Marine Policy ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

A new typology of benefits derived from marine protected areas

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ARTICLE INFO

Article history:
Received 19 November 2009
Accepted 7 December 2009

Keywords:
Marine protected areas
Ecosystem-based management
Economic valuation

ABSTRACT

Global decline of marine resources has triggered a worldwide demand for changing the way ocean resources are managed. Ecosystem-based management approaches have emerged using marine protected areas (MPA) as the main tool. Several classifications of marine protected areas benefits have been made, but all have focused only on the benefits to humans, neglecting many important benefits accrued to nature. This paper presents a new comprehensive classification of MPA benefits that will provide scientists and managers with an inclusive framework to accurately identify and account for all possible benefits derived from MPAs. The paper also analyses the methods available for valuing these benefits. A total of 99 benefits were identified within nine main categories: fishery, non-fishery, management, education/research, cultural, process, ecosystem, population and species benefits. These categories are arranged in two main divisions (direct and indirect benefits), which, at the same time, fall within the realms of benefits to humans and to nature.

1. Introduction

Recurring management failures and the global decline of marine resources have triggered a worldwide demand for change in the way coastal and ocean resources are managed [1–3]. Traditionally management measures have tended to be reactive and sectorial, allowing a great margin for malfunctions. Conversely, proactive and integrated approaches are becoming more relevant, and as a result a change to ecosystem-based management is taking place [1,4,5].

The ecosystem-based approach to natural resource management combines ecological, social and economic considerations toward achieving the goal of the sustainable use of natural resources. According to Slocombe [6], this approach relies upon the following principles:

1. partnerships and citizen participation;
2. science-based approach;
3. long-term goals;
4. comprehensive perspective.

Based upon these principles, ecosystem-based management requires a genuine and meaningful relationship between stakeholders to correctly address issues, identify opportunities and find common solutions that truly support economic prosperity, lasting livelihoods and ecological health and sustainability. The management process must be based on, and make optimum use of, the best available scientific knowledge (ecological, social and economic) as a foundation for the decision-making process, which in turn should establish targets and long-term goals to ensure the preservation of ecosystem conditions that sustain public benefits and opportunities into the future. Finally, management has to be a learning process in which decisions are continuously reviewed and revised so that decision making is not paralyzed by uncertainty. It must adapt to changes in social values, environmental conditions, political pressures and available knowledge.

Despite the obvious advantages of ecosystem-based management, its operationalization is still far from achievement. To guarantee good long-term outcomes, implementation of the ecosystem-based management approach should take place at a global scale. Unfortunately, current socioeconomic issues in the international arena do not allow for its worldwide application, for example, poverty, discrepancies in levels of economic and political development, wars, etc. Credit should be given, however, to many national and regional initiatives that look to implement such an approach: for example, Sabana-Camagüey Archipelago, Cuba [7]; Australia's representative system of marine protected areas [8] and the North Sea basin [9]. There are other significant limitations to ecosystem-based management such as: governmental and institutional inertia to the change, inadequate legal frameworks, socioeconomic constraints (e.g., dictatorial societies that obstruct open public participation) and significant lack of knowledge and uncertainty about nature's functioning.

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0308-597X/$ - see front matter © 2009 Published by Elsevier Ltd.
doi:10.1016/j.marpol.2009.12.002

On the positive side, there has been increasing international support for this approach. Several international "soft" laws have been enacted to encourage a change in marine management approaches by explicitly recognizing that the marine environment is an "integrated whole that is an essential component of global life-support system and a positive asset that presents opportunities for sustainable development" and calling for "new approaches to marine and coastal area management and development … that are integrated in content" [10]. In the decade since then, the marine protected area (MPA) has emerged as the "new approach" of choice.

Marine protected areas (MPAs) are an important component of the ecosystem-based approach to conserving marine resources [11,12]. They can be implemented in a great range of economic and social conditions, and exist in a wide array of designs [13,14]. MPAs provide a legal and institutional framework to deal with the complex problems that exist in coastal zones [1,5,15–18] fostering achievement of the sustainable development paradigm [11,14,19,20].

Despite worldwide agreement with all the elements presented above, the question of how truly effective MPAs are still remains as a challenge for managers and scientists [21]. According to Kelleher and Recchia [22] and Kelleher [13] an MPA must clearly define objectives against which its performance is regularly checked using a monitoring program to assess management effectiveness. Management should be adaptative, meaning that it is periodically reviewed and revised as guided by the results of monitoring. Evidently, by following this model, managers should be able to assess MPA effectiveness, but the real world situation is different. Many MPAs have been promoted by international and national donor agencies following an agenda that usually does not match national/local interests or capabilities. These donor agencies have been promulgating a universal recipe based on the dubious assumption that "one size fits all". Many countries have embarked on MPA initiatives without the necessary legal and institutional framework [21,23,24]. A top-down approach to MPA implementation has dominated the international scenario [23]. Socio-economic issues have had a secondary relevance for many MPA initiatives; they have mainly been based on ecological considerations [13]. Consequently, many promising MPA programs have failed, and their potential as a management tool has been compromised.

To fully assess the success of MPAs, national governments or any other entity responsible for MPA implementation have to be able to clearly identify all possible benefits that may accrue from the MPA and from that point clearly state their objectives. Consequently, this paper aims at providing managers and decision-makers with a typology of MPA benefits that allows them to fully identify, classify and ultimately valuate the benefits provided by MPAs.

2. A typology of MPA benefits

Misunderstanding of management objectives has prevented MPA managers from accurately assessing their effectiveness [12]. This lack of clear evidence for human and non-human benefit maximization within MPA programs has resulted in wastage of money and time, loss of financial support and, more importantly, loss of public confidence. The comprehension that benefits should constitute the management objectives for MPAs makes the issue of definition and identification of ecosystem goods and services, as separate items, very important within the MPA domain. Accordingly, I consider ecosystem goods as the direct and often measurable items, such as food, raw materials (minerals, medicinal components) and aesthetic and cultural values that accrued directly to users of the MPA. Ecosystem services are indirect and often hard-to-measure processes (ecosystem functions) that support life on the planet (e.g. climate regulation, shore protection from erosion, nutrient cycle).

Numerous authors have attempted to classify all the possible benefits derived from MPAs [15,25–29] and from natural ecosystems as a whole [30–32]. This has not been an easy task, given the fast growing marine uses that entail new future benefits from MPAs. To the present, most benefit classification studies have only focused on human-related benefits, ignoring many important benefits accrued to nature. These benefits to nature are indeed as important as anthropocentric benefits because human life itself ultimately depends on them. Also, this human-centered approach is based on the fact that current benefit valuation methods only account for dollar-based values of MPA benefits, rarely taking into account other measurable benefits, for instance the number of species protected or the total area of habitat conserved.

Dixon and Sherman [31] provided a classification of benefits derived from PAs. According to these authors, benefits are associated with each type of PA, and therefore they "flow" from conservation objectives. They grouped benefits into eight main categories. Within each category a series of specific benefits can be allocated. Rodwell and Roberts [33] provide a similar classification:

- recreation/tourism;
- watershed protection;
- ecological processes;
- biodiversity;
- education and research.
- consumptive benefits;
- non-consumptive benefits;
- future values.

There are some shortcomings in this typology. First, MPAs are not only established for conservation objectives; sustainable resource exploitation is also considered an objective for MPAs (e.g. fishery reserves are established to sustain commercially important populations of fish that are exploited). Second, benefits should be treated as management objectives themselves, not simply as assumed outcomes of an MPA's existence. If erroneous, this assumption may impede appropriate evaluation of MPA effectiveness. Finally, the categories for benefit classification tend to be fuzzy and repetitive. For instance, the first five categories seem correct, but they all fall within the seventh category. The same problem arises with the last category, future use, which can be grouped in both the consumptive or non-consumptive benefit categories. In my opinion, these last two categories should have been the starting point for a hierarchical benefit classification.

Costanza et al. [30] provided a list of 17 major ecosystem services, which represent benefits to humans. Contrary to Dixon and Sherman [31], they did not categorize the benefits. This work constitutes the first attempt to put a monetary value on the world's ecosystems. Although there are several inherent conceptual and empirical problems with their approach, which the authors recognized, this work represents a meaningful effort to provide managers and decision-makers with key information to internalize environmental costs in their management models.

One of the most comprehensive classifications of MPA benefits is provided in the marine reserve benefits statement by Sobel [27]. It identifies a total of 69 MPA benefits organized into four main categories:

- protect ecosystem structure, function and integrity;
- improve fishery yields;

Please cite this article as: Angulo-Valdés JA, Hatcher BG. A new typology of benefits derived from marine protected areas. Marine Policy (2009), doi:10.1016/j.marpol.2009.12.002

- expand knowledge and understanding of marine systems;
- enhance non-consumptive opportunities.

This classification is far more useful than the one proposed by Dixon and Sherman [31]. The categories are inclusive and clear. In this, case benefits are arranged within well-defined categories with little repetition or fuzziness. Also, both conservation and exploitation objectives are fully integrated within this classification model.

Following this work, Bohnsack [26] discussed some fishery and non-fishery benefits that MPAs could provide. Many of the listed benefits were the result of empirical evidence and logical thinking, and the author called for more scientific research. He categorized fishery benefits according to their level of scientific support: well supported, partially supported and unproven or inadequately tested. On the other hand, classification of what he called non-fishery benefits was done following three categories extracted from Sobel [27]:

- protect ecosystem structure, function and integrity;
- increase knowledge and understanding of marine ecosystems;
- improve non-consumptive opportunities.

Within these categories, he identified a total of 31 benefits, which have a great deal of resemblance to those provided by Dixon and Sherman [31], Sobel [27] and Costanza et al. [30]. Bohnsack's work could be considered an extension of Sobel's [27]. The difference here is that Bohnsack paid special attention to fishery-related benefits, which have been claimed as most important for MPA establishment.

The National Academy of Science [11] provided a benefit classification in which the benefits are expressed in the goals of MPA establishment. Therefore, benefit achievement depends on the fulfillment of the stated goals. According to National Academy of Science [11], marine systems are able to provide a wide range of direct and indirect benefits to humans, even without exploitation of natural resources. The National Academy of Science classification of benefits has an anthropocentric origin because it accounts for direct and indirect revenues accrued by humans. Direct benefits are mainly based on ecosystem goods and include on-site extractive uses (e.g., fisheries, mining, medical compounds) and on-site non-extractive uses (SCUBA diving, bird and whale watching).

Indirect benefits, on the other hand, are mostly based on ecosystem services and are accrued by individuals who do not use the marine ecosystem directly, but have some interest in its protection (e.g., people who live on shoreline protected from waves by intact coral reefs in MPAs; people who derive spiritual benefits from knowing that a preserved marine environment exists). These indirect benefits are very relevant because they can be essential for human existence. They include the role of marine ecosystems in stabilizing regional and global climates, coastal protection, sequestration of pollutants, biological and chemical processes that remove atmospheric carbon dioxide, produce oxygen and moderate global temperatures [34].

In general it can be said that there is a worldwide consensus on the benefits MPAs can provide; the point relies, however, on the classification of those benefits. Most authors have preferred to use classification systems that are anthropocentric, while few have considered more ecocentric models. Even though, that there is nothing wrong with these two models individually, it would be useful to develop a new classification model that merges both approaches. The goal is to build from existing work to produce a comprehensive typology of benefits from MPAs that allows researchers and managers to more easily recognize and value these benefits. The rationale for this goal includes the facts that:

(a) Most previous initiatives have had an anthropocentric perspective; therefore, all benefits and values have been described without accounting for benefits to the rest of nature.
(b) The current valuation methods only account for dollar-based values of MPA benefits, failing to account for other "measurable" benefits, such as number of species protected or total area of important habitat conserved.
(c) The evaluation of the effectiveness of MPA management requires that all possible benefits be clearly identified beforehand, and related to management objectives.
(d) The more recognition and appropriation of benefits by individuals, the more likely those individuals will lobby for legislation and comply with rules supporting MPAs.

A total of 99 benefits are identified in this study and divided into two main classes: those accruing to humans and those accruing to the rest of nature (Table 1). This classification includes major past studies and thus it is more comprehensive than previously developed classifications. It is also based on a new classification approach from a less anthropocentric perspective.

Within the human benefits category, a further division is made between direct and indirect benefits. Direct benefits are provided mainly by ecosystem goods, while indirect benefits are generally derived from ecosystem services. This division leads us to identify more specific categories (fishery benefits, non-fishery benefits, management benefits, educational/research benefits and cultural benefits).

Direct benefits are further subdivided into two main categories: fishery-related benefits and non-fishery-related benefits. These benefits represent extractive and non-extractive uses of marine resources from which human beings obtain direct and indirect economic revenues. As its name indicates, fishery benefits are those related to fishing activities, and it is notable that they account for 16.1% of all 99 identified benefits. This should not be a surprise since more than the 50% of the scientific literature devoted to MPAs deals with fishery issues. Alder [23], Boersma and Parrish [35], McClanahan [24] and Suuronen et al. [36] have stated that the main support for MPA establishment worldwide has been fishery management, although biodiversity conservation also accounts significantly. Other authors have claimed that the role of MPAs in fishery protection and enhancement is the issue of foremost interest worldwide [2,29,35,37–44]. Despite the fact that true fishery benefits from MPAs have very rarely been unequivocally demonstrated [2,18,29,45], MPAs have been extensively promoted as alternative fishery management tools that enhance fishery yields [35,44,46–51].

Under the non-fishery benefits category fall all other existing marine uses. They include extractive uses such as: mineral and sand mining, seaweed harvesting, coral collection for construction and the non-extractive uses such as SCUBA diving, whale and bird watching, site-seeing of natural areas, and the like. My intention in designating this very broad category is to identify the main benefits expected beyond the fisheries. Many other non-fishery benefits will be identified as MPA uses broaden [11].

Tourism development constitutes a key set of benefits in the non-fishery category that deserve some attention. In the last decade there has been a rapid escalation of tourism-based activities undertaken within MPAs [52], reflecting the common necessity for multiple uses beyond strict resource conservation, towards sustainable resource use. Thoroughly protected MPAs offer pristine habitats that are in high demand by tourists.

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Table 1
Classification of marine protected area benefits[a].

MPA benefits								
To humans					To nature			
Direct		Indirect/off site						
Fishery benefits	Non-fishery benefits	Management benefits	Education/Research benefits	Cultural benefits	Process benefits	Ecosystem benefits	Population benefits	Species benefits
Protect spawning stocks	Allow harvesting of renewable and non-renewable resources	Reduce use and user conflicts.	Improve understanding of natural systems	Improve peace-of-mind	Allow for suitable nutrient cycles	Eliminate second order impacts	Protect natural population structure and functioning.	Protect keystone and dominant species
Increase population fecundity	Expand non-consumptive recreation opportunities (SCUBA, ecotourism)	Reduce incidental and bycatch mortality.	Provide educational opportunities	Enhance aesthetic experiences and opportunities	Protect from coastal erosion	Maximize ecosystem resilience	Protect genetic resources and diversity	Prevent loss of vulnerable species
Foster reproductive capacity	Enhance and diversify economic activities	Reduce variance in yields.	Allow knowledge permanence of undisturbed sites	Foster constructive social activities	Provide physical refuge	Preserve natural communities composition and functioning	Restore population size and age structure	Sustain species presence and abundance
Provide undisturbed spawning sites	Increase wilderness opportunities	Maintain diversity of fishing opportunities.	Provide cumulative understanding from multiple studies at one site over time	Promote spiritual relations and development	Maintain global climate regulation	Ensure biodiversity protection	Protect spawning populations (commercial and non-commercial)	Prevent loss of rare species
Ensure viable spawning conditions	Promote alternative employment opportunities	Allow opportunities for mariculture.	Allow research, monitoring and data collection from untouched sites	Enhance conservation appreciation	Avoid physical damage to habitats	Prevent cascading ecosystem effects	Increase survival rate for juveniles and adults	Protect long-lived species (sea turtles
Improve spawning habitats	Strengthen property and liability rights	Facilitate and simplify enforcement and compliance.	Provide control areas for assessing human-induced impacts	Promote international relations and cooperation	Sustain evolutionary processes	Maintain trophic structure and food web	Increase natural recruitment	Protect slow-growth species
Enhance eggs and larvae production	Broaden and strengthen economy	Improve management and efficiency.	Reduce risks to long-term experiments	Provide foundation to increase public awareness and compliance	Protect critical habitats	Maintain key areas (reproductive, nursery, feeding)	Allow recovery of depleted populations	Protect low-reproductive species
Provide export of egg and larvae	Enhance other forms of income generation	Insure against management failures.	Enhance synergy from cumulative studies	Promote concern for future generations.	Maintain biological diversity	Allow for ecosystem recovery	Increase reproductive outputs	Allow for complete species interaction
Build up fishery recruitment	Protect attractive habitats for tourism	Facilitate stakeholder involvement.	Provide long-term monitoring areas	Improve aesthetic values	Allow for the transformation, detoxification and sequestration of pollutants			Protect migratory species
Support sport trophy fisheries		Reduce possibility of irresponsible development	Maintain memory of natural ecosystems	Preserve and expand historical knowledge				Restore species abundance and biomass
Allow for spillover of adults and juveniles		Promote holistic approach to management	Provide sites for enhanced primary and adult education	Facilitate cultural resource management				Restore species diversity
Increase abundance of overfished stocks (inside and outside the reserve)		Promote bases for ecosystem management.	Provide sites for high-level graduate education					
Reduce overfishing			Provide undisturbed areas for particular experiments					
Increase spawning stock biomass			Preserve archeological sites					
Enhance spawning density			Provide biological information from unfished populations					
Diminish fishery-related genetic impacts								

[a] Adapted from National Academy of Science [11], Bohnsack [26], Sobel [27], Costanza et al. [30], Dixon and Sherman [31].

Symmetrically, tourism provides a crucial means of financing MPAs, and may keep more damaging forms of development away from sensitive marine environments. Of course, too much tourism development can produce very negative change in marine ecosystems in MPAs. Several examples of SCUBA diving impacts on coral reefs have partially demonstrated this [17,53,54]. Still lacking, however, are comprehensive studies that measure the degree of compatibility between tourism activities and the long-term existence of MPA benefits. Such studies should shed light on the modes and magnitudes of tourism activity that should be allowed within MPAs as well as the actual and potential impacts that these activities have on the biological, economic and social components of MPAs.

The indirect benefit category encompasses those that accrue to individuals who do not use the protected marine ecosystem directly. Two specific sub-categories are identified here: educational-research and cultural benefits. The combination of research and educational benefits in one category should not be interpreted to mean they are the same thing, despite obvious linkages. Research results can extend beyond the education ambit to encompass knowledge acquisition and adaptative management. Nonetheless, for the sake of simplicity in the model these two are considered together, and account for 15.1% of the total number of benefits identified. Educational-research benefits play a key role in MPAs management. Among other things, they provide the major source of information upon which to adapt management and shape people's understanding and awareness that ultimately enhance cultural benefits. Improved comprehension of nature's functioning, in turn allows for the better implementation of an ecosystem-based approach in the management process.

The relevance of cultural benefits derived from MPAs is expressed in the role they play in the development of biocentric values among human populations. The degree to which nature is valued for its own sake is a function of people's beliefs about their relationship with nature. These beliefs are critical for explaining the adaptations of human cultures to their local, regional and global environments, and also to explain the development of a conservation ethic towards natural resources. A clear example of this is given by Dunlap et al.'s [55] finding in a 24-nation poll that 50% of people chose environmental protection over economic benefits. It has been demonstrated that people fully committed to nature conservation can play a significant role in supporting MPAs because of their influence on regulatory policies for nature conservation enacted by governments. It follows that cultural benefits are ultimately responsible for the acceptance of MPAs by society.

Management benefits of MPAs have thus far been left out of the analysis of direct and indirect benefit categories. This is because management benefits are generally both direct and indirect in nature (graphically represented by a shade of gray in the management cell of Table 1). For instance, the reduction of incidental fishing mortality (by catch) may have a positive effect on the Catch per Unit of Effort index (CPUE), resulting in an increase in revenues that constitute a direct benefit to humans. On the other hand, the management benefit of promoting foundation for ecosystem management clearly forms part of the indirect benefits that helps in the enhancement of people's understanding and compliance with MPAs and in the development of the management process itself. Similar analysis can be done with the rest of the benefits identified within this category. It should be clear to the reader that benefits identified here are neither inclusive nor final; many more can be recognized and added to the list.

Four main categories of benefits to nature are identified: process benefits, ecosystem benefits, population benefits and species benefits. These categories attempt to cover all possible benefit recipients in the non-human "world", including biotic and abiotic elements. Despite the undisputed links between the population and species categories, these two are separated by the different ecological footprints and economic relevance that each one has.

Most of the benefits included within these categories present indirect but vital links to humans. For instance, many of them represent indirect benefits essential for the survival of human beings (i.e. global climate regulation, shore protection, recovery of depleted populations on which humans live). Although the shade of gray is the same as the one used for indirect-benefit categories, it does not imply that all benefits to nature should automatically be considered indirect benefits to humans.

Natural benefits are ultimately responsible for an MPA's existence and have extensively been used to promote MPA initiatives. Unfortunately, the fact that most of them have not been successfully demonstrated and have not been included in valuation studies, due to their non-market character, has provoked poor social compliance with MPAs. It is obvious that more research is needed to determine the real magnitude of these benefits, and how to assign them a monetary value for inclusion in economic models.

Two more general comments should not escape readers' attention. First, all benefits identified in Table 1 have not been completely demonstrated. Indeed, most of them are the result of logical thinking and theoretical analysis rather than empirical evidence. Only 33% of the identified benefits actually enjoy well-supported evidence in the scientific literature, while the remaining 67% have only partial support or no support at all [11,26]. Needless to say the "lucky" 33% encompass most of the direct benefits. Second, as a result of biased human analysis models, a mere 30% of the benefits are actually taken into consideration in valuation studies, leaving out an impressive 70% of them. This huge disproportion is the result of:

(a) An anthropocentric approach to the assessment of MPA benefits.
(b) Imperfections of the current human economic valuation system that do not internalize environmental issues.
(c) Current methods of analysis that only account for market-based benefits.

Due to these limitations a great deal of information has been left out of past analysis and this has, in turn, left scientists and managers with few options to accurately assess MPA effectiveness. A clear need for integrative research is obvious, and a thorough revision of current valuation methods and models is also necessary, if MPAs are to be legitimately claimed as the best tool for the sustainable development paradigm in the marine realm.

In this regard the last part of this paper is devoted to succinctly describing existing benefit valuation methods, assessing their relationships to already identify benefits, and to provide a benefit valuation framework that allows MPAs managers to assess their effectiveness.

3. Valuation methods

Perhaps one reason why the marine environment has been so degraded by human activities is because we have not been able to fully understand its true value. This "human mistake" has its roots, in part, in the fact that we take what we have for granted; and in part because our economic valuation system does not account for values not directly related to the market. This fact has also been called "market failure" [31,56]. Many other factors are

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also responsible for market failures but those will not be analyzed in this paper (for a comprehensive review of these factors, refer to [31]). Marine conservation has traditionally been based on ecological concerns and goals. However, as human pressures on marine and coastal ecosystems have intensified, so economic approaches have started to play a key role in the establishment and operation of MPAs. Particularly, it has been recognized that issues such as financial viability and economic sustainability are of central importance to the success of MPAs [14].

Valuation is the process of putting a monetary value on goods and services [57]. This process has been an essential part in human life, and has been considered a rather straightforward task when goods and services are sold in the market.

There are three major factors that make valuation of MPA benefits a complex task. Firstly, ethical concerns probably create the biggest problem when valuing the environment. Many people simply believe that it is immoral to put a price tag on nature, thus making it more difficult to do value estimation [11,30,58–61]. Secondly, market failure or market imperfection is responsible for distorted market prices that do not reflect the true value of these benefits [14,31,58]. Thirdly, current valuation methods are based on market prices only, making it impossible to account for benefits that are not quantifiable in monetary forms (e.g., number of endangered species protected, total area of critical habitat protected, environmental knowledge acquire by MPA visitors and the general public). Despite these shortcomings, there is an increasing demand to counter development schemes (e.g., coastal tourism, mariculture, fisheries) that promise large financial returns, with solid arguments based on valuations of the social and economic benefits provided by MPAs. These arguments should help in demonstrating that various benefits can make MPAs self-financing entities, especially in developing countries, and a truly excellent tool to achieve sustainable development.

It does not matter whether the good or service (benefit) is market or non-market based, the underlying principle of valuation is to try to obtain a sense of people's preferences for the good or service. Economists argue that individuals, not the government, are the best judges of what they want [60]; thus, the theory of economic valuation relies on individual preferences and choices. Following this line of argument, the economic value of a particular non-market benefit is measured by the maximum amount of other "things" (usually money) that a person is willing to give up to obtain the mentioned benefit (good or service). This is what has been called "willingness to pay" (WTP) [31,56,60,62]. An alternative way to assess these preferences or choices is by estimating the "willingness to accept" (WTA), which refers to how much a person is willing to be compensated for a lost benefit [56,60].

In general there are three major accepted approaches to the valuation of benefits in monetary terms: (1) market prices or revealed WTP, (2) circumstantial evidence or imputed WTP and (3) surveys or expressed WTP. The market price or revealed WTP approach measures the value of those market-related benefits. In other words, the methods grouped within this category are good to estimate direct use values (extractive or non-extractive); therefore, value estimation is easy. For example, with this approach, to estimate the value of fishery and non-fishery benefits we just need to obtain the current value of, for example, fish in the market or the price paid by a tourist to SCUBA dive within a MPA. Dixon et al. [63] estimated that revenues from SCUBA diving (a direct non-fishery benefit to humans) in the Bonaire Marine Park were about 4.8 million USD per year. Hodgson and Dixon [64] estimated gross revenue to fisheries, as a result of MPA implementation, of USD $28 million in El Nido, Philippines. Gonzalez et al. [65] anticipated that non-fishery benefits (SCUBA dive and cruise activities) represent around USD $200,000.00 y^{-1} to the Punta Frances Marine Protected Area, in Cuba.

The circumstantial evidence or imputed WTP approach values benefits by estimating what people are willing to pay, or the cost of actions they are willing to undertake, for an equivalent benefit obtained in a different setting (if the foregoing is correct, then omit: with the intention of avoiding the adverse effects of a benefit lost). For example, coral reefs provide effective coastal protection from erosion and bad weather. The amount that people pay to avoid coastal erosion in areas similar to those protected by the coral reefs can be used to estimate WTP for the coastal protection services of the coral reefs. This approach uses observable market prices for one good or service (surrogate market goods), that is closely associated with the market-unrelated good or service, to estimate the value of an environmental good that does not have its own price [31]. One of the main shortcomings of this approach is that in the majority of the cases no surrogate market goods can be found, therefore many benefits are not valued accordingly or are completely neglected.

Finally, the survey or expressed WTP approach is meant for those goods and services that are not traded in markets, and are not closely related to any marketed good from which a surrogate value can be estimated. This impedes attempts to reveal people's WTP through their market purchases or actions. In these cases, surveys are used to ask people directly what they would pay for a good or service, based on a hypothetical scenario, from which their WTP can be projected. One of the best examples of the application of this approach to value benefits from coral reef biodiversity (ecosystem benefits) is given by Spash [61]. This author undertook a contingency valuation method in two Caribbean countries (Curaçao and Jamaica) and he found that in both countries the total WTP averaged USD $25.00 per person. He also analyzed the motives behind respondent's monetary valuations and found out that lexicographic preferences can be very common and create problems for interpretation of contingency valuation method results. In simple terms, lexicographic preferences exist where respondents are unwilling to accept any trade-offs for the loss of a benefit. In the case of coral reefs it means that survey participants considered that there was no possible compensation for the loss of coral reef biodiversity (for a more complete analysis refers to Spash [61]).

Table 2 summarizes the three approaches including their particular methods. It also presents an overview of each method and their advantages and limitations. This table graphically expresses what methods are appropriate to value MPA benefits identified in Table 1. As can be seen, valuation methods using the market price or revealed WTP approach can be used to assess the economic value of fishery, non-fishery and some management benefits. On the other hand, valuation methods using circumstantial evidence or imputed WTP and expressed WTP approaches could be used to value the remainder of benefits identified in Table 1. It is remarkable that the vast majority of MPA benefits appear not to be market-related. According to Tables 1 and 2 only 30% of the benefits can be valued directly based on market prices, while the remaining 70% require the use of surrogate and expressed values. This fact should lead scientists and managers to develop alternative valuation methods that are not based on the dollar-value of benefits and more importantly to conclude that benefit valuation based on market prices only is not a realistic approach to decision support for MPA management.

Given that MPAs are a clear product of a decision-making process, benefit valuation is a very important issue. At the same time the ultimate decision of whether or not to establish a MPA will depend on a variety of factors, the quantified and non-quantified benefits expected from protection, the costs of protection, the potential net benefits for alternative uses of the site, social issues, and so on. Consequently, the need to justify MPAs in social, economic and developmental terms has become

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Table 2
Summary of dollar-based valuation methods[a].

Approaches	Methods	Overview	Advantages	Limitations
Market prices (Revealed WTP[b])	Market price	Estimates economic values for ecosystem goods or services that are market related.	People's values well defined.	Market data may not be available for all products.
			Price, quantity and cost data are easy to obtain.	Market imperfections do not reflect true values.
			Uses actual observed data.	Has no account of external effects that affect prices (i.e., seasonal variation).
			Uses standard accepted economic techniques.	Cannot easily measure large-scale changes that affect supply and demand.
	Productivity	Estimates economic values for ecosystem goods or services that contribute to the production of commercially marketed goods.	Straightforward methodology.	Only valued resources that can be used as inputs in production of marketed goods.
			Relatively inexpensive.	Requires considerable scientific information.
			Data readily available.	May become difficult to apply in certain settings.
	Hedonic pricing	Estimates economic values for ecosystem or environmental services that directly affect market prices of some other good.	Estimates values based on actual choices.	Only benefits related to housing prices can be measured.
			Property markets are good value indicators.	Requires people's knowledge regarding environmental attributes.
			Property records are reliable.	Outside effects influence people choices (e.g., taxes).
			Versatile method.	Relatively difficult to implement.
			Data easy to obtain.	
	Travel cost	Assumes that the value of a site is reflected in how much people are willing to pay to travel to visit the site.	Based on actual people behavior.	Assumes people travel for just one purpose.
			Inexpensive to apply.	Issues such as availability of substitute choices, and opportunity costs limit the analysis.
			Results easy to interpret.	Limited scope and application.
			Allows for large sample size.	
Circumstantial evidence (imputed WTP)	Damage cost avoided	Estimates economic values based on costs of avoided damages resulting from lost ecosystem services.	Provide a rough indicator of economic value (subject to data constrains).	Assumes that expenditures fairly reflect value of benefits.
	Replacement cost	Estimates economic values based on costs of replacing ecosystem services.	Less data and resource intensive.	Does not consider social preferences.
	Substitute cost	Estimates economic values based on costs of providing substitute ecosystem services.	Provide surrogate measures of value for services difficult to measure.	Considers environmental actions and regulations based only on benefit/cost comparisons.
			Data or resource limitation affects the methods.	The replacement cost considers fully substitution between the market good and the natural resource.
				To be used only after project implementation and proper assessment of people's WTP.
Surveys (expressed WTP)	Contingence valuation	Estimates economic values for virtually any ecosystem or environmental service by asking people WTP directly.	High flexibility.Most accepted to assess Total Economic Value.Results easy to analyze and describe.ely used, therefore, methodologically proven.	Controversial results.
				People lack of knowledge of environmental valuation.
				Survey and questionnaire design problems.
				Lexicographic preferences.
				Personal preferences.
				People behavior.
	Contingence choice	Estimates economic values for virtually any ecosystem or environmental service by asking people to make trade-offs among sets of ecosystem or environmental services.	Allows respondents to think in terms of trade-offs.	Some trade-off may be difficult to evaluate.

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Table 2 (*continued*)

Approaches	Methods	Overview	Advantages	Limitations
			It is better to estimate relative values than absolute ones. Minimizes biases from open-ended questionnaires. Reduces risk of getting protest bids and symbolic values.	Respondent behavior not well understood. Requires more sophisticated statistical techniques. Untested validity and reliability. Expressing answers in dollar values may lead to greater uncertainty.

[a] Adapted from King and Mazzotta [60].
[b] WTP: willingness to pay.

almost universal, especially in developing countries, where resource scarcity and poverty make them prone to overexploit marine resources. Therefore, to fully assess the success of MPAs, national governments or any other entities responsible for MPA implementation have to be able to clearly identify all possible benefits that may accrue from the MPA, and from that point clearly state their objectives. It is evident that designating significant areas of coastal regions as MPAs will alter both the kind of benefits (or ecosystem goods and services) provided by the marine environment and the distribution of these benefits among different groups of individuals.

National governments should be aware of this fact to properly manage and maximize these benefits in the interests of their citizens. Correct early identification and assessment of MPA benefits will facilitate public acceptability of MPAs [21,66].

4. Conclusions

Benefits derived from marine protected areas are numerous, and their clear perception is essential for the success of these ecosystem-based management tools. A clear understanding of MPAs benefits can be used to set achievable management objectives, to rigorously evaluate management outputs, allowing for adaptative management and last but not the least important: to help in the promotion and understanding of MPAs. Several attempts have been made to classify MPA benefits, and a total of 99 are identified in this paper as contribution to the welfare of human and non-human components of marine ecosystems. The classification framework provided in Table 2 is a work in progress, remaining open for the inclusion of newly recognized benefits. It constitutes a comprehensive classification model based in the integration of two themes: anthropocentric and biocentric. This classification draws from the work of others in forming a new synthesis of MPA benefits. Its value lies in a framework that simplifies the identification of MPA benefits and facilitates their valuation.

Future work on this topic should devote special attention to benefits accrue to the non-human components of marine ecosystems. Identification of such benefits has not been easy. Whether we like it or not our set of values and knowledge, which are based on anthropocentric views and incomplete reference systems, provoke us to literally disregard the potential benefits to nature. As a result, their true valuation becomes extremely difficult, and decisions will therefore be biased toward environmental degradation based on the assumption that forgone benefits to nature are negligible. This shortcoming in our analysis models should be corrected as soon as possible; otherwise no ecosystem-based management or adaptative management would be enough to counteract current trends in natural resource exploitation.

One way to correct this mistake could be through a change in how MPAs are recognized by decision-makers, users and public. Often MPAs are considered as conservation efforts that cannot be justified in economic terms, therefore their long-term existence is uncertain. How can this perception be changed?

It has widely been accepted that natural capital constitutes our most precious asset, and it has also been recognized that this form of capital is under extreme pressure due to continuous economic growth and increasing consumption rates by human beings. Natural capital, once incorrectly considered infinite and fully substitutable by manufactured capital, is currently a limiting factor in human economic activity. Therefore, we must do something to revert this situation and increase the supply of natural capital for the future. Investing in natural capital is what ecological economists have been calling for as a way to ensure long-term sustainability of natural resource use.

Investing in natural capital essentially means to bring to a halt our current consumption rates in order to allow natural systems to restore natural capital stocks and thus maintain production. Increasing investment in manufactured capital rather that in natural capital (i.e. building more fishing boats when what is needed is more fish) accelerates the rates at which over exploited resources are driven further toward total depletion. In other words, the only way to build up the natural capital is to protect renewable resources from exploitation, so that they can grow. Of course, non-renewable natural capital must be treated differently. The rate at which nature produces these resources is so slow, that there is nothing we can do to regenerate the available stocks. The only way to preserve these types of natural capital is to refrain from using them or use them as little as possible; and to use some portion of the income from their exploitation to invest in alternative renewable solutions (e.g. alternative sources of energy: wind, tides, etc.).

Economists have suggested various ways to make investments in nature. The best accepted idea is by reducing throughput, which is the volume of materials flowing from the environment through the economy and back to the environment as wastes. Two ways of reducing throughput are based on the so-called "IPAT equation". This equation states that Impact=Population × Affluence × Technology. One way is by reducing population growth at a global scale, and the second is by increasing efficiency per throughput unit. Although both ideas seem very straightforward they are not easy to achieve in the real world. First of all, global population growth reduction is far from achievable today due to obvious political, economical and cultural reasons. Secondly, even if we increase efficiency of resource use, continued throughput growth means that the losses of goods and services from forgone natural capital exceed the gains from converting it to manufactured capital. Consequently net total welfare will decline, making it ineffective to continue. As can be seen the solutions proposed by economists based on the IPAT equation are

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logical but far from achievable. Therefore, a more practical approach is required based on what is actually achievable in current resource systems and societies users.

If we go back to the basic meaning of investing in nature, which is to leave natural capital alone, a practical approach is to design and implement effective MPAs. The preservation of portions of the marine and terrestrial environment in areas where resource use and users are controlled constitutes a practical way to invest in natural capital, with the added incentive of possible making profits from alternative use activities such as tourism. Daily et al. [67] provided a practical example of this, although not for a MPA *per se*. These authors talked about an Australian firm (Earth Sanctuaries, Ltd.) that is listed as the world's first conservation company. This firm essentially buys land and restores native vegetation and wildlife earning income from tourism, consulting and wildlife sales. In summary, if we are able to promote the idea of the MPA as a practical tool for investing in natural capital then we will:

- portrait MPAs in economic language, which ultimately will make them part of existing economic models;
- help to making MPA benefits fully accountable despite their origin or type;
- give MPA a business side that will attract more investors and money and
- increase public understanding of MPAs and compliance with their protection regulations.

The synthesis of the main benefit valuation methods provided in this paper should help scientists and managers to understand their advantages and limitations, and to work toward the use of non-dollar-based methods. It should be understood that the economic nature of the dominant valuation methods applicable to MPAs will only provide us with the economically efficient option, which may not be the best option in terms of social acceptance or environmental benefit. A good example of this is given by King [68] who stated that "…the real economic value of oysters, their highest and best use, is in their natural role as "the kidneys" of the Chesapeake Bay and not as a temporary source of direct income or recreational enjoyment for fishermen…" (pp. 329, 331).

Regardless of all the pros and cons there is a worldwide agreement that MPAs constitute tools with high potential to deal with the increasing deterioration of natural capital. Their holistic nature allows for the implementation of ecosystem-based management actions. No matter under what socio-political system or management category MPAs are established in any country, the goal of sustainable development will have higher odds of being achieved through the use of this rather proactive management tool than by keeping attached to currently ineffective management measures. Therefore, MPAs stand up as a more suitable way for achieving sustainability in marine resource exploitation and for maintaining a large array of vital ecological goods and services provided to man and to the rest of nature.

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