ARE MARINE PROTECTED AREAS IN THE TURKS AND CAICOS ISLANDS ECOLOGICALLY OR ECONOMICALLY VALUABLE?[1]

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Abstract
Marine Protected Areas (MPAs) are often advocated by ecologists as a method of conserving valuable fish stocks while ensuring the integrity of ecological processes in the face of increasing anthropogenic disturbance. In the Turks and Caicos Islands there is little evidence that current MPAs are ecologically beneficial but there are indications that boundary changes may enhance queen conch and finfish production. Implementing boundary changes usually requires political will and, hence, quantifiable economic benefits. Assessing the value of reef fish is particularly important because they are potentially valuable for consumptive and non-consumptive purposes. We demonstrate the non-consumptive economic value of increased Nassau grouper size and abundance to the dive tourism industry through a paired comparison conjoint survey of visiting divers. Our results suggest that accounting for the non-consumptive economic value of increased Nassau grouper abundance and size may have a large impact on the economic viability of ecologically functional MPAs.

Keywords: *MPA economics; Nassau grouper; conjoint analysis; nonmarket valuation; paired comparison*

Introduction
The inshore marine environment provides humans with a wide variety of ecological and economic services (Moberg and Folke, 1999) and is especially important in tropical developing countries where economic opportunities are limited. Many demersal fisheries operate at or beyond their sustainable limits (National Marine Fisheries Service, 1997; National Research Council, 1999) and the demand for fish continues to grow. The management of a marine fishery is a difficult task (Botsford et al., 1997; Costanza et al., 1998) and in the tropics, where ecologically complex ecosystems are under heavy pressure from rapidly increasing anthropogenic stress and are typically managed by institutionally weak governments, the problem is exacerbated (Roberts and Polunin, 1993; Roberts, 1997; Johannes, 1998; Mascia, 2000).

Traditional fisheries management has focused on the optimal exploitation of individual stocks of commercially important species despite the fact that most demersal fisheries involve multiple species. Regulatory approaches aim to control either fishing mortality and/or effort by means of quotas, gear restrictions, size limits, vessel permits, and/or seasonal closure (King, 1995). These strategies often have high transaction costs (North, 1990) and are thus ineffective in many cases (Roberts, 1997).

In the tropics, the management of the inshore environment has proved problematic due to the complexity of the dynamic coral reef – seagrass – mangrove ecosystem and confounding anthropogenic pressure (Johannes, 1998). Many tropical species are particularly vulnerable to overexploitation due to the wide variety of fishing methods used in artisanal commercial reef fisheries (Munro and Williams, 1985). Grouper, for example, comprise about 10% of the total coral reef finfish yield worldwide and is amongst the most endangered family. In 1996, 21 species of grouper were proposed for the IUCN 'Red List'; of these three species are critically endangered (Hudson and Mace, 1996).

In recent years, marine protected areas (MPAs) have received much attention as an alternative approach to traditional fisheries management (Plan Development Team, 1990; Roberts, 1997; Murray et al., 1999). Ecologically, MPAs are thought to be able to simultaneously address problems that traditional management cannot. The primary goals of MPAs are to protect critical habitat and biodiversity, and to sustain or enhance fisheries by preventing spawning stock collapse and providing recruitment to fished areas (Medley et al., 1993; Johnson et al., 1999; Murray et al., 1999).

From an economic perspective, the use of MPAs offers several theoretical advantages over the traditional management measures. MPAs, like terrestrial protected areas, may provide substantial non-consumptive economic use value by providing opportunities for recreation, education, scientific research (Dixon, 1993; Ruitenbeek, 1999) and indirect use value by

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increasing ecological resilience (Perrings et al., 1995). Protected areas may also provide non-use values for humans who value the existence of protected environments and species even though they have no plans to personally visit or use them. In addition to providing value to humans through the provision of valuable ecological goods and services, MPAs have other potential advantages. Transaction costs (North, 1990) associated with information collection, contracting, monitoring and enforcement are potentially lower when using MPAs compared to other information-intensive fishery management tools (Roberts and Polunin, 1993; Agardy, 1994; Costanza et al., 1998; Johannes, 1998; Mascia, 2000).

Unless the ecological impacts of MPAs are demonstrated and linked directly with economic value, it is unlikely that decision-makers within government will consider MPAs as viable policy tools for managing coastal resources. In order to demonstrate the utility of MPAs, it is imperative that the potential economic benefits of marine conservation be clarified. A complete accounting of the benefits of conservation may actually help tip the balance of a cost-benefit analysis in favor of the conservation option.

In the tropics, the tourism industry is an important part of many economies (ARA Consulting et al., 1996). Increasing demand for nature-based tourism ensures that protected areas (Gössling, 1999) and a healthy environment (Huybers and Bennett, 2000) are important production inputs for the tourism industry. Viewing wildlife is recognized as providing economic value to participants and is a basis for both terrestrial (Gössling, 1999) and marine (*e.g.*, Loomis and Larson, 1994; Davis and Tisdell, 1998) tourism industries.

The objective of our study is to assess the existence of non-consumptive economic benefits of MPAs in the Turks and Caicos Islands (TCI), British West Indies. We hypothesize that viewing healthy coral reefs and vibrant fish communities adds value to the experience of visiting tourists. Our research specifically examines the value of Nassau grouper (*Epinephelus striatus*) through a paired comparison conjoint survey. It assesses the added value that increased grouper size and abundance contributes to the dive experience for visiting divers to the TCI. In the balance of this paper, we outline the potential ecological benefits of MPAs in South Caicos, TCI. Next we outline a framework for assessing the potential economic value of these ecological benefits of MPAs. We then review the paired comparison survey methodology and results, and conclude with a discussion on the implications of the results for the TCI dive industry and government policy makers.

The Turks and Caicos Islands

The Turks and Caicos Islands (TCI) are located at the southern end of the Bahamian archipelago and are relatively pristine compared to other countries in the Greater Caribbean basin. Commercial fishing for spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*) has been a mainstay of the local economy for decades but tourism emerged as the number one industry in the country by the early 1990s (Turks and Caicos Islands Government, 1996). While the pristine reefs are a prime attraction for tourists, increasing tourism is putting pressure on the nearshore coral reef environment. Growing tourism combined with tariff protection for the TCI fishing industry has led to an expansion in the market demand for local seafood and resulted in increasing fishing pressure on potentially vulnerable stocks of conch, lobster and carnivorous reef fish such as groupers, snappers and grunts (Christian-Smith and Darian, 2000).

A National Parks Order formally established 33 terrestrial and marine protected areas in 1992 (Homer, 2000). Government management of MPAs has been in a state of flux over the last ten years and there is currently a restructuring in process that will soon cleave responsibility for park operation away from the Department of Environmental and Coastal Resources (DECR) to a new National Park Service (NPS).

There are four designated MPAs on South Caicos: Admiral Cockburn Land and Sea National Park (ACLSNP); East Harbor Lobster and Conch Reserve (EHLCR); Admiral Cockburn Nature Reserve; and Bell Sound Nature Reserve. ACLSNP and EHLCR are adjacent (Figure 1) and effectively encompass the Admiral Cockburn Nature Reserve. The Bell Sound Reserve is on the north side of the island and was implemented to protect bonefish habitat and stocks.

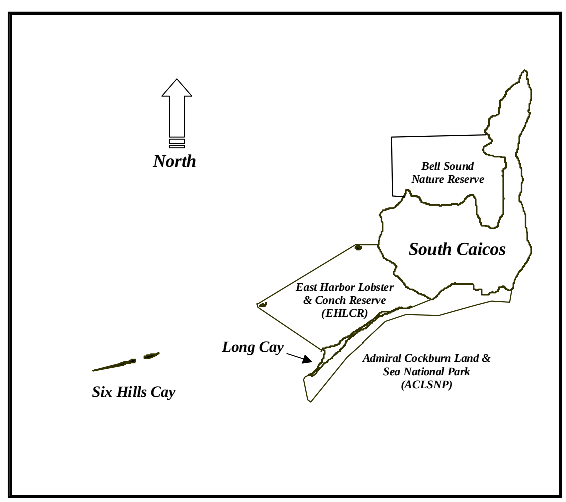

Figure 1: Marine Protected Areas of South Caicos, Turks and Caicos Islands

The Ecological Value of South Caicos MPA

Spiny Lobster

Stocks of spiny lobsters are heavily exploited around the world due to their high market value. From Bermuda to southern Brazil, *Panulirus argus* is one of the most heavily fished and commercially significant shellfish throughout its range (Butler and Herrnkind, 1997) and are the principal commercial fishery resource in the TCI. The fishery is managed by the DECR and management regulations include a closed season, an 83-mm minimum carapace length, a prohibition on the harvest of berried or tarred females, and a prohibition on the use of SCUBA or chemicals such as detergent or bleach. In addition, lobster fishing is prohibited in the South Caicos MPAs.

Spiny lobster larvae are pelagic and individuals may remain in the water column from 6- to 12-months and are therefore subject to dispersal over a range of hundreds or even thousands of kilometers (Lipcius and Cobb, 1994). This suggests that fluctuations in ocean currents may alter annual patterns of larval movement and make it difficult to causally link the effects of increased larval production within MPAs to fisheries benefits in other areas.

Some evidence does show that MPAs protect juvenile lobsters until they mature and move out of the reserves into surrounding areas (Davis and Dodrill, 1985; MacDiarmid and Breen, 1993). However, empirical evidence demonstrating that populations of exploited species may recover is limited (Kelly et al., 2000a) and documented benefits of these reserves to the conservation and management of lobsters are sparse (Childress, 1997).

There is little fishing activity in the vicinity of the South Caicos MPAs while more distant fishing grounds outside the area are heavily exploited. Unpublished data collected by the Center for Marine Resource Studies (CMRS) shows the average length of lobster caught in several fishing grounds around South Caicos (Table 1). The average carapace length of lobsters from the shallow, sheltered and accessible areas such as Six Hills (8-km from the fishing port, Figure 1) is often under the 83-mm legal minimum. Remote areas that are deeper, less accessible and exposed to adverse sea conditions – such as East Side, Bush Cay and White Cay (up to 40-km from the harbor) – have much higher average lengths.

Table 1: Mean Length (mm) of Lobsters Landed in Fishing Regions near South Caicos

Sampling Period	Spiny Lobster Average Carapace Length (mm) East Side	Six Hills	Bush Cay	White Cay
Fall 1993	101.2	88.0	99.1	101.0
Spring 1994	114.4	77.3	106.6	101.5
Summer 1994	102.1	78.8	105.7	111.0
Summer 1998	100.7	80.8	97.5	97.5
Fall 1998	103.0	83.0	101.0	101.0
Average	104.3	81.6	102.0	102.4

Legal minimum carapace length = 83 mm

Many of the undersize lobster are landed early in the season during the phenomenon known locally as “The Big Grab” (Olguin et al., 1998). Any TCI citizen is entitled to a fishing license for a nominal fee and during the month of August many part-time fishers take leave from other jobs and travel to South Caicos for the lucrative opening of lobster season (August landings have accounted for 25% to 40% of total annual landings since 1989). These part-time fishers are not usually skilled free divers and their technical skill limits many of them to fishing shallower areas where lobsters are smaller.

The catch trends from various areas, anecdotal information from fishers (Moran, 1992) and biological evidence that *P. argus* commonly undertake long-distance migrations (Herrnkind, 1980) suggest that lobsters are migrating from shallow to deeper waters as they grow older and larger. It appears, however, that they are being intercepted prior to reaching the refuge of deeper water. An effective strategy for lobster conservation in the TCI would involve a large protected area (Childress, 1997) in the core of the Caicos Bank to protect juveniles and their migration routes from shallow to deep habitats. However, it is unlikely that such a plan could be implemented, as it would be even more difficult to enforce remote MPA boundaries than size limits. We see more effective enforcement of current size limits as the solution to lobster overfishing; this would allow substantial numbers of adults to reach the refuge of deep waters and grow to reproductive size.

Queen Conch

The queen conch is a large marine gastropod found throughout most of the Caribbean, southern Florida, and Bermuda (Brownell and Stevely, 1981). Because queen conch are slow moving and inhabit shallow water, they are relatively easy to collect and have thus been a staple food item throughout the Caribbean for hundreds of years (Brownell and Stevely, 1981; Stager and Chen, 1996). Fueled by increases in demand, commercial fisheries developed in many regions during the early- to mid-1900's (Ninnes, 1994). Consequently, fishing pressure on queen conch stocks quickly became intense, bringing some stocks, such as those off of Bermuda, to the point of commercial extinction (Brownell and Stevely, 1981; Mulliken 1996).

In the TCI, commercial landings of queen conch have been recorded since 1904 (Ninnes, 1994). Although landings have been quite variable throughout the years, the size of landed conch has decreased over time and the need to harvest in more distant, deeper waters has increased, suggesting that stocks may be declining (Ninnes, 1994). To address concerns regarding the possible decline of queen conch stocks in the TCI, fisheries legislation was enacted to help regulate harvest rates (Mulliken, 1996). To date, harvesting regulations include size limits, equipment restrictions, licensing and export quotas, and a seasonal closure of the fishery. In addition to these traditional fisheries management techniques, an MPA, EHLCR, was established off of South Caicos in 1993.

As with any marine reserve, one of the anticipated benefits of the MPA was an increase in abundance of queen conch within the reserve (Bohnsack, 1993; Murray et al., 1999). A recent study demonstrated that five years after its establishment, the density of queen conch within EHCLR was nearly double that in similar habitat outside the reserve (Tewfik and Bene, in press). The study also found that adults dominated the age/size structure of the queen conch population within the MPA, whereas juveniles dominated populations outside the reserve. This result is no doubt due to the limited harvesting within the reserve, which enables individuals to fully grow to the adult life stage (Stoner and Ray, 1996).

Given the increase in density of queen conch inside the MPA, it is reasonable to hypothesize that spillover from the reserve might enhance local fishing yields (Bohnsack, 1993; Murray et al., 1999). However, preliminary results of spatial surveys conducted within and adjacent to the MPA suggest that the current reserve boundaries do not promote the spillover of adults into fished areas (Danylchuk, unpublished data). Extremely shallow sandbars run adjacent to two borders of the reserve and queen conch are rarely found in these areas. Since queen conch prefer moderately dense seagrass beds that provide food and shelter (Stoner and Waite, 1990), their near absence on these shallow, sandy areas is not surprising. Moreover, as queen conch grow they tend to expand their home ranges to include deeper waters (Hesse, 1979; Stoner and Ray, 1996), further reducing the likelihood of adults dispersing over shallow sandbars. Although deeper water does occur near the remaining border of EHLCR, this section of the reserve abuts ACLSNP and the offshore boundary rapidly exceeds the depth range for queen conch (Stoner and Sandt, 1992).

Although the potential for spillover of adults from EHLCR into locally fished areas is limited, spawning activity within the reserve may help support local queen conch populations. Studies in the Bahamas indicate that the distribution of queen conch is directly related to larval supply, and high densities of late-stage larvae tend to be found in areas where stable aggregations of juvenile queen conch also occur (Stoner and Davis, 1997). Given that conch larvae have a relatively short planktonic stage and local oceanographic conditions can retain larvae between 10- and 100-km from where they were hatched (reviewed in Appledoorn, 1997), it is likely that larvae originating in the MPA supply other core conch nurseries downstream of the reserve.

To realize the full potential of the EHLCR as a fishing reserve, it may be necessary to revisit the siting of the reserve boundaries. At present, the spillover of adults to fished areas is impeded by the lack of contiguous, suitable habitat, limiting the contribution of the MPA to the local fishery. As such, it may be worth examining whether the size of the reserve could be reduced to enhance the local harvest. However, further research is needed to determine whether changing the location of the boundaries will have any substantial effects on the breeding population and subsequent larval supply to fished areas downstream of the reserve.

Reef Fishes

Since fisheries are size-selective, the establishment of MPAs is expected to increase both the average size and abundance of exploited species. In general, MPAs have proven effective in this capacity, particularly with regard to large carnivorous species such as groupers (Serranidae) and snappers (Lutjanidae) which are long-lived, slow-growing fishes with delayed reproduction (Polunin and Roberts, 1993; Rakitin and Kramer, 1996; Sluka et al., 1996, 1998; Johnson et al., 1999; Tupper and Juanes, 1999). These families are among the most important both commercially and recreationally throughout subtropical and tropical waters (Sluka et al., 1996; Sluka and Sullivan, 1998; Beets and Friedlander, 1999). Since fecundity of fishes increases exponentially with length (Wootton, 1990), an increase in both average size and abundance of fish within MPAs should lead to substantially greater fish production than in adjacent fished areas (Plan Development Team, 1990; Roberts and Polunin, 1991). Theoretically, small MPAs could produce as many eggs as much larger fished areas (Man et al., 1995). Whether or not this production will enhance local fisheries depends on local oceanographic processes that transport larvae from protected spawning areas (Tupper and Juanes, 1999).

In order to be effective, MPAs must be planned with the ecology of target species in mind (Murray et al., 1999). In particular, MPAs must encompass the habitats used by a target species and must also encompass most of the species' home range (Kramer and Chapman, 1999). The more time fish spend outside the MPA, the higher their risk of fishing mortality. Thus, MPAs are rarely effective in protecting highly migratory species. Some groupers, such as the gag, *Mycteroperca microlepis*, and the Nassau grouper, *Epinephelus striatus*, may migrate several hundred kilometers to spawning aggregation sites, during which time they are vulnerable to fishing (Tupper, 1999). These species may spend significant amounts of time outside of small MPAs, reducing the benefits of protection.

Abundance and size of several commercially important reef fishes, including Nassau grouper, were measured within several habitat types in fished reefs and in a small MPA around South Caicos (Tupper, unpublished data). There was no difference between fished and unfished areas in mean size or density of any grouper species. It was determined that Nassau grouper preferred windward Pleistocene reef formations along the edge of the drop-off, at a depth of approximately 20-m. These high-relief formations, which provide abundant caves and crevices in which groupers could shelter and ambush prey, were not present within the MPA. This suggests that habitat preference may be more important than fishing pressure in determining the distribution and abundance of Nassau grouper. In contrast, Sluka et al. (1996) found no significant relationship between habitat variables and the abundance of Nassau grouper. They also found that Nassau grouper, in addition to several other grouper species, were more abundant and larger within the Exumas Cays Land & Sea National Park (central Bahamas) than on adjacent unprotected reefs. However, The Exuma Cays do not possess the same type of high-relief windward reefs nor the steep drop-off that typifies the TCI shelf edge (M. Tupper, personal observation). Several studies have shown an association between groupers and high-relief habitats (Nagelkerken, 1981; Sluka, 1995; Sluka et al., 1996, 1998). It is likely that in the absence of preferred habitat types, fishing pressure would become the major factor influencing distribution and abundance of exploited reef fishes.

Another possible explanation for the differing results of protection in the Exuma Cays and TCI is that fishing pressure on Nassau grouper and other reef fishes is probably higher in the Exuma Cays. In the TCI, the fishery is directed mainly at queen conch and spiny lobster; finfish are most often taken opportunistically as bycatch of the lobster fishery (Kassakian, 1999). In order to see any effects of establishing an MPA, the area must be subject to a lower level of fishing pressure than surrounding areas. It is possible that the level of fishing pressure around South Caicos is too low to cause a detectable difference in fish size and abundance between the MPA and surrounding areas.

Table 2: Density (number of individuals per 100 m^2) of grouper species in protected and fished areas of the wider Caribbean region[1].

[1] *Sample areas are arranged from heavily fished (left) to no fishing (right). BMR = Barbados Marine Reserve; ECLSP = Exuma Cays Land & Sea Park; ACLSNP = Admiral Cockburn Land & Sea National Park. Table modified from Chiappone et al. (2000). Barbados data from Chapman and Kramer (1999). South Caicos data from Tupper (unpublished).*

Grouper Species	Barbados	SE Cuba	Dominican Republic	Florida Keys	S Exumas	N Exumas	S Caicos	BMR	ECLSP	ACLSNP
Cephalopholis cruentatus	0.08	2.30	0.95	0.97	0.16	0.60	0.16	0.16	0.27	0.15
C. fulva	0.16	0.63	0.35	0.01	1.30	0.44	1.86	0.24	0.52	1.78
Epinephelus adcensionis			0.04	0.04	0.01	0.01	0.06		0.04	0.08
E. guttatus			0.08	0.04	0.13	0.20	0.26		0.14	0.20
E. itajara							0.02			
E. striatus				0.01	0.16	0.20	0.62		0.35	0.48
Mycteroperca bonaci				0.04		0.01			0.01	0.01
M. tigris				0.02	0.01	0.06	0.14		0.12	0.16
M. venenosa					0.02	0.01	0.08		0.05	0.05

Indeed, Table 2 shows that the density of all species measured at South Caicos rivaled or exceeded densities reported for these species within MPAs elsewhere in the Caribbean (Chapman and Kramer, 1999; Chiappone et al., 2000). Thus, the ACLSNP may not be effective in protecting reef fish stocks around South Caicos simply because they are not currently in need of protection. However, the fishery situation in the Turks & Caicos Islands is rapidly changing. Increasing demand for finfish from the hotel and restaurant industries has rapidly increased the demand for grouper and snapper on the more developed islands of Grand Turk and Providenciales (Christian-Smith and Darian, 2000). The South Caicos MPA may therefore prove useful in the future, particularly if its boundaries are extended to include the preferred habitat of Nassau grouper.

Potential Economic Value of TCI MPAs

Economic Theory

To implement MPAs in developing countries will usually require more than simply providing evidence of their ecological value. Ecological arguments may hold little weight if there are not economic benefits associated with MPAs. If the economic benefits of marine conservation can be tied to the health of economically important industries (*i.e.*, tourism), then MPAs may be considered a realistic management option. A critical step in MPA implementation is to demonstrate the linkages between ecological health and economic opportunity.

Public environmental goods such as environmental quality are those that have no market impacts and are therefore impossible to value using standard economic techniques (Boyle and Bishop, 1987). Concentrating on direct use value (*i.e.*, the value of enhanced fishery production for consumptive uses) and ignoring nonmarket values can lead to the underestimation of the economic benefits of conservation, a bias in the decision-making process, reduced social welfare and a misallocation of societal resources (Randall, 1993). A total economic value (TEV) framework based on Dixon and Pagiola (1998) is useful for considering the potential economic value of the diverse ecological services that MPAs are thought to provide. The main focus in valuation will vary for different MPA ecological services; the primary types of economic value that the various services are likely to provide are highlighted in Figure 2.

A number of methodologies have been used for assessing the value of ecological goods and services. These include Travel Cost Methodology (TCM) (Fletcher et al., 1990), Contingent Valuation Methodology (CVM) (Hannemann, 1984) and, most recently, a number of techniques adapted from marketing research and broadly known as conjoint analysis (Johnson et al., 1995; Roe et al., 1996; Hanley et al., 1998; Farber and Griner, 2000). These methodologies can be divided into two general categories: those that rely on revealed preferences and those that rely on stated preferences. TCM is a revealed preference method because it uses real expenditures that people make on recreational travel to statistically analyze willingness to pay (WTP) for environmental quality. CVM and conjoint surveys, on the other hand, are methodologies that rely on stated preferences. In these surveys, people are queried about their preferences in surveys that present hypothetical market situations. These surveys allow the derivation of values for goods and services that would otherwise have to be excluded from cost-benefit analyses.

	Total Economic Value					
	Use Value				Non-Use Value	
	Direct		Indirect	Option	Existence	Bequest
Potential Ecological Benefits	Consumptive	Non-Consumptive				
Increased Abundance		X				
Increased Size		X				
Spillover to Fishing Grounds	X					
Larval Export	X					
Increased Ecosystem Resilience			X	X		
Maintain Biodiversity					X	X

Figure 2: Total Economic Value Framework and Areas of Focus for MPA Valuation

There has been an increasing amount of environmental research using conjoint methodologies developed in other fields of economics (Louviere, 1988; Carson et al., 1994). These include choice experiments (Roe et al., 1996; Hanley et al., 1998; Farber and Griner, 2000; Huybers and Bennett, 2000) and paired comparison conjoint analysis (Johnson et al., 1995; Johnson et al., 1998). The strength of conjoint approaches derives from the use of nearly orthogonal survey designs that statistically isolate the effects of individual attributes on choice (Hanley et al., 1998). In a paired comparison conjoint analysis, survey respondents are presented with a choice of product profiles, each of which consists of a number of attributes. Each attribute can take on a number of specific levels that influence the value consumers perceive for the product. Whereas CVM asks respondents whether they are willing to pay a fee to improve environmental quality, a paired-comparison conjoint survey asks respondents to provide a rated comparison of two different profiles. We ask: what is your preference, on a scale of 1 to 9, of the baseline profile compared to an alternative profile?

While beyond the scope of the current paper, it is possible to derive measures of consumer welfare that are comparable with those derived using CVM using re-scaling of the ratings, a probit model and maximum-likelihood estimation techniques (Johnson et al., 1998). For current purposes, we concentrate on demonstrating the added value that increased environmental quality can provide to divers. This can be done assuming a simple linear utility function and using ordinary least squares (OLS) to estimate regression coefficients that can then be used in market simulations. While theoretically correct estimates of consumer welfare are important for comprehensive cost-benefit analyses and possibly for setting park entrance fees, the demonstration of the economic potential of MPA protection is in itself a strong educational tool for government decision-makers in developing countries.

Survey Methodology: Diver Preferences for Nassau Grouper

The focal species for our study was Nassau grouper because it is thought to have both consumptive and non-consumptive use values for the restaurant and dive industries, respectively. The goals of this survey are to: (1) identify key environmental attributes that add value to the experience of TCI dive tourists; and (2) assess the price sensitivity of divers to changing levels of these key attributes.

Key attributes were identified through interviews with dive tour operators, and experienced sport and professional divers in the TCI. Appropriate levels were chosen based on expert judgement, survey pre-testing and a pilot survey. Revisions to the pilot survey were incorporated to a second draft survey and further feedback obtained from survey respondents and dive operators. The final survey instrument used a total of five attributes and a total of twenty levels: size of dive group (3-7, 8-14, 15-23, and 24-30); presence of other species (1 or more lobster, 1 or more sea turtles, 1 or more reef shark, and none of the above); Nassau grouper abundance (1, 3, 6, or 12 fish per dive); Nassau grouper average size (small 2.27-kg, medium 6.80-kg, and large 13.61 kg); and dive price ($40, $41, $45, $50 or $60 per 20-minute single tank dive).

The four sizes of dive group span the most common range for dive charters in the TCI. We found through initial interviews that seeing “big stuff” was very important to divers and that sharks, turtles, dolphins, eagle rays and whales are some of the charismatic megafauna divers most commonly expressed interest in seeing. We included an ‘other animal’ attribute in the survey, which included reef shark, sea turtle and spiny lobster. Aggregations of lobster are known to attract sport divers in New Zealand (Kelly et al., 2000b), however the potential recreational value of lobsters had not previously been considered in a Caribbean context before and was therefore of substantial interest.

The conjoint survey questions were designed using Sawtooth Software’s Conjoint Value Analysis (CVA) software package (Sawtooth Software, 1996). An optimally efficient paired comparison survey would be both orthogonal (*i.e.*, attributes vary completely independently) and balanced (*i.e.*, each attribute is shown an equal number of times). This survey used five attributes with a total of twenty levels, yielding a potential design space of over 917,000 possible paired comparisons. Because paired comparison surveys are cognitively challenging and can lead to respondent exhaustion (Huber, 1997), it is important to limit the number of questions in a survey. In this survey, we limited the number of questions to eighteen.

The CVA experimental design module identifies promising experimental designs by examining a pool of potential CVA questions selected randomly from the design space. D-efficiency (Kuhfeld et al., 1994), a measure of the goodness of a specific experimental design relative to the ideal orthogonal balanced design, is calculated for a pool of questions five times larger than the desired survey size. Paired comparisons that contribute little to the overall statistical efficiency are eliminated one by one until an 18-question survey design was obtained. This procedure was replicated twenty times and the survey design with the highest D-efficiency was retained and used in the final survey instrument. A sample question is shown in Figure 3: for most people, Option 1 was strongly preferred to Option 2 because it was a dive with a smaller dive group, reef sharks were present, and there were more and larger grouper for only $5 more per dive.

Category	Option A	Option B
Size of the Dive Group	15-23 Divers per Group	24-30 Divers per Group
Presence of Other Animals	1 or more Reef Sharks	No turtle, shark, lobster
Grouper Abundance	6 Groupers per Dive	3 Groupers per Dive
Average Grouper Size	Large Grouper: 30-lbs	Medium Grouper Size: 15-lbs
Price of the Dive	$45 per Single Tank Dive	$ 40 per Single Tank Dive

1	2	3	4	5	6	7	8	9
A is much better		A is somewhat better		A & B are about equal		B is somewhat better		B is much better
Please circle a number from 1 to 9 that reflects your rating								

Figure 3: Paired Comparison Survey Question

A dummy variable OLS regression technique was used to estimate conjoint utilities as a function of the independent variables dive group size, presence of other animals, the abundance and average size of Nassau grouper, and the price of the dive. Based on expert opinion and pilot survey feedback, increasing grouper size and abundance were assumed to provide increasing utility while increasing dive price and group size were assumed to lead to a reduction in respondent utility. No *a priori* relationship was assumed for the presence of other animals.

The regression coefficients – known in marketing literature as part-worth's – were calculated and used in the CVA market simulator. Total utility for each of a variety of hypothetical dive profiles being simulated were calculated for each survey respondent. The product with the highest overall utility for each respondent is assigned a score of '1', while all other profiles are given a score of '0'. The market simulator averages the 'first choice' preference scores across all respondents and calculates percent market share for each hypothetical dive profile in a particular simulation.

The final paired comparison questions, along with questions about environmental attitudes, MPA knowledge, and demographics were distributed to visiting divers in the TCI via commercial dive operators and to student and non-student visitors at the Center for Marine Resource Studies. A total of 80 usable survey responses were used in this analysis; this represents an overall response rate of approximately 30%.

Survey Results

Female respondents accounted for 56% of the 80 usable survey responses. 65% of the respondents were under 30 years of age and 73% of respondents were American citizens. 94% of respondents had at least some college education and 33% had household incomes over US $125,000. This was the first visit to the TCI for 79% of respondents. The most important factors influencing the dive profile choice according to respondents was dive group size (46%) and overall species diversity (36%); only 9% of respondents stated that dive price was the most important factor in their comparison tasks. Individual utility regressions were conducted on the 80 individual survey responses. The overall fit of the regressions was high, with an average R^2 of 0.97. This is indicative of a high level of internal self-consistency in decision making for respondents.

The regression coefficients were then used to calculate utility for various scenarios and calculate market shares for competing dive profiles. Consider first a baseline scenario in which a survey respondent faced four alternative dive package profiles for their next SCUBA dive. They can choose between: (1) a dive with a very large group of 24 – 30 divers for the most economical price of $40; (2) a dive with a slightly smaller group of 15 – 23 divers for a slightly higher fee of $45; (3) a dive with a medium size group of 8 – 14 divers for $50; or (4) a dive with a small group of 3 – 7 divers for the most expensive price of $60. For all cases, assume that the environmental conditions are the same: the diver sees one small 2.3-kg (5-lb) grouper and no other animals (lobster, shark, sea turtle) during a 20-minute dive. Given the stated preferences of the current sample respondents, about 31% of these divers would choose the smallest and most expensive $60 dive profile. Another 34% would choose the medium size group for $50, while the remainder of respondents would choose one of the more economical, larger dive groups.

Now consider alternative dive profiles in which the abundance of Nassau grouper increases compared to the baseline scenario. This could be due to the effects of an MPA or because dive operators take their clients to more remote and pristine dive sites. From a theoretical perspective, variations in travel costs to a particular site are economically equivalent to a per trip entrance fee to the same location (Cameron, 1992). When we simulate an increase in grouper abundance for the most expensive $60 dive profile while holding grouper abundance in other dive profiles constant, we observe an increasing market share for the expensive dive with each increase in Nassau grouper abundance (Figure 4).

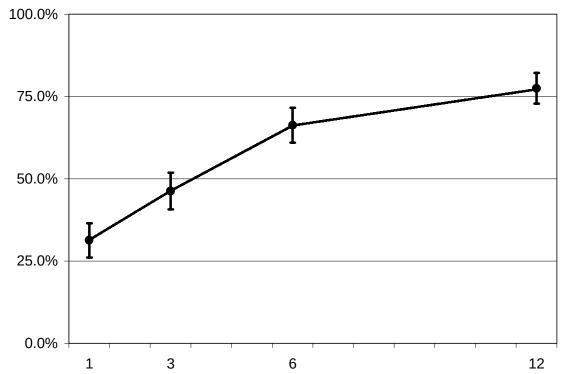

Figure 4: Small Group Dive Profile (p=$60) Market Share for Varying Levels of Grouper Abundance

An increase in abundance from one to twelve Nassau grouper per dive results in market share for the small, expensive dive profile rising from 31% to 78%. Increasing grouper abundance adds value to the dive experience. Dive operators could charge higher prices and increase revenue by taking clients to sites with higher grouper abundance. Alternatively, MPA entrance fees could be used to capture consumer surplus resulting from increased grouper abundance. An increase of $5 per dive, for instance, would have little impact on the number of dives if there were abundant Nassau grouper at a protected dive site. Note that we observe increasing market share but a flattening in the curve from six to twelve Nassau grouper per dive. This is indicative of decreasing average marginal utility for increasing grouper abundance.

Turning to Nassau grouper size, we observe an almost linear increase in market share for the expensive dive profile as average fish size increases from 2.3-kg (5-lbs) to 13.6-kg (30-lbs) average weight (Figure 5). Unlike the case for Nassau grouper abundance, there is no indication of diminishing marginal returns to size.

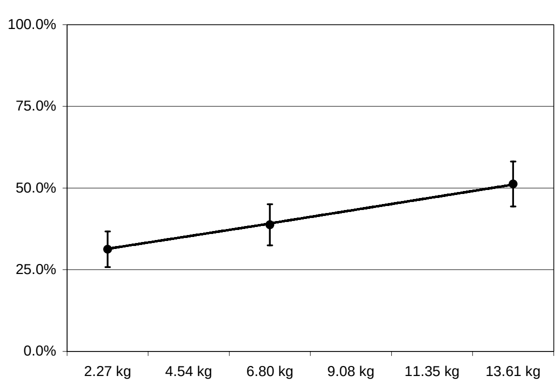

Figure 5: Small Group Dive Profile (p=$60) Market Share for Varying Levels of Grouper Size

The simulations in which the various other animals increased in abundance demonstrated that all the other reef species – spiny lobster, sea turtles and reef sharks – added value to the dive experience of TCI divers. As Figure 6 illustrates, the presence of one or more spiny lobsters increased the small group market share from 31% to 61% in this simulation. Market share for small group dive profiles increased even more, to 85%, with sea turtles and reef sharks.

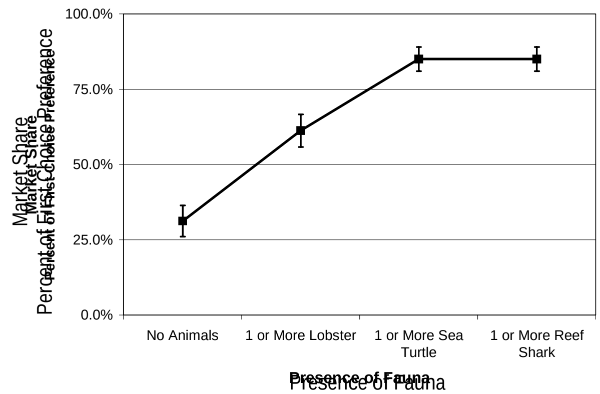

Figure 6: Small Group Dive Profile (p=$60) Market Share for Varying Levels of the Presence of Other Animals

Finally, we simulated the effect of price increases on market share for the small group profile in the absence of any other animals and with a baseline of 1-small 2.3-kg grouper. As the price of the small group dive profile increased from $40 to $60, there was a sharp decline in market share for the small group, from 91.3% (s.e. = 3.16) at $45 per dive, to 71.3% (s.e. = 5.06) at $50 per dive, to 31.3% (s.e. = 5.18) at $60 per dive. This high degree of price sensitivity in the absence of increasing environmental quality is in line with anecdotal information about dive clients from dive operators and is indicative of the price competitiveness of the dive industry in the TCI.

We can also analyze specific demographic groups using the Sawtooth market simulator. In this analysis, we conducted three market segmentation simulations: one of female versus male; one of divers under the age of 30 versus those 30 or older; and one of divers with basic SCUBA certification (resort or open water diver) versus those with advanced certifications (advanced open water or above).

We found no significant differences in market shares for divers with varying certification. Our results showed that there was a significant difference between male and female divers with regards to the price of the small group dive: when the price of the small group dive was $45, the small group market share for females was 86.7%

versus 97.1% for males (t=1.80). The difference in market shares for genders were not significant at higher prices for the small group dive.

When examining younger versus older divers, we found a significant difference in market share for the small group dive. Only 19.2% of the divers under 30 years of age chose the most expensive dive profile, compared to 53.6% of the older divers (t=3.15). In the absence of any special dive features, the older group was less price sensitive than the younger divers. In addition, there were significant differences between younger and older divers for all levels of grouper size (Figure 7). Increasing grouper size, however, added proportionally more value to the dive experience for the younger divers.

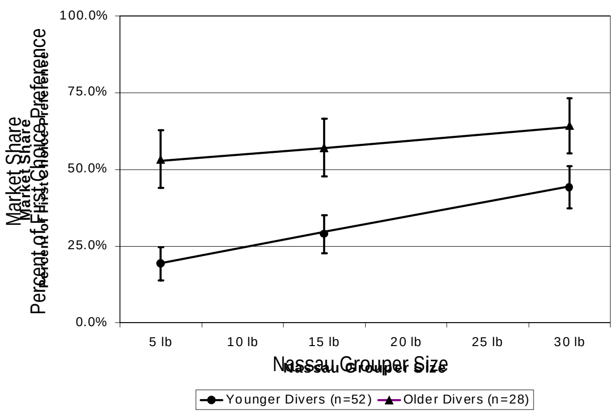

Figure 7: Grouper Size Influence on Small Group Dive Profile (p=$60) Market Share by Demographic Segment

Discussion

Lesson 1. Ecological Effectiveness of MPAs

An important lesson emerges from the South Caicos research – there can be no economic benefits of MPAs if MPAs are ecologically ineffective. This should be a straightforward truism but, unfortunately, MPA design is often guided by principles of geographic convenience or does not fully consider the complex organisms and ecological systems that MPAs are designed to protect. In South Caicos, we currently find little solid evidence of the ecological effectiveness of current MPAs due to the arbitrary design of the reserves.

In the case of spiny lobster, we believe that MPAs are likely to be an ineffective management option for the TCI. The long larval period of the spiny lobster (Lipcius and Cobb, 1994) makes it relatively unlikely that the Caicos Bank lobster population is self-recruiting. There are also complications in linking spawning and recruitment because of the myriad environmental factors that affect larval transport, settlement, and juvenile recruitment (Childress, 1997). If recruitment results from spawning in other areas of the Caribbean, there is little incentive for local fishers to invest in local conservation efforts. The participation of fishers in conservation efforts requires that they feel dependent on the resource and that they have the capacity to impact the state of the system (Mascia, 2000). In South Caicos, the first condition holds but, due to biological and institutional factors, the fishers do not seem to feel that their actions might help conserve the lobster stocks (Olguin et al., 1998). The solution for lobster conservation is likely to lie in more effective enforcement of existing size regulations rather than MPA expansion and, at a regional level, research and negotiations that implement policy at a scale appropriate to take into account the cross-border transport of spiny lobster larvae.

For queen conch, MPAs are much more likely to be effective fisheries management tools in the TCI. Conch have a short larval period (Appeldorn, 1997), so the Caicos Bank population is almost certainly self-recruiting. We suspect that queen conch disperse from core nursery grounds to deeper habitat dominated by seagrass as they grow older. If correct, this means that there should be good potential for designing MPAs that protect core nursery grounds and adjacent adult habitat, producing commercially valuable spillover to areas outside of reserves. When the link between the protection of nursery grounds and spillover benefits to the local fishery can be demonstrated, it is much more likely that fishers will actively support MPAs because it will be in their economic interest.

The ecological effectiveness of MPAs for local reef finfish is also uncertain. While evidence does suggest that size and abundance of key reef species does increase in MPAs (Murray et al., 1999), the effects of any particular MPA are highly dependent on site specific factors (Kramer and Chapman, 1999; Tupper and Juanes, 1999). Like lobster, marine fish species of commercial interest tend to have long larval phases and it is difficult to link larval output to juvenile recruitment. Nassau grouper do migrate from their home range to spawning sites and hence may spillover, for better or worse, to commercial fishing grounds along the migration path.

One issue that is clear in the TCI is the lack of protection for important spawning aggregations and migration corridors. Aggregations are highly vulnerable to fishing pressure (Russ and Alcala, 1989; Russ, 1991; Sluka et al., 1996; Sluka and Sullivan, 1997) and need protection to ensure the maintenance of long-term reproductive capacity. The larval output from aggregations may be valuable at both local and regional levels. MPAs and/or seasonal closures are thus likely to play an important role in the conservation of the stocks of important reef species like groupers, both in the TCI and beyond. For finfish, like queen conch, boundary changes to existing MPAs will be necessary to promote conservation and fishery production benefits. The exact nature of the boundary changes remains under investigation.

Lesson 2. Economic Analysis – Start with the Obvious.

A second lesson that arises from the TCI research is to start economic valuation with the obvious. We have seen that quantifying the ecological effects, and hence the consumptive use value, of MPAs is difficult for the tropical inshore environment. It is relatively easier, however, to assess any increase in size and abundance of animals within an MPA. In a country like the TCI, where tourism is the most important part of the economy, it makes logistical and economic sense to start valuation efforts by focusing on the non-consumptive use value that tourists hold for the natural environment.

Recreational activities such as snorkeling and SCUBA diving are amenable to a variety of valuation methodologies. An important aspect of tourism valuation is that it concentrates on localized spatial and temporal effects. The impacts of increased environmental quality on the reefs are of immediate economic value for snorkelers and SCUBA divers. Divers are also already paying for their experience, so the marginal value of increasing environmental quality has the very real potential of generating more revenue for dive operators or for government. Contrast this with the case of existence value: while people from around the world may hold some intrinsic value for knowing that TCI coral reef organisms are protected, the actual mechanism for transferring the consumer surplus from the beneficiary of conservation efforts (*i.e.*, people around the world) to those that bear the costs of conservation (*i.e.*, TCI residents, fishers, and dive operators) is highly problematic. The ability to relate costs and benefits at local scale is one of the key characteristics of successful renewable resource management institutions (Ostrom, 1990; Gibson et al., 2000).

Lesson 3. Non-Consumptive Use Value can be Significant.

Finally, we have learned from our analysis that the non-consumptive use value that divers hold for increased grouper size and abundance, and for the increased presence of other key reef species, is potentially large.

Increasing Nassau grouper abundance and mean size had positive effects on market share for the expensive dive group in the simulations. In the case of abundance, the net revenue increase was 13.0% for increasing from one to twelve grouper per dive (*i.e.*, the difference in total value between the baseline and target scenarios, $s_i p_i$, for market share s_i and dive price p_i, i=1-5 dive group size options). Similarly, the increase in net revenue as a result of an increase from small to large Nassau grouper was 5.6%. Simulations showed diminishing marginal utility for increases in grouper abundance but we did observe a near linear increase in market share with increasing grouper size. Based on conversations with dive operators, it appears that divers may be correlating grouper size and overall dive quality as the rarer, large Nassau grouper are indicative of unfished (Sluka et al., 1998) and therefore superior dive sites

Both reef shark and sea turtles had a large impact on market share in the simulations. This is not unexpected, as both groups of animals are among the most popular with dive tourists. The strong impact of lobster on market share, on the other hand, was unexpected. While it is known that spiny lobster aggregations are an attraction for divers in New Zealand (Kelly et al., 2000b). Our general view in the TCI had been that lobsters were of value only for consumptive use. While our results are preliminary, they are the first of which we are aware that indicate Caribbean spiny lobsters may have a quantifiable non-consumptive value for tourists.

Our survey showed that divers are relatively price insensitive when animal abundance was high but that there was strong resistance to higher prices for dives that differed only by group size. This is consistent with the experience of dive operators in the TCI; they were very cognizant of the importance of dive price as a factor in client decision making. Dive operators fully realize that maintaining reef quality – coral diversity and fish abundance – is crucial to the success of their businesses. At the same time, however, they tended to be very wary of any increases in dive price that might be caused by MPA user fees. Their caution stems from a wariness of the government's ability to actually transform MPA revenue into concrete actions to protect the reefs.

Government, on the other hand, has a mandate to manage public goods for the citizens of the TCI. As with all public goods, there are incentives for users to free-ride on the contributions of others and a tendency for society to under-produce public goods as a result (Ostrom, 1990). The emerging NPS is now funded by a 1% value-added tax on hotel accommodation and meals. Revenue for 2000 is projected at approximately $550,000, but this amount is unlikely to finance the management of all TCI MPAs (F. Homer, personal communication). Our study suggests divers hold significant untapped non-consumptive use value for environmental quality that might be used to increase production of the public goods – ecological services – provided by MPAs.

The policy challenge in the TCI is to balance the needs of rural fishers and the growing dive-tourism industry while tapping the typically unrealized and remarkable WTP for nature-based tourism (Gössling, 1999). Conservation of Nassau grouper and other key finfish species could result in a loss of revenue for artisanal fishers in the TCI. However, in the TCI a $5 increase in the price of a dive might lead to revenue of up to $750,000. Thus, the income generated through premium pricing for access to MPA dive sites might be sufficient to compensate fishers for losses of fishing opportunities due to MPA implementation as well as cover the marginal costs of expanded park operations necessary for the protection for the ecological services crucial to the competitiveness of the dive industry.

What do we yet need to fill in the balance of the ecological and economic puzzle? This survey does not provide a quantitative estimate of consumer surplus, but is a first step in that direction and has already yielded results that lend support for the view that ecologically effective MPAs are economically valuable. The logical follow-up is to develop an expanded study that is distributed to a wider audience, possibly via an exit survey at the national airport. The goal of this survey would be to quantify WTP of tourists for specific marine attributes important to their TCI experience. A broader pre-trip survey (*e.g.*, Huybers and Bennett, 2000) would also be very useful in assessing how environmental quality enters into the decision of divers to travel to the TCI and if business and government support for MPAs have value as a signal to environmentally conscious consumers interested in high-quality dive experiences.

Finally, it is clear that an increased effort must be directed to understanding the ecological systems that MPAs are meant to protect in the TCI. Understanding these systems may allow the economic valuation of increased fishery production and ecological resilience. While a full economic calculus may not be necessary to justify protection – there are indications non-consumptive use values alone may be adequate justification for MPAs in the TCI – quantifying these values can only strengthen the case for the development of ecologically functional marine parks and fishing reserves in the TCI.

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