

# Coral reefs and residents of the U.S. Virgin Islands: A relationship of knowledge, outdoor activities and stewardship

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Received 26-VII-2009. Corrected 05-II-2010. Accepted 12-VII-2010.

**Abstract:** To test the hypotheses that U.S. Virgin Islanders' knowledge about local coral reefs is correlated with behavior, and that different sociological groups of residents have different patterns of knowledge and behavior, a mixed approach to surveying residents was used: (1) personal interviews were held in public locations and (2) an online version of the survey was administered to residents of the U.S. Virgin Islands. From July-October 2008, 462 residents over 18 years old were surveyed. Results indicate that people who engaged in outdoor activities knew significantly more about coral reefs (Spearman  $p < 0.01$ ,  $r^2 = 0.128$ ). Those more knowledgeable about coral reefs engaged in more positive stewardship activities (e.g. beach clean-ups) (Spearman  $p < 0.01$ ,  $r^2 = 0.127$ ). Negative behaviors (e.g. anchoring on reef) were not significantly correlated with increased knowledge of coral reefs (Spearman  $p = 0.911$ ,  $r^2 = -0.000025$ ). Fishers did not have greater ability in identifying *Acropora palmata* coral than non-fishers ( $\chi^2 = 4.138$ ,  $p = 0.126$ ); however, swimmers, snorkelers and divers (as a class) were more able to identify *A. palmata* than non-swimmers ( $\chi^2 = 9.764$ ,  $p = 0.002$ ). Most residents identified sea turtle species as endangered (hawksbill turtle, 78.9%) but only 48.2% of the responses included *Acropora* spp. as threatened. Resident attitudes towards conservation of local resources were overwhelmingly positive. Rev. Biol. Trop. 58 (Suppl. 3): 197-212. Epub 2010 October 01.

**Key words:** knowledge, behavior, stewardship, coral reefs, U.S. Virgin Islands, survey, *Acropora*.

A healthy coastal ecosystem provides irreplaceable goods and services to people and other species. Coastal resources provide protection from storms, are a source for medicinal substances, filter toxins and nutrients, produce oxygen, and sequester carbon dioxide. A healthy coastal ecosystem is integral to the way of life cherished by residents, as seen in the numerous economic, cultural and social benefits, ranging from food provisioning to tourism and recreation (Panetta 2003). As part of the coast, coral reefs must deal with a multitude of stressors, including over-fishing, sedimentation, nutrient enrichment, coral bleaching, and disease; all of which are exacerbated by global climate change and ocean acidification (Drayton *et al.* 2004, Kleypas 2006, Hoegh-Guldberg 2007, Hughes *et al.* 2007). Protecting

coral reefs has become of utmost importance. Thus, natural resource managers, scientists, and policy makers must integrate human social dimensions into their consideration of the ecosystems (Weeks & Packard 1997, Suman *et al.* 1999, Young 1999, Hunter & Rinner 2004, Fox *et al.* 2006, Oigman-Pszczol *et al.* 2007, Cinner *et al.* 2009). Humans make decisions on a daily basis that directly and indirectly affect the present and future environment on a local and global scale (Alessa *et al.* 2003). We need to better understand the basis of human actions, how decisions are made, and what makes culture change.

In many cases, knowledge impacts behavior. Surveys are a means to identifying behaviors, beliefs, attitudes, perceptions, and educational misconceptions, as well as

sociological patterns, within a population. For example, a survey in the Pacific Rim National Park of British Columbia found that people with more knowledge engaged in more depreciative behaviors (such as littering, overturning rocks) within the intertidal Park than those with less knowledge; moreover, personal attribution and perception of the ecosystem were more important in determining a person's behavior than knowledge (Alessa *et al.* 2003). In another study, people of a tropical, coastal tourist town in Brazil had large misconceptions (Oigman-Pszczol *et al.* 2007). Residents and tourists did not correctly perceive or recognize corals, or understand what their function is in an ecosystem. Increased knowledge did not lead to a positive environmental attitude; people with more knowledge pertaining to corals engaged in more depreciative behaviors (e.g. collecting organisms). Even those people that were employed in ocean-related jobs, such as divemasters, fisherman, and nautical store owners, had little knowledge of corals and their role in the ecosystem. If such a comprehension gap exists between resource users and resource managers in this coastal town, then what would a similar survey within the similarly-situated U.S. Virgin Islands (USVI) reveal? The objective of this study is to address the need for information on attitudes, beliefs, knowledge levels, and the demographics of marine resource users, and to investigate behavioral relationships between USVI residents and their environment.

In the USVI, environmental education and outreach programs have traditionally been geared towards youth but the older age groups have not been as exposed to similar programs. Therefore, generational differences in knowledge, and therefore behavior, could exist between age groups. Shifting baselines (Pauly 1995, Knowlton & Jackson 2008) might also apply to U.S. Virgin Islanders; older generations might perceive coastal ecosystems differently from younger generations, meaning that without the experience of living near a healthy reef, younger generations could perceive current reefs as being healthy, despite what they have learned about the poor status of today's reefs.

Also, because strong cultural traditions exist in the USVI, surveys could reveal a correlation of knowledge and behavior among sociological groups (e.g. fishermen). Some Islander families warn their children about engaging in outdoor activities, such as swimming, which they believe are harmful (pers. observ.). This fear of the water is passed on, and less involvement in the outdoors may decrease knowledge and conservation ethic in these children, who eventually grow up and make important choices about their environment. Science-based management depends on people; although studies have been conducted elsewhere, no published record of resident knowledge and behavior with regards to coral reefs exists for the USVI. With a focus on coral reefs and residents, this study was designed to provide a link between scientists, local resource users, and resource managers. In general, we hypothesized that islanders' knowledge about coral reefs is positively correlated with their behavior, and different sociological groups of USVI residents exhibit different patterns of knowledge and behavior.

## MATERIALS AND METHODS

**Population and site description:** The U.S. Virgin Islands are a territory of the United States and include three large islands—St. Thomas, St. John and St. Croix. Tourism is the largest industry in both St. Thomas and St. John while in St. Croix, the largest and most populated island, the major industries are tourism and oil refining (Crossett *et al.* 2008). Accessible only by boat, St. John is approximately 6 km east of St. Thomas and mostly parkland or undeveloped. The primary language spoken in the home is English (68%), followed by Spanish or Spanish Creole (20%), French or French Creole (10%), and other languages (2%) (Crossett *et al.* 2008). St. Croix fishermen derive 62% of their income from fish traps whereas the St. Thomas/St. John fleets derive 45% from fish traps, and the St. Thomas/St. John fleets are larger and more capital-intensive than the St. Croix fleet (Agar *et al.* 2008). Despite no-take zones and protected areas on all three

islands, coral reefs and fish populations continue to suffer (Drayton *et al.* 2004).

All surveys took place on St. Thomas, St. John, and St. Croix. Sites for surveys included public areas such as Kmart, Tutu Park Mall, Frenchtown Deli, Coki Point, Nisky Center, Cruz Bay, Sunny Isle Shopping Center, Christiansted, Fredriksted, Bordeaux Farmers Market, and Cane Bay. The sample size was 462 individuals, which is large with respect to the population size of the USVI (112 812 people in 2007, U.S. Virgin Islands Bureau of Economic Research 2009). People that had resided in the islands for more than six consecutive months were considered a resident. Only residents over the age of 18 were included because they make decisions through voting, in contrast to tourists and children.

**Survey approach:** To increase the number of responses and combine the advantages of different methods, a mixed approach to surveying residents was used: personal interviews were held in public locations utilizing either the (1) online version of the survey (created using www.Surveymonkey.com and accessed with laptop computers that had broadband internet service) or (2) a paper version of the survey. To maximize the number of web-based responses, the survey was advertised in the local newspapers and on a local radio station. Personal interviews in public locations allowed participation by people who may have difficulty with reading (questions were read by interviewer) or who may not have internet access. Interviewers were trained undergraduates, all of which are native U.S. Virgin Islanders, working alongside the principal investigators.

**Survey design:** The survey was designed to be completed in less than 20 min. and the participants were informed of this at the beginning of the survey. A consent form stated that all information would be anonymous and that the results would be made available to the public. All protocols were followed in applying for human subject research, and the survey was deemed exempt by the University of the

Virgin Islands Institutional Review Board. A pilot survey (June 2008) aided in the design of the official survey (July–October 2008). All questions were asked in a sensitive and objective manner, and each person had the option of terminating their survey session if they no longer wanted to participate for any reason (see Settar 2009 for survey).

This survey was designed to assess both knowledge and behavior in terms of coral reefs. “Knowledge” questions included (1) basic ecological definitions related to coral reefs, (2) identity of specific organisms typically found on and around reefs, and (3) awareness of status of federally endangered/threatened species. For example, “What is coral?” was asked to gauge whether islanders know that coral is a living animal. Residents were asked to identify a picture of *Acropora palmata*, elkhorn coral, because it was once a common reef-building coral (Bellwood *et al.* 2004) but has recently been federally listed as a threatened species (Anonymous 2005, Hogarth 2006). Residents were asked to identify the herbivorous urchin, *Diadema antillarum*, because knowledge of its die-off in the 1980s (see Lessios *et al.* 1984; Hughes *et al.* 1985; Carpenter 1990), and now its possible recovery (Edmunds & Carpenter 2001; Knowlton 2001; Miller *et al.* 2003; Carpenter & Edmunds 2006), is important for local understanding of reef management. “Behavior” inquiries included how each respondent directly or indirectly interacted with the reef, for example: snorkeling, fishing, and boating; walking, camping, or socializing on the beach. These interactions were labeled as “outdoor activities”. Also, questions concerned environmental stewardship, such as participation in community beach clean-ups, or actions taken without regard to the reef, such as anchoring on coral. Demographic questions about employment, age, gender, and education levels were placed at the end of the survey.

**Survey analysis:** To test for knowledge and behavior correlation, each individual received an overall score for general coral reef knowledge as well as a score for two

separate behavior categories: coastal-related outdoor activities and environmental stewardship activities. Five knowledge questions comprised a total of nine points: three open-ended, organism identification questions; one multiple choice, endangered species question; and one multiple choice, definition of coral question. For the coastal-related outdoor activities score, one multiple choice question, which listed outdoor activities, yielded a possible thirteen points. For the stewardship score, one multiple choice question asked participants to list activities; positive or negative activities that were checked off on the list contributed to either the “positive stewardship” score or the “negative stewardship score”. For all multiple choice questions, an “other” comment box was an option in case there were any choices that had been neglected in the listed choices, and these were included in the analysis. Taken together, these three overall scores were used for correlation analyses. Interpretation of the correct answer for the open-ended identification questions was broad; for instance, if an individual answered the *Acropora palmata* picture identification question by writing “coral”, instead of listing the scientific or common name, it was accepted as correct. Also, for the endangered species multiple choice question, respondents received positive points for all correct answers but did not have points subtracted if they also listed incorrect answers. The remainder of the survey was analyzed for descriptive statistics, and for differences between groups, chi-squared tests were used. Results were analyzed using the statistical software package SigmaPlot 11®.

## RESULTS

**Description of Sample:** 462 people surveyed were clearly not a random sample of U.S. Virgin Islanders (Table 1); many individuals and groups were not represented, mainly because of language barriers. A large portion (44.8%) of people fell in the “18-30 year old” age category, and the least amount (1.6%) were in the oldest, “71 and above”. Slightly more

females than males were surveyed and most of the sample was born in the continental U.S. (47%; Table 1). A large proportion (40.4%) of people cited the continental U.S. as being where they received their primary education (pre-school through senior/12<sup>th</sup> grade); however, most (44.5%) received their primary education in the USVI (Table 1). When asked to cite their highest level of education, 42.3% claimed to have a college undergraduate degree (Table 1).

Although not enumerated, comments from those that did not want to participate in the survey revealed unease about “taking a test” and some did not want to take the survey because they felt they knew nothing about the ocean. Others felt strongly that the information gathered would be used against them at some point in the future so chose not to take the survey. Overall, optional comments from the people surveyed were overwhelmingly positive regarding conservation of their coastal environment as well as in learning more about their reefs, and how to take more conservation action (Table 2). Many people expressed concern regarding the future of their coral reefs as well as concern for the attitudes and behaviors of U.S. Virgin Islanders towards their coral reefs.

**Knowledge: Reef Organism Picture Identification:** The USVI residents could generally identify some coral reef organisms. When presented with a picture of the once common coral, *Acropora palmata*, elkhorn coral, presently, federally listed as threatened, 110 people (23%) correctly identified the picture with either the common or scientific name (Table 3); all except four of these people were swimmers, snorkelers or SCUBA divers. More people that swim, snorkel, and/or SCUBA dive were able to identify *A. palmata* than those that do not submerge themselves in the water ( $\chi^2=9.764$ ,  $df=1$ ,  $p=0.002$ ). Of the 191 fishermen surveyed, 22 were commercial and 169 were recreational fishers (three fishers did not label themselves as either category). The act of fishing does not correlate with ability to identify the picture of *Acropora palmata* when

TABLE 1

A. Demographic information from the combined web and interview surveys.  
 Total sample N= 462 although each demographic factor has its own N value due to incomplete surveys.  
 B. Available comparative demographic information is given from the USVI 2000 Census; N=108,612.  
 For both A,B, data is arranged from highest → lowest percentage, not by category

## A. Survey data

Demographic Factor	Category	% of sample
Age (years) n=440	18-30	44.8
	31-40	17.5
	41-50	15.7
	51-60	14.3
	61-70	6.1
	71+	1.6
Gender n=441	female	52.6
	male	47.4
Location of Birth n=406	United States (state-side)	47.0
	US Virgin Islands	36.2
	other Caribbean island	16.7
Employment n=462	non-marine-related	87.2
	marine-related	12.8
Highest Level of Education n=402	college degree	42.3
	high school	27.4
	other	13.9
	masters	11.7
	currently in undergrad	10.9
	doctorate	3.7
	currently in grad	2.2
	8th grade	1.2
	none	0.5
Location of primary education n=416	U.S. Virgin Islands	44.5
	United States	40.4
	other Caribbean island	9.1
	other	6.1

fishers (both recreational and commercial) and non-fishers are compared ( $\chi^2 = 4.138$ ,  $df=2$ ,  $p=0.126$ ). Employment in a marine-related job increased ability to identify this coral compared to others ( $\chi^2 = 86.710$ ,  $df=1$ ,  $p < 0.001$ ). Age also played an important role in identifying *Acropora palmata*; in the 18-30 year old age category, fewer people were able to

identify elkhorn coral compared to older generations ( $\chi^2 = 17.856$ ,  $df=5$ ,  $p=0.003$ ).

Sea urchins were the most commonly recognized reef organism. A picture of the herbivorous invertebrate, *Diadema antillarum*, was identified correctly as urchin, sea egg (local term although not exactly correct), long-spined sea urchin, or *Diadema antillarum* (Table 3) by

TABLE 1 (Continued)

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 For both A,B, data is arranged from highest → lowest percentage, not by category

## B. USVI Census 2000 data

Demographic Factor	Category	%
Age (years)	35-44	14.5
	45-54	14.3
	25-34	12.6
	55-59	6.2
	65-74	5.4
	60-64	4.4
	21-24	4.3
	18-20	3.8
	75+	3.0
Gender	female	53.3
	male	46.7
Location of Birth	USVI-born	71.7
	other	28.3
Level of Education (based on age in yrs)	25+ High School or higher	60.6
	18-24 High School or higher	59.5
	25+ Bachelor or higher	16.8
	18-24 enrolled in college	16.3

TABLE 2

Categorized, optional comments made by residents of the U.S. Virgin Islands at the end of the survey; N=169

Category	% Response
positive about reef conservation & awareness; hopeful	59.2
people need more knowledge/awareness of reef	14.2
positive suggestions towards future surveys	9.5
coral reefs and fisheries in terrible shape	5.9
negativity towards survey	5.9
ocean is taken for granted	3.6
concerns for economy	1.8

TABLE 3

Percent correct answers when asked to identify pictures of common reef organisms. Correct answers included specific species names (scientific and common) as well as urchin or coral, respectively; N=462

Organism	% Correct Identification
<i>Acropora palmata</i> / elkhorn coral	23.0
<i>Diadema antillarum</i> / long spined sea urchin	87.0
<i>Gorgonia ventalina</i> / common sea fan	76.0

402 people (87.0%); some comments revealed misconceptions about the degree of danger of sea urchins (Table 4). Of the correct respondents, only 37 (9.2%) of these were not swimmers, snorkelers or SCUBA divers. As we will see later, most of the sample listed themselves as “swimmers” (87.5%), so the sample was biased towards individuals that submerge themselves. Of the total group of non-swimmers, -snorkelers, or -divers (58 people), 64.4% were correct in identifying the urchin picture.

The U.S. Virgin Islanders sampled were generally knowledgeable about sea fans, which are common on USVI reefs, although not all respondents understood that a sea fan is a coral. When presented with a picture of the common sea fan, *Gorgonia ventalina*, 351 people (76.0%) correctly identified the picture as a fan coral, sea fan, coral, gorgonian, common sea fan, or the locally known “sifter coral” (used locally for sifting flour) (Table 3 and see Table 4 for comment) and of these 351 people, 31 were not swimmers, snorkelers or SCUBA divers. Of those surveyed, 36% indicated that sea fans are coral. Of all responses only 11 people (3.3%) incorrectly labeled the sea fan as some sort of plant, five of which were non-swimmers.

**Knowledge: What is coral?** U.S. Virgin Islanders from this sample have a good understanding of what a coral is. When asked “What is coral?” the most common response (based on number of responses and not number of people)

TABLE 4

Sample comments made by US Virgin Islanders about the sea fan and urchin pictures from the survey

Sea Fan:

“Sadly, all I can say is that I have seen local jewelry makers using these to display earrings on!”

Urchin:

“looks like what you would call, i forgot the name. but if it chooks you in the feet it would go into your foot. you would have to prick yourself to get the black worm out”

“do not know the name but i know they sting”

“3 sea urchines (sorry i am a horrible speller) Don’t touch them because they will hurt!!! but after they die, they make a beautiful shell”

“a live amoeba don’t step on it”

“Poisonous sea urchin”

“it is sea egg that can kill you”

was “living organism” (87.7%), followed by “animal” (35.4%) and then “plant” (22.1%) (Fig. 1). Several participants (n=24) also noted that a combination of the available choices on the survey, animal/plant/rock/living organism, was as appropriate as simply responding “living organism” or “animal”.

**Knowledge: Endangered Species** U.S. Virgin Islanders were familiar with some endangered species (Fig. 2). Overall, the leading response to, “Which of the following are endangered species according to the Endangered Species Act?”, was the hawksbill turtle (79.0%), and the other four sea turtles listed took second, third, and fourth place as most recognized as endangered/threatened, while elkhorn/staghorn coral fell in at fifth place (48.0%) for response to this question (Fig. 2). Of all the people surveyed, 16.9% correctly identified the picture of *A. palmata* as well as knew that it is threatened, and all of them were swimmers, divers or snorkelers. Of this group, 69.0% were fishers.

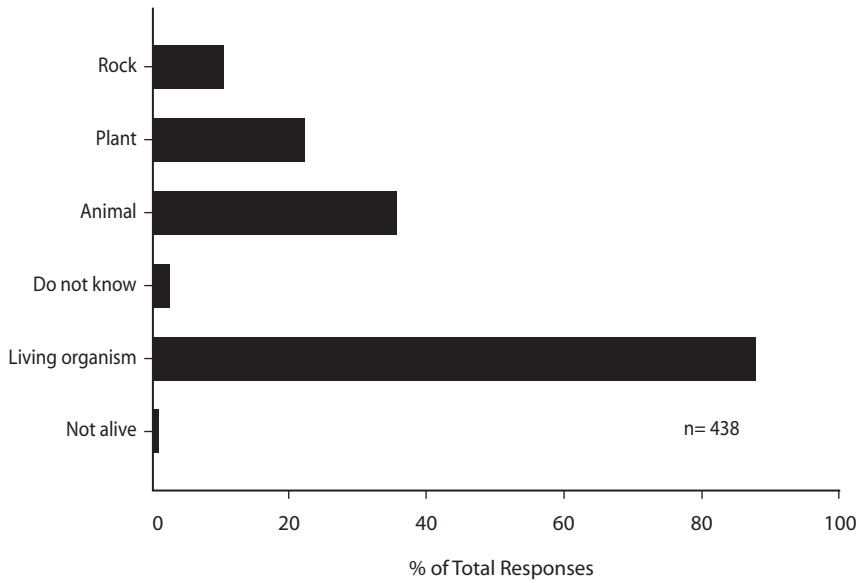


Fig. 1. U.S. Virgin Islanders' response to the question, "What is coral?" Acceptable responses included living organism, animal, or a combination of living organism/animal/plant/rock.

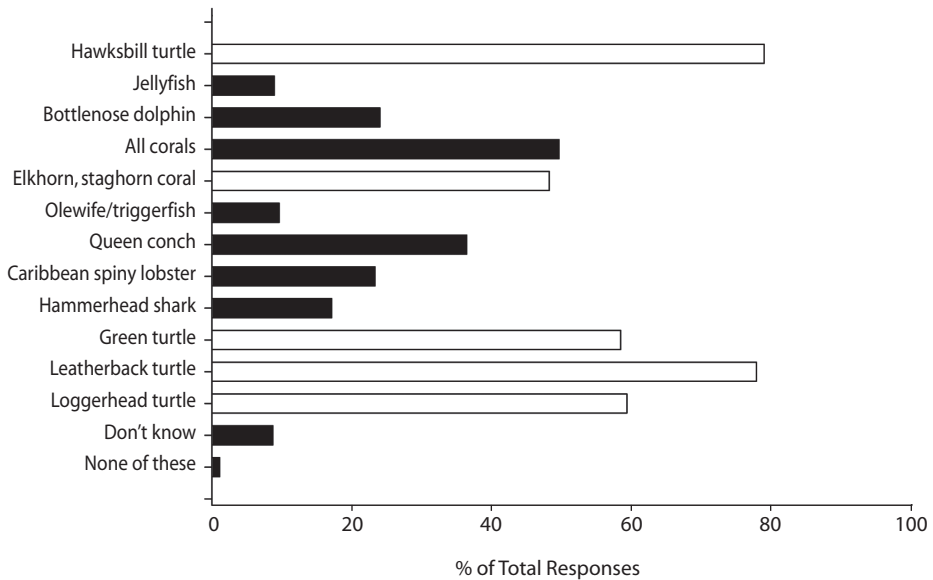


Fig. 2. Responses of surveyed U.S. Virgin Islands residents to the question, "Which of the following are listed as endangered or threatened according to the Endangered Species Act of the U.S. federal government?" Light-colored bars indicate correct answer.



**Behavior: Outdoor activities** Virgin Islanders engage in a variety of activities on land, on water and in water (Fig. 3). The most cited activity was swimming (87.5%) and the least cited was kite-boarding (1.6%). Walking/hiking on the beach was also a popular response (76.1%). Snorkeling was the third most common activity (64.5%) (Fig. 3). Fishing comprised 41.7% of the responses and of those that fish, reef fish are the most targeted compared to other types of fish; rod and reel (61.9%) and hand line (58.8%) are the most common method of fishing.

**Behavior: Stewardship** For Virgin Islanders in this sample, the most common positive stewardship activity was “watch TV programs about the environment” (82.7%) whereas the most common negative activity was “shell-collecting” (28.1%). “Picking up trash in the ocean” (53.5%) and “Beach clean-ups” (50.3%) were the second and third most common positive stewardship activities (Fig. 4).

Some people recognized the importance of ecosystem goods and services as well as their role in impacting the ocean. When asked, “Do you feel you have an impact on the ocean?” 84.5% of people responded “yes”, 12.2%

replied “no”, and 0.03% replied “minimal/not much/sometimes”. Of the people that responded to the question, “Do you believe ocean conservation to be an important issue for residents of the U.S. Virgin Islands?” 99.0% responded “yes”. When individuals were prompted for an explanation for their specific response of “yes”, the most common reply was tourism/economy (37.0%), followed by “environment/biodiversity/natural balance” (13.0%), then “recreation/enjoyment/beauty” (11.0%), and then “culture/we are surrounded by it/it is our home” (10.0%) (Table 5).

**Knowledge and Behavior: Correlation analysis** Overall, in this sample people who engaged in more outdoor activities were more likely to have general knowledge of coral reefs, demonstrated by a weak but significant correlation (Spearman  $p < 0.01$ ,  $df = 100$ ,  $r^2 = 0.128$ ). People who had general knowledge of coral reefs were more likely to engage in positive stewardship activities, for example, attending beach clean-ups or public events related to the local environment (Spearman  $p < 0.01$ ,  $df = 100$ ,  $r^2 = 0.127$ ). Negative behaviors towards the environment, such as walking or anchoring on the reef, were not significantly correlated with

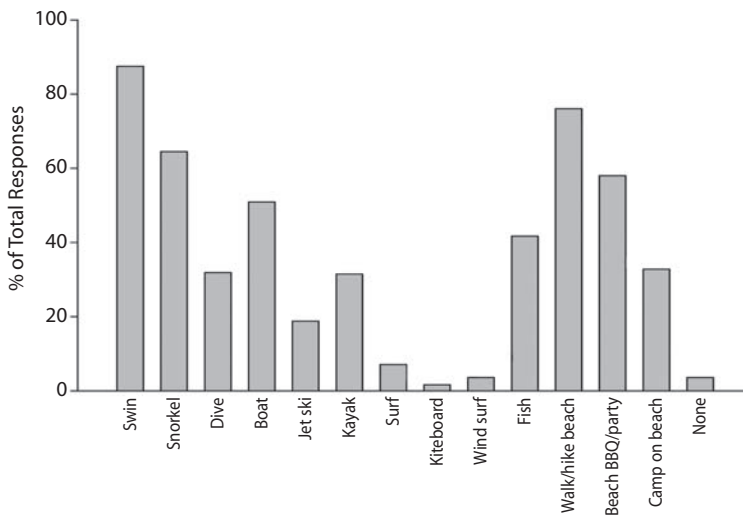


Fig. 3. Summary of U.S. Virgin Islander outdoor activities from survey; N=448.

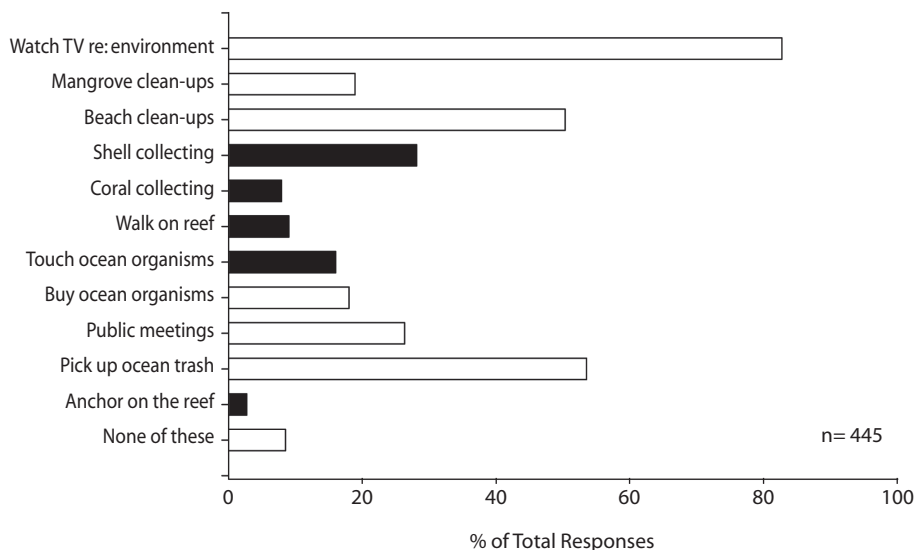


Fig. 4. The responses to the question asking, “Which of the following behaviors do you engage in?” in the survey of U.S. Virgin Islanders. Dark bars indicate negative activities.

TABLE 5  
Reasons why 99% of U.S. Virgin Islands residents (N=403) stated ocean conservation to be important; 1% felt conservation was not important

Category	% of Sample
tourism/economy/livelihood	30.6
biodiversity/environment/natural balance	12.8
recreation/enjoyment/beauty	10.6
existence/home/culture/surrounded by it	10.0
food	7.8
shoreline protection	4.4
it is dying	4.4
fish populations	4.2
human health/well-being	3.6
future	3.1
habitat	2.2
pollution/keep it clean	1.7
if ocean dies we die	1.7
education/research	1.4
water supply	0.6
ocean was here first	0.6
there is only one ocean	0.3
medicine	0.3

increased knowledge of coral reefs (Spearman  $p=0.911$ ,  $df=100$ ,  $r^2=-0.000025$ ). A re-analysis with stricter scoring of correct answers did not change the overall results (Settar 2009).

The mean general knowledge score for the USVI sample was 6.4 points out of nine possible points. The mean outdoor activity behavior score was 4.9 points out of 13 possible activity points; sample mean for negative stewardship score was 1.6 points out of five and the mean positive stewardship score was 2.3 points out of five possible points. Various groups differed in their knowledge and behavior scores. Although fishers’ knowledge of coral reefs was not significantly greater than non-fishers (mean=6.7 points for fishers, 6.2 for non-fishers; Mann-Whitney  $U=23006.5$ ,  $p=0.052$ ; Table 6), the mean number of outdoor activities participated in by fishers (6.1 points) was significantly greater than the mean of non-fishers (4.0 points) (Mann-Whitney  $U=14410$ ,  $p\leq 0.001$ ), as was the mean participation in positive stewardship activities (mean=2.5 for fishers, 2.2 for non-fishers; Mann-Whitney  $U=22685$ ,  $p=0.029$ ).

TABLE 6  
*Mean survey scores for some groups of U.S. Virgin Islands residents.  
 Survey pertained to coral reef knowledge and behavior*

(Max possible score)	Knowledge (9)	Outdoor Activities (13)	Positive Stewardship (5)	Negative Stewardship (4)
divers/snorkelers	6.6	5.1	2.5	1.6
non-divers/snorkelers	6.1	4.4	1.9	1.6
fishers	6.7	6.1	2.5	1.8
non-fishers	6.2	4.0	2.2	1.4

People who SCUBA dive and snorkel are more knowledgeable about coral reefs, are more active outdoors, and participate in more positive stewardship activities compared to those that do not engage in these activities (Table 6). The mean coral reef knowledge score for SCUBA divers and snorkelers (taken as a group) was 6.6 points, which was significantly greater than the mean knowledge score of 6.1 points for the non- SCUBA/snorkelers (Mann-Whitney  $U=13588$ ,  $p\leq 0.001$ ). The SCUBA/snorkeler group scored a mean of 5.1 points in outdoor activities, significantly greater than the mean 4.4 points scored by non-SCUBA/snorkelers (Mann-Whitney  $U=5071$ ,  $p\leq 0.001$ ). People in the SCUBA/snorkeler group engage in significantly more positive stewardship activities (mean=2.5 points) compared to those that do not SCUBA dive or snorkel (1.9 points) (Mann-Whitney  $U=12100.5$ ,  $p\leq 0.001$ ); however, there is no difference between these two groups in terms of negative stewardship activities (both scored a mean of 1.6 points, Mann-Whitney  $U=2595$ ,  $p=0.381$ ).

## DISCUSSION

Survey design is extremely important in gaining robust results and making conclusions. As with any survey, objective results depend greatly on the honesty of the participant, as well as on the participants' interpretation of the questions being asked (Yates 1971, Schuman & Presser 1981); therefore, these results should be interpreted cautiously. This sample of Virgin Islands residents was not

random and unfortunately some individuals and groups were not represented, for example, non-English speaking individuals (Spanish and Spanish-Creole, French and French-Creole, Census 2000), children under the age of 18, and residents that annually leave the islands in the summer months. That being acknowledged, the results from our survey indicate relationships that cannot be disregarded.

The hypothesis that a person's knowledge is positively correlated with behavior is supported, albeit weakly. The more a U.S. Virgin Islander is physically involved with the coastal environment, the more general knowledge of coral reef organisms he or she has. In turn, the more informed a U.S. Virgin Islander is about local coral reefs, the more likely he or she will be involved in positive environmental stewardship activities. Negative behavior towards the reef, (like anchoring on the reef, collecting corals and shells, etc.), was not significantly related to either high or low levels of coral reef knowledge. These findings contrast with the study in Brazil (Oigman-Pszczol *et al.* 2007) where increased knowledge did not necessarily lead to a positive environmental attitude and people with more knowledge engaged in more depreciative behaviors, such as coral collecting. Possibly this is due to cultural differences as well as the fact that their study included tourists. Also our USVI findings contrast with Alessa *et al.*'s (2003) study which concluded people with more knowledge of ecology engaged in more depreciative behaviors (for example, overturning rocks and littering) in a rocky intertidal area. Their finding might be

attributed to cultural differences as well, and the types of people they approached in the Park could have been a specialized group and not necessarily a random sample of the public. Also, because rocky intertidal habitats are different from coral reefs, different behaviors could be inspired. In a survey of Americans in 2003, Steel *et al.* (2005) found that if people experience coastal environments and develop environmental values then they are brought closer to the problems faced in coastal and ocean areas. Thus, the results of Steel *et al.* (2005) are similar to our results.

An interesting finding is that SCUBA divers and snorkelers are more knowledgeable about coral reefs, more active in the outdoors, and engage in more stewardship activities compared to people that do not dive or snorkel. The more a person is in the water and physically experiencing the coral reef environment, then the more curiosity is spurred, and this possibly even induces concern, and therefore positive actions towards the reef. Future outreach and education programs should probably be designed around snorkeling and SCUBA diving activities whenever possible.

While U.S. Virgin Islanders are generally informed about their local reefs, and most feel that tourism is the major driving force behind ocean conservation (Table 3), some misconceptions are apparent. Compared to their strong ability in identifying the status of sea turtles, U.S. Virgin Islanders were not very successful at identifying acroporid corals as a threatened species on the U.S. Federal Endangered Species List (Fig. 3), and compared to pictures of urchins and sea fans, U.S. Virgin Islanders were the least familiar with the picture of *Acropora palmata* (Table 3). Apparently Islanders are well-informed about sea turtles, which could be attributed to the regularly scheduled community outreach program conducted by local sea turtle researchers, or because sea turtles are charismatic megafauna. Also, acroporids were only recently listed as threatened while sea turtles have been listed for more than 30 years. The high recognition (87.0%) of sea urchins could be attributed to the fact that Islanders

are wary of the danger of urchins. Some of the comments made by participants indicated that some U.S. Virgin Islanders believe urchins to be deathly poisonous, and at the very least extremely painful when stepped on (Table 4). While *Diadema* do contain toxins in their spines, they are not life-threatening to humans. Some Virgin Islanders may fear getting in the water because of misconceptions about urchins, and therefore pass this information along to others. Other participants mentioned that many U.S. Virgin Islanders do not know how to swim (although the study population shows that 87.5% are swimmers, Fig. 4), so the misconceptions of various dangers in the water could be keeping some Islanders from getting wet, and therefore, they may not be as knowledgeable about endangered species such as acroporid corals, given that outdoor activities increase knowledge of the reef. Other comments indicated that people do not know what “endangered” means; some participants said in conversation that they thought sharks and jellyfish were “endangered” because they are “dangerous”.

The ability to identify elkhorn coral, along with being educated of its threatened status, is important for several reasons. If a person is active in USVI waters, he or she may come across *Acropora* spp. at some point, if not regularly. Given that knowledge, behavior and stewardship are related (as shown in the correlation analyses), it could be expected that the individual would respect this coral and steer clear of it while enjoying time in the ocean. Fishers could come into contact with *Acropora palmata*. Fishing, both commercial and recreational, is a vital component of the USVI community and economy (Agar *et al.* 2008), and we found that reef species are the most targeted group of fish; thus, fishers will most likely encounter special challenges as they continue to fish amongst the coral reefs of the Virgin Islands. Knowledge of reef species, as well as stewardship, is key. U.S. Virgin Islanders who engage in swimming, snorkeling and SCUBA diving are more able to identify *Acropora palmata*, than those that do not

engage in such activities. Also, fishing does not increase the ability of identifying this coral, but people with marine-related jobs in general are more able to identify this endangered species compared to those in non-marine jobs. Careers in marine industries are an obvious choice for U.S. Virgin Islanders, although only 12.8% of the people surveyed reported having marine-related jobs (Table 1). This result is opposite to what Oigman-Pszczol *et al.* (2007) found: that people in marine industries were not familiar with common corals and the reef ecosystem. This could be due to cultural or educational differences between regions.

The differing lengths of time that outreach and education programs regarding threatened and endangered sea turtles and corals has been available to the public might lead to differing levels of awareness across age groups in this study population. Older generations may have had experience with *Acropora* when it was more abundant in USVI waters (Gladfelter 1982), whereas younger generations probably do not encounter this coral as often. Another hypothesis is that younger generations are not as involved with decisions regarding the reef compared to older generations, so they are not as informed. Also, younger generations may spend more time with different technologies, such as portable internet devices, cell phones, and television, instead of going outside and experiencing their environments as older generations used to (Louv 2006, Karevia 2008, Pergams & Zaradic 2008). This result is important because young people are the future decision-makers for the USVI; therefore, younger generations might need to be targeted for outreach and education on conservation issues.

The highly positive attitudes of U.S. Virgin Islanders may be related to the high level of socioeconomic development and education. Cinner *et al.* (2009) recently described more healthy reefs in most highly developed areas of the Indian Ocean. They investigated relationships between human population density, a multi-dimensional index of socioeconomic development, reef complexity, and condition of coral reef populations, and found that in areas

of intermediate levels of economic development, fish biomass was four times lower than at sites with low and high development. Taken together with the information gained in this study, further multi-disciplinary investigation which links social and ecological systems could be useful in the USVI, not only in designing effective education and outreach programs that parallel the changing resident populations, but also in maintaining marine protected and un-protected areas.

In this study of USVI residents, the correlations between coral reef knowledge and behaviors with respect to coral reefs were weak. Involvement in outdoor activities, such as diving and snorkeling, only explains part of the coral reef knowledge levels of residents, as well as stewardship activities (both positive and negative). Most likely, a number of these factors act together throughout a person's experience, leading to behavioral decisions. A further method of investigating what typically motivates a person to seek environmental knowledge or behave in a certain way towards the environment could be to ascertain "personal attribution", as Alessa *et al.* (2003) did in their study. Determining the extent to which a person feels responsible towards their local environment, in combination with determining knowledge levels, might explain why general knowledge of the reef is common but more explicit knowledge is not, or why negative behaviors towards the reef (like anchoring on coral or collecting coral) are still occurring.

Future surveys of U.S. Virgin Islanders should consider refining this survey. A larger sample size, which includes the multiple languages spoken in the USVI, would represent more of the population and could yield stronger results. A survey of the millions of tourists that come to the USVI, in conjunction with residents, would enable an interesting comparison, as would a survey of children's knowledge and behavior. To understand how different education efforts influence behavior, it will be important to experimentally test how residents learn about the reefs and apply information towards their behaviors.

Previous experimental studies in other areas have demonstrated the effectiveness of specific interventions. For example, a study in the Chicago Zoo demonstrated increases in patrons' knowledge of apes after they received a short lesson (Ross *et al.* 2008). Littlefair & Buckley (2008) demonstrated that trained guides within a World Heritage site altered patron behaviors, that guided interpretation reduced the impacts of litter and trampling, and that different interpretation techniques were more effective for different impacts. Would learning about coral reefs immediately affect a U.S. Virgin Islander's behavior, and what approaches work best in favor of conservation education and behavioral change towards becoming better stewards of coral reefs?

#### ACKNOWLEDGMENTS

We thank the Lana Vento Charitable Trust and a U.S.G.S. State Partnership Program grant for funding this research. NSF-HBCU-UP grant HRD-0506096 funded undergraduate assistants. This project would not have been possible without USVI community participation. We greatly appreciate R. Boulon, T. Corke, S. DeAnda, C. Ellis, K. Engerman, F. Fergusson, A. Frappier, S. Goode, S. Hale, B. Kojis, L. Noori and A. Rogers for help in administering surveys and advice.

#### RESUMEN

Para probar las hipótesis que el conocimiento de los pobladores de las Islas Vírgenes de EEUU con respecto a arrecifes de coral está correlacionado con su conducta, y que los grupos sociológicos de residentes tienen pautas diferentes de conocimiento y de conducta. Se utilizó un enfoque mezclado para analizar a los residentes: (1) entrevistas personales en ubicaciones públicas y (2) una versión en línea de la entrevista fue administrada a residentes de las Islas Vírgenes. De julio a octubre 2008, 462 residentes mayores de 18 años de edad fueron entrevistados. Los resultados indican que personas que practicaban actividades al aire libre sabían mucho más acerca de los arrecifes de coral (Spearman  $p < 0.01$ ,  $r^2 = 0.128$ ) y las más informadas sobre arrecifes de coral se involucraban en

actividades más positivas para su manejo y conservación (Spearman  $p < 0.01$ ,  $r^2 = 0.127$ ). Las conductas negativas (por ejemplo, anclando en el arrecife) hacia el ambiente no estaban correlacionadas con un mayor conocimiento de los arrecifes de coral (Spearman  $p = 0.911$ ,  $r^2 = -0.000025$ ). Los pescadores no tenían una capacidad mayor de reconocer el coral *Acropora palmata* que no pescadores ( $\chi^2 = 4.138$ ,  $p = 0.126$ ); sin embargo, nadadores y buzos fueron más capaces de identificar *A. palmata* ( $\chi^2 = 9.764$ ,  $p = 0.002$ ). La mayoría de los residentes saben que las tortugas marinas están en peligro (Tortuga carey, 78.9%) pero solo el 48.2% saben que *Acropora* está anemazada. La actitud de los residentes hacia la conservación de los recursos locales es altamente positiva.

**Palabras clave:** conocimiento, conducta, responsabilidad, arrecifes de coral, Islas Vírgenes EEUU, *Acropora*, encuesta.

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