## A SOCIO-ECONOMIC TOOLBOX OF ARTIFICIAL REEF PROJECTS

Jorge Ramos, IPIMAR, jramos@cripsul.ipimar.pt
Miguel N. Santos, IPIMAR, mnsantos@cripsul.ipimar.pt
David Whitmarsh, CEMARE, david.whitmarsh@port.ac.uk
Carlos C. Monteiro IPIMAR, cmonteiro@ipimar.pt

ABSTRACT

It is widely accepted that in sea bottom areas where there is a scarcity of rocky formations and declining marine fish due to fisheries pressure, the deployment of artificial reefs (ARs) is a possible way to mitigate the problem. If ARs have an ecosystem-based fisheries management goal that means their presence is believed to be a *sine qua non* condition to maintain the sustainability of coastal ecosystems. However, decisions relating to the deployment and management of ARs arguably need to be guided by the dictum that 'an artificial reef that is not useful to people is not a successful reef'. The issue of 'AR usefulness' is raised because there are many studies on reef assessment, but usually focusing solely on biological approaches. Thus, these approaches are usually not enough to prove or refute the above premise. So, it is of fundamental importance to involve the affected people, i.e., stakeholders. With that in mind, the present study presents a socio-economic 'toolbox' where it is intended to find out people's involvement, belief, attitude and behavior concerning artificial reef's deployment. The toolbox is based on a flexible research design and includes three types of assessment that can be done in the scope of social and economic evaluation of ARs, namely: (1) Monitoring and description, (2) Social analysis, and (3) Economic assessment. In each one there are used different data collection and measurement techniques.

Keywords: Artificial reefs (ARs), diving, fisheries, policy objectives, socio-economic, toolbox.
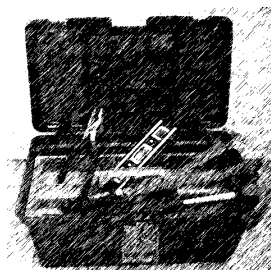
THE NEED OF A COMMON GROUND

The scarcity of fish resources and human pressure over coastal zones are major problems at the present time. Artificial reefs (ARs), man-made structures placed in the sea, offer a possible way in which these problems might be mitigated. It is generally accepted that in order to achieve the best results, ARs have to be planned in advance addressing exactly the purpose for which they are intended. It is also recognized that some important studies have to be done before deployment in order to compare pre-deployment results with those after establishing the project (Mathews 1981). Most of those studies should be related to monitoring, whether biological, oceanographic or socio-economic. Indeed, if possible, all should be carried out together. Monitoring tasks should continue after deployment, and reefs should undergo a systematic assessment in order to make possible comparisons pre- and post-deployment to evaluate the impact and performance derived from it. However, until now most of the monitoring studies are focused solely on the species settlement, colonization and assemblages (Jensen 2002, Bortone 2006). Not much is known about questions concerning AR users: who are they, where/when the use occur, or why the use occurs. Such information is fundamental because most decision makers judge reefs according to their contribution for human satisfaction (Milon et al. 2000).

The objective of this paper is to shed some light on a number of the social dimensions relating to the deployment of artificial reefs. The intention is not only to create a link between those who use or have a stake in the reefs, but also to contribute to knowledge by introducing and suggesting the adoption of some methodological approaches (tools) that could be used in future socio-economic studies of ARs (Figure 1).
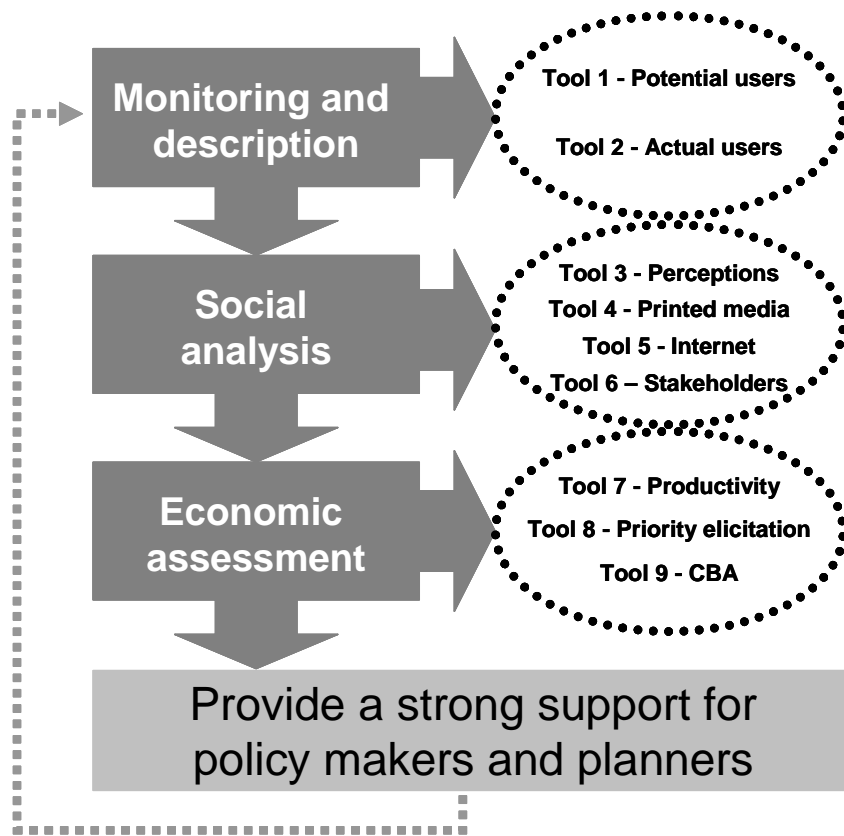
Figure 1. – Conceptual model of the socio-economic toolbox of artificial reef projects.

MONITORING AND DESCRIPTION

Rationale

Monitoring can provide an ongoing verification of progress toward achievement of objectives and goals by keeping on track the utilization of system resources. Reef managers can employ monitoring to determine who uses some given ARs and why there are reasons for their use. Monitoring can start before, during or after a given development, but ideally it should start as early as possible and be extended for as long as possible (Barrow 1997). Seaman (2004) considers three types of AR monitoring: physical (e.g. temperature, reef movement and stability, longevity), biological (e.g. species abundance or diversity, production) and socio-economic (e.g. expenditures, usage, costs/returns).

The objective in monitoring and description ARs should focus on to find answers to questions related to: the use of ARs, ARs quality, benefits/cost and biological productivity, and the need of the public. This section will focus on two primary data collection techniques used to monitor ARs. **Tool 1** based on interviews with potential users along the research area to obtain answers to the main questions related to socio-economic reef use. **Tool 2** focuses on direct site observations over one AR and the collection and interpretation of data derived from actual users to answer the entire set of questions. Both techniques can help to decide better what can be done in terms of management based on regular monitoring data.

Tool 1 – Objective: Find out potential AR users

Settings – It is important to know activities as small-scale and commercial fisheries and charter boat operators (angling and diving activities). For commercial fisheries the local or regional Directorate of Fisheries usually keeps a record of fishermen and vessels, and based on its information it is possible to estimate the total number of vessels registered. The first attempt in such study is then to go towards those people living in coastal fishing communities, briefly characterize them and investigate what might be their interest in using the AR structures. Fisheries may have been replaced by tourism. By its turn tourism may attract more young people than fisheries.

Instruments – (1) Interviews – The type adopted should be semi-structured questionnaire-based interview. Pre-determined questions for commercial fishermen and recreational users should include information on their identification, type of activity, AR expected consequences, and activity costs. (2) Secondary Sources – These instruments can be useful as a starting point to know more about the object or subject of study and also to cross-check information collected from other sources.

Data collection – It is important to define geographical areas for sampling purposes. The number of people in each sample is dependent of several factors such as: number of people working in the activity, daytime, eligibility of the interviewed person, availableness of people and willingness to participate. Interviews should not take too much time (e.g. around half an hour each and may be recorded). The interviewer should take notes directly on the questionnaire paper.

Measurement – The first question concerning the impact of ARs' deployment is to find out who is actually using the human made reefs. Therefore people should be asked if they already used any of the ARs in the vicinity. To explore further the first question and determine who actually is interested in the AR issue, people may be asked if they are in favor of the deployment of more ARs. The second major question to be answered is to know 'where' people practice their activity. Here there are at least two directions that can be followed: the depth range and the distance from the origin port or area covered to carry out the activity. The third question can be explored in several ways (e.g. day/night, days of the week, and type of gear/activity according to seasons). The fourth question is to ascertain why use the ARs. These questions are completely based on the expectations of those who claimed to have never used the ARs and are supported by previous experiences of those who already used them. Simple descriptive statistics may be sufficient to analyze data and compare results. A value of the chi-square can be calculated, and tested to see if it is statistically significant (Zar 1996).

Tool 2 – Objective: Find out actual AR users

Settings – It is important to think about the selection of a practical AR to carry out direct site observations (DSOs). It is important to collect the maximum information about the selected AR (e.g. dimension, depth range, type and design of structures, deployment date, and location). It is also fundamental to cross-check observational and documental data by identifying the main activities (e.g. find out fishing gear used in the vicinity of the reefs, and compare the type of fish sold in the local market and fish that can be caught in the reef). Information on landings is very useful. Charter boat and diving operators may advertise locally sea trips to the ARs.

Instruments – (1) Direct Site Observations (DSOs) – Through non-participant direct site observation (e.g. data collection from inside a research vessel via filling in a specific form). The form entries consist of information derived both from vessels operating near a given AR area and fishing gear already deployed prior to the observation period. GPS, radar and binoculars are essential devices to gather accurate observational information. (2) Secondary Sources – Landing records of the observed vessels from the local Fisheries Directorate.

Data collection – It is possible to identify vessels' number plates, people onboard, type of gear used, and target species, but for instance it is impossible to know gear effort and catch in weight by simply observing a vessel in operation. DSO implies a vessel operating nearby the reef sites and should include technology to position the submerged reef structures (GPS), to detect them (echo-sound), and perceive other nearby vessels (radar). It is desirable to cover the entire daytime period, which can be very expensive and requiring personnel on the site for extended periods of time. Observations should be standardized according to time. It is necessary to identify deployed gear, which generally needs a highly skilled person in fisheries issues to perform the task. A smaller AR might be easier to monitor than a large one. A larger AR can be monitored via aerial photography (Tinsman and Whitmore 2006), but can become very expensive if it is intended to carry this out for a long period of time (Milon 1991).

Measurement – Simple descriptive statistics may compare vessel patterns on and around the reef (e.g. number of vessels operating simultaneously in the AR area). The time series of vessel occurrence is also useful for monitoring purposes (e.g. number of vessels/observation along months or seasons and their frequency according to the vessel type). Data on the crew onboard and fishing gear patterns are important to gather. From secondary sources it is possible to find out the vessels observed and check their landings (in terms of quantities, species landed, and landing ports. Hypothesis testing using chi-square tests can be used. A value of the chi-square can be calculated, and tested to see if it is statistically significant (Zar 1996).

SOCIAL ANALYSIS

Rationale

Since the deployment, users accumulate greater empirical knowledge of the effects of ARs. This has some influence both in their attitudes and behavior (e.g. fishing patterns). These attitudes may, of course, be negative as well as positive. Experience and theory suggest that ARs typically give rise to a range of impacts, not all of which may be perceived as beneficial by users. To deal with the perceptions that stakeholders have about the ARs may not be an easy task. Even those stakeholders who use the reefs have their own expectations about reef productivity. Thus, the only stakeholders that can 'touch' and 'see' the ARs and their functioning are the divers group. These are the people who can have the clearest picture of the reefs as a whole. All these insights are important to take into account when asking stakeholder group representatives about their perception of impacts.

The objective in social analysis should focus on to find out about stakeholders' and media perceptions of reef deployment and its consequences or impacts (**Tools 3, 4, 5 and 6**). All the social approaches should ask about impacts derived from reef deployment, the aim being to assess the perceptions of the different stakeholders involved.

Tool 3 – Objective: Find out stakeholders' perception of AR impacts

Settings – It is important to investigate the local community's perceptions of the artificial reefs, and to see to what extent people regard the reef program as having been successful. We would contend that the opinions of stakeholders are crucial in this context. When there is a consensus amongst key individuals and groups over the objectives of ARs, it becomes easier to establish whether these objectives have been adequately addressed and how close they are to being reached. By contrast, lack of consensus makes it more difficult to derive a clear and unambiguous indicator for evaluating performance. Stakeholder opinions about environmental, social, as well as economic objectives need to be considered, and this sort of data typically has to be collected via surveys (Milon et al. 2000).

Instruments – (1) Questionnaire survey – As a first step in the study, it is important to define dimensions expected to be impacted by reef deployment (e.g. environmental, social, and economic). For each dimension, factors likely to be affected by deployment should be identified, and from these to construct an item-pool (Bell 1999, Robson 2002), which should include all the perceived predefined impacts. Prior contact with potential respondents should be established either by post or e-mail. This should be accompanied by an introductory letter explaining the objectives of the proposed work. The questionnaires should be addressed to representatives of different local/regional institutional bodies. (2) Secondary Sources – It should be collected information about potential respondents. This sort of instrument can be useful to facilitate prior contacts and evaluate eligibility or interest in the AR subject, and to cross-check information collected from the questionnaire.

Data collection – Though the consultation is principally a retrospective assessment of the performance of the established in situ reefs, the responses given to the questions also give an indication of the expected effects of the established reefs and how far they are likely to meet the needs of stakeholders. Indeed, the attitudes of affected parties regarding the acceptability of ARs should be an element in any decision regarding future reef deployment, particularly as regards design and location. In choosing respondents to take part in the survey, individuals should be pre-selected from a key-stakeholder database/list. The panel should be constructed from key-stakeholders based on their agreement to take part in the survey.

Measurement – Key-stakeholders can use 5-point Likert scales to state their positions about impacts (Murray and Betz 1994, Cripps and Aabel 2002, Kennish et al. 2002). After collecting all questionnaires, perceived impacts of the AR deployment should be assessed according to their scores and the analyses carried out. To evaluate the level of the impact, it is important to define a priori what constitutes a 'positive impact', since this underlay the whole concept and measurement of success in policy terms. The survey can be plotted using a 'radar' diagram. Though the approach is simplistic it has the advantage of representing to respondents (usually policy makers and planners) the impact of an intervention in a clear and easily understandable manner (Ten Brink et al. 1991). Using this graphical representation we can obtain a visual impression of whether an impact on any one dimension or factor has been positive or negative. The analysis of the results can be undertaken by separating the panel of stakeholders according to the group interests. To demonstrate the differences in stakeholders' positioning, hypotheses can be tested for the whole impact using a simple t-test (Zar 1996).

Tool 4 – Objective: Find out what does the local printed media say about ARs (content analysis)

Settings – One way to find social variables and the way they vary is by searching in the newspapers (e.g. regional printed press). After that, an attempt should be made to find out whether regional newspapers covered the subjects and in what circumstances. Examples of those relationships can be: changes in the amount of ARs' use, types of fish targeted, type of social group using the sites, and/or level of satisfaction. The objective of the content analysis is to ascertain the importance attached to sea-related news, with respect to each of the subjects chosen. The aim also is to find out if AR-related news featured in the newspapers.

Instruments – For sampling purposes, periodical press should be consulted, bearing in mind certain important aspects (e.g. each title has to have a general regional scope, and each title has to be from sea-related towns). It is intended to find out the impact and importance of the news relating to ARs and/or other sea-related news.

Data collection – The method consists of a time-series sampling, selecting newspapers for example starting from the year of the first AR deployment. A structured sampling should be then carried out for several periods of time pre-selected. Newspapers should be selected according to their periodicity as well, but focusing more on the weekly and bi-weekly ones. A sample of a reasonable number of titles per year

should be carried out (at least 30 or over). All the news articles should be selected according to their reference to sea subjects. The news items should be divided into different categories.

Measurement – The importance of the subjects should be then evaluated through the use of ratios. Each ratio consists of the number of times each subject appears divided by the total number of newspaper issues sampled. Higher ratios represent greater significance accorded to the subject in the time series considered. However, it is also necessary to investigate whether news' importance is related to positive or negative impacts of the activity. To carry out this social impact analysis based on this type of media, newspapers should be separated by title content analysis (negative or positive impact) and by news size (where larger article size equates with higher impact). For the latter measure, the news items should be divided into different categories (e.g. one page, half a page, quarter of a page, and so on).

Tool 5 – Objective: Find out what does the internet say about local ARs (document analysis)

Settings – If it is difficult to collect data relating to the social impact caused by the deployment of ARs in the study area, if collecting data from the printed media in the region again shows no signs of changes brought about by the reef deployment, then one way to face these problems is to use internet documents and to proceed with their content analysis.

Instruments – Using a search engine, it should be searched the terms 'artificial reefs' and '<the area considered>'. These should show several entries. The next step is to sample all the first let's say 100 or so documents, ignoring all scientific files and the ones that are supposed to be repeated. In addition to this, the analysis should focus solely on the contents relating to the AR subject found in the study area, even if there are other subjects in the document.

Data collection – In this particular content analysis study, the focus is to find out in a set of text documents the frequency of occurrence of terms relevant to the social dimension of the ARs present in <the area considered>. Basically, the number of times that particular concepts (codes) appear in the selected texts should be counted. By comparing the number of times and the distribution of concepts, some insight is gained into the types of modes of discourse that the selected sources of information give to the object of analysis, i.e. the ARs in the area considered.

Measurement – The text size might vary from sample to sample, as well as the size of each recording unit. The recording unit consists in part or whole of selected sentences and paragraphs from the document text that match the different codes chosen in advance. To do this, it is necessary to examine the context where the recording unit is set in order to code it accordingly. There is a wide range of potential categories that can be analyzed. The contents of the samples should be assigned to two different types of AR-related categories: demand and supply. Each of them can subsequently be divided into several sources of data (e.g. administrative, forum, news, political). Additionally, they can be divided into different topics (e.g. fisheries, diving). The direction (i.e. favorable or not) of the treatment can also be considered. The categories can treated as exhaustive, i.e., presuming everything relevant to the AR study could be categorized in at least one category. The coding strategy consists of the selection of some main dimensions (e.g. cultural, demographic, historical, and other), further divided into several different categories. The process of coding the documents should be done by at least two people. Tests of reliability should be done, and the process repeated until reliability is attained.

Tool 6 – Objective: To carry out a stakeholder analysis in order to know who are the winners and the losers

Settings – According to Milon et al. (2000), in order to carry out a social assessment of ARs, it is necessary to conduct comparative monitoring of social variables that follow the objectives of the AR

project and are coherent with them. One method of achieving this is by doing a stakeholder analysis (Grimble and Wellard 1997, Kontogianni et al. 2001). The involvement of the stakeholder may be dependent on the degree of ownership felt and attributed to the activities of the development and the outputs generated by it (Lim et al. 2005). People included should be not only those directly involved in the project development outputs, but also all those who mark their stake by showing an interest in the outcomes of the project (Jenkins 1999). The importance of stakeholder analysis is therefore to contribute to the social analysis of the AR program, where the range of perspectives and values those stakeholders hold have to be recognized, whether they are supporting the AR structures or opposing them.

Instruments – Diversified information collected from secondary sources concerning stakeholders is useful for stakeholder analysis purposes.

Data collection – The approach used is based on the one proposed by MacArthur (1997), but slightly modified. In the analysis six stages are involved: (1) identify the most important objectives and purposes of the AR program (i.e. the policy objectives); (2) list all the different parties that may have any interest in the ARs (i.e. primary, secondary and external stakeholders); (3) determine the interests of the different stakeholders concerning the different policy objectives of the project (i.e., the stakes whether positive or negative); (4) consider the impact of the project to each stakeholder, and also the influence or power each stakeholder has on the program according to their own interests and influence on the project outcomes; (5) account for interactivity along the program, (which may include new stakeholders and/or actions to address the proposed program objectives resultant in that inclusion), and (6) establish the levels of stakeholders' participation during the different phases of the AR program.

Measurement – All of the above stages are represented by four types of matrix: (1) stakeholder table, where four main columns are presented (1st listing the stakeholders by class, identification and sector, 2nd listing the interests of the stakeholders, 3rd pointing out the potential project impact on stakeholders on a scale from -2 to 5 , and 4th showing the importance of each stakeholder influence on a ranking scale from 1 to 5 in relation to the objectives of the AR program); (2) stakeholder classification matrix, where a scatter diagram is developed to represent the positions of each stakeholder in relation to the project impact (x-axis) and stakeholders' influence or power in their own interests (y-axis); (3) stakeholder interaction matrix, where the aim is to predict stakeholders' interaction with the ARs and their likely attitudes and behavior towards it; and (4) participation matrix, which is a description of the different types of participation that stakeholders have throughout the project development (ranking scheme).

ECONOMIC ASSESSMENT

Rationale

According to Milon et al. (2000), one potential way of carrying out an economic assessment of artificial reef performance is by determining whether the reef project is an efficient public investment. Any analysis within this subject area requires support based on socio-economic data in order to evaluate the benefits and costs related with any AR project (Whitmarsh and Pickering 1995). The data collected are then used in order to document how a reef is performing. Based on this background knowledge, an attempt can be made to accomplish the task of achieving the economic efficiency of the ARs in a given deployment area. Focusing on economic efficiency, it is important to establish whether effectively, the AR program is a good or bad project. Basically it is important to establish whether the monetized value from project benefits exceeds the project costs and to what extent.

The objective in economic assessment is to investigate the above questions. Three approaches can be adopted. One of them is based on scientific survey catch records (**Tool 7**). The second approach aims to find out about maximizing benefits from fishing/diving by prioritizing criteria and alternatives through the use of the AHP methodology (**Tool 8**). Finally, the third approach is a cost benefit analysis (CBA) on the deployment of a pilot reef and its use (**Tool 9**).

Tool 7 – Objective: Analysis of artificial reef productivity

Settings – In the case of fisheries, it is possible to quantify fish catches and market prices if adequate data is available. As Milon et al. (2000) point out, to carry out an economic impact analysis based on AR deployment, it is possible to calculate variations in catches and revenues derived from fish market sales. The aim in this tool is to see whether variations in a given currency (e.g. dollars) per unit of effort could be explained statistically by 'reef effects'. In order to verify this, reef effects are subsequently divided into four categories (i.e. reef presence, reef type, reef location, and time since deployment) and tested statistically.

Instruments – (1) Fishery trials (FTs) – Scientific surveys can be carried out using traditional fishing gear to simulate commercial fisheries. (2) Electronic data – Detailed data on observed vessels fishing in the reefs can be collected from the Directorate of Fisheries. Data reporting official landings and respective selling market prices can be used to cross-check DSOs.

Data collection – FTs should be carried out in identified areas. If there are different AR structures, they should be categorized and sampled accordingly. Control sites for each reef type should also be used for comparison purposes. Control sites should be located far from each artificial reef (e.g. from one nautical mile onwards), but at the same range of depths and similar distance from the coast.

Measurement – In order to perform an economic analysis based on AR productivity approaches it becomes important to make a judgment about the socio-economic performance of reefs. Monetary valuation is relatively straightforward where the reef effects can be quantified (e.g. weight of fish caught) and where market prices can be used to value the output (Whitmarsh et al. 2008). Therefore, the calculations for the productivity approaches should be based on: (1) Paired samples t-test of mean (test if there were differences between reef versus control catches, the different types of reef structures, the location of reefs, and time periods), and (2) Multiple regression econometric model (develop a model to use qualitative variables to test value of fish per unit of effort, i.e. VPUE). The model accounts for the separate effects of the different variables. Some binary (i.e. dummy) explanatory variables should be included in order to calculate their influence on revenues.

Tool 8 – Objective: Analysis of fishing and diving reef priorities

Settings – (1) Fishing – Especially in the last decade, artificial reefs (ARs) have become an important tool in coastal management (Pickering et al. 1998), in most cases aspiring to fulfill a fisheries function (Jensen 2002). In terms of the efficiency of commercial fisheries there is some doubt as to whether or not ARs contribute to higher fishing revenues compared to other commonly fished sites. By determining which criteria are preferred in choosing a ground to fish, vessel skippers are attributing 'a value' to the site. Studies on this topic state that, often a compromise between multiple objectives has to be found, and that there is a need to find a balance between multiple objectives and goals in fisheries management (Sumpsi et al. 1996). (2) The use of ARs specifically for recreational purposes (such as SCUBA diving) has been assessed by a number of authors (e.g. Bockstael et al. 1986, Milon 1988). Milon (1991) and Rhodes et al. (1994) suggest that their results would be of interest to those responsible for the planning, development and management of marine ARs. Mead and Black (1999) have studied multiple objective offshore reef

programs and their concomitant social and economic impacts, where ARs were aimed at producing amenity enhancement (such as surfing, diving, fishing, and beach recreation).

Instruments – The 'decision problem' or main goal to achieve is then to get consistent support for the management of fishing grounds/diving spots through the data provided by commercial fishermen (, or for diving the respective demand and satisfaction level for each of the site types examined (e.g. via logbooks and/or respondents own perceptions). Finally, as part of the 'decision problem', it should be also attempted to find out if AR modules are as interesting to fishermen and divers as other types of grounds or reefs. Here the efficiency analysis is conducted by using the analytic hierarchy process (AHP).

Data collection – Seminars in different local communities can be conducted with fishermen or divers regarding ARs. At the end of each presentation it is important to establish contacts with some skippers or divers that decide to collaborate in the survey. A priori some goals have to be selected for the groups (e.g. to gauge interest stimulated by the presence of the ARs, to get feedback about their actual use, and to get collaborators or key-informants). Questionnaires and logbooks can be used to collect data.

Measurement – Logbook sheets provide quantitative data that can be subsequently used to elicit weights, whereas the AHP questionnaire asks potential or actual users directly to elicit weights. The AHP approach is used to find out which criteria are usually chosen to go fishing or diving. So, at the top of the AHP tree stands the main goal skippers/divers choose in order to maximize benefits from fishing/diving in the long run (Saaty and Vargas 2001). It is important to study the problem of measuring fishing/diving efficiency in each of the sites contemplated. The next step is to establish the criteria taken into account in the decision to fish/dive at one site rather than another.

Tool 9 – Objective: To carry out a cost-benefit analysis

Settings – Cost-benefit analysis (CBA) estimates the relative economic efficiency of alternative projects and policies by comparing benefits and costs over time. Turner (2000) emphasizes that CBA identifies the most efficient investments from the perspective of societal welfare, generally including both monetary and non-monetary values (consumer and producer surplus). The use of a CBA is because some of the benefits of the project can be monetized in discounted net benefits/net present value (NPV) terms and associated with users as in the case of commercial fishermen (Whitmarsh 1997, Milon et al. 2000). ARs can host many different species, not only fish, but also other living organisms. Many of these species have commercial value. In addition, there is some degree of human competition for AR resources and reef use. For example, an AR area can be used to harvest fish from wild stocks, but it also has the potential to support fish and shellfish production in off-shore aquaculture units, diving tourism, among other amenities that can be due to reef deployment.

Instruments – CBA makes use of a wide range of methods for estimating values of market and non-market goods and services. The method can use a productivity approach, but the analysis should address the question of whether or not the potential yield-enhancing effects of reefs are sufficiently large to make reef deployment worthwhile as an investment. This requires a closer examination not only of the costs of the project but also the time horizon over which the benefits are expected to accrue.

Data collection – The economic benefits engendered by the reefs have accrued over several years (i.e. since their deployment), and the normal procedure for dealing with this situation in project appraisal is to discount the net benefit stream over a specified time horizon. The resulting net present value (NPV) and its associated indicators (BCR and IRR) can be used to judge the worth of the investment. However, it is important to show AR yield in terms of biomass. So it is fundamental to use a proxy for biological growth function. The function should show evidence that over time there is a relationship between the biomass production and reef maturity on a unit of volume, and the age of the AR.

Measurement – After deployment, it should be assumed that the area would be devoid of life, but that after a short while some species should be attracted to the structures, and once they received protection and food there, they should become 'attached' to the reef. Scientific trials in the may give an idea of fish species composition (e.g. Santos and Monteiro 1997, 2007). In a CBA including only small-scale fisheries it can be assumed that the fish that are sold in the local fishing market are caught by local fishermen and that the catches have similar species composition. The average fishing market price is also necessary. Project costs include the investment made in the construction and deployment of the structures. It is important to assume the lifespan of the AR structures (e.g. 50-year period for modules made of concrete). Indirect costs represent the opportunity cost of fishing at the AR on a full-time basis. During the times fishermen use other places than ARs, they forego income they would obtain from fishing at the reef. Direct costs are those variable costs including repairs and maintenance of fishing gear and vessel; and fixed costs including fuel, insurance, inspections, and licenses for both fishing gear and vessel.

CONCLUSION

The present paper tries to demonstrate that artificial reef deployment has multiple impacts within different domains. As well as the expected physical and biological effects, it is also important to consider that attitudes and behavior are changed as a result of this intervention. Documenting and measuring these wider human effects, however, required the use of a range of different methodological tools. The tools that can be used for the socio-economic study of artificial reef projects have several advantages and disadvantages (Table 1). It is the contention of this paper that policy makers and planners who are concerned with assessing the full socio-economic consequences of artificial reef deployment should be aware of such a requirement. To put the point at its simplest, multiple impacts necessitate multiple metrics. It is for this reason that the 'Toolbox' approach is so strongly advocated.

Table 1. – Summary of the socio-economic toolbox.

Tools	Method	Specific focus	Advantages	Disadvantages
Tool 1	Survey	Potential users of ARs	- It is a good starting point	- Interviews tend to take too much time
Tool 2	Direct site observations	Actual users of ARs	- In situ observations - Data collected from DSOs are relatively accurate - It is possible to have a 'scent' of the reef area	- Can be intrusive - Time consuming - Just possible during daytime - Observations have to be taken without being seen
Tool 3	Survey	Perceptions and attitudes towards ARs	- Potential to identify research priorities that policy makers and planners need to know	- Some people may be better informed than others
Tool 4	Documentary analysis	Printed media relating to ARs	- Observe without being observed - Data sources usually are easily accessible and diversified	- News items are easily biased - The importance of the news is highly subjective

Tool 5	Documentary analysis	Internet sources relating to ARs	- Observe without being observed - Data are readily accessible - Low cost	- Limited documents available - Documents were written for other purposes
Tool 6	Survey	Stakeholder gains and losses following AR deployment	- It is an easy way to show the interests, impact and influence of the interest groups	- The quality of the results is highly dependent on the type of information collected
Tool 7	Productivity analysis	Catches and revenue at reef and non-reef sites	- It is possible to find out reef productivity	- It can be costly
Tool 8	Multicriteria analysis (MCA)	Preferences and choices relating to AR characteristics and options	- Easily explain the problem - Achieve rational results due to logical decomposition of the problem - Transforms subjective qualitative information into objective quantitative data	- Using different methods to analyze may result in completely different results - The researcher may perceive the problem very objectively whereas participants may perceive it subjectively
Tool 9	Cost-benefit analysis (CBA)	Appraisal of AR projects in terms of NPV etc.	- It is possible to identify the most efficient projects	- It is difficult to have real data, because usually there are used estimations

REFERENCES

Barrow, C. J. (1997). *Environmental and Social Impact Assessment: an introduction.* London, U.K.: Edward Arnold.

Bell, J. (1999). *Doing your research project: a guide for first-time researchers in education and social science.* 4th Ed. Buckingham, U.K.: Open University Press.

Bockstael, N., A. Graefe, I. Strand, and L. Caldwell (1986). *Economic analysis of artificial reefs: a pilot study of selected valuation methodologies.* Artificial Reef Development Center Technical Report No. 6, Sport Fishing Institute, Washington, D. C.

Bortone, S. A. (2006). A Perspective of Artificial Reef Research: The Past, Present, and Future. *Bulletin of Marine Science* 78(1): 1-8.

Cripps, S. J. and J. P. Aabel (2002). Environmental and socio-economic impact assessment of Ekoreef, a multiple platform rigs-to-reefs development. *ICES Journal of Marine Science* 59: 300-308.

Grimble, R. and K. Wellard (1997). Stakeholder methodologies in natural resource management: a review of principles, contexts, experiences and opportunities. Socio-economic Methods in Renewable Natural Resources Research. *Agricultural Systems* 55(2): 173-193.

Jenkins, G. P. (1999). Evaluation of stakeholder impacts in cost-benefit analysis. *Impact Assessment and Project Appraisal* 17(2): 87-86.

Jensen, A. (2002). Artificial reefs of Europe: perspective and future. *ICES Journal of Marine Science* 59: 3-13.

Kennish, R., K. D. P. Wilson, J. Lo, S. C. Clarke, and S. Laister (2002). Selecting sites for large-scale deployment of artificial reefs in Hong Kong: constraint mapping and prioritization techniques. *ICES Journal of Marine Science* 59: 164-170.

Kontogianni, A., M. S. Skourtos, I. H. Langford, I. J. Bateman, and S. Georgiou (2001). Integrating stakeholder analysis in non-market valuation of environmental assets. *Ecological Economics* 37: 123-138.

Lim, G., H. Ahn, and H. Lee (2005). Formulating strategies for stakeholder management: a case-based reasoning approach. *Expert Systems with Applications* 28: 831-840.

MacArthur, J. (1997). Stakeholder Analysis in Project planning: Origins, Applications and Refinements of the Method. *Project Appraisal* 12(4): 251-265.

Mathews, H. (1981). Artificial reefs site: selection and evaluation. In: Aska, D.Y. (Ed.), *Artificial Reefs: Conference Proceedings.* Florida Sea Grant Report 41, pp. 50-54.

Mead, S. and K. Black (1999). A multipurpose, artificial reef at Mount Maunganui Beach, New Zealand. *Coastal Management* 27(4): 355-365.

Milon, J. W. (1988). *The economic benefits of artificial reefs: An analysis of the Dade County, Florida reef system.* Florida Sea Grant Report Number 90, Florida Sea Grant Program, Gainesville, Florida.

Milon, J. W. (1991). Social and economic evaluation of artificial aquatic habitats. In: Seaman, W. and Sprague, L. M. (Eds.) *Artificial habitats for marine and freshwater fisheries.* San Diego: Academic Press, pp. 237-270.

Milon, J. W., S. M. Holland, and D. Whitmarsh (2000). Social and economic Evaluation methods. Chapter 6. In: W. Seaman (Ed.) *Artificial reef evaluation with application to natural marine habitats.* Boca Raton, FL: CRC Press, pp.165-194.

Murray, J. D. and C. J. Betz (1994). User views of artificial reef management in the southeastern U.S. *Bulletin of Marine Science* 55(2-3): 970-981.

Pickering, H., D. Whitmarsh, and A. Jensen (1998). Artificial reefs as a tool to aid rehabilitation of coastal ecosystems: investigating the potential. *Marine Pollution Bulletin* 37(8-12): 505-514.

Rhodes, R. J., M. Bell, and R. S. Pomeroy (1994). Scuba diver expenditures associated with South Carolina's artificial reefs. *Bulletin of Marine Science* 55 (2-3): 1350.

Robson, C. (2002). *Real world research: a resource for social scientists and practitioner-researchers.* 2nd Ed. Oxford, U.K.: Blackwell.

Saaty, T. L. and L. G. Vargas (2001). *Models, methods, concepts & applications of the analytic hierarchy process.* Boston, MA: Kluwer Academic Publishers.

Santos, M. N. and C. C. Monteiro (1997). The Olhão artificial reef system (south Portugal): Fish assemblages and fishing yield. *Fisheries Research* 30: 33-41.

Santos, M. N. and C. C. Monteiro (2007). A fourteen-year overview of the fish assemblages and yield of the two oldest Algarve artificial reefs (southern Portugal). *Hydrobiologia* 580: 225-231.

Seaman, W. Jr. (2004). *Artificial Reef Monitoring in Florida Coastal Counties* [online]. Available from: http://nsgl.gso.uri.edu/flsgp/flsgpt04001.pdf [Accessed May 2005].

Sumpsi, J. M., F. Amador, and C. Romero (1996). On farmers' objectives: a multi-criteria approach. *European Journal of Operational Research* 96: 64-71.

Ten Brink, B. J. E., S. H. Hosper, and F. Colijn (1991). A quantitative method for description and assessment of ecosystems: the AMOEBA approach. *Marine Pollution Bulletin* 23: 265-270.

Tinsman, J. C. and W. H. Whitmore (2006). Aerial flight methodology to estimate and monitor trends in fishing effort on Delaware artificial reef sites. *Bulletin of Marine Science* 78 (1): 167-176.

Turner, R. K. (2000). Integrating natural and socio-economic science in coastal management. *Journal of Marine Systems* 25: 447-460.

Whitmarsh, D. (1997). Cost benefit analysis of artificial reefs. In Jensen, A.C. (1997). European Artificial Reef Research. *Proceedings of the first EARRN conference*, March 1996 Ancona, Italy. Southampton Oceanography Centre, pp 175-194.

Whitmarsh D. and H. Pickering (1995). *Economic appraisal of artificial reefs: Case-study.* Research Paper No. 85, Centre for the Economics and Management of Aquatic Resources (CEMARE), University of Portsmouth, Portsmouth, U.K.

Whitmarsh, D., M. N. Santos, J. Ramos and C. C. Monteiro (2008). Marine habitat modification through artificial reefs: an economic analysis of the coastal fisheries of the Algarve, Southern Portugal. *Ocean & Coastal Management* 51: 463-468.

Zar, J. H. (1996). *Biostatistical analysis.* 3rd ed. Upper Saddle River, N J: Prentice Hall International.

ACKNOWLEDGEMENTS