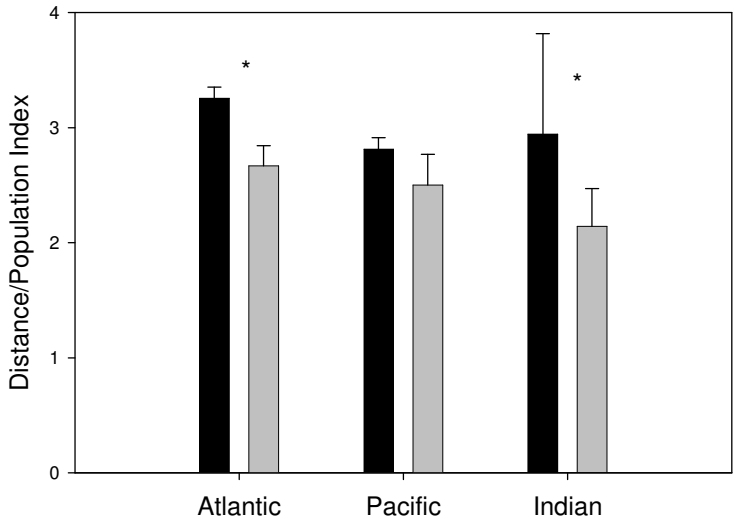

Figure 2. Mean Distance/Population Index (+ SE) calculated for Crossing and Non-Crossing surveys performed in the Atlantic, Pacific and Indian Oceans. Statistically significant differences as calculated by a t-test are denoted by *.

The abundance of two of the five key coral reef indicators (lobster and grouper) are quite low, with less than one lobster and four grouper recorded on an average survey of 400 m^2 of reef area. As shown previously, butterfly fish are more abundant in the Pacific while Haemulids are more common in the Atlantic – a natural biogeographic difference (HODGSON and LIEBELER, 2002). Hard coral cover is higher in the Pacific than the Atlantic.

Figure 3

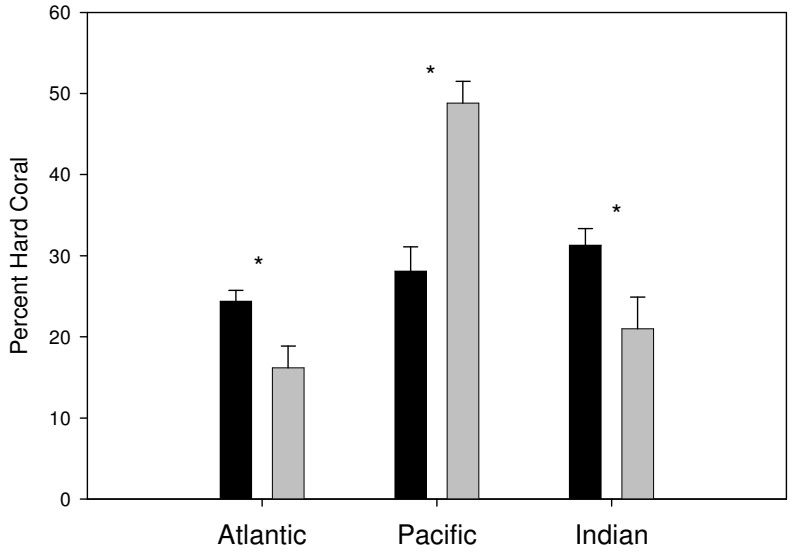

Figure 3. Mean percent hard coral (+ SE) calculated for Crossing and Non-Crossing surveys in the Atlantic, Pacific and Indian Oceans. Statistically significant differences as calculated by the Mann-Whitney Rank Sum test are denoted by *.

The percent hard coral at Crossing and Non-Crossing sites in the three ocean regions is shown in Figure 3. The percent of hard coral was significantly higher at Non-Crossing than Crossing sites in the Indian and Atlantic oceans (Mann-Whitney Rank Sum Test, $p<0.01$) with the opposite trend observed in the Pacific (Mann-Whitney Rank Sum Test, $p<0.01$). The density of grouper was higher at Crossing sites in the Atlantic and Pacific oceans (Figure 4). This difference, however, was only significant in the Atlantic (Mann-Whitney, $p<0.01$). The density of butterflyfish was higher at Non-Crossing reefs than on Crossing reefs in all three oceans (Figure 5) with this difference significant in the Atlantic (Mann-Whitney, $p<0.01$). Lobster were observed in very low densities in both Crossing and Non-Crossing reefs with this organism being almost non-existent on reefs in the Pacific (Figure 6). Non-Crossing reefs in the Atlantic had the highest observed density of lobsters, however, it was not significantly higher than the density of lobster on Crossing reefs in the Atlantic. Similar to lobster, the density of Haemulids was highest on Non-Crossing reefs in the Atlantic (Figure 7) but not significantly different than the density of Haemulids on Crossing reefs in the same region. The density of Haemulids was similar on Crossing and Non-Crossing reefs in the Pacific and Indian Oceans.

Figure 4

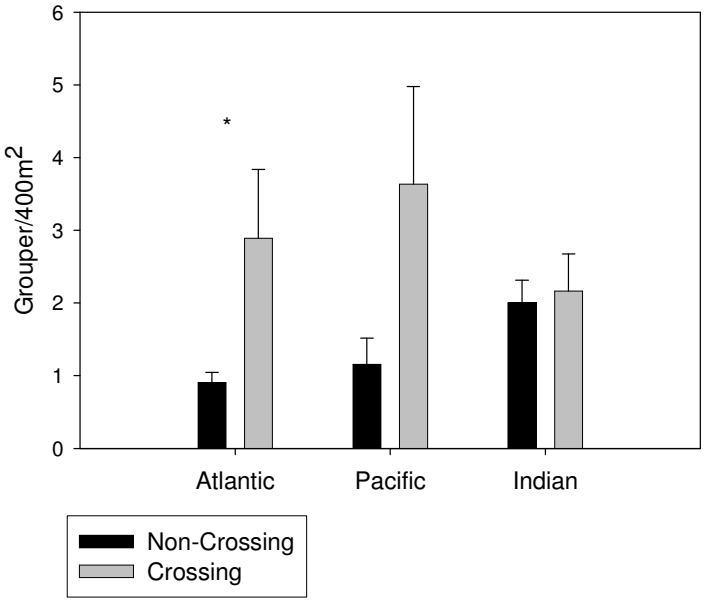

Figure 4. Mean percent grouper (+ SE) calculated for Crossing and Non-Crossing surveys in the Atlantic, Pacific and Indian Oceans. Statistically significant differences as calculated by the Mann-Whitney Rank Sum test are denoted by *.

Figure 5

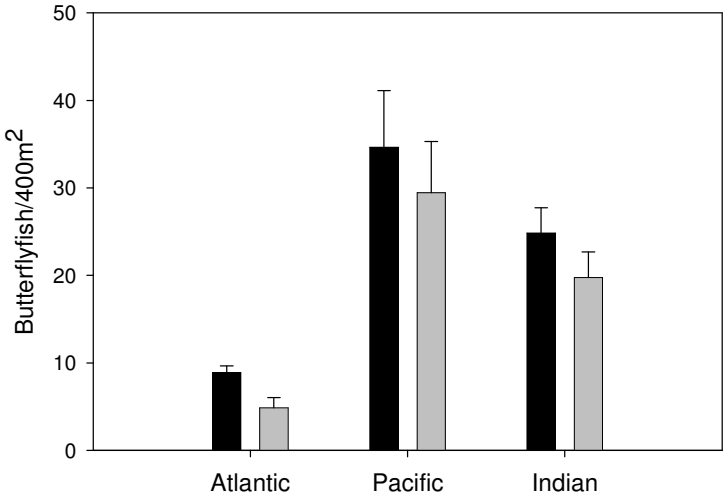

Figure 5. Mean percent butterfly fish (+ SE) calculated for Crossing and Non-Crossing surveys in the Atlantic, Pacific and Indian Oceans.

Figure 6

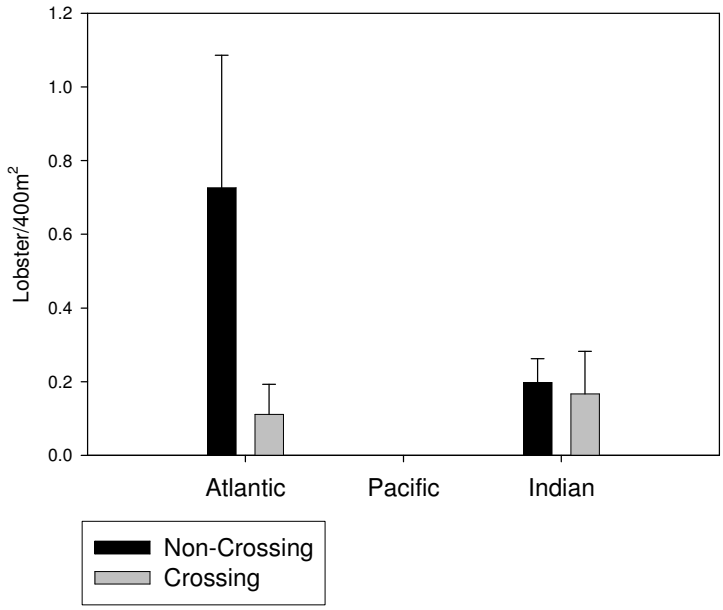

Figure 6. Mean percent lobster (+ SE) calculated for Crossing and Non-Crossing surveys in the Atlantic, Pacific and Indian Oceans.

Figure 7

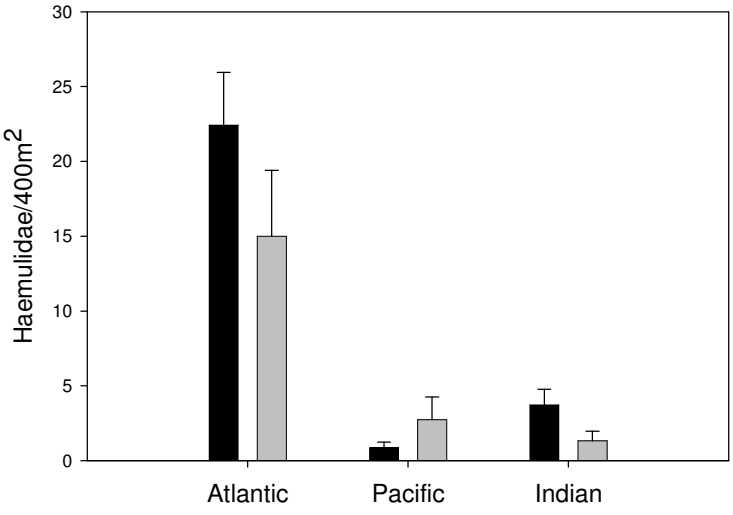

Figure 7. Mean percent Haemulids (+ SE) calculated for Crossing and Non-Crossing surveys in the Atlantic, Pacific and Indian Oceans.

DISCUSSION

Together, Quiksilver and Reef Check have used the data gathered on The Crossing to demonstrate that, on average, even very remote reefs have been negatively impacted by human activities. The DPI comparison demonstrated that Crossing sites were on average more remote than general Reef Check sites. The mean abundance of key food species (lobster and

grouper) was about five times lower than the levels observed at well protected coral reefs indicating that remote sites are susceptible to anthropogenic extractive impacts. However, the relatively higher abundance of grouper at Crossing than non-Crossing sites in the Atlantic and Pacific indicates that these more remote sites may offer some level of protection to this highly desirable food fish. The lower percent cover of hard coral in the Atlantic and Indian oceans is most likely a result of the fact that most Crossing surveys were carried out on more exposed reefs than Non-Crossing surveys. On average, more exposed reefs would be expected to have lower coral cover. It appears likely that the small sample size of the 1999 Crossing sites was biased towards reefs with high coral cover.

While there are many different possible ways to measure human impacts, these results support the view that even remote sites have been affected by human impacts. Since a major impact on reefs is fishing, and it is known that fishermen now travel globally to catch fish, this is not a surprising result and matches previous conclusions (HODGSON and LIEBELER, 2002).

Without coral reefs, most tropical surf breaks would not exist. Living coral has created the reef framework that barrels like Cloudbreak, Teahupoo, G-Land, and Cloud 9 call home. Coral reefs, however, are much more than "tube-builders." Having existed for more than 100 million years, coral reefs are the most biodiverse aquatic ecosystem on the planet. These "rainforests of the sea" do much more than produce perfect surf and protect coastlines from storm waves. In the new millennium, reefs will provide the genetic material that will be used to develop new drugs to fight cancer and other illnesses, work that has already produced numerous promising pharmaceuticals effective against both cancer and AIDS (HODGSON and LIEBELER, 2002). Coral reefs provide food for hundreds of millions of coastal people worldwide and are economically valuable for tourism, the world's largest industry.

Sadly, coral reefs face an unprecedented global crisis due to overfishing, blast and poison fishing, sedimentation, and global warming. The symptoms of the global coral reef crisis crept up slowly and it was not until recently that the scale of the potential catastrophe was recognized. By sponsoring Reef Check on The Crossing, Quiksilver is playing a leading role in raising awareness about coral reefs by allowing Reef Check to obtain much needed data from remote reefs and to share the educational message about coral reef conservation with cultures around the world. Reef Check scientists aboard the Indies Trader have surveyed reefs in the most remote corners of the world's oceans to determine the extent of human impacts on coral reefs and attempt to locate pristine reefs untouched by long-distance fishing activities or global pollution to provide a "baseline" against which to compare more heavily damaged sites.

CONCLUSION

The Quiksilver Crossing is an excellent example of private sector support for conservation efforts. The results of the five-year expedition demonstrate that remote reefs may be in equally poor condition as sites near large population centers due to long-distance fishing and other human impacts. These results further emphasize the need to invest in coral reef conservation everywhere reefs are found. In addition to the Crossing, Reef Check offers one way for the international surfing community to become educated about the global coral reef crisis and to participate directly in implementing solutions. The partnership between Reef Check and Quiksilver promotes stewardship and conservation among the surfing community that depends on coral reefs to produce that "perfect wave."

ACKNOWLEDGEMENTS

We are deeply indebted to the thousands of Reef Check volunteers who are Reef Check and provide their time and resources to collect data for our global database. We wish to thank Martin Daly and the crew of the Indies Trader for their continued support of our data collection efforts. Crossing data were collected by Reef Check scientists Owen Bruce, Matt Dunlap, Michelle Eich, Beatrice Ferreira, Camilla Floros, Ricky Grigg, Moshira Hassan, Marie Kospartov, Ed Lovell, JP Quod, and Dan Reinman. Jenny Mihaly from Reef Check headquarters provided invaluable logistical support, data entry, and quality assurance. Finally we wish to express our sincere gratitude to Quiksilver for the continued support of the partnership with Reef Check. Specifically, the efforts of Robert McKnight, Bruce Raymond, Kirk Willcox, Jim Kempton and Naomi Black have succeeded in turning this partnership from a dream into reality.

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