TOTAL ECONOMIC VALUE FOR PROTECTING AND RESTORING HAWAIIAN CORAL REEF ECOSYSTEMS

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Introduction

Services Provided by Coral Reefs

Table 1. Goods and services provided by coral reef ecosystems

Goods		Services				
Renewable resources	Nonrenewable resources	Physical structure	Biotic	Biogeochemical	Information	Social and cultural
Commercial and recreational fisheries	Coral blocks, and sand for building materials	Construction of complex structural base for habitat by hermatypic corals	Maintenance of coral reef habitat processes and functions	Nitrogen fixation	Historical record of contaminants	Recreation such as ecotourism, diving, and snorkeling
Pharmaceuticals and medical raw materials	Raw materials for production of lime and cement	Protection of shallow aquatic nursery and feeding habitat from severe wave action	Provision of spawning, nursery, breeding, and feeding area for many species	Carbon cycling	Historical record of salinity	Cultural and religious values
Raw materials (primarily seaweed) for production of agar, carrageenan, and fertilizer	Mineral oil and gas	Protection of shoreline property from severe wave action and erosion	Maintenance of species and genetic diversity	Calcium sink	Historical record of sea temperature	Maintenance of traditional lifestyles
	Shells and corals for jewelry and souvenirs	Construction of new land	–	Export of dissolved organic matter, nutrients, and plankton to nearby habitats	Monitoring of environmental pollution impacts	Aesthetic values and artistic inspiration
Live fish and corals for aquariums	–	Provision of sand to tropical beaches	–	Assimilation of waste (particularly petroleum)	–	–

Source: Adapted from Moberg and Folke, 1999, Table 2.

Threats to Coral Reefs

- Coral reefs appear to be resilient in response to natural disturbances that occur periodically, such as destructive storms, outbreaks of predators, or shifts in oceanographic conditions; however, they are less able to adapt to chronic, persistent disturbance (Moberg and Folke, 1999)
- The primary global threat to reefs is increased sea temperature, which results in coral "bleaching"
- Destructive fishery practices
- Mining and dredging
- Sedimentation, pollution, and waste
- Non-sustainable tourism (Cesar, 2000).

Study Objective

- Use a stated choice study to determine the total willingness to pay (WTP) of American citizens for various programs that protect coral reefs around the main Hawaiian Islands (MHI).

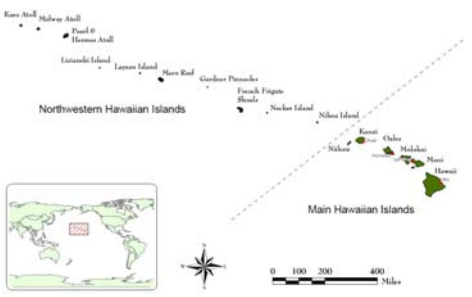

Figure 1. Hawaiian archipelago.

Methods

- Timeline of survey development
  - Focus groups
  - June 2004 one-on-one interviews
  - Expert, stakeholder, and client input
  - External peer review
  - 2005 Office of Management and Budget (OMB) clearance
  - 2005 pretest
  - 2008 OMB clearance
  - April 2009 one-on-one interviews
  - 2009 pretest
  - Survey administration (2009–2010)
  - The survey was administered to three internet panels: the American National Election Study (ANES), Stanford University's Face-to-Face Recruited Internet Survey Panel (FFRISP), and Knowledge Network's established internet panel [the KnowledgePanel™ (KP)].

Table 2. Completed cases by panel (RR rate %)

Panel	Completed cases
ANES	**2,335 (31%)**
FFRISP	942 (TBD)
KP	1,308 (8.1%)
Pooled	4,585

- Outline of the survey
  - Introduction to the instrument and its purpose.
  - Discussion of baseline conditions.
  - Overview of two primary threats to coral reefs around the MHI.
    - Overfishing
    - Ship accidents
  - Choice experiment questions: respondents are asked to choose their most-preferred program out of four programs, the most-preferred of the remaining three, and the most-preferred of the remaining two. This elicits their full contingent ranking of program choices.
  - Current program (status quo): price = $0, 1% of corals reefs protected by no-fishing zones, 0 acres repaired by ship injuries each year.
  - Reef repair program: price > $0, 1% of corals reefs protected by no-fishing zones, 5 acres repaired by ship injuries each year reducing recovery time by 40 years (10 years instead of 50 years).
  - No-Fishing Zones Program: price > $0, 25% of corals reefs protected by no-fishing zones, 0 acres repaired by ship injuries each year.
  - Full Program: price > $0, 25% of corals reefs protected by no-fishing zones, 5 acres repaired by ship injuries each year reducing the recovery time by 40 years (10 years instead of 50 years).
- Debriefing questions.

Table 3. Experimental design matrix

Version	Current program	No-fishing zones program	Reef repair program	Full program	Discount factor
1	$0	$45	$35	$75	$5
2	$0	$45	$55	$100	$0
3	$0	$45	$95	$130	$10
4	$0	$45	$135	$160	$20
5	$0	$75	$35	$110	$0
6	$0	$75	$55	$125	$5
7	$0	$75	$95	$150	$20
8	$0	$75	$135	$200	$10
9	$0	$110	$35	$135	$10
10	$0	$110	$55	$145	$20
11	$0	$110	$95	$200	$5
12	$0	$110	$135	$245	$0
13	$0	$170	$35	$185	$20
14	$0	$170	$55	$215	$10
15	$0	$170	$95	$265	$0
16	$0	$170	$135	$300	$5

Results and Discussions

- Weights were used to adjust for sampling designs in order to generalize results to the U.S. household population.
- Data from the three panels were pooled for analysis. The report offers a weighted comparison between the three panels.
- Construct validity and scenario acceptance analyses revealed that ranking behavior consistent with economic theory and the effectiveness of the survey instrument. Respondents who were more likely to choose an alternative program over the current program had the following characteristics:
  - Higher income
  - Likely to visit Hawaii
  - Have heard about coral reefs
  - Believed the ship repair and/or no-fishing zones programs would be effective
- Believed over-fishing or ship injuries were serious problems.
- For this analysis, the team used a rank-ordered probit model, which fits respondents' program choices into a utility-theoretic framework that is used to estimate WTP.
- In analyzing attribute-based stated choices, economists assume that the differences across respondents' choices are attributable to variation in both observed characteristics (e.g., the respondent's income) and random variation. Our model includes several variables to account for the variation in observed characteristics.
- Using the parameter estimates from the rank-ordered probit model, we estimated mean WTP for each program.

Table 4. Responses across programs for each choice question

	Current Program	No-Fishing Zones Program	Reef Repair Program	Full Program	Alternative Program over Current Program
First choice (Q11)	28.0%	27.0%	14.5%	30.4%	71.9%
Second choice (Q13)	10.4%	38.8%	29.0%	21.8%	89.6%
Third choice (Q15)	12.0%	28.8%	43.8%	15.4%	88.0%
Fourth choice	49.6%	5.4%	12.7%	32.3%	50.4%

Conclusions

The rank-ordered probit model estimates WTP for the enlarged no-fishing zones to be approximately three times WTP for the ship strike restoration program. All estimated covariance terms are significantly different from zero, which allows us to reject the null hypothesis that the error terms are independent. Estimated correlation coefficients among the programs range from 0.86 to 0.90, indicating that preferences for the different programs are, indeed, highly correlated. The estimated standard error for the combination program is almost twice as high as for the individual programs and is statistically different from them, confirming the hypothesis of heterogeneity. A number of covariates are significant explanatory variables in the choice model with the expected signs, including cost of the program, household income, the likelihood of visiting Hawaii in the next 10 years, and being a self-described very strong environmentalist.

References

Cesar, H.S.J. (ed.). 2000b. Coral reefs: Their functions, threats and economic value. In *Collected Essays on the Economics of Coral Reefs*. CORDIO, Department for Biology and Environmental Sciences, Kalmar University, Sweden. pp. 14–39.

Moberg, F. and C. Folke. 1999. Ecological goods and services of coral reef ecosystems. *Ecological Economics* 29:215–233.