PANEL FIVE

ECONOMIC VALUATION OF CORAL REEFS

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Economic Values of Coral Reefs: What Are the Issues?

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Our concerns for the inherent values of coral reefs—both biological and economic—are central to their conservation and use. There has been much discussion at this workshop about the importance and values that people assign to coral reefs. However, at the same time we see that coral reefs are being destroyed around the world and that reefs are not being managed in a sustainable manner.

If something is recognized for its beauty, its biological richness, its opportunities to provide goods and services to individuals and societies, why is the same resource not being better managed? Earlier this week I had a visit from Matthew Wright from Jamaica, who is doing some very useful work on the Negril coral reef system in his country. He discussed the analysis being done on the importance of the reefs to the tourism industry and the Jamaican economy, and yet there is no money from the government for protection and management

Why is this? Why do we see this dichotomy—on the one hand, the widespread expression of interest in coral reefs and their conservation and protection, and, at the same time, the lack of resources to provide even minimum levels of management?

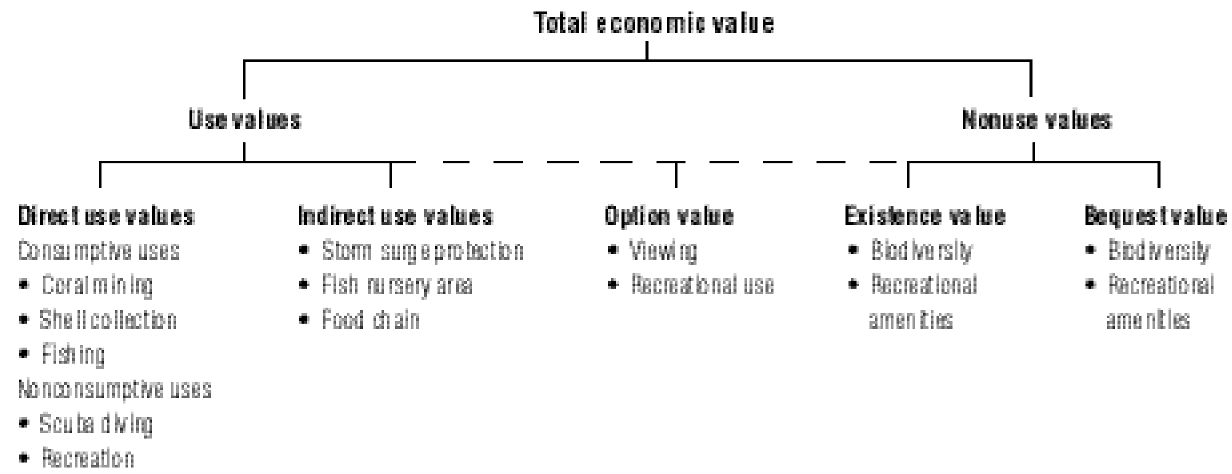
Part of the explanation for this state of affairs is the difference between economic values and monetary prices, and understanding that people and governments are often responding to monetary price signals. Economics can help explain this dichotomy. Coral reefs have been called the rain forests of the sea, and they face many of the same problems that rain forests face. We talk about the values associated with healthy rain forests and the importance of sustainable management and protection, yet we see the same widespread use of destructive practices and lack of resources for management.

Valuing the Known

A major problem, both for tropical rain forest's and for coral reefs, is that we tend to place values on what we can easily identify or see. The unknown is often assigned a value of zero—hence market forces reflect that portion of the goods and services that we can identify and can buy or sell. However, for both the rain forest and the coral reefs, there may be important values that we do not even know about yet, or ecosystem services that are only incompletely understood.

A useful theoretical construct is a concept called total economic value (TEV). This is a simple heuristic device stating that the total value of any resource is composed of different components, and some of these components are easy to identify and value, and others are either unknown or very intangible. As seen in figure 1, the components of TEV range from very concrete and marketable use values (on the left side), to uses that are more indirect, to values associated with mere existence of the resource or the possibility of leaving it for one's children. All

Figure 1. Total economic value of coral reef ecosystems



of these values are real; it is just that some are easier to measure and monetize, while others are much more difficult. The direct use values on the left side tend to be monetized and included in most calculations about the "economics" of coral reefs; the harder-to-quantify values on the right are often ignored. The sum of all of these values is called the total economic value, and this number is an economic measure, as opposed to a financial measure.

Components of Value

Think about coral reefs and their economic analysis: most analyses of coral reefs focus on a very small set of these values—frequently on the values associated with direct use of the reef and associated economic activities. These are called direct use values and may be either consumptive uses (such as collecting corals, shells, or reef fish) or nonconsumptive uses (such as recreation—snorkeling or diving—or sailing). In this case, the term *nonconsumptive* merely means that one can use the resource without destroying it; the difference is between observing reef fish as a scuba diver and catching and eating the same fish! In general, direct use values—consumptive and nonconsumptive—are unfairly easy to quantify, and we have learned a great deal about how to place monetary values on these uses. In fact, since direct use values are frequently driven by market forces and the desire to obtain a private financial return, these uses are the easiest to value. Some of these uses are destructive: for example, the collection of shells or mining of coral to produce lime. Other uses are nondestructive: recreational benefits can also be included in the calculation and may be an important form of nonconsumptive use.

In different situations, one form of direct use may be more important than another. For example, Herman Cesar discusses some very interesting results from Indonesia, where the direct use values of coral reefs—for fishing, lime production, the collection of shells, and other things—is considerable. These are all examples of consumptive, direct uses, and he estimates the financial returns to the individuals involved in each activity. In other locations, nonconsumptive uses are very important. Sport diving, a growing industry worldwide, is a nonconsumptive use of coral reefs and their associated habitat. Certain areas of Indonesia are developing into well-known scuba-diving destinations. Nonconsumptive uses have the attraction of allowing many individuals to enjoy the same resource and, with proper management, leave the resource healthy and productive.

In addition to direct use values, there are a number of other use values associated with coral reefs. Indirect use values, the second component of the TEV calculation, are important ecosystem values associated with healthy coral reefs. These include the following: the role of reefs in protecting coastal areas in times of storms; coral reefs acting as a nursery area for reef fish, and healthy reefs serving as part of the food chain for a wider range of sea creatures, including the pelagics. Many of these uses have been discussed here and are well known from the literature.

Most of these indirect uses, however, are usually not easily valued. Markets do not exist for most ecosystem services. Estimates have been made for some of these, however. One can value the catch of reef fish or other fish dependent on the reef. If the cause-effect link can be established, the calculation of monetary values is not very difficult. But what about the protective value of a reef in terms of coastal storm protection? Economic values for this service can be calculated but usually are not included in any analysis of the "value" of a coral reef. Consequently, most indirect use values are ignored when decisionmakers consider alternative uses for coral reefs.

The third type of values listed in figure 1 are option values, which are often difficult to measure. The concept of an option value is relatively straightforward: I want to protect this coral reef so that I may have the option to use it in the future. I do not know if I will or will not use it, but it is worth something to me to protect it and consequently I am willing to pay some amount of money to retain this potential future use. Option values can then be thought of as a form of deferred-use value.

Many nongovernmental organizations have been very effective in capitalizing on these feelings and mobilizing donations based on the willingness of individuals to pay for this option value. Save the humpback whale! Protect coral reefs! Or what have you. It helps, of course, if whatever you are trying to raise money for is attractive. Fortunately for coral reefs, they are beautiful and the phase "rain forest of the sea" is as much a marketing ploy as a scientific statement. Public information (TV specials, museum and aquarium exhibits, the activities of the Cousteau Society) are all very important in raising public awareness and thereby helping to create this option value. It's no coincidence that the WWF uses a panda, or the Cousteau Society uses the dolphin, as symbols. Perhaps some other species (such as a rattlesnake or sea grass beds) is in fact more important ecologically, but it is not as likely to be as useful in raising money!

The *nonuse values* on the right side of figure 1 include pure existence values and bequest values. These represent the willingness to pay by individuals or societies to maintain a resource for the future, either just so they know it is there, even if they don't plan to use it (existence value) or to leave the resource to their children or grandchildren (bequest values). Since these values are nonuse values, they involve no present-day consumption of the resource, and are therefore the most difficult to measure and value. Usually some form of survey technique is used to identify and quantify nonuse values. These values can be considerable, however, and are important in both rich and poor societies.

The components of this whole suite of values—from direct use, both consumptive and non-consumptive, all the way to existence and bequest values—are all important and form part of the total social valuation of coral reefs. Note, however, that these values do not necessarily say anything about the inherent or intrinsic biological value of coral reef ecosystems as such. Economics is a social science that is anthropocentric and places values based on people's uses (and perceptions) of any resource. Economic analysis does not do a good job of valuing biodiversity per se.

Nevertheless, the economic information contained in a total economic value calculation can be very powerful in making the case to decisionmakers and others responsible for allocating financial resources that the benefits of protecting and managing coral reefs in a sustainable manner are substantial. And since the TEV approach captures both the easily identified financial returns from direct uses of the reefs, as well as the more difficult and often nonmarketed values associated with indirect uses, option values, and nonuse values, it reminds the decisionmaker that much more total value is produced by healthy coral reefs than just those limited uses that can be easily valued using market prices and market transactions.

Minding Our Ps and Qs

The major problem in valuing coral reefs relates to identifying what are the various components of value, and what monetary prices to assign to them. Since economics is based on individuals' expressions of value, the results are usually very site-specific, and one has to be very cautious about generalizing results from one study to other, very different locations.

A recent article by Bob Costanza and colleagues on the value of the worlds' ecosystems included a "value" for the world's coral reefs (Costanza and others 1997). The estimate illustrates the danger in using the "benefit transfer" approach whereby values determined in one study are applied to other locations. In the Costanza study the estimate of the global value of coral reefs was made by taking a per hectare estimate of various use values (the *P*, or price) and multiplying it times the global area of coral reefs (the *Q*, or quantity). In this case the *Q* was 62 million hectares of coral reefs, and the total *P* was some $6,075 per hectare. Of this, fully half was attributed to recreational use: US$3,008/hectare/year. (The other large item was disturbance regulation, worth $2,750/hectare/year.) The result of this exercise was a very large estimate of the economic value of the world's coral reefs—a total of $375 billion per year. Obviously there are locations (such as well-known dive destinations like the Caymans, Bonaire, or the Red Sea) where high levels of revenues from recreational use are generated. Many of the world's coral reefs, however, are remote and little visited and do not generate this level of use (and economic value). Although flawed, this type of analysis does help to raise awareness that there are values associated with healthy coral reef ecosystems. The danger is that any economic estimates ultimately have to pass close scrutiny from the Treasury or Ministry of Planning if the results are to be believed and resources allocated for coral reef protection.

What can economists do, therefore, to make estimates that recognize the range of values associated with coral reefs and are also believable? Here it is important to introduce two concepts. Once concept central to much of environmental economics is that of externalities. Externalities are quite simple: they occur when an action that one takes has an effect on someone else, and the affected person is not part of the decisionmaking system. This leads directly to the second concept, the divergence between individual perceptions of value and societal perceptions. For example, in the Philippines, some fishermen use dynamite for blast fishing, which also destroys the reef, thereby harming others who depend on the reef via artisinal fishing or recreational diving. The blast fishing imposes an externality on the other users of the same reefs. But because the others are not part of the management process, they don't have an input into the decision to use blast fishing or an alternative measure, some of which may be much less destructive to the reef. Because of the existence of externalities, there is a divergence between private benefits and costs, and social benefits and costs. Simply put, the search for private financial gains by the blast fisherman imposes much larger costs on society. This divergence between private and social perspectives is the fundamental reason why we see so many perverse and destructive actions being taken in the use of the world's coral reefs.

The existence of externalities is a pervasive problem in the management of coral reefs. Herman Cesar, in his presentation on valuing coral reefs in Indonesia, talks about precisely this issue. He has carefully identified, in the case of Indonesian coral reefs, who benefits and who loses by each use or threat to the coral reefs. By quantifying the economic numbers involved, and the number of persons involved in each activity, he is able to point out those uses that generate large amounts of private benefits for a few individuals and also impose larger social costs on Indonesia because of externalities. By identifying these numbers, it is possible to discuss realistic management interventions. In some cases the private financial benefits are very large (for example, the live fish trade in species like the Napoleon wrasse for the Hong Kong Chinese seafood restaurant market). The number of individuals involved are few; their private gain is large. In other cases, such as coral reef mining to produce lime, the number of individuals involved is large but the per-person return is small. Each problem presents a different management challenge.

Second, the existence of externalities relates to the issue of property rights and who has rights to use coral reefs. In many traditional societies, reefs were part of the community-managed resource base. In Hawaii, for example, the traditional land management unit was called the *ahupua'a*, which was a slice of land that went from the top of the mountain down to the edge of the coral reef. Thus the individual or group who owned the *ahupua'a* owned an entire functioning ecosystem, a self-contained economic and environmental unit. Any externalities were thereby internalized, and the land managers realized that actions taken in the upper watershed (such as agricultural production or logging) would have an affect both on the water quality on the taro fields in the lower watershed well as in the coral reef and the coastal fish ponds. Since all impacts were contained within the system (with clearly defined integrated property rights), decisions were made taking these impacts into account and thereby balancing any tradeoffs involved.

The Hawaiian *ahupua'a* system is the ideal world; it very rarely exists today. Usually externalities are present, and they lead to the results that we observe: mismanagement, overuse, needless destruction of precious resources.

Some Final Cautions

Economics has a very important role to play in making the case for improved management and conservation of coral reefs. Perhaps most important, economic analysis helps to get some of the numbers on the table. Often these numbers are large and they are useful in getting attention. However, be careful in using and presenting these results. Always explain to the minister of planning or finance that the values that are identified are largely related to direct use of the coral reef—both consumptive and nonconsumptive uses—and may also include a few indirect use values.

Because of the nature of economic analysis, these values are anthropocentric and are determined by how people perceive the various benefits and costs. Consequently, those coral reef areas that are heavily visited for recreation, or have an active fishing population living around them, will appear to have much higher values than remote systems. But we also know that the remote areas may be extremely important for the health of the entire worldwide coral reef ecosystem.

Accordingly, one has to be careful not to confuse prices with true value. Economists can do a good job on estimating the prices and economic returns from different uses. However, as economists, we probably do a pretty poor job on estimating the ultimate values—and this is precisely where scientific information is crucial for effective conservation and management of coral reef systems. Conservation of some parts of a reef system can be easily justified on economic grounds—for example, one can market recreational uses. Other reefs, however, may be remote and inaccessible, or buffeted by storm surge on the windward side of islands, and are not good for recreational diving. This does not mean that they do not have values. But these values may be more difficult to estimate using the traditional tools of economic analysis.

There are a few important lessons to keep in mind when using economic analysis to estimate the economic values of coral reefs:

- Coral reef ecosystems normally contain pervasive externalities. There is often no formal connection between those taking an action and those affected by that action. This has to be recognized, because it explains most of the observed management failures. All too often, "win-win" management solutions are not being followed because the same management options are seen as "lose-win" from an individual perspective — I lose so that others can gain. This situation is exacerbated by weak or unclear property rights. And given the open-access nature of most coastal areas, it is politically very hard to assign property rights to a coral reef to any individual or group.
- Prices are often lacking or hard to measure for many of the goods or services provided by healthy coral reefs. Economists can do a

pretty good job of estimating values for some uses of coral reefs; for many others (especially indirect uses and nonuse values), however, it is much more difficult. Economics has done a great deal in the last few years, and there are many more examples of economic analyses of coral reef ecosystems. A number of these have been presented at this conference. However, because of pervasive externalities, and valuation problems, markets often fail. Coral reefs are like terrestrial protected areas. If left to market forces alone, most of the world's reefs and protected areas will be destroyed because of the externalities and weak property rights. It is therefore an appropriate, legitimate area for intervention on the part of governments as representatives of society. Therefore the three Ps are needed: Planning, Pricing and Policies. Unfortunately, without them we will see continued destruction of much of this unique, valuable and precious resource.

Reference

Costanza, Robert, and others. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387: 253–60.

Indonesian Coral Reefs: A Precious but Threatened Resource

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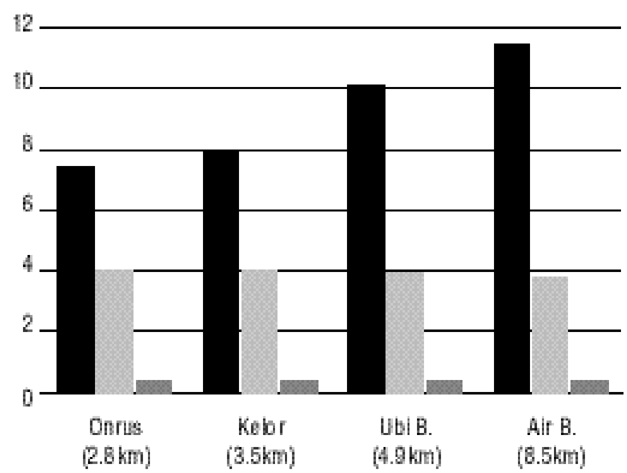
Coral reefs and their associated marine life constitute one of the greatest natural treasures of Indonesia.[1] Both their quality and their quantity are impressive: Indonesia is located at the center of the world's coral reef diversity, and, with some 75,000 square kilometers of coral, it holds approximately one-eighth of the world's coral reefs.[2] Coral reefs form the core of their livelihood for hundreds of thousands of Indonesian subsistence fishers, and are a source of food security in times of agricultural hardship. They also provide a natural barrier against wave erosion, thereby protecting coastal dwellings, agricultural land, and tourism beaches. They are a potential source of foreign exchange from divers and other marine tourists. In addition, because of their unique biodiversity, they are of great interest to scientists, students, pharmaceutical companies, and others. These and many other functions give coral reefs an important and growing value.

Despite this, the quality of coral reefs in Indonesia is declining rapidly. Even remote reefs in unpopulated areas are not free from man-induced deterioration. Anthropogenic (man-made) threats range from destructive fishery practices to pollution, and from dredging to tourism-related damages. At the moment, only 29 percent of Indonesian reefs are in good condition (that is, with more than 50 percent of live coral cover). In Ambon Bay and near the Thousand Islands, off the coast of Jakarta, once-pristine reefs have been transformed into dead wastelands over the last 20 years. Figure 1 shows this deterioration as measured by the maximum depth of live corals in four islands in Jakarta Bay.

The five main man-made threats leading to coral reef deterioration in Indonesia, are:

- *Poison fishing,* in which cyanide is squirted on coral heads to stun and capture live aquarium and food fish, but killing coral heads in the process
- *Blast fishing,* whereby small bombs are detonated in shallow reef areas, killing targeted

Figure 1. Temporal and spatial comparison of maximum depth of living coral reefs for four islands in Jakarta Bay



Source: Tomascik and others 1993; references to primary data are given in the article.

schools of fish, but also killing larvae, juveniles, and corals

- *Coral mining,* in which corals are collected and smashed for house construction and lime production
- *Sedimentation and pollution,* as a result of logging, erosion, untreated sewage, and industrial discharges, which smother and kill the corals
- *Overfishing,* which does not destroy corals but reduces abundance and diversity of fish and invertebrates.

Private Gains versus Social Costs

Powerful economic forces are driving the observed destructive patterns of coral reef use, often rendering short-term economic profits, sometimes very large, to selected individuals. Measures for coral reef protection are often presumed to conflict with economic development, and are said to require a sacrifice of economic growth. However, this study shows that this perception stems mainly from a failure to recognize the magnitude of costs to the present and future economy resulting from reef degradation. Table 1 shows estimates of the benefits to individuals and losses to society from each square kilometer of coral reef destruction, providing an economic rationale for preventive or remedial efforts. For coastal protection and tourism losses, we have given both "high" and a "low" scenario estimates, depending on the types of coastal construction and tourism potential. High-cost scenarios are indicative of sites with high tourism potential and coastal protection value. Low-cost scenarios are indicative of sites with low tourism and coastal protection value.

Some of the most important values of coral reefs, such as those to future generations and intrinsic values, cannot be quantified. However, since the economic benefits from reef destruction are often used to justify continuation of these destructive practices, quantifying the costs associated with coral reef degradation is important in making a balanced assessment of the benefits and costs of various threats. The analysis is mainly based on observable data such as the value of the decline of fish catch or expenditures by hotels on groins to temporarily prevent beach erosion. Total costs should thus be interpreted as rough estimates of the lower range of true costs associated with reef destruction. The numbers in table 1 are generated on the basis of available data, using hypothetical examples of sites subject to one individual threat.

Table 1 clearly points out the devastating economic consequences of a policy of inaction. In fact, for none of the threats do the short-term benefits even approach the long-term costs (using a 10 percent discount rate and a 25-year time horizon).[3] For example, coral mining is estimated to yield net benefits to individuals of US$121,000 per square kilometer of reef (in net present value terms), while causing net losses to society of US$93,600 in fisheries value,

Table 1. Total net benefits and losses due to threats of coral reefs
(present value; 10 percent discount rate; 25 year time span; in US$; per km^2)

	Net benefits to individuals	*Net losses to society*				
Threat/function	***Total net benefits***	***Fishery***	***Coastal protection***	***Tourism***	***Others****	***Total net losses*** *(quantifiable)*
Poison fishing	33	40	0	3-436	n.q.	43-476
Blast fishing	15	86	9-139	3-482	n.q.	98-761
Coral mining	121	94	12-260	3-482	›67.0**	176-903
Sediment/logging	98	81	_	192	n.q.	273
Sediment/urban	n.q.	n.q.	n.q.	n.q.	n.q.	n.q.
Overfishing	39	109	_	n.q.	n.q.	109

Ranges indicate sites of low and high value in terms of tourism potential and coastal protection value.
n.q. = nonquantifiable
* 'Others' includes loss of food security and biodiversity loss (nonquantifiable).
** Forest damage due to collection of wood for lime processing is estimated at US$67,000.

US$12,000 to US$260,000 in coastal protection value, US$2,900 to US$481,900 in tourism value, US$67,000 in forest damage, and unknown costs due to lost food security and biodiversity. Sometimes, the differences are even larger. For blast fishing in a high-value scenario, the costs are estimated to be more than 50 times higher than the benefits. Note that in the low-value sites, the largest cost to society is forgone fishery income, while in the high-value sites, coastal protection and tourism form the largest losses. Obviously, costs and benefits are very site-specific, and numbers will vary, depending on local circumstances.

Major Threats

Poison Fishing

With Hong Kong, China, restaurant prices as high as US$60 to US$180 per kilo for certain types of groupers and Napoleon wrasse, the wild-caught live fish trade has a gold rush-like character. Though Indonesia has only recently become involved in cyanide fishing, it is now the single largest single supplier of these fish for the Asian food market, holding more than 50 percent of the total share (Johannes and Riepen 1995) and a total value estimated at some US$200 million per year. Both in the restaurant retail business and in the older aquarium fishery, cyanide is nearly exclusively used as the "cost-effective" way of harvesting live fish. If current catch rates continue, the live-caught restaurant fish business will probably collapse economically in about four years (Johannes and Riepen 1995), as rapidly decreasing stocks in Indonesia will make remoter Pacific islands and Papua New Guinea fishing grounds more profitable.

Large-scale poison-fishing vessels operate in remote and unpopulated areas of Indonesia, leaving behind a mosaic of coral destruction. Table 2 shows estimates of costs and benefits of these operations for the whole of Indonesia, under the assumption that this business will become economically nonviable in four years because of a decline in catch rates. Rough estimates of a sustainable alternative in the form of hook-and-line live-grouper fishery, as used in

Table 2. Costs and benefits of all remaining Indonesian large-scale poison fishing and their sustainable alternative
(25-year horizon; 10% discount rate; in US$1,000,000)

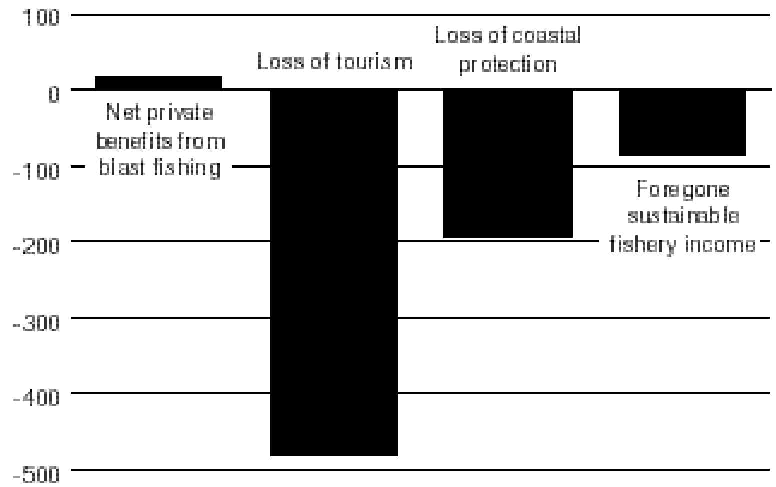
	Present *(with cyanide)*		***Sustainable*** *(with hook & line)*	
	Costs	***Benefits***	***Costs***	***Benefits***
Direct costs/benefits				
Sales of grouper		475.5		680.8
Labor	108.1		154.7	
Boat, fuel	79.2		204.2	
Cyanide	6.3		0.0	
Scuba/hookah	15.8		0.0	
Side-payment (6.7% of sales)	31.7		0.0	
Subtotal (direct)	241.2	475.5	359.0	680.8
Indirect costs/benefits				
Coastal protection	0.0		0.0	
Forgone tourism	280.2		0.0	
Hospital, mortality	n.q.		0.0	
Biodiversity, etc.	n.q.		0.0	
Subtotal (indirect)	280.2	0.0	0.0	0.0
Total costs/benefits	521.4	475.5	359.0	680.8
Net benefit to society	**-46.0**		**321.8**	

Australia and elsewhere, are also presented. Note that even in the absence of any alternative, the large-scale poison fishery creates a net quantifiable loss to Indonesia of US$46 million over four years. On the other hand, a sustainable hook-and-line fisheries option could create foreign exchange for the country, jobs for an estimated 10,000 Indonesian fishers for many years to come, and net benefits of some US$321.8 million (in present value terms).

Blast Fishing

Though forbidden in Indonesia and elsewhere, and despite the inherent dangers, homemade bombs are still a very popular fishing gear used to catch schools of reef fish and small pelagics

Figure 2. Net present value of blast fishing to individuals and associated losses to society per square kilometer of reef



and thereby "earn money the easy way." In the past, the explosive charge came from World War II bombs, though fertilizers and illegally purchased dynamite, often from civil engineering projects, are currently used. The explosion shatters the stony corals and kills fish and invertebrates in a large surrounding area. Over time, blast fishing damages the whole reef and thereby destroys the resource base of many subsistence fishers. The analysis, shown in table 1, illustrates that the costs in terms of forgone sustainable fishery income alone are nearly six times as high as the short-term gains from blast fishing (US$86,000 versus US$15,000). The other losses to society, in terms of forgone coastal protection and tourism, are even higher in areas with high tourist potential or considerable coastal construction. These losses are estimated at US$193,000 and US$482,000 respectively, as illustrated in figure 2.

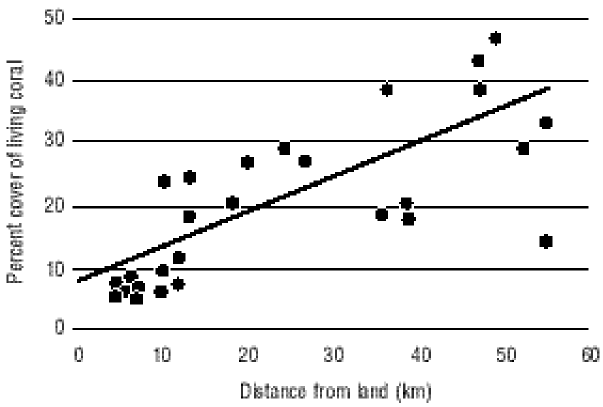
Coral Mining

Corals have long been used for building material and for the production of lime, as well as in the ornamental coral trade. The lime is often used as plaster or mixed with cement to reduce costs for private dwellings and local administrative offices. Coral mining not only destroys reef flats, and thereby its coastal protection function, but leads indirectly to logging of secondary forests, which furnish wood used for lime burning. The external economic costs of this logging are estimated at some US$67,000 per square kilometer of coral flat mined, as much as the total rent that all the miners get for this area. Coral mining used to be very widespread in Bali, where some hotels are now paying high prices (over US$100,000 a year) to mitigate the resulting beach erosion. Hotel-chain managers have learned from this and state that the status of coral reefs is currently a decisive criterion in site selection for new resorts. Mining activity is still practiced on other islands with large tourist potential, such as Lombok, where total net costs to society are estimated to be 7.5 times higher than the net benefits to individuals.

Sedimentation and Pollution

Sedimentation, both from urban areas and from logging activities, smothers corals as it prevents them from capturing sun light and plankton—their primary sources of energy and nutrition. Pollution, from both agrochemicals and industrial discharges, can also kill corals. These problems are particularly acute close to estuaries of rivers and urban centers. Figure 3 shows the correlation between live coral cover and distance from land for islands near Jakarta. For urban-induced sedimentation, no economic costs have been calculated: typically they vary dramatical-

Figure 3. Relationship between live coral cover and distance from land



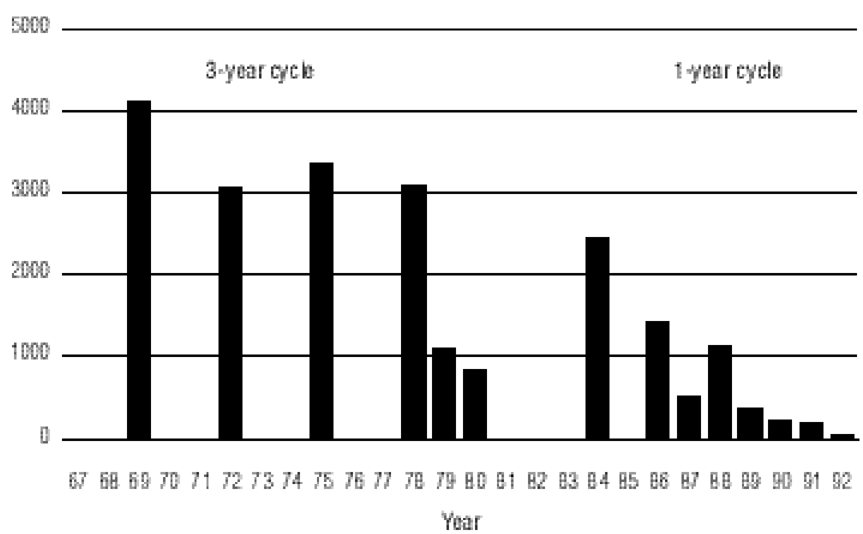
ly with the site, and reduction of discharges often has many other economic benefits (such as sanitary improvements and disease control), making the costs to corals probably minor. Estimates by Hodgson and Dixon (1988) for logging-induced sedimentation damage to a coral reef in Philippines showed costs 2.8 times higher than the associated benefits.

Overfishing

Though not necessarily as destructive as the other threats described above, overfishing does damage coral reefs, mainly through a reduction in fish diversity. It also decreases the value of corals to recreational divers, who are eager to see both large predators and an abundance of small, colorful fish. For the cost-benefit calculation of overfishing, we have abstracted from forgone tourist revenues and only estimated the loss in rent from the fishery at "open access" compared with the "maximum sustainable yield." The present value of this loss per square kilometer is US$ 70,000, as given in table 1. This means that on average, coral reef fisheries could produce an additional US$70,000 in net present value per square kilometer of reef if effective management was introduced.

In general, the necessary reduction in effort to avoid overfishing and achieve optimal sustainable yields is on the order of 60 percent (McManus and others 1992). Alternative income generation, for instance in ecotourism, could be one way of bringing about this reduction in effort. Besides lowering the total effort, fisheries management efforts should also focus on the creation of sanctuaries and the establishment of closed seasons. Figure 4 shows the dramatic difference in yield between a three-year harvesting cycle and a one-year harvesting cycle for mother-of-pearl shells (trochus) in Maluku. Note that the three-year closed seasons ending in 1978 gave an average yield of 3,400 kilograms, or

Figure 4. Yield of trochus (mother-of-pearl) in Noloth (Central Maluku) in 1969–1992
(per kilogram)



more than 1,100 kilograms per year. In the annual collection pattern followed since 1987, the average yield per year is just over 400 kilograms. Transfer of fishing rights to local communities, as well as reintroduction of traditional rights, such as the *sasisasi* system in Maluku, are other effective ways of dealing with overfishing and destructive fishing practices.

Balancing Winners and Losers

Given the high societal costs created by these threats, the question arises as to why the threat exists in the first place. Two stakeholder issues seem to be of critical importance: the size of the stakes per person, and the location of the individual causing the threat relative to the location of the threat itself. With respect to the first point, the size of the stakes per person, table 3 shows the private benefits that accrue to the various groups of stakeholders as well as to each of the persons/families/boats/companies involved. The total amount of benefit is equal to the value presented in table 1. The column marked 'Others' presents the payments to third persons, sometimes referred to as 'political rents'.

Note that the net benefits per square kilometer to individuals seem to be highest for coral mining. However, if we look at the private benefits per stakeholder (person/boat/company), poison fishing and logging-induced sedimentation have by far the highest private incentives, ranging from US$2 million per company in the case of logging to over US$ 0.4 million per boat in the case of poison fishing (in present value terms). Side-payments are also particularly high, very roughly estimated at some approximately US$0.3 million to US$1.5 million for some receivers of large payments. On the other extreme, coral mining is a very marginal activity for the families involved, though the side-payments are not negligible.

Some major caveats apply with respect to table 3: the stakes per person are calculated on the basis of man-years. For mining, where families are involved nearly full-time with this activity, this approach represents rather well the real stakes per person. But in the case of blast fishing, where many subsistence fishermen use bombs occasionally, the actual stakes involved per person are much lower than the net present value figure of US$7,300 given in table 3. For instance, if blast fishermen use bombs only once a month, rather than every day, the stakes in net present value are less than US$300 per person. A similar story holds for poison fishing, where

Table 3. Net benefits to individuals: totals and amount per stakeholder
(present value; 10% discount rate; 25 y. time-span; in 100 US$; per km2)

Threat/individual	*Fishermen*	*Miners, loggers*	*Others (payments)*	*Totals per km2*
Poison fishing	29 (467 per boat)	–	4 (317–1585 per boat)	33
Blast fishing	15 (7 per fisher)	–	n.q.	15
Mining	–	67 (1.4 per family)	54 (18-54 per person)	121
Sediment/logging	–	98 (1,990 per company)	n.q.	98
Overfishing	39 (0.2 per fisher)	–	–	39

Ranges indicate sites of low and high value in terms of tourism potential and coastal protection value.
n.q. - non quantifiable

Table 4. Size of economic stake and location of stakeholder

Location of the individual causing the threat	Size of economic stakes: Small	Size of economic stakes: Big
Insider	**Coral mining, blasting, overfishing** local threat-based approach	**Sediment** integrated coastal zone management
Outsider	**Overfishing** local threat-based approach	**Cyanide, logging** national threat-based approach

divers are often recruited for short periods of time only, a fact that results in significant overestimation of the real stakes per diver. At the same time, the overall picture that incentives differ dramatically per threat remains valid, and types of management interventions differ accordingly. In the case of urban sedimentation, especially when some large industries are involved, the stakes are probably high, though we have not been able to estimate specific stakes per person for this situation.

For the second point, the location of the individuals causing the threat, it is crucially important to distinguish between stakeholders living in the area where the threat is posed (insiders) versus stakeholders coming from elsewhere (outsiders). For instance, in the case of large-scale poison fishing operations, the captain and his crew are outsiders, as is also often the case with logging-induced sedimentation. Overfishing, on the other hand, can come from both local fishermen (insiders) as well as from outside fishermen. Population pressure and open-access problems, respectively, are often responsible for this situation. Mining and blast fishing are typically activities carried out by the local population, though large-scale explosives fishery operations do exist (Erdmann 1995).

The insider-versus-outsider issue and the size of the stakes per person are highlighted in a two-by-two matrix presented in table 4. The boxes in the matrix refer to the specific threats, such as poison fishing in the "big" and "outsider" box. Note that these are general tendencies, and there will inevitably be site-specific circumstances that form exceptions to this framework.

Designing Appropriate Policy Responses

In Jakarta, local stakeholder consultations are not very useful. If the stakes are small and there is one dominant threat, such as coral mining in some locations on West Lombok, integrated coastal zone management (ICZM) may not be necessary: a very direct approach, such as a small-scale alternative income generation project, might be the easiest way to resolve the threat. If there are multiple threats, ICZM will be the preferred solution, although outsider threats have to be dealt with separately. Based on these features, the following three general types of management approaches are defined.

Local Threat-Based Approach

If the dominant threat(s) or threats in a specific site fall under the categories "small-insider" or "small-outsider," a local threat-based approach is probably appropriate. This typically takes the form of community-based management. Examples are villages with a combination of overfishing and some blast fishing. Appropriate options include alternative income generation activities, enforcement of anti-explosives regulation, and establishment of cooperatives or other types of fishermen groups. Re-introduction of traditional common property resource management (for example, the *sasi* system in Maluku) is another possibility. In some situations provincial regulations need to be adjusted to allow for common property resource management. In cases like coral mining, ad hoc solutions might be appropriate. An example is one village in Bali that stopped coral mining completely after a local hotel offered employment as gardeners to all the mining families.

National Threat-Based Approach

In situations where the categorization "big-outsider" applies for the main threat or threats in a specific location, action at the national level is required. The clearest example is large-scale poison fishing operations, which often take place in remote and unpopulated areas. Strong initiatives at the highest national levels, involving the navy and the police, are the only way to stop this threat, as local and provincial officials are powerless in the face of these operations. Likewise, sedimentation from large-scale logging and mining operations can only be dealt with nationally, as it is at that level that the concessions are negotiated.

Integrated Coastal Zone Management

When sites cope primarily with "big-insider" situations, or if the site is confronted with an array of different threats that cannot be dealt with separately, ICZM seems appropriate. This is, for instance, the case in Manado, with a large, thriving dive tourism industry that is more and more endangered by a variety of threats, from sewage to poison fishing. Other examples might include Jakarta Bay and Ambon Bay, also with a variety of threats related to urbanization and population.

Conclusions

Coral reefs are a precious resource, with a variety of functions, such as subsistence fishery, coastal protection, tourism, and biodiversity. The Indonesian reefs are being rapidly destroyed by a number of different threats, especially poison fishing, blast fishing, coral mining, sedimentation and pollution, and overfishing.

The private benefits to individuals involved in these destructive practices are often considerable. However, the costs to society are much larger, up to a factor of 50 times higher in the case of blast fishing in tourist areas. The divergence between private benefits and social costs implies a highly inefficient outcome that calls for decisive government action to stop these threats.

The policy response to be used differs with the type of threat. In cases where the immediate stakeholders are outsiders and the stakes are big, such as large-scale poison fishing and logging operations, a national threat-based approach is called for. With large stakeholders that are mostly insiders, integrated coastal zone management will be optimal. When the stakes are small, a local threat-based approach would give the most immediate results, typically in the form of community-based management, assisted by appropriate property rights legislation and enforcement.

Notes

1. This paper, authored by Herman Cesar, Carl Gustaf Lundin, Sofia Bettencourt and John Dixon, was reproduced courtesy of the Royal Swedish Academy of Sciences, *Ambio* 26 (6), Sept. 1997.

2. The coral area of Indonesia is commonly estimated at 50,000 to 100,000 square kilometers.

3. Some claim that a lower discount rate than the opportunity cost of capital is called for, given the intergenerational character of the problem, However, this would not qualitatively change the results. Note that a 10 percent discount rate does not imply that all stakeholders will have this rate of time preference; the discount rate is only used for the welfare economic analysis.

References

Cesar, H. 1996. "Economic Analysis of Indonesian Coral Reefs." World Bank Environment Department Paper, Environment Economic Series. Agriculture Operations, Country Department III, East Asia and Pacific Region and Environment Department. Washington, D.C.

Erdmann M. 1995. "The ABC Guide to Coral Reef Fisheries in Southwest Sulawesi, Indonesia." *NAGA: The ICLARM Quarterly.*

Erdmann, M.V., and L. Pet-Soede. 1996. "How Fresh Is Too Fresh: The Live Reef Food Fish Trade in Eastern Indonesia." *NAGA: The ICLARM Quarterly.*

Hodgson, G., and J. A. Dixon, 1988. "Logging versus Fishing and Tourism in Palawan: An Environmental and Economic Analysis." Occasional Paper No. 7. East-West Environment and Policy Institute, Hawaii.

Hutomo M. 1987. "Coral Fish Resources and Their Relation to Reef Condition: Some Case Studies in Indonesian Waters." *Coral Reef*

Management in Southeast Asia, 29: 67–81.

Johannes, R. E., and M. Piepen., 1995. *Environmental, Economic, and Social Implications of the Live Reef Fish Trade in the Asia and Western Pacific.* Jakarta: The Nature Conservancy, Jakarta.

McManus, J. W. 1994. "The Spratley Islands: A Marine Park?" *Ambio* 23: 181-86.

Post, J. C., and C. G. Lundin, eds. 1996. *Guidelines for Integrated Coastal Zone Management*. Environmentally Sustainable Development Studies and Monograph Series No. 9. Washington, D.C.: World Bank.

Tomascik, T., Suharsono, and A. J. Mah., 1993. "Case Histories: A Historical Perspective of the Natural and Anthropogenic Impacts in the Indonesian Archipelago, with a Focus on the Kepulauan Seribu, Java Sea." *Proceedings of the Colloquium on Global Aspects of Coral Reefs: Health Hazards and History.* University of Miami, Florida

Cost-Effectiveness Analysis of Coral Reef Management and Protection: A Least-Cost Model for the Developing Tropics

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The primary research question that is being asked by this project is: "What is the most cost-effective means for achieving a given level of coral reef health?" The research asks a supplementary question that recognizes the operational realities of applying such analyses in the developing tropics. Notably, the research addresses the question: "How can the limited ecological data available in developing countries be used most efficiently in identifying least-cost solutions?"

Many coral reef areas in the tropics are deteriorating under heavy pressure from human and economic activities. There are many practical issues in devising cost-effective policy interventions to manage and protect coral reefs. There is also a key conceptual barrier: a lack of quantitative models to facilitate a comprehensive economic and ecological analysis of the effects of economic activity on coral reefs. This lack has made it difficult to develop a ranking of policy and investment interventions by cost-effectiveness, and thus to develop least-cost plans to manage and protect coral reefs. The central focus of this research is to develop a least-cost model of coral reef management and protection.

A key output of this model will be an optimized cost function, relating marginal costs of reef conservation to coral reef quality. The cost function can be used to identify a set of least-cost interventions for any given target of coral reef quality.

A prototype model is developed that is capable of measuring the cost-effectiveness of single policy interventions, though it is not yet capable of developing an optimized set of interventions. In the prototype model, cost-effectiveness is derived in three steps. First, a baseline is established by developing annual forecasts of economic activity and implied pollutant levels for 60 years and, on the basis of the pollutant levels and oceanographic and biotic conditions, developing annual forecasts of coral reef health. The measure of coral reef health is *coral reef abundance,* the percentage of the reef covered by live coral. Second, the total cost (as a present value) of a policy intervention is derived, along with annual pollutant levels and coral reef abundance after the policy intervention is in place. Finally, the cost-effectiveness is estimated on an annual basis, taking into account improvements in reef health over the entire period, but giving greater weight to early effects. The measure of cost-effectiveness is the unit cost of the impact of the intervention (the cost of a 1 percent increase in coral reef health).

Preliminary estimates of unit costs have been prepared for 10 policy interventions, using data loosely based on Montego Bay, Jamaica. In this case of a poor reef with potential for improvement, the key factors believed to be responsible for deterioration of the reef are sediment and nutrient loads. The most cost-effective intervention is a sewage outfall and pump station that takes the sediment beyond the reef edge. Other case studies include the south coast of Cuaraçao and the Maldives.

The dissemination strategy focuses on in-country workshops and seminars for user groups and stakeholders, government agencies, and private and nongovernmental organizations involved in coastal zone management. It also includes activities to foster cooperation among countries on coordinated environmental policies, strategies, and action plans in the coastal zone, and to provide a consultation mechanism for formulating, strengthening, harmonizing, and enforcing environmental laws and regulations. Workshops were held in Montego Bay, Jamaica, in November 1995 and March 1997, and in Curaçao in November 1995 and April 1996.

This study is complemented by another research project, Marine Resource Valuation: An Application to Coral Reefs in the Developing Tropics (ref. no. 681–05), which is deriving improved estimates of coral reef benefits to be used in conjunction with the cost function.

Responsibility

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Reports

Huber, Richard, Jack Ruitenbeek, Steve Dollar, Mark Ridgely, Frank Rijsberman, and Subodh Mathur. 1996. "A Least-Cost Model for Coral Reef Management and Protection, Phase I: A Prototype Model." World Bank, Latin America and the Caribbean, Country Department III, Washington, D.C.

Resource Analysis. 1995. "Costs Model for Waste Water Treatment, CORAL." World Bank, Latin America and the Caribbean, Country Department III, Washington, D.C.

Rijsberman, Frank, Richard Huber, Susie Westmacott, and Danielle Hirsch. 1995. "Cost-Effectiveness Analysis of Coral Reef Management and Protection: A Case Study of Curaçao." World Bank, Latin America and the Caribbean, Country Department III, Washington, DC.

Westmacott, Susie, Frank Rijsberman, and Richard Huber. 1996. "Cost-Effectiveness Analysis of Coral Reef Management and Protection: A Case Study of the Maldives." World Bank, Latin America and the Caribbean, Country Department III, Washington, D.C.

Marine System Valuation: An Application to Coral Reefs in the Developing Tropics

This project is working to develop improved methods for deriving estimates of coral reef benefits. Such estimates can be used in conjunction with the cost function being developed in a related study (Cost-Effectiveness Analysis of Coral Reef Management and Protection, ref. no. 680–08) to help in identifying an optimal set of interventions for improving coral reef health.

The project adapts and refines existing valuation methods so that they take account of the key characteristics of coral reefs and derive more accurate estimates of coral reef benefits for selected sites. To keep the analysis tractable, the study focuses on three methods for valuing the benefits: direct use valuation, contingent valuation, and marine system biodiversity valuation. The study will apply and refine each of these valuation methods and then develop a synthesized benefits function. It will also identify appropriate policy and institutional reforms for improving the capture of resource values associated with coral reefs in developing countries, and the potential role of the World Bank and other development assistance agencies in helping to effect these reforms.

The study applies direct use valuation to provide a baseline analysis of the direct use benefits accruing to the coral reefs at Curaçao and Montego Bay, Jamaica. Well-established techniques are available for estimating easily quantifiable values associated with direct consumptive and nonconsumptive uses of reefs (such as tourism, demersal fisheries, and mariculture). The study will use contingent valuation to monetize amenity and other noninstrumental uses for the coral reef site in Montego Bay, Jamaica.

The project's work on marine system biodiversity valuation will be more involved. It will require identifying appropriate physical or biophysical indicators in marine systems to which economic values might be attached, and appropriate, quantifiable indicators of biodiversity. It also will require identifying appropriate methods for marine system valuation, based on methods used for terrestrial systems, and for imputing values to natural products. Once the study has identified potential methods for marine biodiversity valuation, it will evaluate them for policy relevance, methodological soundness, operational tractability, and data availability. Up to three of the methods will then be subjected to a preliminary field test.

The dissemination strategy will focus on in-country workshops and seminars targeting those involved in coastal zone management. The workshops will provide training in conducting the contingent valuation survey and in analyzing and collecting data.

Responsibility

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Report

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Discussion

As we move toward the discussion, let me add a few of my own questions to maybe fuel the discussion we're going to have. Going from local examples, like Indonesia, Bonaire, or Jamaica, to the global scene, how does the world community value coral reefs? This is really an interesting question, because it seems that in some environmental scenes, we get from economic evaluation to action quite significantly. Take biodiversity: the GEF movement as one example, and in other cases we seem to have a harder time. So my question to you is—and I'll illustrate it very briefly, and then we'll move toward the discussion—why is it that not all environmental needs are treated equally? Some of the reasons, of course have to do with understanding, but I submit there are other reasons. And you may find this a bit absurd, but I'm saying let's look at CFCs—at ozone depletion, and why did ozone depletion get such attention, and why do we have less of the same quality of attention when it comes to coral reef and marine issues?

Let's look very briefly at some of the parallels as I would see them. We're dealing with global commons. Nations cannot go it alone, and we're dealing with something where people—in the ozone case even more so than in the marine case—had their doubts about science and was it real? Was it really relevant to us? But we got somewhere. The Montreal Protocol is one of the few, albeit small, first successes where the world community got together, found what the problem is, found a way to start addressing it throughout the world, and we're beginning to see some results. The challenge is similar, there's a time clock taking away—on ozone as on coral reefs. We need to turn this around in a few years or else we shall have lost immensely.

Now, with the CFCs, there is a recognition that the phaseout requires industrial restructuring. People were building the wrong refrigerators and air conditioning systems using the wrong gases, and you had to help them remodel their production line. Now coral reefs and marine issues facing very similar issues. They also have industries that, in a sense, drive them. There are industries that build fishing boats in certain numbers—and they sort of push into the market. There is of course the tourism, and there are the land-based sources of marine pollution. Those industries also need looking at. It's not just the nature of what's being produced, but the quantities that are wrong. But you have an entire production system that is built on this and you have an entire, very large group of people that have bought this equipment—borrowed from the banks, and need to pay back their loans. And unless there is some solution for them, unless they go fishing, they have a very hard time getting out of something which—they will real realize—in the long run is unsustainable. So my question is: Why, in your further discussions, not apply some of these positive parallels—like the Montreal Protocol, to the marine discussion and see what is driving the degradation in this particular case?

So to sum up my question, Is there a reason to discuss what is the magnitude of phaseout of the wrong marine practices? Is there a reason to discuss similar strategies as has been found in other cases? And if so, you may find it worthwhile to discuss some of this now, or in your afternoon sessions. With that let me open for discussion.

Charlotte de Fontaubert, Center for International Environmental Law: I have a question for both John Dixon and Herman Cesar about valuation of coral reef. Herman, I couldn't help but notice the big question marks in your cost-benefit analysis with regards to intrinsic value, biodiversity value, and the food security value. Whilst I'm sympathetic to the fickle nature of measuring nonuse values and option values, my question is, By not integrating these values, are you not missing a whole set of arguments that you could use with policymakers in order to give them an extra incentive to take remedial action?

John Dixon: Charlotte, you point out a very important dimension of the problem. As Herman said: what we frequently have to do is start with the most concrete and most directly measurable impacts, partly because you have a better chance, frankly, of convincing the minister of finance in the five minutes you have that it's an issue. I think you should always point out the other dimensions of value and say we know that these are very important, and we do have studies in other settings which indicate some of the magnitude of some of these values. But separate out those values that are quite concrete, and that you can measure. For the other values, we put them in qualitatively, or sometimes quantitatively. Remember you've got to convince someone who's got a lot of demands on their time and attention, and on their budget. And so we start with those uses and values that are the easiest to communicate, but always recognizing that these are only part of the whole.

Herman Cesar: The question is, Where do you stop? There are a lot of functions that we are very bad in measuring. And if you can make your point with a couple of things that are easy to measure, you might actually make a stronger point to the minister of finance than if you try to measure everything. And I agree with what John says—what you do with the others, you say: "These are other functions that are extremely important, but are very difficult to quantify, to monetize." Sometimes you can already make your point by just one or two functions and measuring them. A minister of finance is interested in tourism dollars; is interested in fisheries because that is often related to social stability of coastal communities; is interested in coastal protection because if that is destroyed that often costs a lot of money for next budget in order for the government to restore that. So those are very concrete things that he can think of in terms of his own budget line items Biodiversity, intrinsic values, and all kinds of other things—which I really believe are much more important—might not be the type of things that would help a lot in convincing the minister. So that's why you sometimes need to pick out a couple of functions that are easy to measure and that already make the point.

John Dixon: Remember that the people we are trying to convince are intelligent people, but they are skeptical too. Look at these values assigned to 62 million hectares of coral reef worldwide by Costanza. Disturbance regulation: $2,750 per hectare per year; waste treatment: $58; biological control: $5; food production: $220, recreation: $3,000. Added together you get a big number quickly—over $6,000 dollars per hectare. When you multiply that times 62 million hectares you get a very big number—over $370 billion per year. But you're talking to the minister of planning in Indonesia, or the Philippines, and he looks at these numbers and says: "Do you really think we're getting the magnitude of benefits? We have thousands of hectares of reefs that are not even visited or used at all. And you say we're getting recreational benefits—how do you know that?" If you're going to make an economic argument, make one that's reasonable and sound, and base it on realistic data. Herman Cesar tried to do this in Indonesia, where he looked at actual use values, actual practices, and gave a range of values. You can make up big numbers easily, and they will just as quickly be dismissed and then you lose your whole argument. So start with estimates that are local, concrete and add the other dimensions as appropriate.

Bill Kiene, Smithsonian Institution: This question is probably more directed to education than an economist, but it is something I've wanted to ask an economist. As a marine scientist I have studied a lot the movement of biological and geological products through reef ecosystems. And in doing so, you have direct analogies that relate to economies. I've used some of that to try and understand the way these materials function in an ecosystem, and also used it in presentations to try and describe reefs to people. The question is: Is there a potential, tangible value in using economic models—not only to try and understand how coral reefs work and understand some of the problems they are undergoing—but also potentially use the way coral reefs function as a way to understand the way economies work, and potentially use this to communicate the value of reefs to finance ministers, or CEOs, or the general public as well?

John Dixon: Economy and ecology come from the same root, *Eco,* and they are obviously linked. Getting information—whether you use a fancy model or a very simple model— is not really the issue. It's trying to present it clearly. If you think about the issue of stakeholders—of the private and social perspectives—and the externalities that exist and present the situation in a straightforward manner, it can be very powerful. When you go in and the minister of finance asks, "How important, how valuable are our coral reefs?" and you say, "Very valuable," that doesn't get you very far. If you say: "Mr. Minister, there are ten thousand jobs in this area dependent on direct use, indirect use, consumptive/nonconsumptive uses, these are threatened," these numbers strike home.

And remember: don't confuse measures of economic value with intrinsic, ultimate values—that's a separate issue. We're economists, we look at a subcomponent of the whole, although it's an important one and can be very powerful in making a case for increased resources for coral reef management.

Mary Kasha, Student, New College of Florida: I have a question about the economic value of ecotourism. Yesterday we had a panel speak to us on the various merits of ecotourism as a tool for conservation. Today, Mr. Dustin showed us some of the damages in the Florida Keys that have resulted from that type of tourism. Given that this is a use that's only renewable if we properly managed it, I wanted to ask the panel what they thought of the economic value of this type of tourism, and whether it was applicable to all regions, or whether it was region-specific?

Richard Huber: The three countries—Costa Rica, Belize, and Dominica—which are really making a go of this ecotourism, utilizing marine ecosystems are definitely sharing the benefits, and I think it's one of the several—bioprospecting is another new one that has come on the horizon like ecotourism—which are giving us more apparent economic reasons for preserving these ecosystems.

Dwight Shellman, Shellman and Ornitz: I would like to interject something that has been dawning on me through this whole series of seminar speakers. The actual improvement of the ability of economists like the panelists, to identify externalities—I think there's a missing element, and I would like to engage with other disciplines in maybe exploring it. But the problem that I see is that if we continue to permit externalities to remain external, this will continue to be a public policy discussion. Mr. Cesar's overlay makes an excellent point, and that is, one way to deal with these externalities is to internalize them. And the discipline that is missing here is the legal discipline.

If you look at the people taking the losses—if an American trial lawyer, or an ambulance chaser would look at that scenario, what you would see in many cases is a clientele who has sustained a damage of huge magnitude. And probably, some participants in creating that damage, which would likely be American or multinational corporations who are buying products, that would have deep pockets that would be available to reimburse the losers. And I would suggest that one way to connect the linkage here of internalizing what are now externalities, is to find a case where the taking—that is, demonstrated by those externalities from some population is actually charged back to a corporation to where it either shows up in their balance sheet as a real liability, or as a contingent liability, or as reflected in their insurance policies. So I throw that out as something that I would be happy to explore with others, but I think the state of economic science is improving very rapidly.

Vaughan Davidson: He's right. The first part of my life I was a CPA with Arthur Andersen, involved in audits on a global basis. The last four years I've been on sabbatical. I have a foundation. I'm a trustee with a couple of other people. What I see here is that no one's accruing these costs at the front end. The numbers of plain present value—they don't work in this kind of transaction. Anytime you play with present value, you bring in a number—it's going to be almost zero so many years out. The cost that your creating or occurring the moment you [inaudible] into the river—it's over. So you've got to stop it at the front. The cost should be accrued in total up front, because there's no plan to cover it. What I would contend is like he indicated, we've got to accrue the expenses to match the revenue, otherwise as a value analysis it's bogus. You're not matching costs and expenses. And all the financial statements in the world play with costs and expenses and revenue matched up. That's how the market works, that's how the valuation works. This case is the first time I've ever seen—sitting here this morning—you're not matching costs. You've got bogus numbers. Somebody's missing a big piece here. It's amazing.

Richard Huber: The question, of course, is the value to whom? Not just spatially according to various countries, but in terms of generations into generational value. And it seems to me that that part of the exercise—of being able to increase sophistication of the ability to make these kinds of evaluations is, and part of the charge to economic institutions such as the World Bank—is to include longer-range planning. These may be costs to you, maybe not today, but sometime in the not too distant future.

Maritta Koch-Weser: Just as a clarification, when you say "cost to you," do you mean individual governments, or do you mean the global community?

Richard Huber: I would say both.

Audience question: I'm a marine biologist. I've been reading this work of Dr. Dixon and many others. My question is related to certain observations reported here from Jamaica, also Indonesia. It seems to me that there's a lot of information, scientific data is coming into this calculation. I think that's the right thing, that without that without proper, accurate scientific data it is not possible to valuate a resource, in fact, in economic terms. My question is that how far, and in what way is the data, which has been reported on sedimentation (in the Indonesian case) in pollution (in Jamaica) has been accumulated, gathered. Is there any closer interaction, or are the economics just based on published data—whether it is related to the economic activity or based on previous data—whether the scientific data is related to the economic activity in terms of time and space. I have also noted that contingent valuation and other methods have been used to come to certain valuations. Economic value, particularly in the case of the Jamaican waters, Montego Bay—how far has contingent valuation have considered to be, in economic terms, really reliable?

John Dixon: Many issues were raised by the previous speakers—a number of them will be discussed in more detail in the afternoon session. Basically, the economic analysis presented here included costs and benefits as they occurred—this is the correct way to do it, and it was done correctly. I want to respond to Maritta's original question. If we could mobilize the world community to control CFCs, why not for coral reefs? There are parallels—both are global commons. But the big difference is the number of actors involved for CFCs where you have a dozen producers worldwide. And you can pay them off, because it doesn't affect anything. Whether I make a foam cup using a CFC or something else doesn't matter because I get the product I want. Whether my refrigerator uses CFCs or more ozone friendly product doesn't matter—I get the service I want. But when you're dealing with coral reefs, you've got people who are living, existing off of their management—catching fish, mining the coral. And as Herman Cesar very clearly pointed out in his study, the magnitude of benefits to individuals can be very high. And so the management challenges are much harder. A global effort may well be needed, but it's a lot more difficult to affect ten thousand Indonesian coral miners, or a million artisanal fisherman than it is to negotiate with twelve producers of CFCs worldwide.

Herman Cesar: The reason for economic analysis or economic valuation as I see it is two. One is to show some numbers and show that destructive practices often, from a true economic point of view, don't make sense. And if you look at the impact of John Dixon and Greg Hodgson's study on Palawan in the Philippines that was done in 1988, in the Philippines the impact of this study—in terms of actually having shifted some of the political agenda and the political will—is still enormous. All of the NGOs there still talk about the study, not because the numbers were correct, but because it was so instrumental in trying to get a very simple point across. And secondly, the reason is to actually look at the individual stakeholders and what is driving the system, and that is crucial information if you want to go to an actual management plan. You want to know who is gaining now and how much, and it also comes back to Maritta's point. Maybe it is wrong that there are all these fishing boats, but they are there, and these people are paying off their debts, and you damn well take that into account in your analysis if you want to get to a system that makes everyone better off, and that's the only way to change something. That gives an idea of what you have to do for which people for your management plan. So I see those as the two key issues, and whether everything is taken into account or not, that is, to me, a much less relevant point.

Richard Huber: Relative to empirical data—absolutely—if we don't have empirical data, if we're not going in with good data that the coral reef biologists [use]— the transects, the species diversity, the abundance and percent recruitment—what we're doing is just folklore; it's worthless. So most of the modeling that we've been talking about is basically gathering significant information from local stakeholders, and coral reef biologists, putting this together into an economic model. And without that, for example in Montego Bay [Jamaica], we had a wealth of data—the Nature Conservancy had recently done a rapid ecological appraisal. Rolf Bak, one of the world-renowned coral reef experts, in Curaçao has spent his life specifically looking at those reefs, so we've had volumes of data, and that's extremely important if any of this is going to be meaningful.

Is contingent valuation reliable? That's a good question. It's a really useful tool; I'm glad we have it. There's a lot of skeptics out there. I think we can continue to refine it, and it will be very valuable for us in the future for valuing the benefits of marine ecosystems.