Socio-economic implications of artificial reef deployment: a Portuguese case study

Jorge Humberto Palmeira Ramos

PhD thesis

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The thesis is submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy of the University of Portsmouth.

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Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Table of contents (General)

Table of contents (Detailed)

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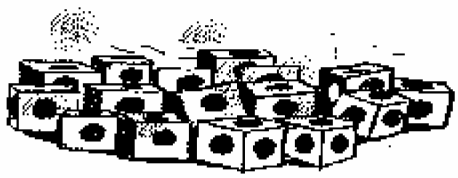
Abstract

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. There are many studies on the benefits of ARs in terms of biological production, but as regards socio-economics a number of important gaps persist. ARs need to be perceived as useful not only for fish enhancement, but also to people. The present study pursues a flexible design, intending to identify some of those gaps and contribute to knowledge of reefs following three lines of inquiry: (1) monitoring and description, (2) social analysis, and (3) economic assessment. The first approach identifies potential reef users along the southern coast of Portugal. Most interviewees declared they did not have any sort of prior AR experience. Direct site observation results in respect of a pilot reef show identifiable patterns of use, principally for commercial and recreational purposes. The social analysis queried perceptions of some stakeholder group representatives regarding the likely impacts attributable to reef deployment. The analyses of documents from the regional press and the internet facilitated the understanding of reefs' impact in such media. A stakeholder analysis highlights the potential impact and influence of each stakeholder group on ARs' policy objectives. Economic efficiency results based on productivity comparisons show that ARs generate twice as much revenue per unit of effort as in control areas (non-reef). The analytic hierarchy process (AHP) results demonstrate that ARs are not the preferred choice for fishermen and divers. The cost-benefit analysis (CBA) indicated that the Olhão AR system (OARS) is a good investment, with a net present value (NPV) of €98,453 at a discount rate of 5%. ARs enhance the economic value both in fisheries and diving activities, but they have additional economic value, due to their capability of providing other goods and services. An adequate management strategy is fundamental for AR success.



Resumo (abstract in Portuguese)

Existem inúmeros estudos acerca dos benefícios recifais a nível de produção biológica, mas a nível de socio-economia há ainda muitas lacunas. O presente estudo, ao identificar algumas dessas lacunas pretende contribuir para o conhecimento das mais valias recifais, seguindo três linhas principais de investigação: (1) monitorização e descrição, (2) análise social, e (3) avaliação económica. Para tal fez-se uma prospecção sobre os potenciais grupos de utilizadores recifais (i.e. pescadores profissionais da frota local e costeira, e utilizadores recreativos do mergulho e pesca) ao longo da costa sul de Portugal. Observações directas na área dum recife piloto mostram que os recifes artificiais (RAs) têm padrões de utilização identificáveis. Na análise social inquiriram-se representantes de vários grupos de intervenientes, quanto a possíveis impactes gerados pela implantação recifal e fez-se uma listagem quanto à sua importância relativa. Analizaram-se documentos provenientes de jornais regionais e internet, de modo a perceber qual o impacte dos recifes nestes meios. Pelos resultados percebeu-se que não existe muita informação no domínio público, com excepção de poucos casos pontuais. A análise de intervenientes permite verificar qual é o potencial impacte das estruturas e a influência que cada grupo de intervenientes tem em relação aos objectivos das políticas públicas do programa recifal. Dos resultados da eficiência económica baseados em comparações de produtividade, podemos verificar que os RAs permitem um rendimento económico cerca de duas vezes superior a áreas controlo (não-recifais). Através do uso do processo analítico hierárquico (AHP), constata-se que quer para os pescadores quer para os mergulhadores, os RAs são utilizados mas não constituem as principais escolhas. Da análise de custo benefício verifica-se que o RA de Olhão foi um bom investimento e que permite obter um valor actual líquido (VAL) de €98.453 após 25 anos de implantação. Os RAs potenciam o valor económico quer nas pescas quer no mergulho, mas têm também outros valores económicos associados devido ao seu potencial na prestação de bens e serviços.

List of tables

List of figures

List of abbreviations and acronyms

3-D	Three dimensional
AD	Administrative body
AFS	American Fisheries Society
AHP	Analytic Hierarchy Process
AR	Artificial reef
ARPDA	Regional Association of Anglers in the Algarve (in Portuguese)
ARS	Artificial reef system
ARs	Artificial reefs
ASMFC	Atlantic States Marine Fisheries Commission
BC	Business cycles
BCR	Benefit-cost ratio
c(i)	Catch within the reef
c(o)	Catch outside the reef (usually a control site)
CARAH	Conference on artificial reefs and artificial habitats
CBA	Cost-benefit analysis
CEE	European economic community (in Portuguese)
CFER	Control of Faro exploitation reef
CFP	Common fisheries policy
CFPR	Control of Faro protection reef
C_i	Dummy variable 'Reef configuration' (section 6.2.)
CI	Consistency index (AHP methodology)
COA	Conflict over areas (section 5.4.)
COER	Control of Olhão exploitation reef
COPR	Control of Olhão protection reef
CPUE	Catch per unit of effort
CR	Consistency ratio (AHP methodology)
CRIPSul	Regional Centre for Fisheries research – Southern Portugal (in Portuguese)
CSF	(3rd) Community Support Framework
CUP	Commercial use pattern (section 5.4.)
d	(Fishing) Days
DA	Decision analysis
DGPA	General Directorate for Fisheries and Aquaculture (in Portuguese)
Dim	Dimension

DM	Decision maker
DR	*Decreto Regulamentar* (if it is a regulatory decree) or
DR	*Diário da República* (if it is reference)
DRA	Regional Directorate for the Environment (in Portuguese)
DRPASul	Regional Directorate of Fisheries and Aquaculture (in Portuguese)
DSO	Direct site observation
DV	Diver
D-W	Durbin-Watson statistics
e	Base of the natural logarithm
EARRN	European Artificial Reef Research Network
ECO	Economic (section 5.2.)
ED	Electronic data
EEC	European economic community
EEZ	Economic exclusive zone
E_i	Dummy variable 'Reef effect' (section 6.2.)
ENV	Environmental (section 5.2.)
EUROSTAT	The Statistical Office of the European Communities
f	Fuel costs
FAD	Fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FER	Faro exploitation reef
FIFG	Financial Instrument for Fisheries Guidance
FL	Florida (United States of America)
FO	(Internet) Forum (section 5.4.)
FPAS	Portuguese Association of Sub-Aquatic Activities (in Portuguese)
FPC	Fishing pattern changes (section 5.4.)
FPR	Faro protection reef
GIS	Geographic Information System
GPS	Global Positioning System
h	Harvesting costs
I	(Artificial reef) Investment
IA	Institutional arrangements (section 5.4.)
ICES	International Council for the Exploration of the Sea
ICQs	Individual Catch Quotas
IFOP	Financial Instrument for Fisheries Guidance (in Portuguese)
ind.	Independent variable

INE	National Institute of Statistics (in Portuguese)
INIAP	National Institute of Agriculture and Fisheries (in Portuguese)
IPIMAR	Portuguese Institute of Fisheries and Marine Research (in Portuguese)
IRR	Internal Rate of Return
ITQs	Individual Tradable Quotas
L	Landings (section 6.2.)
LHS	Latin Hypercube Sampling
L_i	Dummy variable 'Reef location' (section 6.2.)
LTV	Lisbon and Tagus Valley (a region of Portugal)
Luso	In relation to Portugal/Portuguese
Lusophone	In relation to Portuguese speaking countries
MPA	Marine Protected Area
MS	Mississippi (United States of America) or
MS	Management strategies
n.s.	Non-significant results (used in statistics)
NB	Net benefits
NB(@)	Net benefits discounted
NE	News (section 5.4.)
NGO	Non-governmental organization
NJ	New Jersey (United States of America)
nmi	Nautical miles
NOR	Norms of reciprocity (section 5.4.)
NPV	Net present value (or discounted net benefits)
NR	Natural reef
NY	New York (United States of America)
O	Observations (section 6.2.)
OARS	Olhão artificial reef system
OCR	Optical Character Recognition
OECD	Organisation for Economic Cooperation and Development
OER	Olhão exploitation reef
OI	Other institutions (section 5.2.)
OPR	Olhão protection reef
p	Average fish price
PC	Political conflicts (section 5.4.)
PL	Political issues (section 5.4.)
PO	Patterns of ownership (section 5.4.)

POP	Operational Program of Fisheries (in Portuguese)
PS	Power structures (section 5.4.)
QCA	(3rd) Community Support Framework (in Portuguese)
QDA	Qualitative data analysis
r	Discount rate
R	Revenue
RAN	Ratio of aquaculture and shellfish gathering news (section 5.3.)
RF	Recreational fisheries/fishermen
RFN	Ratio of fisheries news (section 5.3.)
RI	Random index (AHP methodology)
RON	Ratio of other sea-related news (section 5.3.)
RUP	Recreational use pattern (section 5.4.)
RV	Research vessel
S(d)	Artificial reef surplus catch quantity per day
S(i)	Unit of artificial reef producer's surplus catch
S(q)	Artificial reef surplus catch quantity per year
S(v)	Artificial reef surplus catch value per year
SA	Sensitivity analysis
SC	South Carolina (United States of America) or
SC	Natural and social scientists (section 5.2.) or
SC	Stakeholder characteristics (section 5.4.)
SCUBA	Self Contained Underwater Breathing Apparatus
SFTs	Scientific fishery trials
SOC	Social (section 5.2.)
t	Time
TACs	Total Allowable Catches
T_i	Dummy variable 'Time' (section 6.2.)
TOT	Total – includes three dimensions (section 5.2.)
UE	Unit of effort
US	United States (of America)
VPUE	Value per Unit of Effort
vs	Versus
WWII	World War Two
Y	(Potential) Yield (in the artificial reef)
Y(t)	(Artificial reef) Production function over time
z	Average unit of effort per user

Part one

Context and Approach

Chapter

1

General Introduction

Contents

Word Count: 2 ,676

1.1. Introduction

1.1.1. Stating the Problem

There is no doubt that the sea is an immensely valuable resource. It can provide food, energy, a way to access other places, a place to practise tourism or sport or simply to meditate or relax. However, most of the sea's richness is found nearby the coast. There lies the highest biodiversity level of marine species (Gray 1997, Myers et al. 2000). For this reason, the areas near the coastline are especially desired by people.

Fishing activities represent one of these sources of marine wealth, and can be considered sustainable so long as the resource base is not jeopardised. However, the increasing fishing effort witnessed in recent decades due to human demand is posing a threat to marine living resources. Alongside this, there is the difficulty of establishing adequate and enforceable management strategies for the exploitation of the mobile resources found at sea. Currently, many areas of the sea in our planet are considered as a common pool resource. Results of this can be attested by the fact that the sea has been subjected to increasing catches on smaller fish and by changes in the targeted species (Pinnegar et al. 2002). Both phenomena may be due to the increasing scarcity of the most demanded species. This is at the present time a serious problem that needs to be solved.

There is a widespread concern about the state of world fisheries, where it is claimed that many fish resources are under threat due to problems related to over-exploitation and inadequate management (FAO 2000). This problem is widely recognised, and despite past failures some countries have succeeded in reducing harvesting pressure and have extracted some economic benefit from their fisheries (Cunningham and Bostock 2005). Aquaculture growth has also partly compensated for falling supplies from the wild fishery (Figure 1.1), though doubts have also been raised over the sustainability of some fish farming practices (Beveridge et al. 1997, Naylor et al. 2000), and the impact that aquaculture has on 'industrial' fisheries such as anchoveta and menhaden (Asche and Tveterås 2004).

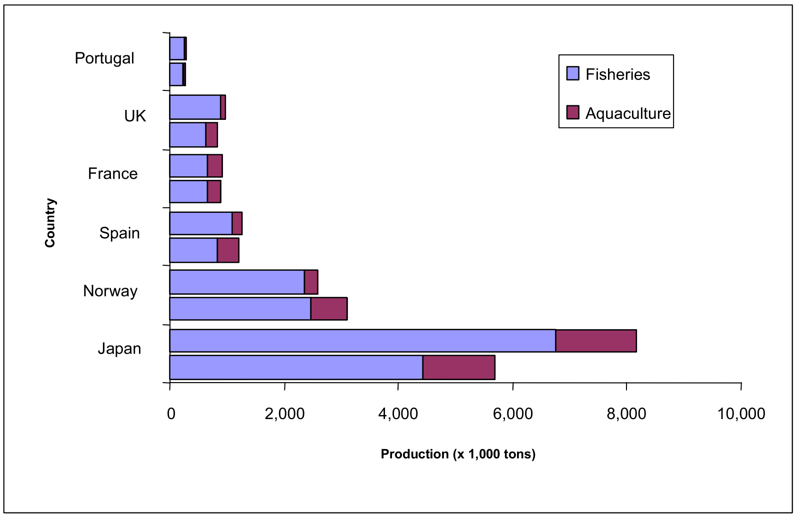


Figure 1.1 – Comparison between some countries in terms of fisheries and aquaculture production for the years 1994 (upper bars) and 2004 (lower bars). (Source: Eurostat 2006).

A further dimension to this problem is represented by the fact that coastal areas are subject to increasing pressure from a plethora of human activities. These include urban development, shipping, and recreational use, all of which are expected to increase in the immediate future. Coastal fisheries and aquaculture clearly adds to this pressure, and as such warrants an integrated rather than a sectoral approach to management. Whether fisheries production should be prioritised over other coastal activities is a matter of debate, but it nevertheless remains true that fish occupies an important place in the national diet of many countries (Figure 1.2).

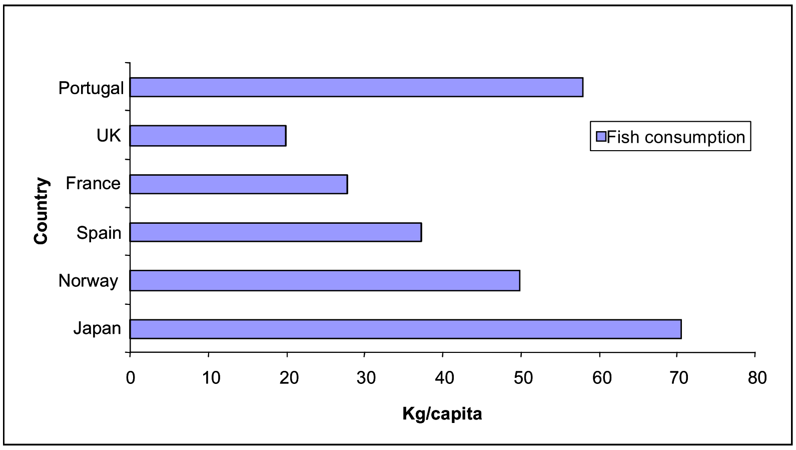


Figure 1.2 – Comparison between some countries in terms of fish consumption per capita in the year 1997. (Source: OECD 2001).

1.1.2. Current Views of the Problem

Fish are considered as renewable resources due to their ability to reproduce themselves in a continuous way. However, this ability may be attenuated by a number of influence factors. For instance when there are bleaching and erosion phenomena from land into the rivers, lakes, estuaries, etc., fish eggs may be under threat and do not hatch. Pollutants drained into the water have toxins that may kill aquatic life and be carried through a long distance. Intensive fishing pressure can disturb that renewability when fish species are caught under their first maturation and spawning stage.

Since the 1960s when it became apparent that advances in technology and their applications to the fishing sector could have a negative effect on catches, several management measures have been developed to mitigate the problem. These have evolved over time, from relatively straightforward attempts at limiting single inputs (e.g. vessel tonnage) to more sophisticated approaches which take account of economic incentives (e.g. ITQs).

Many currents of scientific knowledge claim that fishing resources are under threat whilst others insist that, given effective management and policy instruments, such resources can be exploited at a sustainable level. Indeed, at the present time there would appear to be two polarised views of the future of the world fisheries. They can be simply pointed out as the ‘pessimistic’ and the opposed one the ‘optimistic’.

The pessimistic view has been summarized by Copes (1986) in the aphorism that ‘if something can go wrong with fisheries management, it will’. An especially bleak perspective on the future of world fisheries has been developed by Pauly et al. (1998), in terms of the tendency towards ‘fishing down the food chain’. This means that too much pressure is placed on the fisheries resources, and as a consequence smaller fish and those positioned lower in the food chain are being caught. The worst scenario in this view also claims that if this state of affairs continues we will eventually be consuming detritus (lowest level in the food chain). This theory is based on assumptions that natural raised fish resources are erratic and as a consequence they cannot be kept in a given area. It is believed that to achieve sustainability of fish resources, stable catch compositions are a necessary requirement (Pauly and Palomares 2005).

Against that, however, are a set of more optimistic views on the future of world fish supplies. Those who see aquaculture as solving the problem could be classed amongst these (Caddy et al. 1998), but there are also others who take a more sanguine view on the ability to manage capture fisheries. Cunningham and Bostock (2005) claim that under correct management and policy circumstances fish stocks are completely renewable resources. It is not denied that there are severe problems affecting worldwide fisheries, nor that around three-quarters of these resources are facing several reductions or even extinction due to over-fishing and pollution problems. However, Cunningham and Bostock demonstrate that there are a number of cases of successful fisheries management around the globe, from which important lessons can be learnt regarding the means to achieve sustainability.

The controversy over the future of world fisheries will no doubt continue for some time, but the practical reality is that at the local level some form of intervention is usually required to sustain fish resources and the livelihoods that derive from them. Alongside familiar measures to control fishing pressure, some countries have dealt with the issue from the supply side through the development of artificial habitats. These will now be discussed.

1.1.3. The Artificial Reefs

Origins and adoption

The origin of the use of ARs is quite imprecise, but they appear to have a long history. More recently the idea of using ARs to rebuild fisheries came from an incident that occurred in Japan in the 18^{th} century, when a fisherman discovered that at a site where a boat was sunk more fish were caught there afterwards than prior to the incident. Identical findings with tree logs were reported some decades later in the US.

With at least some scientific evidence to support it, the use of ARs in rebuilding damaged fisheries has started to be taken seriously. Alongside this basic concept has emerged the idea of using different materials including giving a second life to structures as oil rig jackets and tyres. As a result, many coastal countries became enthusiastic about studying ways of getting rid of obsolete materials and at the same time to increase fisheries production. However, it was soon verified that such a success was not so easy to obtain. Many experiences with ballasted tyres and other materials of opportunity proved disastrous after winter storms, causing devastating impacts in recreational areas such as nearby beaches. The positive side was that such results have highlighted the need to regulate the type of materials and conditions that AR development procedures must follow. At the present time there are internationally recognised certain norms and rules for the establishment of the ARs.

The Portuguese fishing context and the ARs

Portugal presents a long coastline and historically has carried out several different types of fishing activities. The importance of fisheries to particular coastal regions of Portugal varies, as indicated by quantities landed (Figure 1.3).

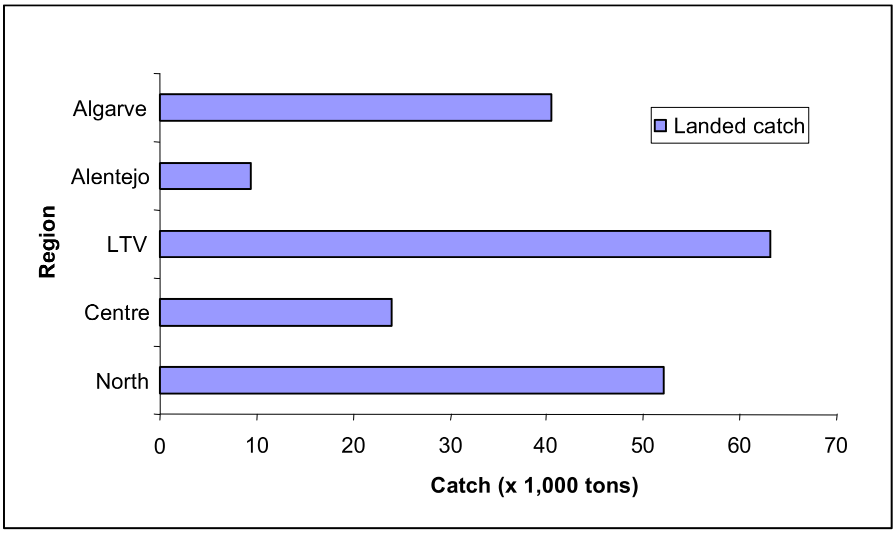


Figure 1.3 – Comparison between the fish landed in the different regions of Portugal mainland: averages for the period 1990-98. (Source: DGPA 2006).

The sardine (*Sardina pilchardus*) is the resource that contributes most to landings in terms of weight around the country (DGPA 2006). In the Algarve (south), despite the undeniable abundance of sardine there is probably a wider variety of species that contribute to increase landings' economic value (once sardine has usually a cheap market price).

In 1986 Portugal joined the EEC (now EU) and adopted its fisheries policy (CFP). That political decision brought some problems, particularly the decrease in the number of fishermen (and the attendant adverse social impact) which was not matched by a reduction in fishing pressure. In addition, in the late 1980s the total catches in Portugal and particularly in the Algarve showed signs of suffering a downward trend, probably due to unsustainable active fishing effort (Moniz and Kovács 2000).

It was considered necessary to mitigate this problem, based on the best-practice methods and experiences of other countries. Interest turned towards artificial reef projects, which had been shown to be at least partially successful in mitigating over-fishing by 'producing' more fish. Accordingly, it was decided to extend the concept in Portugal. Reasons for the choice of the Algarve as the region where the AR program was chosen to be located may be due to the fact that many people there are still dependent upon the fisheries, i.e., it is the Portuguese region that presents the higher rate of registered fishermen by total inhabitants. Even the regions completely surrounded by the sea, i.e., the archipelagos of Madeira and Azores have lower rates. In Portugal, fishing seems to be a residual professional activity in regions other than the Algarve and the Azores (Figure 1.4).

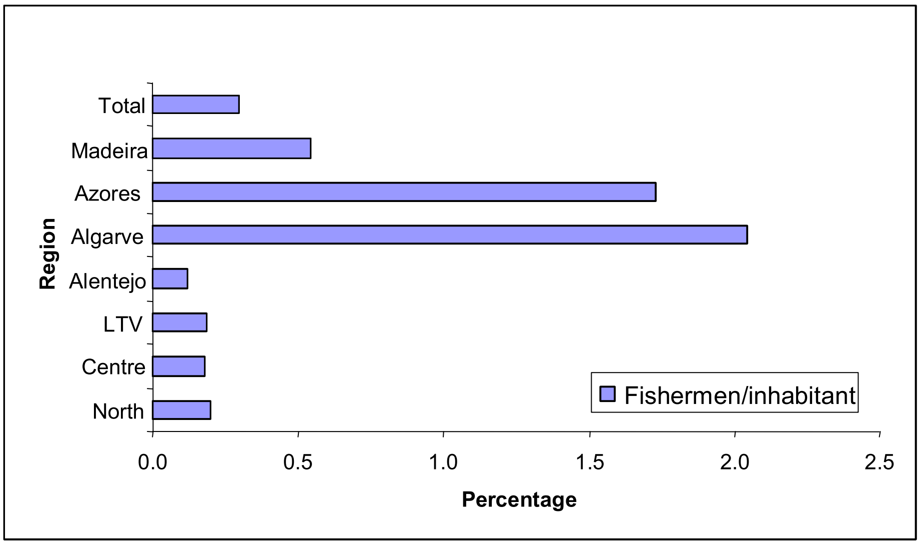


Figure 1.4 – Comparison between the percentage of fishermen (average 1990-98) and the rest of the resident population (year 2001). (Sources: POP 2004 and INE 2006).

The hope and expectation was that fish resources could be rebuilt through AR deployment, provided that the right people and sufficient funds could be secured to initiate the program. However, it seems that the ability that artificial reefs have to enhance fish stocks is only a partial solution for the problem. In fact, it is necessary to know if ARs 'create' marine life, or rather just 'attract' or redistribute species from other areas. This is a classic biological question concerning ARs which is still unresolved. From a socio-economic perspective, however, a major issue concerns the impact of ARs on human activities and specifically the level of fishing effort. It is widely known that if there are no access restrictions to the ARs, benefits may vanish due to overexploitation. In these circumstances, ARs alone cannot be guaranteed to sustain livelihoods, and controls on fishing effort will still be required.

1.1.4. Conclusions

There is a widely recognised problem that in many regions fish stocks are diminishing due to excess harvesting pressure. There are a variety of measures available to tackle the problem, the more innovative of which include 'supply side' approaches such as deploying artificial reefs. In respect to the latter, there are some arguments that have been used as a plausible reason to deploy artificial reefs in general (world's context), and in a particular case (Algarve region of Portugal). However, it is important to have empirical evidence of what positive contribution, if any, these structures have made to sustain coastal resources and the livelihoods that depend on them.

1.2. Structure of the Thesis

1.2.1. Research Framework

The idea of ARs comes from a view that these structures can be used as a way not
The idea of ARs comes from a view that these structures can be used as a way not
only to protect juvenile fish in their transition from inland waters to the ocean, but also to increase fish biomass and support fishing activities. To evaluate the potential of ARs, however, it is necessary to consider the interactions between the natural resource and the human agents involved.

This thesis is based on the premise that the deployment of artificial habitats will necessarily generate incentives, particularly to commercial and recreational fishermen, which will alter the pattern of harvesting activities. It is this human response to the presence of ARs which will determine the net benefits and, crucially, how those benefits are appropriated by the participants.

In order to find out what has been done and what are the results, we commence with a broad literature review. This literature review intends not only to learn from the knowledge developed on the AR subject, but also to find out where there are gaps in the knowledge. The identification of the gaps in the knowledge open the door to pose some research questions for this piece of research and postulate some expected results (the hypotheses). In order to find out answers to the research questions there are developed some research approaches in different scopes (Figure 1.5).

The remainder of this thesis is structured as follows. The second chapter introduces the main theory relevant to the understanding of the functioning of ARs. It also outlines the state-of-the-art on the subject of ARs, the relevant issues and studies concerning the subject, as well as the important lines of enquiry needed to fill the gaps in the literature. This review provides the backdrop to the Portuguese experience of ARs. The third chapter examines the key concepts concerning the socio-economic aspects, including a discussion of the management of ARs and the role of stakeholders. We frame the research problem and main questions to be answered, as well as discussing the research method and data collection and measurement techniques.

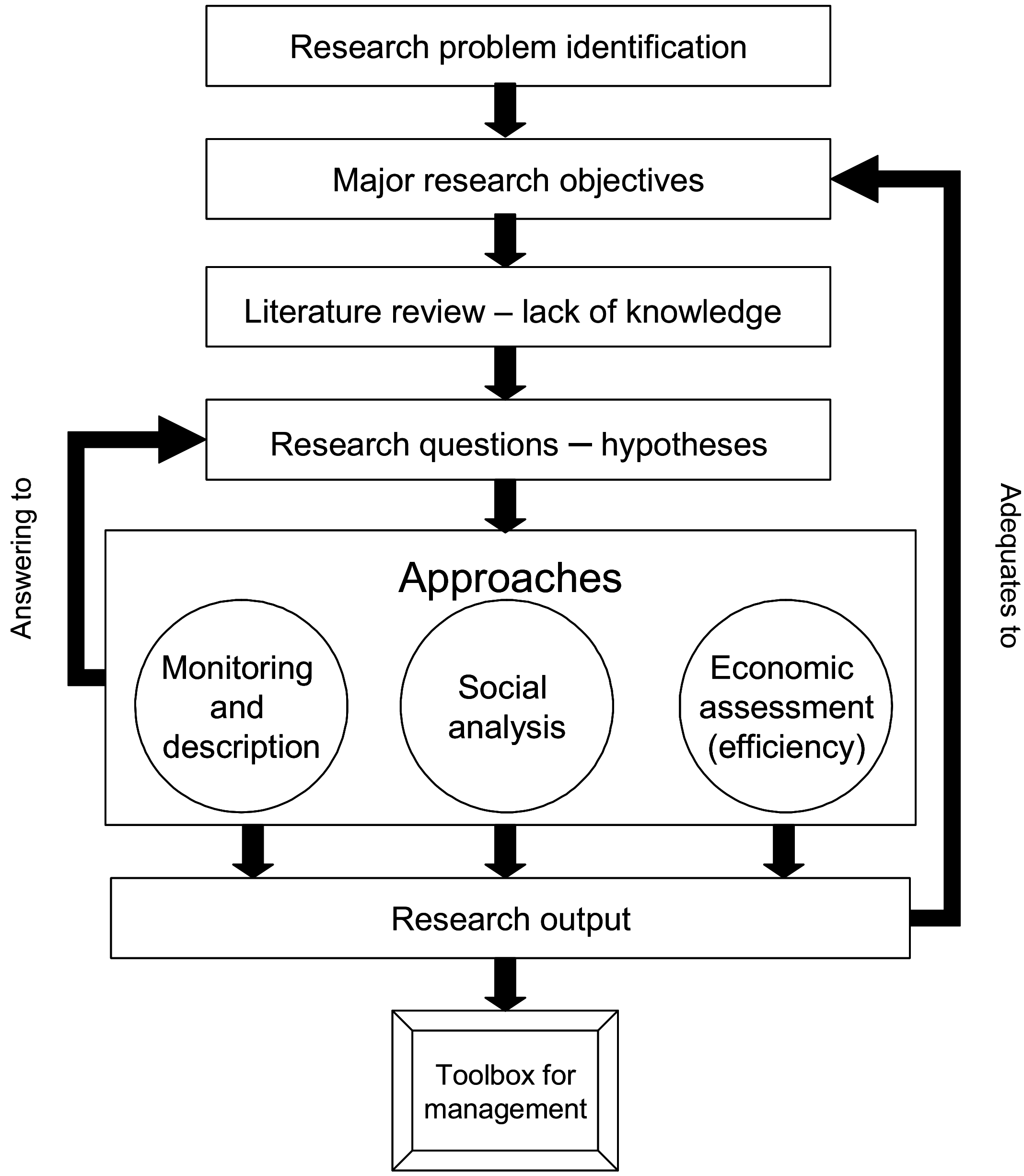


Figure 1.5 – Research framework for this thesis.

The substantive results are presented in chapters four, five and six. Chapter four identifies the potential AR users and where they are located along the Algarve region. It also investigates other questions concerning when and why the ARs are used. In addition, the chapter includes an explanation of the strategy employed to collect data from direct site observations on one of the pilot ARs in the region. Chapter five explores the social dimension of reefs. This is based on a survey method designed to investigate stakeholders' perceptions of the AR impacts. In parallel with this, other methods are used in order to find out the importance of ARs, the people affected by their deployment, and who the winners and losers of the process are. In chapter six an economic assessment is undertaken specifically an evaluation of AR efficiency, through the use of different methodological approaches. These include productivity comparisons based on experimental fishing trials, preference elicitation in order to explain commercial fishermen and diver choices, and cost-benefit analysis of the reef investment decision. Finally, chapter seven draws out the implications of the results, the contribution that the thesis has made to knowledge in this area, and considers the opportunity for future research.

1.2.2. Thesis Objectives

This thesis attempts to shed some light on the introduction of artificial habitats, namely manmade reefs, here designated as artificial reefs or simply abbreviated ARs. There is a generalised idea that these structures have a positive biological impact, but there are still some doubts concerning their social and economic benefits. One of the main reasons for that doubt is the scarcity of relevant or sufficient studies concerning the socioeconomic aspects where reefs are deployed. The work adds to the stock of knowledge on this subject, specifically aiming to:

- Examine the main reasons that lead to the adoption of ARs;
- Review the literature in terms of the state-of-the-art on ARs, their purpose and functioning, and identify the gaps on the socio-economics aspects;
- Adapt appropriate methodologies to the study of the AR human use, namely on: monitoring, social perceptions and attitudes, and economic efficiency;
- Integrate this knowledge of ARs with that of the wider area of marine resource management.

Chapter
2

Literature Review

Contents

Word Count: 13,694

2.1. Introduction

The interest in artificial habitats is not new, whether they are stable structures deployed on the seabed or just surface or middle water floating devices that attract fish. These artificial habitats are known in the literature as artificial reefs (ARs) and fish aggregating devices (FADs), respectively. The structures have indeed been used for a long time, but only became an important issue in terms of marine enhancement in the last 30 years or so. The reason for that increase in the interest may be because it is believed that these artificial structures have a tremendous potential to enhance aquatic habitats.

Given this brief context, the aim of this chapter is to outline: (1) the features of ARs in fact and how they are built, (2) why is there an increasing worldwide interest in the structures, (3) what we know of the performance of ARs, and finally (4) what are the current developments concerning ARs in Portugal.

In order to answer the above questions the chapter is organised as follows. In the next second section we focus on the background theory and origins and use of ARs in the main countries where the concept is implanted. We will also present a list of the most important facts on the subject along with the history. As this thesis is aimed at studying the socioeconomics of ARs, the part which follows will centre on studies that have investigated the demand for ARs. The review of the socioeconomics includes an assessment of the gaps in our knowledge and where research is most needed. This is necessary in order to identify the future potential of ARs. Finally, this chapter will focus on ARs in Portugal, from the decision and the legislative framework to the current research developed on the topic.

2.2. Background

2.2.1. Relevant Theory

Definition

An AR is defined as any structure placed by man in the marine environment. Typically, such a structure is appropriately prepared and strategically located to attract marine life of all kinds. Seaman and Jensen (2000: 5) also add that any AR is intended to influence not only the biological aspect, but also physical, or socioeconomic processes related to living marine resources. Reefs are designed, configured and constructed according to their purpose. The definition of ARs has been changing over time. Accidental shipwrecks, coastal harbour breakwaters and similar structures have been considered as ARs but do not get the support of all people involved with the subject. In 1996 The European Artificial Reef Research Network (EARRN) came up with a definition stating that *'An artificial reef is a submerged structure placed on the substratum (seabed) deliberately, to mimic some characteristics of a natural reef'.*

Responsibility for deploying ARs is a matter of contention. An interesting view is given by Ditton (1979), where it is stated that ARs should be deployed and owned by the public sector in order to make a resource available to the society in general. A consequence of this might be that the financial performance of ARs is a secondary concern. However, if private companies had the opportunity to build ARs in marine waters and to ask for an admission fee, for sure financial return would be a major consideration. As such, the objectives of these two initiating parties are likely to differ. The private sector has to pay attention to people because they are its paying clients, while the public sector can choose and often ignores people in its management activities.

Purposes

One of the questions that can be posed in advance is: 'What is the ARs role and what do we know about their effectiveness?' In the 1960s, when researchers started to think seriously about the question of the ARs as a fish stock regenerating measure, there were vague plans concerning diverse aspects of the theme. From empirical knowledge emerged the idea that long-lasting sunken structures had a fish production potential relatively higher when compared with an empty space. In several places around the world, ARs have been deployed aimed at supporting commercial or recreational fishing activity, or simply as a protection of fish and marine habitat (Milon 1989a,b). At the present time it is generally accepted that AR purposes may vary or be combined (Box 2.1), and continuing evaluation has to be done in order to check if the purposes to what the ARs were built are being achieved. However, there are few examples of AR evaluations when compared with the number of reef developments worldwide. The reason for this lies in the fact that evaluation is too often left as an afterthought rather than being included in the integral planning process (Lindberg and Relini 2000).

Box 2.1 AR purposes

The mechanisms that influence AR dynamics are diverse and this sort of structure has many purposes. Among the main ones are:

(1) *Ecological* – To restore or enhance fish species, providing shelter, protection, food availability, etc.

(2) *Economic* – To provide easily accessible and safe locations for different types of users. For instance Japanese ARs have usually just commercial fishing purposes (Akio 1990, Simard 1990, 1995), while in the US ARs are mainly used for recreational anglers and divers' enjoyment (Gannon and Ugoretz 1994, Hushak and Kelch 1999, Hushak et al. 1999, Ditton and Hunt 2001, Hunt and Ditton 2001).

<u>Function</u>

The rationale for artificial habitats provided by sunken structures is that, once the material is deployed it acts in the same way that naturally occurring rock outcroppings do in providing hard substrate necessary in the basic formation of a live-bottom reef community. This is attained by placing suitable long-lived, stable and environmentally safe materials (usually steel or concrete), on an *a priori* selected area of the sea bottom. Despite the fact that ARs can be nearly made of almost any material, the experience of developing the structures have shown that long lived materials and adequate location are believed to be fundamental reasons for reef functioning success (Mottet 1981, Grove and Sonu 1985).

Many different types of materials have been utilized as ARs, aimed at the enhancement of marine resources at lower cost. Examples of such materials are: scrapped tyres (Meier and Eskridge 1994, Murphey and Gregg 1994, Collins et al. 1995), automobiles (Kanenaka 1994), vessels (Meier and Eskridge 1994, Murphey and Gregg 1994, Monteiro and Santos 2000, Santos and Monteiro 2001), coal waste (Carleton et al. 1982, Ludwig 1986, Jensen et al. 1994, Sampaolo and Relini 1994, Shao et al. 1994, Collins and Jensen 1995) and obsolete oil structures after decontamination (Reggio et al. 1986, McGurrin and Fedler 1989, Reggio 1989).

The choice of adequate materials can be useful to promote the capacity of producing more fish. With growing evidence of positive results, scientists started to clarify the objectives that ARs were expected to achieve. The combination of knowledge from several areas made it possible to adapt a given type of AR to the species that were the likely users of that new habitat. The adaptation of suitable materials to the development of structures with given dimensions in specific sites made it possible to establish enlarged durability limits. This fact also allowed studies of several topics in situ. Despite many advantages relating to savings from using scrap materials ('materials of opportunity'), much consideration should be given to stability and durability of materials as the major factors affecting the AR success. It is desirable to choose highly stable and durable materials such as concrete, benefiting from their high design flexibility contrary to the scrap materials (Mottet 1981, Sheng 2000).

For instance in Japan, the country that leads AR technology and the number of deployed structures, there are several types of materials used as ARs (Simard 1995), with concrete modules being notably widespread units (Morikawa 1999). These structures have provided effective socio-economic benefits at the traditional fishing village families level (Akio 1990).

2.2.2. The Demand and Supply of ARs

There is a great variety of people and entities interested in using ARs (Santos 1997). At the international level there are three main geographical areas with major activity and interest in ARs. They are: Japan, the US, and more recently Europe.

Japan

The Japanese diet over many years has become highly dependent on living marine resources. The Japanese demand for fish is enormous and they are the world‘s largest consumers of this source of protein. Due to the need for a large amount of fish production to supply and satisfy a highly exigent market, the Japanese have to face this problem very seriously and find adequate responses to it. The perception that rocks, tree logs, and other inert materials when deposited in the sea-bottom constitute a favourable space to the creation of marine life led the Nippon people to begin investing in the artificial reefs. The Japanese ARs have a great variety of shapes and have existed since the 17th century. There are records of several enhancement experiences during the 19th and early 20th century (Ino 1974). Nevertheless, it was only in 1952 that the government started with the ARs deployment programs in large scale. The introduction of several types of ARs was planned with different purposes to attain. The Japanese government nationally financed the reef building in order to improve their commercial fisheries. All reefs in Japan are private property (Szedlmayer 2000), however AR capital is considered corporate rather than private (Simard 1996).

Japanese reef objectives vary, from maximising fish catch to the protection of juveniles, as well as in some cases serving to manage aquaculture zones. According to Simard (1995), the efficiency of the ARs in Japan can be seen at several levels: (1) biological – where a high success rate has been found, (2) fisheries production – where it was found by local managers and fishermen that fish shoals are attracted to the structures, (3) socioeconomic – mainly related with time and energy savings and to normalize fisheries, (4) general economy – Japan has a large number of fishermen, many of whom have benefited from reef developments supported by the government. ARs have helped promote the idea of changing the mode of production away from fishing and hunting and towards husbandry as farming and breeding. In this country AR success is evaluated through their popularity amongst fishermen and in terms of harvests value in comparison to deployment costs (Bohnsack 1989). There is no other government in the world that gives more support for marine enhancement on a large scale than the Japanese one (Mottet 1985). The Japanese reefs are made of durable non-waste materials which are designed and constructed by engineers (Bohnsack and Sutherland 1985).

The United States

In the US the first references to ARs started in the 19^{th} century. Some AR developments were done in the beginning of the 20^{th} century, but it was just after the WWII that many developments were done concerning reef deployment and subsequent studies. Those developments aimed at enhancing recreational fisheries (Stroud 1974). The demand for ARs in the US occurred due to the fact that increasing number of anglers found that Atlantic and Gulf coasts sea bottoms were flat (i.e. there was scarcity in rock or other types of irregular bottoms) and for that reason did not find relevant concentrations of fish. Anglers had to travel offshore to find out areas with outcroppings to fish. The AR construction occurred as a need to have fish banks near the coast, and was usually promoted by fishing clubs (Stone 1974).

However, ARs in the US were also seen as a reliable way of disposing of several kinds of solid waste. In areas where there was scarcity of waste disposal land, as in the case of the Virgin Islands, the possibility of constructing ARs made of junk cars was studied in locations where fishermen did not usually fish (Dammann 1974).

Bohnsack and Sutherland (1985) refer to the main differences between ARs deployed in Japan and in the US. A particular focus was on the scarcity of funds in the US, and the use of scrap materials and voluntary work to construct ARs. Until the 1980s the problem of financing reef projects remained, as well as finding stable funding sources. The need for a cooperative work among the industry, public and government was recognised at both state and federal levels. Communication to resource managers about the economic and environmental benefits from AR construction was claimed to be urgent (Stone 1985). More recently there has been an increase of involvement between institutions. As a result of that there is for example the case of the Gulf of Mexico States where the oil industry is involved in programs where the huge amount of obsolete oil rig structures (mainly steel jackets) are used as ARs. Currently the US has the largest rigs-to-reefs program in the world (Kaiser and Pulsipher 2005). Many scrap naval vessels and armoured vehicles are also used as ARs in some states, having the support of divers for their future deployment (Ditton et al. 2002). There are innovative ways of using ARs as in Hawaii and Bahamas where there were created businesses related to submarine tours to the AR locations (Seaman and Hoover 2001).

Europe

In Europe, France and Italy are probably the countries that were ahead in terms of reef development. The AR experience started in the Mediterranean Sea in the late 1960s with the participation of governmental agencies from both countries. They pioneered reef development in Monaco (Allemand et al. 2000).

France's interest in ARs was stimulated by the Japanese and United States experiences. It was based on the idea of finding a reliable way of solid waste disposal and supported by the fact that has become known that many obsolete structures (as old ships, junk cars and other waste materials) if properly deposited on the sea ground will fairly soon provide food and shelter for fish after aggregating lower taxa settler organisms. The idea was thought to have a double positive environmental impact: getting rid of scrap materials and benefiting from fish settling in the sunken structures (Beguery 1974).

Italy has developed much AR activity, and this country was the first one to use extensively the structures in Europe. Many programs have been developed and assisted by both EU funds and local government and fishermen's associations (Jensen 2002). Experiments have been done with ARs made of different materials and sited in places with different characteristics, where there have resulted different levels of success.

Later in the 1980s, countries as Spain, United Kingdom, The Netherlands, Greece, Finland, and Portugal took the initiative of promoting ARs. More recently countries such as Ireland, Denmark, Norway, Poland, Romania, Ukraine, Russia and Turkey have followed. The majority of ARs deployed in Mediterranean play a role of protecting valuable sea-grass beds from trawls (Bombace et al. 1993, Goutayer et al. 1994). It is intended to widen the scope to a fisheries function (Jensen 2002). One of the Portuguese cases deserves to be highlighted (the Algarve program), since at the present time it is the largest AR program made from durable non-scrap materials in Europe. It has been followed as a model of deployment by pioneer countries, as the case of France (Neves dos Santos IPIMAR personal communication 2005).

As in the Gulf of Mexico states, some countries in Europe have shown interest in the rigs-to-reefs concept. Particular interest has been manifested by Norway which wants to use obsolete steel jackets of the oil rigs in the North Sea (Baine 2002, Cripps and Aabel 2002, Jørgensen et al. 2002).

Basically in Europe the ARs have been deployed to protect habitat and allocate marine resources, having some incipient experiences on fisheries and aquaculture use. The development of ARs having the specific purpose of enhancement and conservation of fisheries has not been carried out so far, despite some perceptions to the contrary (Lindberg and Relini 2000).

Other countries

Following Japan many other countries subsequently since the 1970s have developed national plans and programs not only in the US, but also in Thailand, India, Taiwan, Malaysia, Australia, and the South Pacific Islands (Seaman and Sprague 1991: 33). The Philippines have been using ARs made of different materials since the 1970s (Montemayor 1991, Watanuki and Gonzales 2006). More recently there have been deployed ARs in African countries like South Africa (Mann-Lang 2000) and Senegal (Watanuki and Gonzales 2006).

In the South Pacific most of the ARs and FADs were created with the purpose of enhancing small-scale fisheries in poor local communities where fishing activity is the main source of income. Their construction usually benefits from the enthusiasm of local communities and involves their work (Chullasorn and Promokehutima 1984, Chabanne 1990, Venkatasami 1990, Willmann 1990). In Australia the ARs have been popularly used to create surf waves and protect the coastline. They are recognized as having a positive economic impact on the local businesses and this is attributed directly to these developments (Lanagan 2002).

Brief conclusion

Seaman and Jensen (2000: 16) state that at the present time the AR field has matured and methods developed from the coral reef experience can be transferred and adapted. They contend that, from now on, it is necessary to encourage research which is holistic and multidisciplinary.

2.2.3. Chronology

Artificial habitat developments have been dominated in the past by Japan followed by the US. More recently the interest has been spread worldwide, as one can see by consulting Table 2.1.

Table 2.1 – Milestones related with ARs. Sources: Mottet (1985), Stone (1985), Seaman and Sprague (1991), and Jensen (2002).

Date	Country	Contribute and/or action
943	Japan	First reference to the use of artificial structures placed in the water.
Late 1600s	Japan	Submersion of hard substrates in coastal areas to enhance kelp production in Northern Japan.
<1800s	Japan	A fisherman fishing by chance near a sunken ship caught an abnormal amount of fish. When the ship disappeared fishermen sunk large wooden frames weighted with sandbags in waters 40 meters deep. Three months later, fishermen netted larger numbers of fish, more than they used with the sunken ship. In the following decade they sank several hundreds of units. Similar tasks were performed in other areas.
1860	US	First reference to ARs construction in the US. The reefs were made of oak or pine sunk in eight feet of water (SC).
1870s	Japan	Fishermen from the Iwate Prefecture transported over 100,000 rocks (40 to 50 cm diameter) to an intertidal area for the culture of the seaweed fu-nori.
Early 1900s	Japan	Many efforts using different materials were used to enhance fisheries.
1916	US	Reefs made of butter tubs half filled with cement. Construction by the Boatmen’s Association (NY). Many of the individuals made their living by taking out anglers. Provided fish for about 30 years and were rebuilt after WWII.

<1930	US	Freshwater ARs known as brush shelters were in use before the 1930s. However it was just at that time the structures were recognised by managers as having good potential. Brush shelters were deployed in Michigan lakes.
1930	Japan	National funding available for a large variety of enhancement projects.
1935	US	Ocean AR construction. Four vessels and tons of other materials were sunk in NJ. The reef was located 10 miles away from coast at 20 meters depth. A one-day round trip was advertised for anglers.
1936/7	US	The success of previous reef stimulated the construction of two other reefs by two local associations in the same state.
1940s	US	There was little reef construction, other than rebuilding 6 of the ones constructed in 1916. Records were kept of the numbers and species caught.
>WWII	Japan	Deployment of Tsuki Iso structures (means quarry rocks positioned by men in the coastal area)
1950	US	Construction of McAllister Grounds in NY with debris from Manhattan building demolition.
1952	Japan	A governmental subsidy program allowed the widespread application of artificial fishing reefs. Advent of various modernistic reef modules.
1953	US	Construction of the Schaeffer 'Beer Case Reef' in NY. Built of 14,000 concrete filled Schaeffer beer cases.
1954	Japan	A program named by the government as Jinko Gyosho (means artificial fishing reef) was started using reef made of concrete and other durable material blocks.
	US	First reef constructed in the Gulf of Mexico. It was constructed under the efforts of the Alabama Department Conservation and cooperating sportsmen's groups. 250 automobile bodies were sunk. Anglers started catching several species of fish six months after deployment.

	US	The Texas Parks and Wildlife Department followed Alabama by deploying both estuarine and ocean reefs to improve sport fisheries.
1957	US	In Hawaii started scientific studies to know more about man-made reef structures. Concrete shelters were built with very positive results. Car bodies and damaged concrete pipe were then deployed.
1958	Japan	The expansion of the previous program, namely by deploying larger structures. Oh-gata (means large size reef) was used as a new category of reef for large-scale fisheries. Another type of reef called Nami-gata (means reef of ordinary scale) were also deployed for fishing communities purposes.
	US	The California Department of Fish and Game began their evaluation. Many studies about effectiveness and cost of reef materials and benefits for fishermen are still on progress today.
1960	US	A concrete block reef in the Virgin Islands was built and studied with excellent results after 28 month results. Following this it was recommended reef deployment for enhancement of sport and commercial fishing around the Virgin Islands. Research on freshwater reefs was expanding.
1960s	Japan	There were covered 3,427 sites with Nami-gata (920 thousand m^3) and 439 sites with Oh-gata (1.3 million m^3). The Japanese government invested 10 billion yens.
	Europe	First steps were done to introduce ARs in the Mediterranean Sea.
	US	Fish attractors were developed in Gulf of Mexico, Hawaii and South Carolina. These experiences were also carried out in the 1970s. In early 1980s were also developed in Florida, California and Mississippi.

1966	US	Federal research on marine ARs. The objectives were to establish research reefs along the Atlantic Coast and to determine the best use for them in order to develop and conserve recreational fishery resources.
Late 1960s	Monaco	The first European ARs were created. Their purposes were primarily concerned with nature conservation.
1970	Italy	The first Italian reef was built in the Western Ligurian Riviera. It was composed of 1,300 car bodies sunk between 35 and 50 meters depth. The purpose of the project was to prevent otter trawling and to improve sport fishing in the area. The first deployment of concrete blocks and tyres was begun. Larger scale deployment occurred during the 1970s and 1980s.
Early 1970s	France	There were deployed 99 concrete blocks of 1 m^3 each off Concarneau (Atlantic coast). Some cars were used as ARs off Arcachon (Atlantic coast).
1971/4	US	Fish populations were studied on reefs constructed of vessels and tyres in 11m of water (SC). Reef economic studies reef related were undertaken.
1974	Japan	Third phase of the program, by approving the 'Act of Coastal Fishery Development'.
	US	First international conference on artificial habitats was held in Houston (Texas).
1975	Australia	Second international conference on artificial habitats was held in Brisbane.
1977	Monaco	The Monaco Underwater Reserve was created as part of an environmental restoration project to rehabilitate flora and fauna.
	Philippines	In the Negros Island old tyres were used as AR material. The project was headed by the Siliman University. Later, pyramid shaped ARs were constructed by villagers using bamboo (a common local resource) with concrete for enhancing local fishing sites.

1978	Thailand	The Department of Fisheries constructed 34 concrete and tyre reefs as part of a marine conservation program. It was also intended to enhance coastal fishing and reduce conflicts between artisanal and commercial fishermen.
Late 1970s and early 1980s	Japan	Seven year national plan with a budget of $870 million (1985 rate), where the national government paid 50 to 70% of the costs of selected projects. More than 1/3 of the money was allocated to ARs. Rocks were placed to enhance the production of different seaweeds such as kelp, wakame, and agar-agar. Rocks are also supplied to create habitat for abalone, snails, sea urchins, saltwater crayfish, and sea cucumbers.
	US	Many studies were initiated to evaluate techniques commonly used in Japan and Taiwan, or to develop new techniques. Japanese AR technology was transferred to the US in order to provide benefits for both recreational and commercial fisheries. Japanese fibreglass-reinforced plastic were tested in FL by a private company. Biological and cost comparisons were made between these reefs and rock made ones built in the same area. New reef construction technique involving mineral accretion and the use of coal combustion waste products. In 1980 500 tons of a proper coal combustion waste products was used to construct reef block off Long Island (NY).
	South Pacific	By the early 1980s basically all countries and territories in the South Pacific Ocean had instituted or planned programs to use fish-aggregation devices (FADs) to enhance pelagic fisheries.

	Israel	Four small modules of tires bound by steal and fibreglass bars were deployed off Haifa for enhancing fisheries purposes.
	Kuwait	Three tire modules were deployed the first artificial habitats in the Arabian Gulf.
1982	Guatemala	The first reef in the Atlantic Coast of Central America was built in an estuary.
1983	US	Third international conference on artificial habitats was held in Newport Beach (California).
1984	Costa Rica	On the Pacific Coast of Central America the first AR was built in Costa Rica. Two years later 5,000 car and truck tires had been deployed.
1986	India	After the success of workshops about ARs in the Madras coast, the Indian Government asked for proposals to develop a large-scale project.
	Spain	Some ARs were built. Their purposes were primarily concerned with anti-trawling.
1987	US	Fourth international conference on artificial habitats was held in Miami (Florida).
1990	Europe	Many European countries started scientific studies focusing AR deployment.
1991	US	Fifth international conference on artificial habitats was held in Long Beach (California).
1995	Japan	Sixth international conference on artificial habitats (CARAH) was held in Tokyo.
	Europe	Establishment of the European Artificial Reef Research Network (EARRN) with funding from the European Commission (EC) Agriculture and Fisheries (AIR) program. The formal network consists of 51 scientists from 36 laboratories within the European Union (EU) who are active in the AR research.
1997	US	Attraction versus production symposium (AFS)
1999	Italy	7th international conference on artificial habitats (CARAH) was held in San Remo (Liguria).

Early 2000s	Europe	In 2002 there were eight countries in Europe who were carrying out AR programs. Some other countries had shown interest, although with no licensed structures.
	Norway	This country became interested in the rigs-to-reefs concept.
	US	This country is also interested in the rigs-to-reefs concept.
2003	Portugal	The Europe's largest AR system is completed in the Algarve. Around 43 Km^2 of reef modules are covered in the sea. More than 20,700 modules were deployed with a combined weight of 73,133 tons.
	US	Concrete reef balls are registered as a trademark. Cremated human ashes are added into the composition of the reef balls™.
2004	Italy	39th EMBS in Genoa. One of the Conference Themes' was Artificial Marine Habitats.
2005	US	8th CARAH international conference on artificial habitats was held in Biloxi (Mississippi).

2.3. State-of-the-Art

2.3.1. Current Knowledge and Research Trends in ARs

Introduction

The increasing importance of the artificial structures is reflected in the AR conferences that have been held since 1974. Since that date until the present days there has been produced an extensive literature on the subject. Bortone (2006) refers to the trends in our knowledge of this issue. So far, just in the eight international conferences on ARs there have been presented over 720 oral communications in different areas related to ARs along with over 500 peer-reviewed papers both in the proceedings of those conferences (around 300) and elsewhere (over 200). The same author also points out the increasing number of presentations up until the 5th conference (held in 1991) and afterwards a decreasing trend. However, other parallel events have been promoted. For example the symposium on ARs and FADs held in 1990 in Colombo (Sri Lanka), the European Artificial Reef Research Network (EARRN) created in 1995 where there were developed the main lines of investigation on the area in Europe, or the 39th EMBS held in 2004 in Genoa (Italy) composed of two sessions where one was entirely dedicated to the ARs subject and where most of the presentations were from works carried out in the scope of EARRN.

The countries where there is most material published are the US and Japan, where in the latter the majority of the works are published in Japanese. There are many sources of information related to ARs in a wide variety of types of documents: peer-reviewed literature (papers published in journals), books, project reports and governmental documents, theses and dissertations (grey literature), popular media (leaflets, newsletters, newspapers, etc). The sources of information where one can find the above relevant studies vary, but nowadays with the advent of information technology, the electronic medium is an easy and fast way to have access to a larger scale of literature about the subject. It is important to know what has been done so far on the subject of ARs, the research trends, the issues that are increasingly being subject to study, and also the ones that are being put aside. Answers to this sort of inquiry help us to develop the state-of-the-art concerning ARs. Accordingly, a bibliometric approach was adopted, as outlined below.

Material and methods

For seeking the information considered relevant to carry out this literature review, two methods of search were used: manual and computerized.

For the first method, it was decided that the most valuable sources of information on the AR literature would be the ones published in the conference proceedings of previous events on the subject. To do so, there were identified all the conference proceeding papers published so far. There were found all publications. They were published mainly in international peer-reviewed journals: four in the Bulletin of Marine Science (3rd, 4th, 5th and 8th conferences respectively for the years 1985, 1989, 1994, and 2006), one in the ICES Journal of Marine Science (7th conference held in 2002), one in a Texas A&M University publication (1st conference held in 1974), and another one in a Japan International Marine Science and Technology Federation publication (6th conference held in 1995). For the 6th conference many papers were published mostly in Japanese. For the 2nd conference (held in 1975) there were published only six papers.

Afterwards, it was decided to split the total number of papers found into seven areas, according to the main idea developed in the paper itself, as follows: (1) biology and environment, (2) management and policy, (3) design and engineering, (4) social and economic, (5) chemical and/or physical oceanography, (6) fish aggregating devices (FADs), and (7) other issues or non-stated main area. The scope for this was to find out where there were allocated the main themes of research.

For the second method, a literature review was undertaken where there were used scientific databases on the subject of ARs. The main objective was to find out where could be found the highest number of peer-reviewed papers using the main search term “ARTIFICIAL REEFS”. For that purpose there were selected four different scientific portals: (1) Ingenta Connect, (2) Science Direct, (3) Blackwell Synergy, and (4) ISI Web of Knowledge. The one presenting the greatest number of papers was chosen.

After that choice, a further selection of 32 additional key-terms that are related with the AR subject was also used in conjunction with the main search term. It was used a wildcard character – asterisk (*) – to substitute one or more characters in each of the key-terms. These key-terms were then ranked and found their trends in two time periods: (1) non-recent, and (2) recent. However, it is important to consider that the relevant information is collected from the patterns (or trend) that the subjects take in both periods of time. To do that it was used the following formula (Equation 2.1):

$$P_i = \frac{(B_i - A_i) \times T}{T \div k_i} \div 100$$ Equation 2.1

where T is the total number of papers on the AR subject published in both periods, A is the number of papers published in the first period, B is the number of papers published in the second period, k is the total number of papers on key-term published by subject, and i is the key-term in analysis (1 to 32).

It should be noted that the use of both approaches can lead to double counting of some of the papers. However, because two different ways of analysing the papers were used - the first by the main subject developed in the paper (author sensibility to context), and the second by the key-terms used in the paper (electronic analysis) – the double counting problem is not relevant because the analyses of the results are treated separately.

Results

For the conference proceedings an interesting trend was found. The first and second conferences were mainly composed by generalist papers where it was intended to develop the guidelines for future research. The third, fifth and seventh conferences were clearly dominated by papers concerned with biological and ecological approaches. The fourth and sixth were the ones that had the most balanced structure in terms of areas covered. The eighth evidences a large decrease in terms of papers published, but shows an increase in terms of papers published on the socio-economics aspects (Figure 2.1).

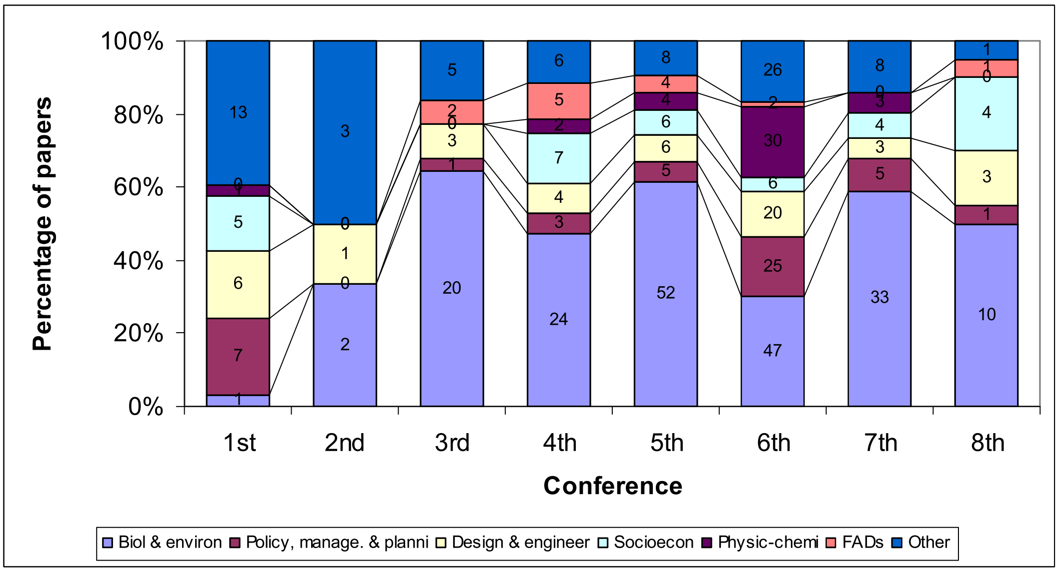


Figure 2.1 – Number of peer-reviewed papers published in some of the AR conference proceedings over time.

In terms of conference presentations converted into conference proceeding papers or abstracts published in peer-reviewed journals, there is a decline in the latest events (Figure 2.2).

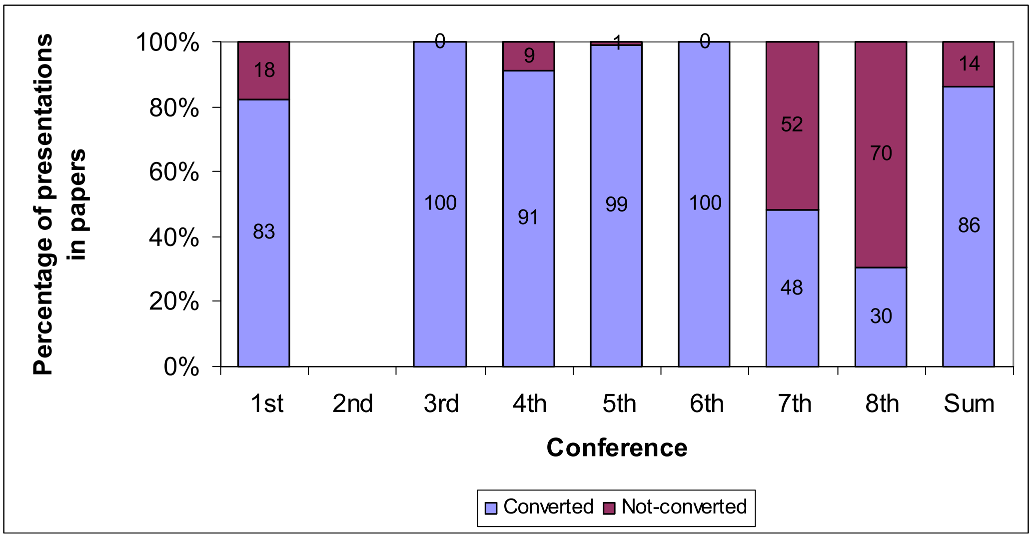


Figure 2.2 – Conference presentations and papers published in conference proceedings.

For the computerized method, the portal that provided more results on ARs was the ISI Web of knowledge where 438 peer-reviewed articles in international journals were found (17 May 2006). The periods of time comprised: (1) 1973 up to April 2001, and (2) May 2001 until May 2006 (latest 5 years). For the latest period were published 171 papers on the subject, against 267 in the earlier period. It was also found that for the last five years there were published around 34.2 articles per year[1] (Table 2.2).

Table 2.2 – Results of peer-reviewed papers search in ISI Web of Knowledge.

Measure	All papers	1st period	2nd period
Number of papers on "Artificial reefs"	438	267	171
Annual average number of papers	13.3	9.5	34.2
Sum of occurrence for 32 key-terms	1,527	756	771
Average number of key-terms per paper	3.5	2.8	4.5

The key-terms that are most commonly used in the AR peer-reviewed literature are shown in the Figure 2.3 in a ranking graph. Where both lines are approximately together that means the key-term has a normal trend. Where there is a gap between a square and a triangle that means there are changes in the key-terms use over time. The result is that larger the gap, larger the change. When squares are at the top, that means the key-term is being used more often recently than in previous peer-reviewed papers; when the triangle is at the top, it means the key-term is being used more often in the past literature.

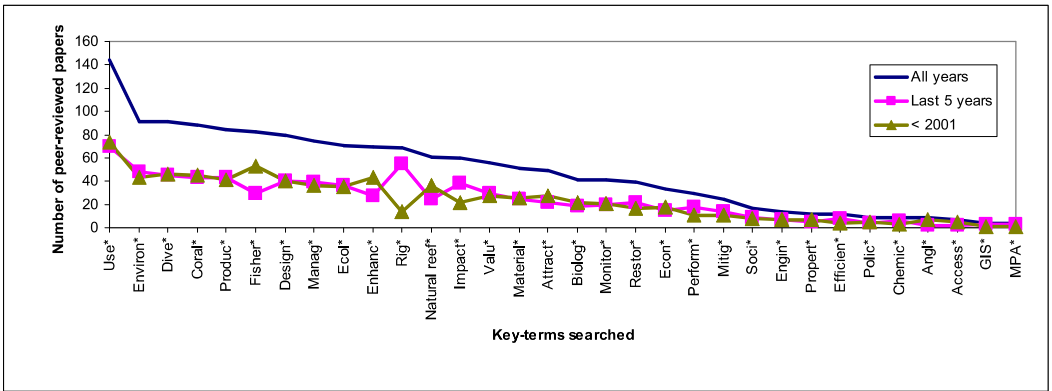


Figure 2.3 – Important key-terms found in the AR peer-reviewed literature.

Using the Equation 2.1 we can rank and score the key-subjects that have suffered from major variations in both periods of time. The top 5 are related with the subjects

[1] Bohnsack and Sutherland (1985) refer that the average annual peer-reviewed publications for the period 1966-1983 ranged between 4.4 and 8.0.

that can be found more often in recent papers, whereas the bottom five are the subjects that had more importance in least recent papers (Figure 2.4).

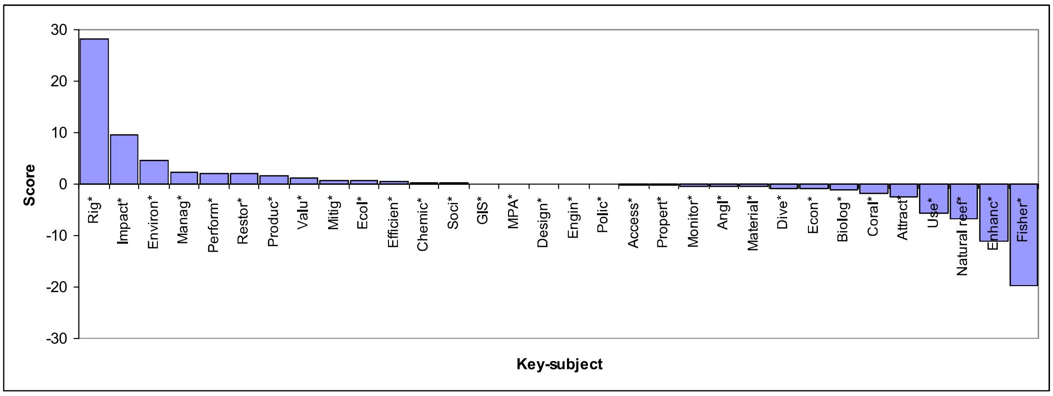


Figure 2.4 – Ranking of the key-terms related to ARs along time.

Discussion

From the analysis of the conference proceedings over these last 32 years of research published on the subject of ARs it is clear biological and environmental themes are dominant in the majority of the material published. These aspects are related with fish assemblages and reef colonization (usually species listings), and comparisons between the different reef types or substrata.

The decline of papers published in the proceedings of the last conferences (CARAHs) may be attributable to the fact that the research presented in those conferences was still in progress at the time of submission. It may also be because the research was subsequently published elsewhere (e.g. higher impact journals).

When analysing the key-terms, it seems that the main subject that has been recently considered in the relevant literature derives from the key-term ‘rig*’, which immediately relates to the ‘rigs-to-reefs’ approach. The high rank for this term in recent years may be due to the fact that the powerful oil-industry can sponsor such projects. Many researchers have an interest in focussing their projects in this subject because they have a greater chance of getting funding from the oil industry to do so. Another issue where there is much recent material published is related with the key-term ‘impact*’. The words derived from this term can be used in many different areas, which means that it can be complex to try to find out which are the main aspects related with ‘impact’; they can vary as much as ‘environmental impact’, ‘economic impact', 'social impact', 'fishing impact', and an non-ending number of other 'impacted' issues. However, there are no doubts that in recent years the term is in fashion. The third most important key-term is 'environ*'. This can empirically mean that there are research 'environmental' concerns that have been developed in recent years. It also can mean that due to the fact that most of the researchers investigating the AR subject come from the natural sciences background, it seems more plausible to them to develop environmental-related inquiries.

On the opposite side is the key-term 'fisher*' and related words. The decline in use of this term in the scope of ARs may be due to the expansion of natural sciences studies where the term is rarely used; in contrast to other areas of knowledge, where the term is more likely to be used as in a legal (policy) or socio-economic context. The boom of AR projects occurred in the 1970s until early 1990s (the trend in AR conferences presentations mirrors this fact), and at that time many projects seemed to have the intention to help local communities in the fishing sector or enhance fisheries. That was achieved in some cases (Bohnsack and Sutherland 1985), but there were also some failures (Whitmarsh 1997a). The second least used key-term in recent years is 'enhanc*', which can be highly related to fisheries, and for the same reason its use has diminished. Papers dealing with the relationship between ARs and natural reefs have also been in decline.

Conclusions

The first conferences showed that most studies were concerned with AR construction. More recent ones have shown an increasing refinement on other areas of research. At the present time in many countries there is already a significant amount of research done, mainly in biological sciences. Few relevant studies have been developed so far considering socioeconomic and management aspects. In these latter areas it seems that the actual line of inquiry is still quite immature concerning the subject of ARs.

The use of wildcards in the key-terms is a good help, but has also some drawbacks. The key-terms searched do not always reflect exactly what it is intended to be found. For example, when searching for the key-term 'soci*', despite being intended all the words derived from the basic structure (such as: social, socio, sociability, sociable and others that are related with human use of reefs); the fact is that the key-term can also be related for instance with marine species 'social' relationships. In this way the key-term for the purposes of this thesis is overestimated.

It seems that the most popular key-terms may somehow reflect where there is more money available to carry out certain type of studies. By contrast, the key-terms that are not so fashionable in recent years denote that funding has not been allocated to those areas as before, or the related areas do not attract researchers anymore.

2.3.2. Lines of Enquiry with Relevant Interest

The main themes

In the first conference dedicated to ARs it was stressed that AR deployment seemed to be a good measure to improve fish enhancement in coastal waters, and contended that international attention should be given to ARs in their potential use in fisheries management (Mauermann 1974). It was recognised that, despite some knowledge accumulated up to that date, much information was still needed in order to develop the full potential of the structures (Stone 1974). Since that time the need to gather different stakeholders in the planning process in order to minimise negative impacts derived from reef deployment has become apparent (Ahr 1974). Socioeconomic studies concerning the benefits of ARs were explored, though focussed mainly on comparisons fish catches from sport fisheries using either ARs or NRs as attractor devices (Buchanan 1974, Crumpton and Wilbur 1974, Ogren 1974). Some clues were also given in order to verify if developments were efficient in economic terms or not (Shepard 1974).

The success of the first conference on ARs stimulated an interest in this subject and an enthusiasm for similar events, and as these have happened a greater number of scientists and others have participated in them. Since that time, refinements to the approaches to deal with the structures have been increasing, because more technology and knowledge became available on the subject.

Over time a substantial body of information about ARs has been developed. In parallel with the conference proceedings and other peer-reviewed papers, there have also been published five relevant books in English, compiling guidelines in what needs to be done to attain real success with reef deployment. It should be noted that one of the books was about the state-of-the-art in Europe and followed the first

EARRN conference held in 1995. These books were edited by D'Itri (1985), Seaman and Sprague (1991), Jensen (1997), Jensen et al. (2000) and Seaman (2000a). From the analysis of these works it is apparent that there is an increasing trend towards a broader coverage of themes. If the first book gave more emphasis to the reefs for biological enhancement and the historical aspects related with AR demand and supply, the last one benefits from the refinement of all accumulated knowledge from previous works in all the relevant areas related to ARs. For the first time were combined all the essential disciplines required for evaluation, including: engineering, economics, biology, and statistics. There were also covered the most fundamental aspects for reef development, such as: design of reefs, multi-disciplinary methods of investigation, data analysis, examples of applying the methods to reefs built for different purposes, and case studies of typical reef evaluation procedures. It also included the knowledge of researchers not only from Japan and the United States, but also from other parts of the world where AR knowledge has been improved.

Fundamental steps towards reef effectiveness

It is now 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 socioeconomic. Indeed, if possible, all should be carried out together. However, in the pre-deployment phase there are also many other important steps that can compromise a project development as: (1) to find out availability of funding to support the investment, (2) reef potential locations have to be chosen accurately, where oceanographic and geological studies on the properties of each location have a vital importance at this stage, (3) legal requirements to deploy the structures, (4) stakeholders consultation for assessing their interests and minimize potential conflicts, (5) design and engineering of the structures, and finally when the best conditions are gathered (6) proceed with the deployment. 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 in the places where ARs are established.

It has been found that after reef deployment there is usually an increase in: fishery catches, nursery grounds and protection of over-harvested fish stocks, showing evidence of the cause-effect of the ARs (Nakamura 1985). This occurs due to the fact that reefs can be deployed aiming at three biological goals: attraction, productivity enhancement, or stock diversification (Milon 1989). However, despite having that intention, until today not much is known about ARs' real function; or at least this is a very controversial issue. Is it production of fish or instead just attraction, or even a combination of both? Accredited scholars and researchers are quite divided concerning this aspect, and many papers have been published theorizing the problem or asserting opinion on the subject (e.g. Osenberg et al. 2002, Powers et al. 2003, Brickhill et al. 2005). This issue is particularly important for the socioeconomics evaluation, once the value of benefits derived from reef development (whether monetized or not), are viewed as a priority for assessing reefs' success (Pickering and Whitmarsh 1997). The rationale is based in two suppositions: (1) if ARs just attract fish species from a natural reef, the success of the AR is due to the competition with a neighbour NR, and the benefit for the entire system may be none (Bohnsack and Sutherland 1985, Whitmarsh and Pickering 1997); however (2) if in a given AR there is an increase of overall biomass (evidence of production) of certain fish species without disturbing the existing natural habitats, that means the AR has a greater chance of being successful even under fishing pressure (Powers et al. 2003). An objective answer to this sort of inquiry can be extremely important. For that reason, comprehensive studies on the given ARs may facilitate the process of understanding their real functioning. In its turn, this sort of information can be very useful, for example in accomplishing enhancement purposes, since managers should know how AR structures actually work and how effective they really are.

The importance of the materials' choice for ARs' effectiveness

Much has been discussed about what sort of AR materials are most effective. Many types of material can be used, and examples include: quarry boulders, scrap or obsolete structures and concrete made structures. Materials choice is often subjected to their availability and expected effectiveness (Sheng 2000). However, questions related to the design are raised when trying to determine if reefs' shape fits into the purpose they are aimed at. Research has shown that this depends on the stated objectives of the project (Seaman 2000b).

It is common to find in the literature two examples of reefs: obsolete vessels or navy ships (e.g. Meier and Eskridge 1994, Jones and Welsford 1997, MacDonald et al. 1999, Leeworthy et al. 2006) and concrete made modules (e.g. Duval and Duclerc 1986, Bombace et al. 1993, Meier and Eskridge 1994).

On the one hand, obsolete vessels/ships can be highly effective for diving purposes, and usually have the advantages of being deployed at cheaper cost and being displaced with lower environmental and aesthetic impacts, but their duration is usually relatively short. Scrap vessels made of wood have the limitation of the material durability when in the water, as well as iron or steel hulled ships that get rusty much more easily. The real effectiveness of AR vessels has been found when they are used to divert mass diving tourism from coral reefs (Van Treeck and Schuhmacher 1999a, 1999b).

On the other hand, concrete made modules deployed have their effectiveness recognized to mitigate fisheries negative impacts from trawling and diverting harvesting pressure from natural habitats (Bombace et al. 1993, Fonda 1996, Revenga et al. 2000), but usually have higher implementation costs (due to construction), but have the advantage of being considered as long-lasting structures.

Both types of ARs can potentially provide: (1) substrata for benthic fauna and flora, (2) additional food related with this aggregation and (3) recruitment habitat for individuals that would otherwise be lost (Pickering and Whitmarsh 1997). However, it has been demonstrated that not only the materials used, but also the design the ARs have in meeting target species habitat requirements (in terms of their body shape, size and age) are of major importance in their success/effectiveness, as explained by several authors (Spanier 1991, Jensen and Collins 1996, Fabi and Fiorentini 1997). Other additional considerations for AR success may be related to location, adequate planning and management (Bohnsack et al. 1994), as well as the diameter of their holes and crevices when present and overall size and volumetric coverage (Beets 1989, Campos and Gamboa 1989, Collins et al. 1991, Bohnsack et al. 1994, Bombace et al. 1994).

It seems that the success/effectiveness of ARs has been discussed mainly in terms of their materials and design, but not including the human interaction with the reefs after their establishment. So far, there is no significant literature attesting how a given management measure alters the effectiveness of ARs when stakeholders such as divers and/or fishermen or other are included in the system.

Social and economic

The biological effectiveness of the ARs is usually supported by biologists and corroborated by some of their studies (Bohnsack and Sutherland 1985, Milon et al. 2000), but the explanation for that effectiveness may vary amongst authors. Thus, biologists rarely take into account that reefs' success is highly dependent upon human interaction with the structures. Many authors report that fishing effort and catches increase at the reef sites when compared to their controls (Buchanan 1973, Arculeo et al. 1989, Polovina and Sakai 1989, Santos and Monteiro 1997, 1998). However, that trend is usually found in the short run (i.e. few years after deployment), which cannot be used as a strong evidence of success for the lifelong of the project. It has also been reported that, over time if effort increases, CPUEs decline (Buchanan 1974, Whitmarsh and Pickering 1997). Other AR failures that have been found in the past were caused by: wrong choice of materials and sites of deployment, storms destruction, gear destruction, damages on corals and sea beds (Bohnsack and Sutherland 1985).

The studies on the economic impacts provoked by ARs have been only initiated in the 1980s (Seaman et al. 1989), and despite some studies on the subject, there is still a lack of rigorous techniques for this type of assessment. As seen in the previous section, the choice of materials, design and location are fundamental aspects in terms of determining economic performance of AR structures. In addition, the socio-economic performance should not only take into consideration the CPUE measurements, but also other type of impacts and values (Polovina 1990, Mead and Black 1999). Both approaches are important, but seem not to be sufficient.

In the economic analysis of ARs, methodological approaches have been adapted to calculate reef impact and efficiency. Methods such as seeing how the presence of ARs contributes to the increase in the number of boats and expenditures in recreational activities in a given area are important to consider (Buchanan 1973, Talhelm 1986, Rhodes et al. 1994). Probably one of the best examples of the need to address these issues is presented by Milon (1991), where a way is proposed to carry out socioeconomic studies on ARs and FADs in order to widen the range of techniques to evaluate AR effectiveness. The study focuses on monitoring, impact assessment, and efficiency analysis, since these are the evaluation areas considered most important to measuring social performance. A central concept is the benefit cost ratio (BCR) and how it can be calculated for an AR. Despite being a good approach, however, this method is arguably too simplistic where it assumes a constant catch ratio surplus. There is also the empirical problem of how to satisfactorily monitor and obtain consistent 'producer surplus' measures that arise from reef deployment.

The influence that human intervention has over the reefs is extremely important, since this may determine success or failure. That is why the 'reefs' effectiveness' is still an arguable question in socioeconomic terms, especially when it is related to effective management of the structures (Milon 1989, Whitmarsh and Pickering 1997). The problem of how to address adequate management is often related with the establishment of access rights (Ostrom 1990). Open access resources, common pool resources, restricted access or access subjected to property rights are the main management options available that can dictate the real success or complete failure of a given AR project (Pickering et al. 1998, Baine 2001). Here resides the weakness of most studies done so far on ARs, including extensive ones; they rarely take into consideration these aspects, especially by 'forgetting' to include the social dimension. The contention of this thesis is that it is crucial importance to know stakeholders' perception and attitude concerning the ARs and include them in the management process.

2.3.3. Research Requirements

There are many issues that need to be addressed concerning research on ARs (Anonymous 1998, Bell 2003). Some of these were flagged up in 1990 by the Atlantic States Marine Fisheries Commission (ASMFC), which reported results from a worldwide survey. More recently Jensen (2002) has indicated specifically that more information is needed on reef effectiveness and the documentation of benefits.

To be sure, it is important to have data on harvests from the ARs and associated resources. It is also important to know if artificial reefs can work as resource conservation refuges without the need to spend much in enforcement. Another need is the socio-economics aspect of fishery science, where there is not enough knowledge about the public benefit of the program (by means of knowing who uses the reefs and to what extent), but it is also important to know the cost-benefit relationships derived from reef deployment, and how these can be connected to productivity derived fisheries or from other factors, such as user accessibility. Another aspect that is important that managers would like to know is if the size and location of the reefs have any bearing on major variables (e.g. yield) or parameters (e.g. growth, survival rates, and carrying capacity). There is a feeling that data results from pilot reefs may not apply to reefs of a larger scale. Dynamic modelling of the resources is also necessary in order to understand reef equilibrium production, as well as established quantitative data from stocks of different reefs in order to make comparisons.

2.4. The Artificial Reefs in Portugal

2.4.1. Legislative Framework

Fisheries

In Portugal the main legal arrangement that regulates the fishing activity is the *Decreto-Lei* # 278/87 of 7th July. This law established the legal framework for the fishing activity within the coastal area up to the 12 miles zone and the entire EEZ. There is also the *Decreto Regulamentar* # 43/87 of 17th July that rules the most important aspects related with the above *Decreto-Lei*, in which are defined the national measures to adopt for the conservation of the biological resources applicable to fishing in both interior and oceanic waters under Portuguese sovereignty and jurisprudence. This defines the national policy for fisheries management, establishing the characteristics of vessels, fishing gear allowed (e.g. mesh size, dimension of gear), minimum landing sizes, and other characteristics susceptible of being found in the fisheries scope. Later there were changed some of the aspects related with this *Decreto Regulamentar* by having adopted the DR # 28/90 of 11th September and its *Portarias* # 813 to 816/90.

Recreational use

Concessions for fishing in Portugal have been regulated since 1965 (*Portaria* # 21286 dated 13th May), previewed by DR (1962). That diploma is still active. There is regulation/legislation in place concerning recreational fishing in most of the rivers and connected interior waters. However, in coastal waters just general legislation is applied. When the recreational use takes place from the beach, the *Decreto-Lei* # 309/93 dated 2nd September regulates specific conditioning concerning sea angling and snorkelling spear fishing according to the type of anthropogenic use each beach is subjected. Recreational maritime fishing is defined by the legal framework where there is a purpose to targeting animal and vegetal species for recreational purposes in ocean, maritime and non-maritime interior waters. Recreational fishing includes both leisure and sport, and can be designated by tourist fishing when practised in vessels operating in maritime-tourist activities (DR 2000b).

AR referenced: Portugal

In EU terms the Commission's Decision # 92/73/CEE of 20th December 1991 approves the multi-annual orientated program for aquaculture and marine protected areas management presented by Portugal in the Regulation # 4028/86/CEE scope. In the execution of the program special attention is dedicated to the interaction between the aquaculture sector and the environment.

Some aspects considering the creation of ARs were stated in 1995 by the *Resolução do Conselho de Ministros* # 38/95 dated 21st April and the *Despacho Conjunto do Diário da República II Série* # 98 dated 27th April. The first by promoting strategic orientation lines for the coastal zone management strategies able to protect and enhance sea resources, where there is the inclusion of 'management instruments' namely more selective type of gear and the deployment of AR systems. Studies are encouraged related to the impact, technology and valorisation of the sea resources. The diploma includes the on-going projects, where the actions in the Algarve coast contemplate decommissioned vessel hulls' recycling, the creation of AR systems with the main objective of promoting the protection and making available fisheries resources, and studies related with the fishing stocks ecology and conditions to explore them in order to reduce the negative impact of fisheries. The second diploma, in its turn includes the technical aspects concerning dredging operations and related materials. It also considers the creation of ARs by using scrap and waste material. In the Centre region of Portugal the 140 Km coastal strip from Ovar to Marinha Grande integrates the possibility to sink vessels and develop ARs with the main objective towards coastal protection (DR 2000c).

On the 2nd March 2001 the *Despacho Normativo* 10/2001 was presented approving the regulation concerning the Application Measures 'for the protection and development of the aquatic resources' found in DR (2000a), where the mainstream is to promote more efficiency in the use of the natural resources, through the introduction of new technologies and promoting innovative projects as is the ARs' case. Applied research as well as observation, monitoring and information systems and assessment and forecast instruments are conditions that have to be assured in order to get financial support. The diploma states that for the AR projects to have access to finance:

(1) Promoters need to have certain conditions as such: (a) fiscal administration, social security and paying institution regularised, (b) organised accounting in legal terms, (c) to gather technical and scientific merit in sea sciences or to have an agreement with such institutions;

(2) Projects should satisfy the following conditions: (a) to exhibit investments over €100K, (b) to demonstrate that the project is a collective benefit, (c) to foresee a technical and scientific attendance of the reefs' impact on the sea species and on the environment during at least five years, (d) to guarantee financial covering of the project, (e) to demonstrate the accomplishment of the legal dispositions in terms of public and environmental elicitation.

The *Resolução do Conselho de Ministros* # 22/2003 dated 18th February was scheduled with the objective to approve the Program FINISTERRA (Coastal Zone Intervention Program). The program has the intention to re-qualify and re-manage the Portuguese coastal zone through the adoption of diverse measures and interventions to tackle the coastline retreat. Artificial reefs with the purpose of attenuate coastal erosion are eligible in the investment.

In a more recent development, legislation was enacted for the Management Plan of the Natural Park of Arrábida (which exists since 1976), which *inter alia* refers to the prohibition of any kind of AR deployment (DR # 161, *I-Série-B* by the DR 2005).

<u>Summary</u>

A review of what has been published in connection with ARs in Portugal shows that there is no specific legislation considering reef use in the country. Given that the ARs so far are all deployed in coastal waters, reef users are subjected to the general regime adopted in such circumstances. The only legislation published so far considers the proposal and concretization of the reef projects by the promoting institutions as stated above. The evidence of more policy pressure especially in recent years denotes that there are increasing interests in the deployment of AR around the coast and adjacent waters.

2.4.2. The AR Decision

Background

Most of the marine species are found in the coastal areas. This is where fish, invertebrates and other species have the conditions to spawn, feed, and match other biological needs. This potential is increased if there are additional inland or estuarine water systems. Historical evidence shows that fishing activities are usually prone to development in areas where valuable and/or abundant fish can be found. There is also evidence that where there is high fishing pressure, there is the need of establishing adequate management strategies in order to guarantee a sustainable exploitation of such resources.

In the last decades ARs have been developed as a response to the problem of fishing pressure. In the past it has been perceived that the ARs had exclusive use as structures to aggregate fish with the main objective being to increase fishing revenues. More recently, the ARs are seen as having a wider scope of applications, namely ecological (to: increase fish production, promote biodiversity, protecting young fish, etc.).

Main reasons for the choice

Due to the apparent success of the Japanese (and other countries) in rehabilitating their coastal fish species through the use of AR structures, the Portuguese Institute of Fisheries Research (IPIMAR) took the opportunity of getting financial support from the 'Integrated Regional Development Plan' to start a pilot project using these sort of structures in the Portuguese coast. The decision about the area to deploy these structures was done according to what was considered of fundamental importance for the reef site decision by previous international experiences on the subject. It is agreed that the site choice should be done according to the following criteria:

- There should exist an abundance of large amount of estuarine or inland waters;
- The area should have moderate sea conditions (waves and currents), which are fundamental for reef stability and function;
- Scarcity of rocky formations;
- Intense exploitation on the fishing resources.

Amongst the Portuguese coastal areas, the Algarve southern coast was chosen due to the fact that it was the one that gathered the most favourable conditions on the above criteria:

- The region presents the largest inland water system in the country (Ria Formosa lagoon), and other important water systems as the Ria de Alvor lagoon and the Guadiana river estuary;
- It is the region where the waters are calmer due to its proximity to the Mediterranean waters;
- The Leeward area is composed almost exclusively of sandy or sandy-muddy substrates and due to that considered as having low biomass productivity;
- The Algarve is the region of Portugal where there are more people depending upon fisheries.

2.4.3. The Algarve Reefs Program

Defining purposes

Portugal has been investing in the Algarve region in an AR deployment program since 1989, when the first studies on viability were commissioned. The scientific, design and engineering consultancy decided that the structures should be non-polished concrete modules deployed in the most impoverished coastal zones, i.e., sandy and muddy sea bottoms (Santos and Monteiro 1997, 1998). ARs were planned to occupy a macro-spatial localisation ranging between 16 and 40 meters depth. This depth was considered appropriate so as not to interfere with fishing activities in shallower waters, while still retaining their functionality which would otherwise be lost in deeper waters. Deployment and monitoring are also feasible at a depth of 16 to 40 metres (Santos 1997). ARs localisation is adequate for the artisanal fleet operational use. This fact attempts to demonstrate the structures' usefulness in maintaining the fishery, by facilitating the capture of fish (Monteiro and Santos 2000).

Initially there were necessary preliminary technical studies to establish a correct localisation of the structures in two different sites, through the bio-ecological characterisations, taking into account aspects as:

- Currents' strength, slopes, type of sea-bottom sediment, etc., in order to determine the stability of the artificial modules;
- Primary production, water column, abundance of nutrients, etc;
- Studies of the benthic and fish fauna.

<u>Pilot phase</u>

In 1989 deployment started of two pilot reef systems made with concrete: the Olhão and Faro reefs. It was intended to carry out one of them in a zone lacking of local rocky substrate (Olhão reef, located in front of the Armona sandy-barrier island). The other site (Faro reef, located off the Ancão peninsula) had somewhat different characteristics, i.e., was in the proximity of rocky formations (Figure 2.5). Both sets are located in a zone in the vicinity of the Ria Formosa lagoon. This geographic location was supposed to complement the lagoon as a nursery, thus providing juvenile fish with increased substrate conditions where they could find food, as well as protection and lower vulnerability. In addition, it was thought also that AR deployment in these areas would increase species aggregation and create new habitats.

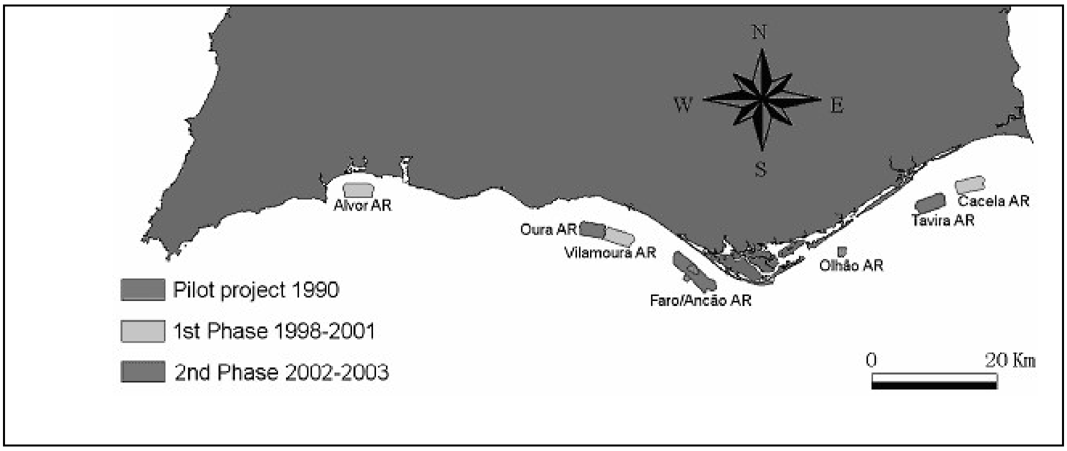


Figure 2.5 – General scheme of the artificial reef complex of the Algarve coast.

Each reef set was composed of a group of protection and another of exploitation modules. The protection group has 735 small cubic modules, distributed in 21 sets, occupying 39 ha, in depths ranging between 16 and 22 meters. The exploitation group is composed of 20 blocks of larger dimensions, with two distinct formats, distributed in five sets, occupying an area of 21 ha, at depths ranging from 25 to 40 m (Santos and Monteiro 1997, 1998).

Consolidation phase

Based on the American (Lindquist and Pietrafesa 1989, Stephan and Lindquist 1989) and Italian (Bombace 1986, 1989) practice of using sunken old and obsolete vessels, in 1996 the Portuguese experience of ARs was extended to these different materials. A donated redundant trawler was sunk off the Ancão peninsula. All potentially dangerous substances were removed as well as useless parts so that basically what was deployed solely the iron hull and the bridge of the vessel.

After apparent encouraging results from the pilot reefs' functioning[2] (INIAP/IPIMAR 2003) it was decided to create a larger program where it was intended to multiply the AR modules envisaging the creation of a reef complex in the Algarve coast composed of seven ARs. This time, financial support was available from the Financial Instrument for Fisheries Guidance (FIFG)[3]. Funds were then obtained and in 1998, further AR deployment throughout the Algarve coast was done (first phase). The pilot and first phase costs were evaluated at around €3.5 million (at 2000 prices). These third and fourth ARs (Vilamoura and Cacela respectively) were co-financed by the FIFG program and the Portuguese Government (75 and 25% of the investment, respectively). The second phase, consisting of the fifth, sixth, seventh, and eighth AR sets (Alvôr, Ancão, Tavira and Oura) was co-financed by the Operational Program to the Portuguese Fisheries (POP 2000-2006)[4].

The design and disposition of these new reefs was identical to the pilot ones, the effect being to extend the areas of deployment. Each system is composed of at least

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[2] Namely: (1) the increased biological production in reefs' area, (2) higher capacity to host fish populations, (3) good colonization rates in terms of fish, and (4) the increase of fishing benefits.

[3] In Portuguese it is abbreviated to IFOP. In brief this program has structural measures aiming to: (1) contribute to a balance between fish resources and their exploitation, (2) reinforce exploitation structures' competitivity and the development of firms economically viable in the sector, (3) enhance the supply and valorisation of fishing and aquaculture products, and (4) to contribute to the revitalisation of the fishing and aquaculture dependent areas.

[4] This Program consists of a specific application of the Structural Funds in the context of the Third Community Support Framework (QCA III).

2,940 minor modules of 3 tonnes each and 36 major modules of more than 40 tonnes each (Figure 2.6). The entire complex has 20,748 modules in total and has a total volume of 100,000 m^3. It occupies in a discontinuous way a total area of 43,5 km^2 and it is estimated that its influence area is over 67 km^2, i.e., equivalent to 6,700 football pitches. The Faro/Ancão artificial reef is currently Europe's largest, extending for 12.2 km^2 and with an estimated area of influence of 17.9 km^2. In total, there were invested around €8 million (at 2003 prices) in the AR program developed in the Algarve.

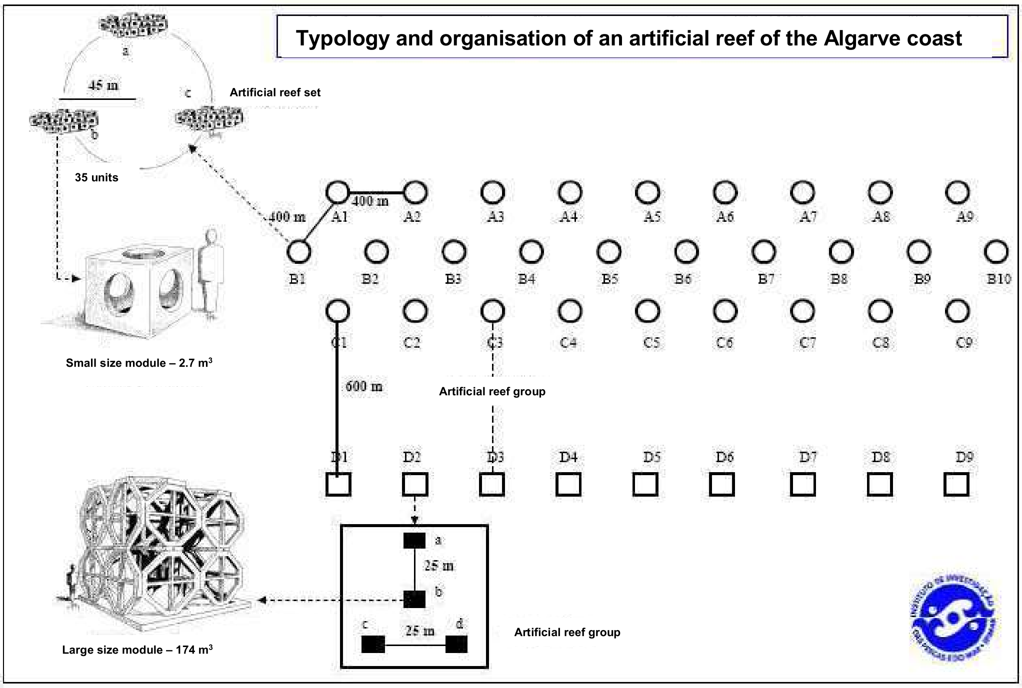

Figure 2.6 – The types of reefs used and their distributional organization (1st and 2nd phases).

Fisheries management and access conditions to the ARs

At the state level, in Portugal the fisheries sector is under the auspices of the Ministry of Agriculture, Rural Development, and Fisheries, which in turn has a secretariat for fisheries where the main management body is the Fisheries and Aquaculture Directorate (DGPA). DGPA is the body responsible for the national fisheries management via a licensing scheme stipulating which type of gear may be used in each circumstance. In 2001 and 2002 some Orders were approved for the renewal of fishing licences. This measure, along with the allocation and transfer of fishing gear, has helped to diminish fishing effort and encourage fishermen to use more selective gear, and consequently causing less damage to the resources (OECD 2003: 237). However, DGPA often consults some other institutions, which have usually a monitoring role such as the Portuguese Institute of Marine Research (IPIMAR) and the Regional Environmental Directorate (DRA). The IPIMAR body provides expertise in fisheries related issues, whereas the DRA has scientists with expertise mainly in environmental and geological issues. The enforcement is carried out by the local port authorities (*capitanias*), through local maritime police.

In the reefs' program planning process the above institutions gave serious consideration to the access conditions to the ARs. In particular, it was considered that the structures should be deployed in a way that should make accessible future commercial exploitation of fish by eligible types of gear[5]. At the same time it was intended not to interfere with important fishing gear (such as dredges) operating in the region. Due to this reason all the structures were deployed in waters deeper than 15 metres.

2.4.4. Policy Objectives

In tandem with the creation of the AR program by the European Union, the Portuguese government and the Institute of Fisheries and Marine Research (IPIMAR), the policy objectives for the ARs were articulated. (Box 2.2).

Box 2.2 AR policy objectives stated by the IPIMAR

Primary goals: (1) to protect juvenile fish, especially those ones having higher commercial value, (2) to promote biodiversity and allow the diversification of catches, (3) to contribute to the recovery of coastal fish resources, (4) to create

[5] The eligible types of gear for use in the Algarve ARs are: trammel, gillnets, small purse seines (both pelagic and bottom), traps, pots and some long-lines. The fleet that uses these gear types is multi-purpose, i.e., it does not just use one gear throughout the year, but changes it according to season or empirical knowledge. This fleet is also the one that lands the highest variety of species when compared with trawl and large purse-seine fleets.

fishing areas and promote a controlled exploitation of coastal fishing resources, (5) to develop a sustainable exploitation strategy, (6) to reduce fishing costs, and (7) to promote alternative fishing management measures.

Other goals: taking into account that ARs can have other potential uses, it was also intended to explore strategies such as: (1) to promote off-shore aquaculture, (2) to carry out fish enhancement/restocking actions, (3) to develop reef-related eco-tourism activities, and (4) to develop integrated studies of coastal ecosystems functioning.

Source: INIAP/IPIMAR (2003)

The IPIMAR expects to accomplish the above policy objectives, and anticipates positive impacts that the program should have (Box 2.3).

Box 2.3 AR progress evaluation

It is a common practice to carry out evaluations in many management programs. Evaluators should be commissioned to perform the task. In this case a design is proposed in order to provide information about the progress over the above goals, with specific tasks to evaluate the following expected positive impacts:

- Bio-ecological by: (1) developing new habitats that will improve the coastal zone value in a large area, i.e., around 50 km^2, (2) increasing the capacity to host and protect juvenile fish, and (3) contributing to recover sea fish resources, mainly those which are subjected to an intense exploitation.

- Fish resources management by: (1) increasing the availability and diversity of fish resources, (2) creating new areas of conditioned fishing due to the fact that more selective and/or less destructive gears have to be used, and (3) increasing fishing revenue.

- Fishing and aquaculture arrangements by: putting in practice innovative and integrated alternative ways of fish resources management, combined with other activities namely off-shore aquaculture and eco-tourism.

- Socio-economic: as a consequence of the above effects.

Source: INIAP/IPIMAR (2003)

The AR policy also acknowledges that any coastal management and arrangement strategy is only viable if it is maintained by the coastal communities which have been supportive for this initiative. It is assumed that the ARs will have a catalysing effect on those fishing communities and their associations on an intended co-management strategy (INIAP/IPIMAR 2003).

2.4.5. Main Studies Developed in the Portuguese ARs

The Portuguese experience of ARs is mainly based on the structures deployed since late 1980s in the southern mainland (Algarve region) and in the Madeira Archipelago, which became operational in the early 1980s. In the mainland, the Algarve research group (IPIMAR/CRIPSul 2007), based at Olhão has been developing research on ARs on the following areas:

Physical and chemical oceanography – so far there have been monitored the nutrients composition and availability in the AR areas; the type of nutrients and their concentrations are usually related to the biological production the structures can promote, whether fish or other organisms (Monteiro et al. 1994, Falcão et al. 2007);

Ichthyology – there have been carried out underwater censuses in some reefs deployed (Santos 1990, 1997), fish assemblages (Santos et al. 1996, 2002, 2005, Santos and Monteiro 2007), as well as fishing trials onboard research vessels using eligible gear identical to those that are utilised by fishermen; estimations of fish production, abundance and biodiversity in the reef areas have been carried out along time (Santos and Monteiro 1997, 1998);

Benthos – there have been carried out studies on the macro-benthonic fauna, namely type of species found, depth effects and timings of ecological succession after deployment (Moura et al. 2006, 2007); comparisons between reefs has also been done (Boaventura et al. 2006);

Socio-economics – there have been carried out studies on the patterns of reef users (Ramos et al. 2006a), reef choices in eco-tourism (Ramos et al. 2006b), and stakeholders' perception on AR impacts (Ramos et al. 2007), which are part of this thesis; apart from these studies no other have been carried out concerning this area of the knowledge;

Restocking – there has been carried out a pilot study on releasing tagged hatched-reared individuals of some Sparidae species in the AR areas and analyzed some aspects related with it (Santos et al. 2006).

In the other region of Portugal where some AR development has been carried out (in the Madeira Archipelago), not many studies have been published so far. There is a research group based in the Funchal Regional Fisheries Directorate that develops institutional work on the AR issue. Some years ago there were commissioned pre-deployment studies to develop about 100 concrete reef units in 15-25 m of water (7th CARAH, 1999), with the objective of restoring marine habitats, studies continued in the southern coast of the Madeira Island (Gouveia et al. 2001). There are ongoing studies. There is a recent study by Ribeiro et al. (2005) which is related to fish assemblages, where there are reported the number and type of species found related to different substrate types including ARs in the Madeira Island.

However, due to an increasing number of tourists that have been using the Madeira Archipelago as a diving destination, the Madeira Regional Government is preparing a legal framework to attract and encourage diving as leisure, as well as scientific and tourism activity, where the deployed ARs are included (MITGN no date). This sort of framework may catapult studies on ARs in this archipelago.

2.4.6. Chronology of the Portuguese Experience of ARs

Before the establishment of the AR system off the Algarve south coast, the first attempts at using ARs were undertaken in the Madeira region in the 1980s. Table 2.3 summarises the Portuguese AR supply since that time.

Table 2.3 – The AR supply in Portugal.

Date	Region	Contribute and/or action
1983	Madeira Archipelago	Trials started with car bodies, tyres, and wooden boats to enhance fisheries harvest. A program was initiated to deploy bus and car bodies for assessment of fish diversity and biomass.
1990	Algarve, south coast	Deployment of the first two ARs in Portugal mainland. Pilot studies.
1996	Algarve, south coast	An iron hull trawler wreck ‘Eng. António Nunes’ was sunk off Faro.
1998	Algarve, south coast	Large scale deployment of ARs started.
1999	Algarve, south coast	The barge ‘Titan’ which was carrying a derrick and some modules to be deployed sunk accidentally off Cacela Peninsula.
2000	Madeira Archipelago	The ship ‘Madeirense’ was sunk off Porto Santo Island.
2003	Azores Archipelago	The 40-metre barge/work platform ‘Pontoon 16’ was sunk on a sandy bottom at a depth of -26m off Almoxarife bay (Faial Island).
2003	Algarve, south coast	The largest AR system is completed in the Algarve. In total there were deployed 10,200 cubic blocks and 120 of other shapes. Around 43 Km^2 of reef modules are covered in the sea.
2004	Centre, west coast	Proposal for an ARS in the Nazaré coast. First studies commissioned.
2004	Madeira Archipelago	Two ARs were deployed off Paúl do Mar and Ponta da Galé (Madeira Island).
2006	Madeira Archipelago	There were deployed 2,500 cubic blocks of 1.4 m^3 near Ponta Pequena (southwest Madeira Island).
2006	Madeira Archipelago	Project proposal for a surf reef in Lugar de Baixo (Madeira Island). This AR is planned also for coastal protection, due to the high hydrodynamics in the area (absence of coastal shelf).
2006	Lisbon and Tagus Valley	There was signed a project to build two AR structures: one surf reef and another to protect the cliffs (Cascais).

2.5. Conclusions

Despite the growing literature on ARs, it seems that the main focus of research is still confined to a few areas of knowledge. In general, it appears that the bulk of scientific production is on fish assemblages and benthic macro-fauna directly related with the ARs, where there is already a broad knowledge. Studies associated with decommissioned oil-rigs into reefs are probably the fastest growing area of reef research, not only in the United States (especially in the Gulf of Mexico), but also in some other geographical areas (e.g. Norwegian North Sea). Environmental and impact issues related to reefs have also been on an increasing trend.

It is clear from the literature that ARs have been successful in many biological respects, such as increasing biodiversity and enhancing areas where modest marine life existed before deployment. However, one can not say the same in respect to ARs' socioeconomic success. Many gaps still exist in our knowledge regarding the impact of ARs on output, income or employment, as well as economic values more generally.

Because AR (and FAD) projects usually involve public funds, it is not sufficient to find out that these projects attain a good biological outcome. Most of the times these projects involve users and other stakeholders that expect to get benefits (whether economic or non-economic) from the deployment. In that respect, it is important to evaluate this wide spectrum of expected returns to the investment and other costs associated with the deployment along the lifetime of the project. It has been found that evaluating just the extractive value (tangible) derived from AR use is quite unrealistic, because often are not considered other values and impacts. It seems that measuring the value of stakeholders' satisfaction (intangible) due to AR use is equally important and fundamental for a correct evaluation of the ARs. The attribution of other values to ARs as aesthetic, conservation, etc., are also of fundamental importance for a correct evaluation, and the actual literature on ARs does not include these aspects. As described above, the literature available seems to have insufficient evaluation of all the values inherent to ARs.

However, the literature does refer to situations where ARs can be a failure in tangible bio-economic terms. For example, in the short run fish tend to aggregate in the reef area (stock externality), and fishermen may be attracted to use the ARs due to the opportunity of catching more fish in a reef area. Thus, in the long run the producers' surplus obtained from reefs' use may dissipate if there is no control on access and as a result the stocks may show signs of depletion.

Relevant published literature on ARs is still scarce in areas where the socioeconomics have the main role. There are some studies where the socioeconomics are referred as important, but they are seldom developed, as indicated previously by some key speaker papers (e.g. Seaman et al. 1989, Jensen 2002).

The long lasting 'production versus attraction' controversy surrounding the main function of the ARs needs more accurate results, in order to address adequately a socioeconomic assessment. It seems that due to ARs, rapid colonization by settler species and their relative equilibrium after that period favours the attraction hypothesis. However, in locations where there are no competing NRs and it is verified that ARs have extra biomass (e.g. Santos and Monteiro 1997), the evidence supports the production effect. However, more research is needed concerning this aspect in order to consider it as a fact.

Concerning the Portuguese ARs, there are a number of questions that call for reliable answers, such as: What is the deployed ARs' main function? Do fishermen catch more fish when fishing in the ARs or not? Do the catches differ when compared before and after deployment? Do we have reliable means to compute effort in and out the ARs? What are the intangible effects derived from the AR modules when compared with other type of reefs?

Finally, it seems important to identify and quantify factors of success and failure in respect to ARs. Probably the largest gap found when doing this literature review is the lack of knowledge and research on the evaluation of reef-based use in terms of long-term sustainability of their resources. An objective research focusing on this aspect can for sure help managers to know if the deployed ARs have been really effective or not. Given this lack of international literature on the socioeconomics evaluation of ARs, the author intends to gather relevant information on the use of the Algarve ARs, and by selecting an adequate methodology to carry out a relevant study on the social and economic performance of these reefs.

Chapter
3

Methodological Approaches

Contents

Word Count: 14,205

3.1. Introduction

From the previous chapter it was found that there are few studies on the evaluation of socioeconomic benefits of ARs, especially those related with intangible measurements or non-extractive value such as human satisfaction. This fact justifies why it is important not only to perform the economic evaluation, but also the social one. Because this study is focused on the Algarve reef program, the evaluation is addressed to the AR socioeconomic related policy objectives as stated by IPIMAR and to check their progress. It is considered necessary to show evidence of the whole value of these ARs. Considering the human use as the main reason to justify the AR program, it is necessary to collect data showing the public involvement and benefit from it. With such evidence in their hands, coastal planners can address a suitable management strategy for AR use access. By addressing the demand for the reef structures, a social and economic assessment has the value of showing to governmental entities the usefulness and importance of such a program in terms of its contribution to coastal area activities management (fisheries, ecotourism, etc).

Following the methodology proposed by Milon et al. (2000), we can consider three types of assessments that can be done in the social and economic evaluation of ARs: (1) monitoring – in order to find out patterns (if they exist) of reef use; (2) impact assessment – to be aware of the social and economic changes derived from reef deployment and consequent reef use patterns in a given area; and (3) efficiency analysis – to find out the net benefits resulted from the reef program deployment. To carry out these assessments there are a number of data collection and measurement techniques that can be used.

This chapter explores the most important concepts related to ARs that are relevant to the assessment of the structures in socio-economic terms. We start by developing a conceptual bio-economic model. This model will serve as the engine to generate research questions and a set of hypotheses, which will be tested along the results' chapters (chapters four, five and six). The research design will also be outlined in which we describe the type of data collection instruments and measurement techniques used to conduct the research process.

3.2. Important Concepts

The process of research in every scientific discipline involves the development of unique sets of concepts (Frankfort-Nachmias and Nachmias 1996). It is intended first of all to define concepts that are important to bear in mind to carry out a specific AR evaluation. There are three concepts that are considered of fundamental importance, which relate to: (1) the dimensions and variables to be covered in the study, (2) management aspects, and (3) interest groups to whom the new structures are addressed and who may derive a value from them.

3.2.1. Dimensions of the Study and ARs' Value

Milon et al. (2000) contend that many people are interested in artificial reefs because they believe reefs have a potential value either for their activities and the environment. In addition, these people's activities embrace a variety of interest groups in: fisheries (commercial fishermen and their associations), recreational activities (anglers and their clubs, divers and diving operators, charter boat operators), and other stakeholders (e.g. city councils, research teams/scientists, fisheries managers, environmentalists, etc.). Box 3.1 shows what dimensions are intended to be covered in the present study.

Box 3.1 Dimensions considered

<u>Social dimension</u>

The social dimension is focused on the demand for ARs. As a result the social assessment in this study tries to evaluate how well the deployment of the reef structures address to the needs of involved groups of people, and if there is any perceived benefit to their livelihoods or satisfaction levels:

- *Fisheries* – it is important to evaluate how aware of the ARs the likely communities affected are, their attitude and likely behaviour toward the structures, and the value(s) attributed to them.

- *Recreational activities* – it is important to gather the perceived expectations and values these people attribute to the ARs and compare them with other site alternatives.

- *Other* – different groups of people that may not be directly involved with reef use may be concerned about the functioning of the structures and their real or potential value; they may want to know if there are any perceived impacts from reef development and if the stated policy objectives have been accomplished.

<u>Economic dimension</u>

An economic assessment of ARs may try to find out how the economy of a given area and its reef related activities and businesses changes as a consequence of deployment. The present study intends to outline the economic impact derived from pilot reefs in the Algarve, including both pre- and post-deployment stages. It is also intended to know how good are the structures in the induction of activities and businesses to be more productive (economic efficiency):

- *Fisheries* – this sector can be examined from two different perspectives: (a) demand side – focuses on performance directly related with the units in the catching sector or CPUEs; (b) supply side – it is important to evaluate also performance related with the potential the ARs offer in terms of commercial species production/aggregation (directly linked to the biological dimension).

- *Recreational activities* – an economic assessment evaluates how demanded are the AR structures and if there is any stimulus by the recreational/tourism operators to take their clientele to reefs. There are also two perspectives: (a) demand side – clients looking for artificial reef related services, and (b) supply side – people who earn money from offering artificial reef related activities/services.

- *Other* – any other activities and people that may be affected by reef deployment; the evaluation of the increment in these activities in the presence of ARs can be a way of determining their benefits.

3.2.2. Managing Resource Use

The management of reef resources is about the adequate action plan to keep resources sustainable. An effective action plan may include one or several management alternatives in terms of access to reef use, seeking for the best trade-off between the resources value, and stakeholders' satisfaction.

Judging AR interventions

In fisheries science ARs may involve many different interests, including people involved with the planning, building, or using the habitats that are affected. AR interventions often seek to enhance the success or efficiency of a fishery resource or achieve environmental management objectives. Apart from Japan and the US, national AR plans are not typical. Deployments can start by governments or interest groups efforts. An AR plan is defined as 'an objective statement of goals for artificial habitat utilization, in the context of national fishery, economic, and environmental policies, accompanied by guidance on ecological, engineering and other logistic constraints, and information on bio-geographic variation over large areas' (Seaman and Sprague 1991: 13-14).

The AR evaluation should be tailored in order to address the initial policy objectives. When an AR is deployed, it should be evaluated in terms of its likelihood of success or failure. Grossman et al. (1997) and Whitmarsh and Pickering (1997) point out that AR construction may have potentially negative aspects concerning reef fish populations and inadequate management, so several perspectives should be taken into account. For example, there are two important factors that should be analysed as: (1) the contextualization of the reef at the geographical and social level, and (2) the facility of its use and exploitable resources availability. This means that it is crucial to establish a reef project with a well defined objective. One example of that is if the area has a depleted stock and the fishing effort can be diverted to another area, then it may be appropriate to deploy reefs so as to create a marine protected area (MPA), as suggested by Pitcher et al. (2001). However, such management intervention in the deployment area should be taken with caution, if there is the risk of emerging social problems (e.g. unemployment, serious user conflicts) in the fisheries sector. Pressure on a political decision addressing people's claims can produce better social stability in the short run. However, there is the challenge of finding out a viable solution that does not put at risk the biological resources. The interests raised by all the people who intervene in the process can be contradictory and sometimes conflicting. The challenge is to get to a solution explaining any form of success.

Adaptive management strategy for resource use

Even if there are positive signs of reefs' contribution to biological effectiveness that success is not guaranteed, if the reefs are used by people. Limiting people's entrance whether by imposing restrictions on fishing, licensing access or defining property rights, or any other, may have a better overall success/effectiveness in the long run in socioeconomic terms than leaving the ARs to an open access or quasi-open access management regime.

Immediately after reef deployment, it may be difficult to establish a management plan without knowing stakeholders' interests on the structures. In addition, it seems difficult to implement an effective management action plan if there is a deficient or no feedback from users. At the same time there is the risk of leaving too much time without a management plan or an inadequate one. In both situations there is a high risk of AR effectiveness failure either by ignoring the management problem or addressing it incorrectly. However, the problem has to be solved.

Though the evaluation may seem a difficult task, the judgement of AR interventions and their management can be eased. The information used to make decisions is typically imperfect, but the decisions need to be made nonetheless. Adaptive management is a strategy that seeks better information and adjusts an implemented action accordingly, as described by McManus et al. (1988), Sainsbury et al. (1994), and Auster (1998). It can consist of many approaches as specific studies, monitoring and other helpful tools. The strategy only works if there is feedback between managers and scientists, and between the public and scientists, where periodic assessment is its work basis. The adaptive management is applied by following a pre-defined protocol, focusing on monitoring efforts defining how to apply certain models in the management process. To do this there should be used pre-defined indicators, monitored over time after a new management strategy is implemented. These indicators can be used to assess the effect of a management action. According to Pajak (2000) indicators have to be practical, sensitive, and able to be monitored and modelled.

3.2.3. Stakeholders or Interest Groups

Evaluating stakeholders and their involvement

Among the human dimensions we have to know how to identify and evaluate stakeholders. A critical aspect of successful ecosystem management is the involvement of a large range of stakeholders. This is done towards the common goals, in order to evaluate the interests of these various participants (Box 3.2). In the present case the habitat modification provoked by the deployment of the AR system is the 'ecosystem'.

Box 3.2 Who can be a stakeholder?

It can be said that the general answer to the above question is anybody that is interested. In a larger spectrum, and due to the variety of interests, it is suggested that stakeholders fit in to at least five categories, as follows: (1) People who: live, work, play, or worship in an ecosystem or near it. (2) People interested in the resource, or its users, its use, or its non-use: they can encourage the use of an object or a commodity (e.g. fishing, angling and spear-fishing) or as an amenity (e.g. surfing, boating and photography). They can also benefit from other values from the resources as therapeutic recreation, spiritual inspiration, or isolating. (3) People interested in the processes used to take decisions: some stakeholders (as the environmentalists) are strongly concerned with all the legal requirements before a decision is been taken. (4) People who pay their taxes: most people who pay their taxes is worried in to know how their money is used. (5) People who represent citizens or that are legally representing or responsible by public resources: elected or appointed officials and members of the agency staff.

Considering an AR ecosystem, a stakeholder in this case is any person or any entity which has an interest in the reef topic and that desires to participate in the decision making process.

Source: based on Meffe et al. (2002).

The main principle to consider with respect to the involvement of the stakeholders is to select potential ones. To include the entire set in all decisions or actions may be impossible. But it is important that all the interested stakeholders or their chosen representatives should be invited and able to participate in the ecosystem management. This is called the 'principle of inclusivity'. The inclusivity can be problematic for certain people, because it means that the stakeholder with opposite or conflicting ideas will participate in a common subject. The challenge here is to get an effective involvement of a stakeholder and help people with different viewpoints to recognise and understand their common interests in working together. In order to achieve these trade-offs it is necessary to use adequate methodological approaches.

Another principle of involvement of stakeholders is 'self-selection', where stakeholders demonstrate their own levels of involvement in the subject and their comfort (or upset) derived from it. The involvement can be visualised as 'stakeholder orbits' (Figure 3.1).

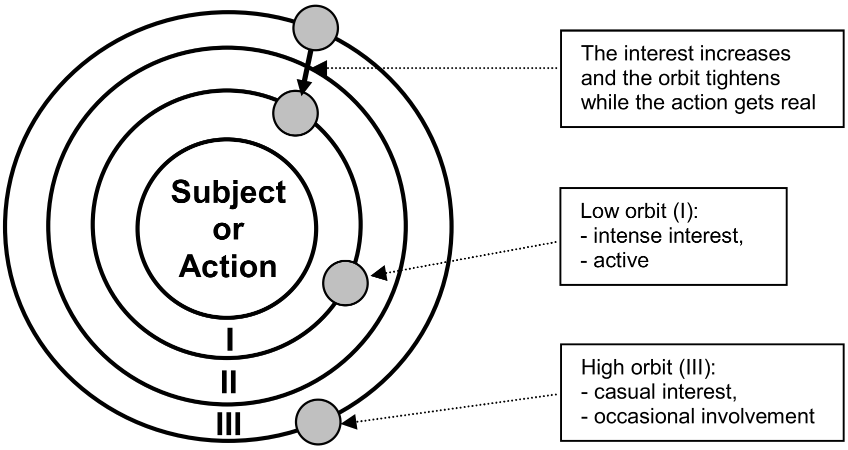

Figure 3.1 – The principle of inclusivity can be represented with the analogy of the satellites in their orbits around the Earth. The level of interest is represented by the grey balloons in their orbits. Source: based on Meffe et al. (2002).

Brief approach to stakeholder analysis

When we talk about AR deployment, voices emerge supporting it (e.g. eligible fishermen) while others may oppose it (e.g. non-eligible fishermen and environmentalists). According to authors such as Milon et al. (2000), stakeholders supporting the idea are those where the expectation is created of future benefit of the outcomes generated by the AR (Box 3.3).

Box 3.3 Stakeholders of low orbit

Having identified the major stakeholders involved in an AR ecosystem and evaluated their probable relationship with it, it is important to collect some information from the stakeholders of low-orbit:

- *Primary information*: name of the individual/group, address, main members, contacts;

- *General characteristics*: mission and formal and informal interests; activities related in other places or other projects; size and scope of influence (e.g. membership, employment, territorial area), formal or informal authority over the activity;

- *Interests*: future outcome to be wished by stakeholders, both in the short and long run;

- *Probable levels of involvement*: ways the stakeholder should wish to participate;

- *Stakeholder needs*: what the stakeholder would need in order to participate, (e.g. from the basic information until an invitation to take a leadership role).

Source: Meffe et al. (2002).

In the present study, stakeholders involved several individuals and institutions. Different tasks were carried out in order to get information from the different people involved (Table 3.1). Stakeholders' selection for each of the tasks was done according to each of the task objectives. The Roman figures refer to the stakeholders' orbit, according to the principles of self-selection and inclusivity:

- Task 1: interviews with potential and actual AR users

- Task 2: direct site observation of an AR

- Task 3: survey for impact analysis of the ARs

- Task 4: survey for AR use (economic efficiency)

- Task 5: diving choices (economic efficiency)

- Task 6: content analysis of newspapers news items

- Task 7: content analysis of internet documents

Table 3.1 – Expected degrees of stakeholder involvement with the AR structures in the Algarve according to different research tasks.

	Stakeholder type	Task						
		1	2	3	4	5	6	7
A	Local fishermen	III	III		I			
B	Coastal fishermen	III	III		I			
C	Fisheries associations			II	I			
D	Fisheries trade unions			II				
E	Individual anglers	III	III					III
F	Anglers' clubs and associations			II				
G	Charter boat representatives	III		II				
H	SCUBA diving (producers)	II		II		I		II
I	SCUBA diving (consumers)	III				II		II
J	Snorkel/spear-fishing	III						
K	Resource managers			II			II	
L	Environmentalists			II				
M	Research (natural sciences)			II			II	II
N	Research (socio-economic sciences)			II				
O	Council representatives			II				
	MODE	III	III	II	I	-	II	II
	Involvement of stakeholders of low orbit	NO	NO	NO	YES	YES	NO	NO

3.3. The Problem

3.3.1. Conceptual Bio-Economic Model

Problem outline

From the supply side, the problem is to evaluate the impact of the artificial structures, specifically if there is a change in the productivity of natural resources and what other sorts of changes occur in the vicinity fishing areas. To do so, it is fundamental to assess the impact and efficiency of ARs in social and economic terms. If the changes are positive, human interaction with the structures are expected to increase, as well as the benefits they get from using the structures. The problem is addressed through an adaptive management strategy. The way this can be carried out depends upon the bidding of the stakeholders involved and the type and quantity of information collected from the entire system (i.e. reefs and people). The latter in its turn depends on the social goals, policies and research objectives.

Theoretic approach to explain the problem by using a model

In the pre-deployment process of a reef project/program the first step is to assure the legal, monetary and logistic support, and the next step to consider is the choice of reef materials, design and deployment location (Figure 3.2) (1). During AR deployment and immediately after, fish (2a) and other species (2b) that were in the site probably swim away due to the disturbing noises and their survival instinct (Mitson and Knudsen 2003). However, those fish and other species may return when the ARs have settled down and the site is as calm as before reef deployment (3). Due to the effects of shelter (4a) and food (4b) availability provided by the structures, the reef becomes more attractive for settler organisms (usually planktonic larva and sessile organisms). The increasing establishment of settler organisms on the reef surfaces may in turn attract fish (5). Due to the Algarve AR depth characteristics, demersal and benthic species are probably the ones that are most attracted to the ARs (Santos and Monteiro 1997, 1998).

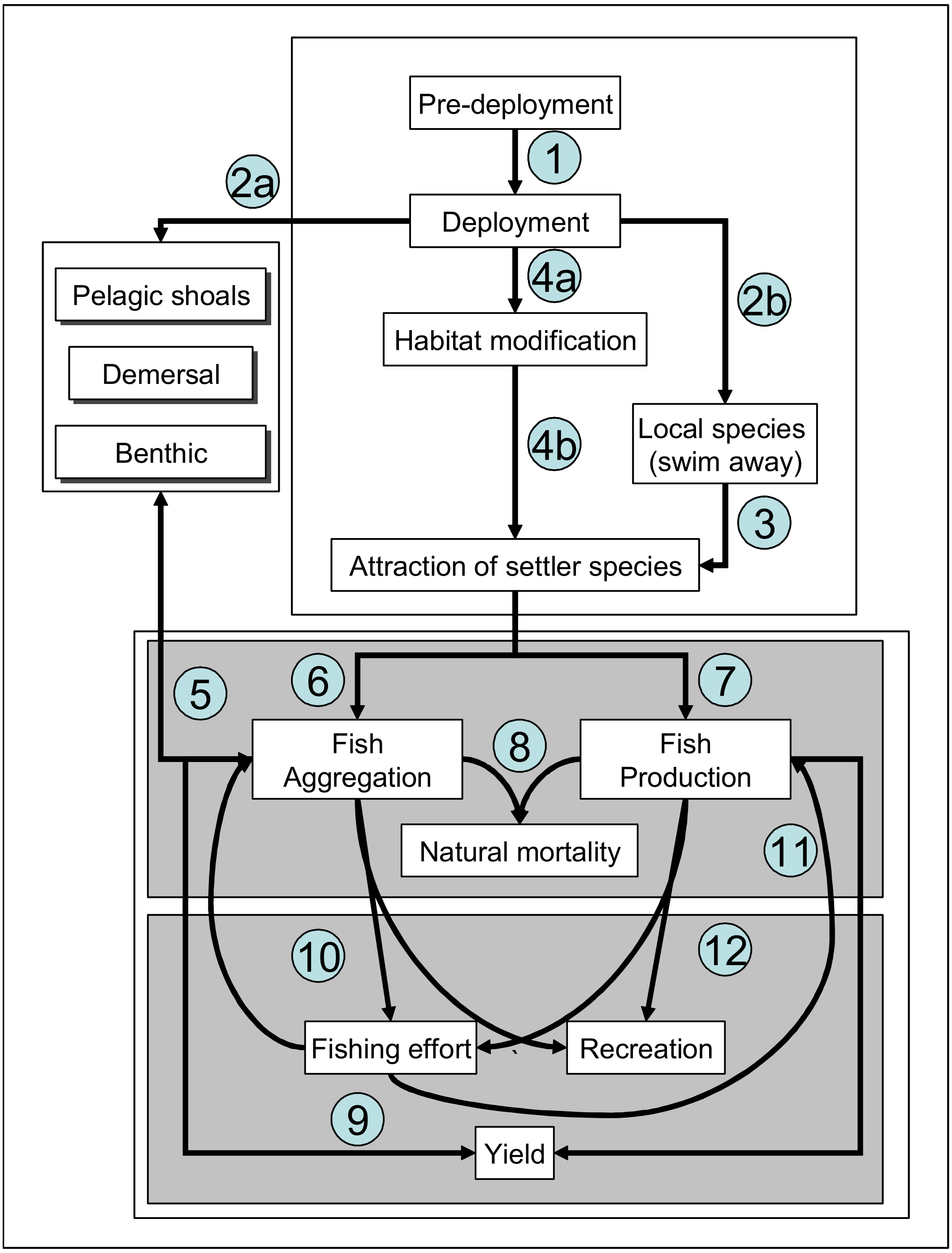

Figure 3.2 – Conceptual bio-economic model showing the implications of reef deployment on resources and users. Top box represents the AR establishment phase, bottom box represents AR already established (lighter rectangle shows biological and environmental interactions, whereas the darker one at the bottom represents human interactions), and the left box represents fish resources from AR surrounding waters. Adapted from Santos et al. (1997) and modified by Whitmarsh and Pickering (1997).

Because of the attraction/production phenomenon higher fish biomass will be available in the mature reefs. On the one hand, the aggregation effect derived from AR deployment may be expected to increase the catchability of fish resources because the reef may concentrate species that would otherwise be dispersed somewhere in the surrounding waters (Stone et al. 1979, Whitmarsh and Pickering 1997) (6). On the other hand, the reef may produce higher fish biomass due to the increased carrying capacity of the system (De Martini et al. 1994) (7). Natural mortality (8) and yield (9) may also change due to expected increase in biodiversity, which means more trophic relationships may occur.

The attraction effect may lead to externalities of competition, having both a biological and a socioeconomic dimension. ARs compete with NRs by attracting fish from the latter, and fishermen are more likely to compete with each other since before reef deployment they were dispersed but now they gather in the reef vicinity to catch the more accessible fish (increased harvesting catchability) (10). The production effect may attract more users because of the expectation of higher catches due to the increased biomass, which may lead to stock depletion (Grossman et al. 1997) (11). Probably, the most likely situation is that both attraction and production effects may occur together (Szedlmayer and Lee 2004). However, whatever the situation, people will tend to use the reefs according to the information that is in the public domain and the access to the structures. Reefs have multiple users that may be attracted to catch fish (fishermen, anglers, spear-divers) (10, 11) or to watch fish and other species in this new habitat (scuba divers) (12).

The biological results of the above model (lighter box) can be positive. However, for the sake of the reef project in socioeconomic terms it is of vital importance to consider a viable management action in terms of human use access (darker box) at the deployment stage, or as soon as possible. In the particular case of fisheries, if there is an open-access fishery or a quasi-open-access fishery, the economic rent derived from AR is at risk of dissipation. If the AR aggregate fish from elsewhere, fishers who were dispersed will compete for the ground and saturate the area with their fishing gear (crowding externalities); if there is the enhancement effect, fishermen will tend to over-harvest due to ease of finding fish in the AR (fish stock externalities). Management strategy measures can be adapted to AR use (Figure 3.3). For example through a management strategy (MS) where it is aimed to control effort to a desirable level, it is necessary to monitor mean landing size of commercial species and to verify that there is no downward trend. As well as monitoring, however, it is also necessary to ensure that fisheries on the reefs are regulated. Economic instruments may enable the resource rent to be captured, as well as keeping yield at a sustainable level.

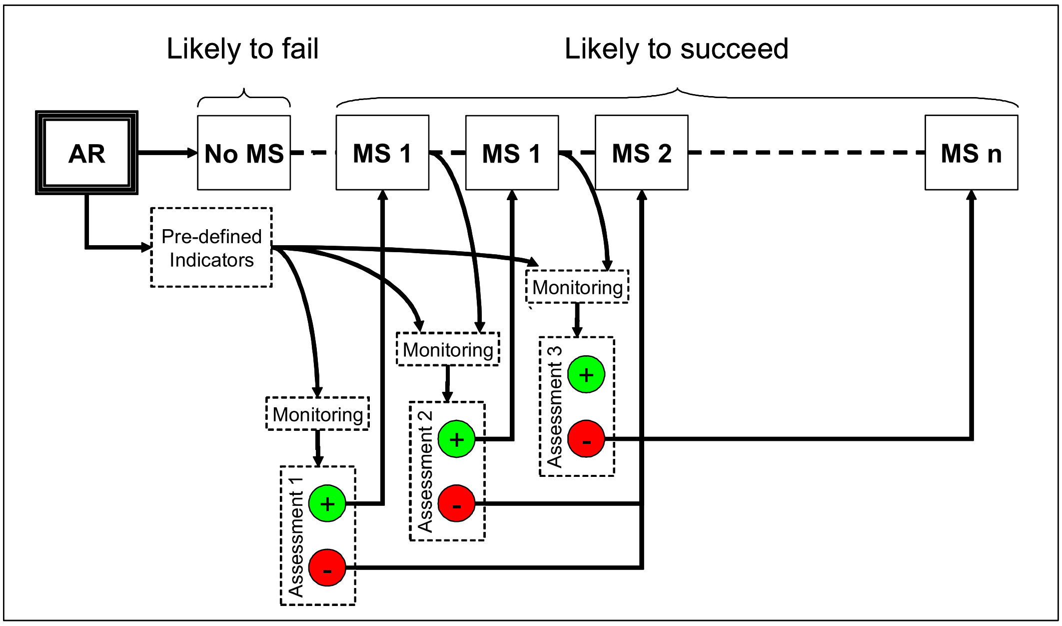

Figure 3.3 – Scheme showing the adaptive management strategy on ARs.

With this human change there is the need of adequate management in order to safeguard the effectiveness of the structures along their lifetime. If no management is applied, i.e., if there is open-access or quasi open-access the structures effectiveness are more likely to fail. An adaptive management strategy is then a plausible solution. Once the indicators for AR success are pre-defined, monitoring tasks can be used to check how well the indicators have been attained. The assessment is an essential part of the monitoring process because raw or unprocessed data is not useful for managers (the decision makers). For this reason the dissemination of the monitoring results is of fundamental importance.

After the evaluation, an overall assessment can be used to establish if an initial management strategy (MS 1) is adequate to respond to the system problems. That assessment may require the consultation of key-stakeholders. If the assessment shows that the MS 1 is not working, then an alternative strategy is needed. A second management strategy (MS 2) should be adopted whenever there are monitoring data showing evident signs of failure to accomplish suitable results. Any alternative management strategy should only be adopted when there is gathered enough information stating the position of the main stakeholders. However, considering that the information is imperfect, an alternative management strategy has to be taken once it is recognised that previous management strategy has failed. According to the interest triggered, some management and legal measures will be proposed in order to use the structures in the best way possible (through adaptive management strategy), always looking for trade-offs between the involved people and having their collaboration or involvement in the process. Successful AR management implies a series of strategies in which those that are recognised as inadequate are replaced by ones that are considered more suitable. The entire process as described before can be simply represented as in Figure 3.4.

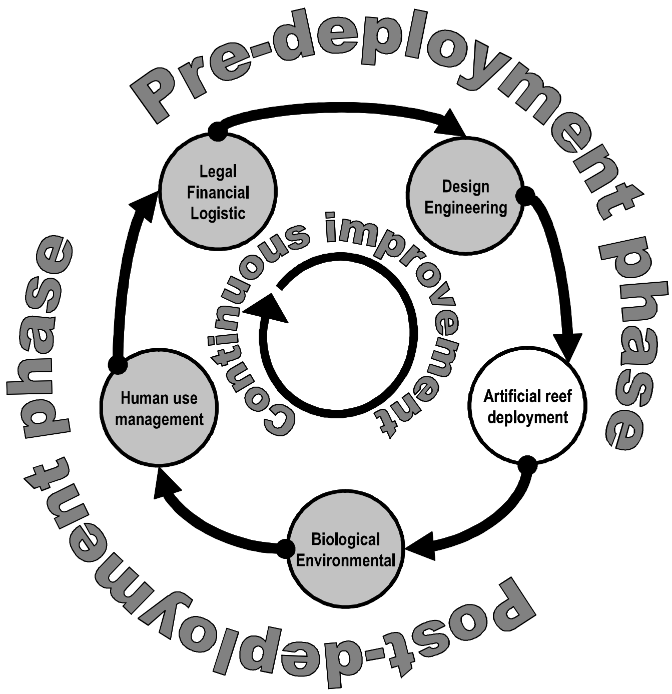

Figure 3.4 – The process of an AR development and the dimensions involved.

3.3.2. Research Questions

This conceptual framework provides the context to the research questions, which can be separated according to the type of assessment, dimension or implication:

- *Monitoring and description*: To know who, where, when, why, what and how the ARs are used. Monitoring is done whenever possible and the description tries to figure out answers to the questions posed above. In the present study it is tried to monitor and describe the oldest AR in the Algarve south coast reef program. Direct site observations may in due course be applied to other ARs, in order to know how far the results of the above investigation vary from case to case.

- *Social analysis*: In this part of the study it is very important to know: (1) what perceptions stakeholders have about impacts provoked by AR deployment, and to be aware that stakeholders' knowledge may vary according to their relationships with the structures; (2) what sort of information is available, where it is available, and who demands for or supplies it; and (3) who are the likely winners and losers derived from AR establishment, i.e. to know to whom and how are the benefits going to be distributed and the likely level of satisfaction.

- *Economic assessment*: This subject is divided into three main sections: (1) economic efficiency analysis, in which the productivity of the reef and control areas in term of value per unit of effort is compared; (2) decision analysis through elicitation techniques based on the analytic hierarchy process (AHP), both in terms of commercial fisheries and diving activities; and (3) a cost-benefit analysis of an artificial reef system and its economic value for commercial fisheries over a 25-year period.

3.4. Research Design: Case Study Method

3.4.1. The Case Study Method

The case study approach involves learning and understanding a particular case or small number of cases (i.e. in a given situation or subject), by intensively focusing on its characteristics and circumstances, and by describing and analysing it. It may be a study of an individual unit of analysis as: a person, a group of people, an institution, a program, etc. Often it involves a particular method of research, where there are small samples and does not follow a rigid protocol. Rather there is an in-depth, longitudinal study of a single case. For these reasons, case studies are possibly the most flexible of all research designs (Hakim 1987). In a case study, field notes are summarized and the analysis uses coding to identify important trends and relationship in the data. The research topic can be studied in some depth with the time scale well defined (Bell 1999). In their essence case studies can be exploratory, descriptive, or explanatory (Yin 1993). The use of each strategy depends on: the form of the research question(s), the control over behavioural events, and the degree of focus on contemporary events. Descriptive case studies may be essentially exploratory if relatively little research exists on the topic in analysis (Hakim 1987).

Design strategies applied in case studies usually focus more on descriptive than interpretative outcomes. It is usually utilized by researchers when there is little or no control over events, and involves the collection and presentation of detailed information about the subject. It often attempts to identify factors affecting success or failure. The detailed and accurate information allows the opportunity to identify the problem, evaluate the information in terms of importance and relevance, formulate possible solutions and evaluate the selection of each one, and can suggest a plan of action for successfully implementing a chosen solution. One advantage of using the case study method is the possibility of intensive analysis of specific empirical details. In case studies results may not be statistically consistent, and typically the findings obtained are not aimed to be generalized to other cases. The case may nevertheless be of value if it raises awareness of general issues. The method is usually subjected to criticism if not carefully designed and done (Yin 1994). Case studies criticisms may be related to their lack of representativeness and rigour due to bias introduced by the subjectivity of the researcher (Hamel et al. 1993: 23).

Appropriate use of a case study is essentially determined by: (a) the type of research question posed which is usually in the form of 'how' and 'why', (b) not requiring control over behavioural events, and (c) focusing on contemporary events. A given case study may involve more than one unit of analysis. This occurs when, within a single case, one has to pay attention also to a subunit or subunits. Case studies as a research tool in terms of design and analysis are used together with multiple methods or other research strategies. In case study research, data collection may include interviews, observations (direct or participant-observation) and documentary sources (including documents and archival records). But the evidence to support case studies may also come from other sources such as physical artefacts. The data collected can be both quantitative and qualitative (Punch 1998). In data collection it is also important to bear in mind: (a) sources of evidence coming from various parts, but converging in facts and findings, (b) the need to assemble evidence in a database, (c) the chain of evidence, by having a natural link between the questions asked, the data collected and the conclusions drawn (Yin 1994).

3.4.2. The Algarve ARs as a Case Study

The ARs are a relatively novel situation in the Algarve. For that reason, few written materials have been produced so far concerning their demand aspects. Due to that fact and because the case study research strategy allows a large degree of design flexibility, it was the main approach chosen to study this subject (Box 3.4.). Here the 'case' is the socioeconomic evaluation of the AR program, and it is intended to carry out essentially an exploratory approach. This case study intends to be holistic concerning the Algarve ARs, but sometimes involves just a specific AR (subunit of analysis) rather than the whole.

Box 3.4. Case Study Definition

Some considerations have to be taken into account to define a case study, as such:

(a) *The type*: Having completely identified the object of the case study, it is important to know its extension. For instance, this case study can be considered as a 'study of roles and relationships'. The justification for this is because it studies the representatives of the fishing communities and other groups interested in the AR subject and consequent management actions. The implementation of this AR program must be studied under several scopes.

(b) *The design*: This involves several steps, which are as follows:

- The conceptual structure: This consideration covers the main features (aspects, dimensions, factors, variables, etc.) of the case study and their possible relationships. It makes explicit what we think we are doing, it helps in our selection of the most important features and meaningful relationships, and focusses also on the collection and analysis of data.

- The set of research questions: In this phase it is important to link the conceptual structure and the research questions in a variety of ways. The study must focus on 'how' and 'why' questions. Consistency between the questions and the conceptual structure is needed. Initially some questions may seem diffuse, but during the involvement with the research they will be refined. In the present study the main research questions are grouped and described in the previous section.

- The sampling options: Due to the fact that is not possible to study everything, a sampling strategy has to be chosen. The decision for this stage relies on: (a) who are the persons to be observed, queried, etc.? (b) Where and at what time is the data to be collected? (c) What sort of events, activities or processes have to be observed or described, etc.?

- The data collection techniques: Having answered what we need to know, why we need to know, where and from whom we are going to get the information, the remaining question is how we can get the information. The nature of the data collection depends on the type of study. Though observation and interviews are widely used in case studies, no method is excluded. It may help the research to develop a case study protocol (essential in multiple case study designs), as well as to conduct a pilot case study. The nature of present case study is more exploratory due to the inexistence of socioeconomic data about the Algarve AR program.

(c) *The general skills needed*: Despite the fact that the case study does not have routine tasks, that does not mean it is a less reliable approach to doing research. The skills needed include having open and enquiring mind in order to have the capacity to ask good research questions, being a 'good listener', being adaptive and flexible, and being sensitive and responsive to contradictory evidence. Figure 3.5 outlines the main considerations to take into account in a case study:

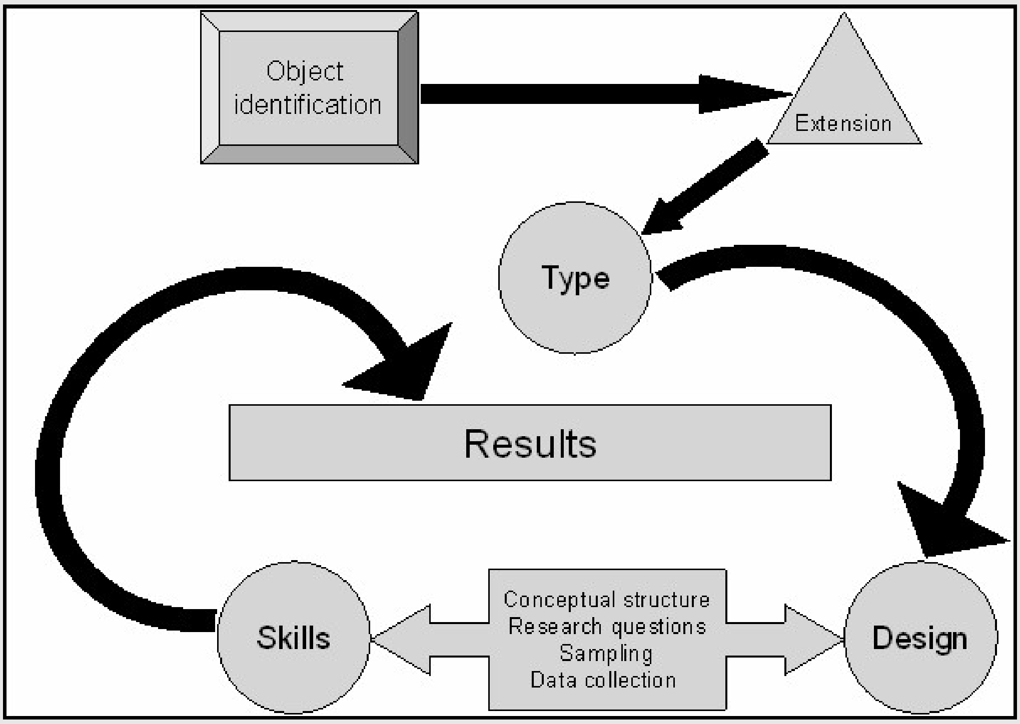

Figure 3.5 – The case-study steps.

Sources: Yin (1994), Bell (1999: 10), Robson (2002).

3.5. Data Collection

3.5.1. Instruments Available

When a research project is started it is the field research which is often utilized for the initial or exploratory phase (Frey and Fontana 1993: 23). There are several techniques available to collect socioeconomic data from the field. Several means were used to collect much of the data presented in this case study. Following Robson (2002) there are a variety of instruments available to collect data that can be used in flexible design research such as the case study method. The sources of information for the present case study are shown in Box 3.5.

Box 3.5. Instruments to collect data

Data can be primary or secondary. When new data are collected by the researcher(s) specifically for a research purpose it is called primary data. When data are collected and/or published by purposes other than a specific research they are called secondary data. Below there are presented four types of instruments to collect data, where the first three are aimed at collecting primary data and the last one secondary data:

1. Direct interviews: First strategy – In the first instance the involved groups of (potential) AR users along the Algarve Region were investigated. After that identification, it was fundamental to establish the first direct contact with them in order to: (a) characterize their patterns of current or potential use, (b) probe their level of knowledge, (c) determine the interest provoked by the structures, and (d) identify main reasons for AR use. A semi-structured interview format was carried out (aided by two different questionnaires). The questionnaires were designed in order cover both commercial and recreational (potential) AR users. Second strategy – Seminars were given at two different fishing communities in order to promote the structures amongst fishermen, and at the end of each an appeal was made to the AR' users to collaborate with the promoting institution (IPIMAR/CRIPSul). The intention was to get involvement from interested skippers by asking questions and getting feedback from them, in order to gather information about their characteristics. Skippers who agreed to collaborate were given a fishing logbook in order to collect data on catches' characteristics in fishing trips on the reef areas and vicinities.

2. Direct observations: Due to the difficulty of observing ARs directly, since the object of study is submerged and its localisation is subjected to ground positioning system information, a technique was developed for identifying and assessing patterns of use and their description based on direct site observations in the vicinity of ARs. The technique consisted of locating the AR system and determining distances from it, where an observational sheet was used to report data on vessels and gear. The data had to be filled in by the IPIMAR/CRIPSul RV skippers'.

3. Surveys: For the socioeconomic assessment it was decided to ask people directly about certain aspects of AR deployment. To do so, there were developed two different survey types: (a) roughly one year after AR deployment, a questionnaire survey with attitude scales was designed to cover a defined key-stakeholder panel, surveying their perceptions about potential impacts derived from the structures; (b) two other questionnaires were designed to survey the economic efficiency of key informant commercial fishermen (essentially contacts from the seminars) and divers.

4. Additional instruments: Documentary sources were also used to collect data. Examples of such include the use of unobtrusive measures (i.e., non-reactive), where the document is not affected by the fact one is using it. To collect these secondary data the techniques used were: (a) archival analysis (electronic files from the fisheries directorate and Olhão city council), (b) content analysis, which is a quantitative method where in this case the type of documents used were newspapers and internet pages.

3.5.2. Direct Interviews

An interview is a research method for primary data collection involving a formal or informal meeting (face-to-face) or a phone conversation (long-distance) between an interviewer and one or more respondents. In order to gather information about given topics or events, the interviewer asks questions in the hope of getting appropriate replies from the interviewee. For the sake of the interview, it is preferable to begin with non-controversial issues, easy to interpret, which are fairly easy to answer. A good start is a way of getting the confidence from the interviewee. More difficult or sensitive questions are left to the end. If something goes wrong, there is at least some useful information gathered already. Questions about the present are easier for respondents. Some background questions may be desirable at the beginning in order to keep as a baseline for the rest of the interview (Patton 2002).

Interviews can be recorded in different ways: (a) ticking boxes (if it follows a questionnaire with closed questions), (b) summarizing answers, or (c) taping for in-depth interviews allowing later data analysis. There are many different types of interview, but the usual typology includes: (a) structured, (b) semi-structured, and (c) unstructured interviews. A highly structured interview can be described as a questionnaire with fixed questions involving a pre-decided order with standardized wording, where the answers to most of the questions have to be selected from the available alternatives. A semi-structured interview involves predetermined questions, but their order is flexible, according to the interviewer perception or appropriateness. In an in-depth interview the respondent is left free to answer without too much interviewer prompting (Robson 2002).

The preparation for interviews requires more or less the same preparations as for questionnaires: selecting the topics, devising the questions, and choosing appropriate methods for the analysis. The schedule has also to be well defined (Bell 1999). Despite the existence of different types of interview as explained above, a widely used approach is based on open ended questions. As one of the main advantages, a face-to-face interview by asking people directly allows the researcher to get interesting information that postal questionnaires cannot. Other advantages include the flexibility to sequence questioning and the control over the respondents' answer (Frankfort-Nachmias and Nachmias 1996).

A disadvantage of interviews is that they can be time consuming. It usually needs more than half an hour, but not more than one hour (otherwise it reduces peoples' willingness to participate, and simultaneously the sample number). Another disadvantage is related with subjectivity (danger of bias). This method can be combined in a given research as for example a case study to complement other types of data collection. Beliefs and attitudes are difficult to get from interviews, due to their complexity and multidimensionality. It is also important in interviews to know the language or terminology used with the interviewees. If there is a willingness to enter into the world of the interviewee and share their norms and values better results are obtained (Rubin and Rubin 1995: 172-173). In the present study the strategy approaches used are explained in Boxes 3.6 and 3.7.

Box 3.6 First Direct Interview Strategy

Purpose: To find out both the demand for the AR structures as well as the interaction with the subject among commercial fishermen and recreational potential users.

Design: A specific questionnaire (including both open-ended and closed questions) was designed to support semi-structured interviews. For the pre-testing phase were included: a fishing skipper, some divers and occasional anglers (target public for the final questionnaire). Some flaws were detected in the dynamics of the questionnaire and in the logical sequencing of the questions. Certain questions presented some inherent subjectivity, and were accordingly removed. For the final inquiry, having identified and corrected the flaws it was decided to collect the data by two different questionnaires, due the fact that two groups of AR' users were involved: professional and recreational. The next step was to print out the final questionnaires. The target group of professional fishermen was selected as a priority (both local and coastal fishing fleets). The reason for this was based in the fact that commercial fishing users were the first ones to intervene as reef users to the detriment of the ones from recreational fishing and diving activities.

Needs: The following step was to obtain interviewers to carry out the questionnaires along the ports and boat ramps chosen. A tutorial about the objectives of the semi-structured interviews was given to two IPIMAR-CRIPSul research assistants who had the task to become interviewers with a neutral profile. The tutorials followed standard social science procedures (e.g. purposes of the questionnaire, selecting sites to sample, selecting skippers who use eligible gear, how to present the theme in order to get users' interest in collaborating, posture to adapt, sensitive topics, ethics, etc). As a strategy for the interviews it was opted to do an opportunistic contact with the skippers in their places of work and in their inland work schedules.

Sampling plan: Due the fact that the strategy for this type of interview consisted in a considerable part in opportunistic contacts, sampling by port was based in determining in advance which would be the best time of day to locate skippers. From the pre-testing phase it was verified to be more convenient to localise them near their vessels, both in landing or gear dispatching operations. As a rule of thumb it was suggested to sample during daytimes from around 9 a.m. to 1 p.m. It was attempted to cover around 5 to 10 % of the eligible skippers operating vessels registered in the five areas of the region. Afterwards, to decide on where to do the sampling, it was necessary to identify the main ports and boat ramps along the Algarve region (consulting some documents from the regional fisheries directorate). To carry out the interviews with fishermen there were selected fourteen sites (including ports, boat ramps, and beaches). For the recreational activities interviews focused mainly in two central towns (convenience sampling).

Box 3.7 Second Direct Interview Strategy

Purpose: The method was used on the grounds that it is an acceptable way of bringing together a group of fishermen from the same community interested in the discussion of the AR topic.

Design: In April and June 2003 seminars about ARs in the towns of Quarteira and Lagos were conducted within the fishing communities. After each seminar, there were gathered small informal groups. The questions addressed to interested skippers were: (1) What do you think about the ARs deployed in the south coast of the Algarve? (2) Is your gear eligible to fish there? (3) Do you think the reefs deployed near here have been contributing to your fishing activity? If no, why not? (4) What are the main benefits from ARs? (5) Do you foresee any problems with the reef access, concerning the different users, such as commercial and recreational? (6) What do you think it is necessary to do to correctly manage the reefs? and (7) Do you want to collaborate in providing us with data for our analysis?

Needs: After the completion of the informal interviews, records about skippers' characteristics and their contact details were compiled, and a fishing logbook was given to each of them. The logbook consists of a cover page with information about the promoting institution (name, address, and contacts) as well as details of: the vessel's name, skipper's name, base port, skipper's address and telephone contact. On the second page there is a letter to the skippers appealing for their collaboration, and also a map where the ARs are positioned. A third page shows the ARs coordinates, and on the following pages there are fields where the entries should be recorded for: date, fishing site, latitude and longitude, nearest reef, fishing gear, corresponding effort (gear dimension, and mesh or hook sizes), and catch weight and species composition. Other logbooks usually have information about time of the entry, weather conditions, boat speed and course, or even more detailed information. However, for the purposes of this study it was considered unnecessary to keep such information. The purpose of such a book is to record data on fishing. In Portuguese fisheries, completion of official logbooks is a compulsory requirement for a fishing licence. However our logbook is not official; it is purely for scientific purposes and is in its experimental phase.

Sampling plan: In each seminar around thirty participants attended. At the end of each presentation feedback was asked from the attendees. Some skippers decided to collaborate, and two informal groups were then formed. Both groups were small (3-4 members). A logbook was given to each of the skippers belonging to the informal groups. There were selected *a priori* four goals: (1) To gauge interest stimulated by the presence of the ARs on the nearby coast; (2) To get feedback about their actual use; (3) To get collaborators (or key-informants) to fill out our logbooks, both in the ARs and out of them; and finally (4) To conduct a brief questionnaire survey on collaborators details. No taping for future transcripts was used.

3.5.3. Direct Observations

Due to the reason that actions and behaviour of people are the main aspects of basically any enquiry, it seems natural to develop a technique in order to watch what they do, and also to record observations in some way and then to describe, analyse and interpret what has been observed. Interviews reveal what people perceive about what happens, whether direct or non-participant observation is more reliable by revealing what actually happens. The first approach to observation is to describe the setting that was observed, as well as activities that took place in the setting, people participating in the activities, and meanings of the observations by the observer viewpoint (Patton 2002: 262).

In this technique the decision focuses mainly in what will be observed, and why (Punch 1998). Observation once mastered is a technique that can reveal characteristics from individuals or groups that could not be discovered by other means (Bell 1999). This research technique requires a researcher or group of researchers to observe and record behaviours related with the occurrence of a given event, case or process. Field observers need to be familiar with the context, but site visits can be more reliable than relying solely on documents or key informant interviews. It is also possible to reveal certain aspects or patterns that many informants may be reluctant to say or be unable to describe adequately (Patton 2002: 262-264).

The direct observation technique as a primary method is a systematic and structured process of gathering information. It can be done by direct vision or be assisted by instruments such as binoculars, telescopes, cameras, etc. The main advantage of direct observation is that any event can be studied in its natural environment, giving a richer understanding of the subject. Another advantage relates to objectivity, without needing to ask people about their views, feelings or attitudes, but by simply watching what they do. The disadvantages are related to the possible change of behaviour when the subjects of study suspect they are being observed. Another problem involves the amount of time needed (Robson 2002). In the present study the strategy approach used is explained in Box 3.8.

Box 3.8 Direct Observation Strategy

Purpose: To allow a punctual evaluation of reef user activity (specifically fishing effort) in order to verify the *modus operandi* of the different AR users *in situ*.

Design: To fulfil the above purpose, a form was developed to be completed onboard research vessels. The form was designated 'Direct Site Observation' or in abbreviation DSO. The experimental design of the first version of the DSO (July 2002) was submitted to a pre-test phase. After some sea observations, a number of flaws were exposed; for example, it was perceived that there was an under-estimation of the total fishing effort in a given area, due to the fact that not enough consideration was given to gear anchored in advance, i.e. prior to when the vessels were observed. In January 2003 the DSO was redesigned in order to allow a correct description of all the fishing effort in each sampling period. Since then it has been used as an appropriate form to collect data. The DSO consists of two parts: (1) observations directed to the vessels seen operating in an area of up to approximately half mile around the ARs in the observational moment, and (2) observations to record gear previously anchored and signalled by buoys (i.e. before the observational moment) up to one and half miles from the reef geographic centre. The filling of the DSO includes several fields: from the id of the vessel's and gear's category, to the crew onboard and target species (first part); and the anchored type of gear, number of buoys, and their relative position to the ARs, both in terms of distance from the AR and direction in relation to the reef (second part).

Needs: To carry out this sort of observation it was considered advantageous to use the IPIMAR's research vessels and correspondent skippers in terms of their experience in anchored gear identification. Therefore, to prepare the observers, a short tutorial was scheduled with each of the skippers about the sampling strategy to adopt and in how to fill in the DSO sheets. The observational sites were also defined in order to delimitate the areas where patterns of use would be found.

Sampling plan: It was decided to carry out sampling as long as necessary, and specifically until patterns of use in the ARs' vicinity became recognised. It was explained to the RV skippers that the observations should be carried out every time the vessel was going to sea, with the purpose of assisting the researchers in their experiments or routines in the ARs, but never with the DSOs as the main purpose.

3.5.4. Surveys

Many phenomena can be observed through observational methods. However for inaccessible phenomena, other methods have to be used. It is common to collect data by asking people to reconstruct the experience of something in a given subject (Frankfort-Nachmias and Nachmias 1996). To do this one may use a survey, which is a non-experimental method of collecting information usually through the use of a questionnaire. It is directed to a group of people selected from a given sampling strategy. It involves a systematic collection, analysis and interpretation of information. The individuals are systematically examined according to the presence or absence (or their relative degrees) of specific characteristics of interest.

A census is a kind of survey where it is aimed to cover the entire population by the same set of questions. When deciding to conduct a survey, it is necessary to consider which characteristics from the total population are important to be represented in our sample, in order to say with some confidence that our sample is fairly representative. It is important to ensure that all the questions have the same meaning for the whole set of respondents. It is intended to gather information from a large sample of individuals, in order not only to describe but also compare or relate characteristics one to another. Surveys provide answers to: What, where, when and how, but not easily to the why (Bell 1999).

A survey is a method which intends to gather information from a sample of individuals of interest. Usually the group from which the information is collected shares some common characteristics. The sample is just a portion of the population which is subjected to be studied. From the research perspective this is important in order to gather factual information needed to evaluate perceptions on the object of analysis. In a survey, detailed verification of what is examined is less important than trying to understand the activity that is reviewed. It is commonly used in marketing in order to increase sales of services and products. Much of it is academic, by means of studying a specific subject in a given society. According to Robson (2002), to carry out a survey there are several steps involved: (a) development of the research questions, (b) draft questionnaire, (c) revision of the draft, (d) pre-test, (e) correct the questionnaire according to pre-test findings, (f) data collection using the questionnaire, (g) coding data and prepare data files, and (h) analyse the data collected and report findings.

The surveys can be conducted in many ways, including over the telephone, by mail, e-mail, or in person. In a survey, unlike an experiment, the researcher is not manipulating anything, but just observing and collecting data for future analysis. One advantage of a survey design is that it can be repeated in different locations at the same time, or in the same location at different intervals of time. This approach allows replication and comparison, and indeed is a measure of reliability. In surveys a standardized language has to be developed (Hakim 1987). In the present study the strategy approaches used are explained in Boxes 3.9 and 3.10.

Box 3.9 First Survey Strategy

Purposes: To get feedback from different AR stakeholder groups about their perception on impacts provoked by reef deployment.

Design: Variables impacted by the ARs were identified, and then allocated into three categories: environmental, social and economic. Due to the fact that it was necessary to measure stakeholders' perceptions there were used scales for the attitude measurement (Likert scales). The next step was to define which stakeholder groups were involved in the AR theme, and create a database with their characteristics. The survey focused almost exclusively in closed questions.

Needs: No extra personnel were needed to conduct it. Due to the fact that most of the respondents represent stakeholder institutions, it was important to schedule appointments rigorously.

Sampling plan: After gathering all the information necessary for constituting a panel of stakeholders, it was important to keep the database updated, and address covering letters and a memorandum (INIAP/IPIMAR 2003) about the places and characteristics of the ARs in the Algarve explaining the purpose of the survey. Two weeks later an appointment was scheduled to collect each of the questionnaires. This strategy was adopted to increase the return rate of questionnaires, and was considered more effective than pre-paid envelopes.

Box 3.10 Second Survey Strategy

Purposes: To investigate how the main AR user groups evaluate the structures in terms of different aspects of efficiency.

Design: This survey was concerned with efficiency, focusing on two different stakeholder groups: (a) fishermen – where these were surveyed in order to establish priorities to maximise benefits from fishing and elicit factors which determine AR efficiency, and (b) SCUBA divers – where it was surveyed which factors enter in the deciding process to dive and to determine what sort of diving sites are preferential for divers both from the producers and consumers point of view. The survey focused mainly on closed questions. For this survey scales were adapted from the analytic hierarchy process (AHP). AHP is a mathematical technique based on pairwise comparisons, and is usually used as a management tool in decision analysis (DA) processes. The technique consists in few steps and is extensively described in the academic and grey literature (Saaty and Alexander 1981, Triantaphyllou and Mann 1995, De Steiguer et al. 2003).

Needs: A special need was to ask fishermen associations' administrative personnel to schedule meetings with fishermen. Diving operators collaborated in the deliverance of the questionnaire survey by their clientele and staff.

Sampling plan: For fishermen it was necessary to enlist the services of a surveyor, whereas for divers that was unnecessary. The reasons for this due to educational differences: divers are usually more educated than fishermen, and are able to self-complete the questionnaire survey.

3.5.5. Additional Instruments

A 'document' is any impression left on a physical object or electronic device by a human being. When used in conjunction with other data, documents can be important for data triangulation (Punch 1998). In some research studies, documentary evidence is used to supplement information derived from other methods such as interviews and questionnaire surveys. It is an important method where there is a difficult or impossible access to the subject of research. In this method there is the so called 'source-oriented approach' where usually there are no predefined questions, but they will be brought about just by the nature and material contained in the sources. There is also the 'problem-oriented approach', where the questions are formulated by reading documents and other secondary sources in order to establish the focus of the research (Bell 1999).

For content analysis it is important to properly select the documents. Often the content of newspapers is used. Content analysis involves counting the number of times 'recording units' occur in a sample such as words, column inches devoted to a subject, etc. A sampling strategy may be defined by sampling a given newspaper over an established period of time. The sample must be sufficiently large to establish reliable conclusions. There are particular situations to consider with the document analysis. Let us take the following examples: if the author of the document is supporting a given action where he and/or she has a stake, or if the author was affected by pressure or fear. In both circumstances the document may be subjected to bias (Bell 1999). In the present study the approaches used are explained in Boxes 3.11, 3.12, 3.13 and 3.14.

Box 3.11 Electronic Archival Analysis Strategy: Fisheries

Purpose: To search electronic documents which could be helpful in giving information about fisheries that can be reef related.

Design: Considered as a 'source-oriented approach', where there were no predefined questions. It was intended to collect data on studied vessels' landings. The file containing information on given commercial vessels (name, number plate, crew, landing ports), and their annual catch (species name, weight, estimated price) was provided.

Needs: Electronic files on the registered fleet for the year 2002 (source: DGPA 2002b) were analysed.

Sampling plan: Request specific institutional services for the electronic version of the documents, in order to make searches. Study the structure presented and the contents in the electronic documents. Gather the information necessary to crosscheck previously collected data.

Box 3.12 Electronic Archival Analysis Strategy: Diving

Purpose: To evaluate the importance of different reef alternatives, namely the AR modules.

Design: Considered as a 'source-oriented approach', where there were no predefined questions. It was intended to interpret the data provided by the diving operators, namely information on the diving site types, location, data, clientele and prices.

Needs: To have access to electronic documents that could give information for diving site alternatives (diving operator logbooks). The electronic files of two diving operators (sources: Hidroespaço 2005 and Portisub 2005) were analysed.

Sampling plan: Ask for the collaboration of diving operators to provide their own data. To study the structure and contents presented in the electronic documents. Gather the information necessary to crosscheck previously collected data.

Box 3.13 Content Analysis Strategy: Regional Newspapers

Purpose: Find out the importance of fishing related news in regional newspapers and also the interest triggered by the AR deployment.

Design: Adopting a ‘problem-oriented approach’, the steps for the content analysis were: (a) Development of the research questions – in this case, after examining the regional newspapers the questions were: ‘Is there a greater emphasis on fisheries issues now than there was 15 years ago?’ and ‘Have the ARs been considered in the regional written media?’; (b) Define the sampling strategy; (c) Decide on the recording unit, (d) Construct categories for analysis, having decided to categorize the newspaper articles by the subject matter: Aquaculture and shellfish gathering, fisheries, ARs, and other sea related issues.

Needs: At least one library where different regional newspapers can be found since 1990 (time when the ARs were first deployed in the Algarve).

Sampling plan: An example of stratification can be applied of approximately 50 newspapers per each chosen year of analysis (if possible dividing the sample by different titles and periodicities and random dates among them).

Box 3.14 Content Analysis Strategy: Internet Sources

Purpose: Try to find out to what extent, and how, the internet is used as a vehicle to communicate both the supply and demand for the structures of the Algarve AR program.

Design: To select the most relevant documents, create a database from them and use qualitative analysis software. The documents can be then categorised according to their type, source and topic, and the analysis done by counting code occurrences and plotting the results.

Needs: To have access to internet. To have access to work with a qualitative analysis software.

Sampling plan: To use a popular search engine where can be searched all the entries that correspond to the terms 'recifes artificiais' and 'Algarve' can be searched, discarding all that are double counted and those of scientific character.

3.6. Measurement Techniques

3.6.1. Summated Rating Scales and Simple Indicators

Measurement techniques such as tests and scales have been developed by psychologists and other social scientists in order to assess people's abilities, propensities, views, attitudes, etc. Measurement scales function to provide some insight into what people feel or believe about a given issue. For attitude measurement, there is a consensus that it is not possible to assess something with a single question. Usually it is necessary to have a set of several items to assess via triangulation (Robson 2002). The best way to research attitudes is by constructing and using appropriate scales. Some issues, such as those related to fisheries management require multiple objective approaches of study. Such studies involve techniques to evaluate stakeholder attitudes, preferences elicitation, etc. (Mardle and Pascoe 2003a,b).

Summated rating scales

The 5-point Likert scale is an ordinal scale commonly used in social sciences. It was developed in surveys by Rensis Likert in the 1930s. It is used to measure the level of agreement with pre-defined possible impact items. It consists of standardised response categories: highly improbable, improbable, neutral response, probable, and highly probable (Likert and Likert 1976, Cripps and Aabel 2002, Kennish et al. 2002, Robson 2002). The summation of the results is then expressed in a spreadsheet and ranked according to each respondent score. The total of each respondent's opinion about the items represents a favourable or unfavourable attitude towards the concepts measured.

The rationale for using summated rating scales is based on the possibility of predicting stakeholders' likely behaviour by evaluating their expressed attitude(s). In the context of the present study, the key stages involved in the process of achieving this outcome are: (1) involvement with the structures, (2) belief in the structures' potential, (3) expressed attitude towards them, and (4) likely behaviour (Figure 3.6).

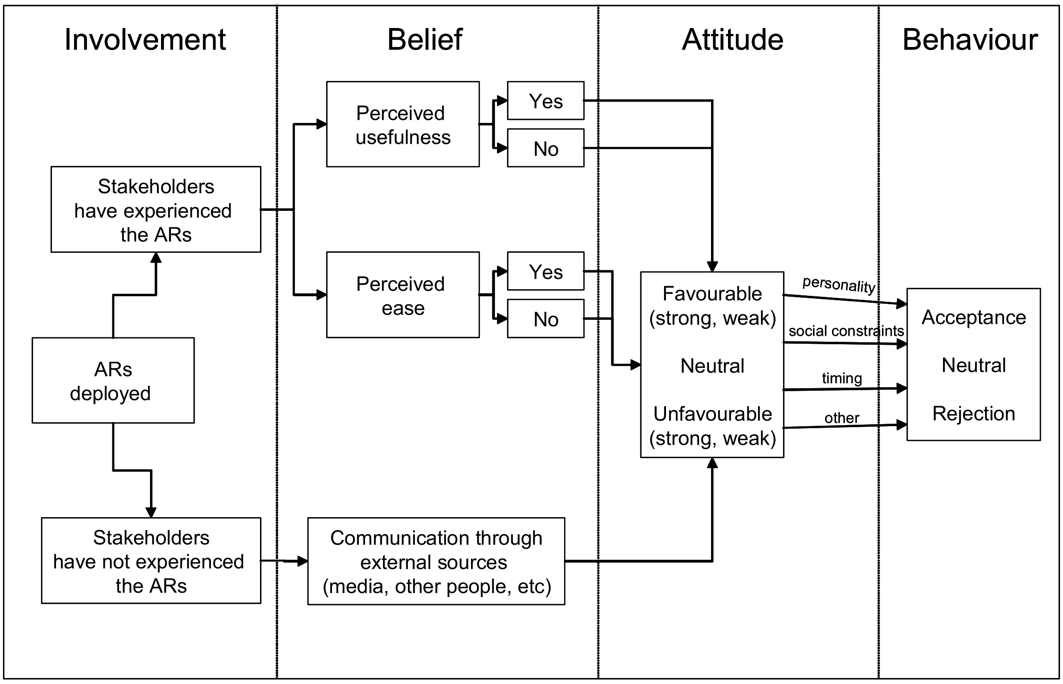

Figure 3.6 – The process of response (behaviour) to the change produced by AR deployment involves the measurement and eventually categorising attitudes of stakeholders.

Involvement with AR structures is related to the knowledge about them. This involvement contributes to attitude formation. There are several sources that may influence attitude formation such as informational influences, direct experience, conditioning, observational learning, social comparison and even heredity (Erwin 2001).

Belief can be considered as a form of judging something to be true, and can range from mere opinion to certain knowledge. Stakeholders may have their own beliefs depending upon their contact with the AR. Those who have experienced the AR may perceive the structures as useful or not and also in terms of access, whether they are accessible or not. Stakeholders who have not had direct contact with the AR may hold their belief depending upon the information given by others. To believe that the ARs enhance socioeconomic performance of stakeholders in this sense is to judge that the structures truly contribute to their satisfaction, even if there are objectively insufficient facts, it is considered subjectively sufficient.

Attitudes come from judgements. They show individuals' preferences for something. Most attitudes in individuals are generated by social learning from the environment.

The link between attitude and behaviour exists and is dependent on several aspects; such as, for example personality, social constraints and timing of measurement. Several factors play a role in an attitude resulting in a particular behaviour. For example, a person may have a positive attitude towards reef usefulness but not use it. Unlike personality, it is expected that attitudes may change during life and experience. Attitudes may also change through persuasion. In our particular case, an attitude can be explained as a learned predisposition to respond in a consistently favourable or unfavourable manner through acting, feeling, or thinking with respect to the habitat modification provoked by the AR. It shows a person's disposition and opinion of the ARs. However, people can also be ambivalent towards the AR subject, i.e., they can simultaneously have a positive and a negative attitude towards it.

Finally, behaviour refers to the actions or reactions of people in relation to the change provoked by the ARs. It is characterized by people's responses to the AR change and that can be observed. Behaviour is an indication of the intention of a given individual or group of individuals. In the socioeconomics context of ARs, attitudes when expressed by behaviours reflect how and what people do feel and think about the subject. The overall behaviour demonstrated by people in relation to ARs will tell us what types of output events, signals, messages, or other indicators will be seen in response to various scenarios or other inputs.

Simple indicators

Simple indicators are presented as an assessment tool to represent general information about an individual, a group of people, a program, or a system. Simple indicators help to describe a certain situation, or how it is functioning/changing over time. They are easy to measure and aim to simplify, quantify, and communicate bunches of information in ways that are more straightforward to understand; and can be used to obtain general information about the state of a phenomenon by means of surveys, or interviews (Daan et al. 2005), or other instruments (Froese 2004). Indicators can be considered as the link between established objectives and action in management. Indicators should be chosen to guide management and to be effective in communicating knowledge. The selection of meaningful indicators to shed some light on the management decisions involves the identification of a common ground between users and research knowledge, addressing the point of allocation and long term sustainability (Degnbol 2005).

Indicators may have different provenances and treatment needs. Biological indicators may require laboratory analyses. For example, the researcher that wants to assess the feeding habits of a given fish species found in the AR needs to carry out an analysis on the stomach content of several individuals of that species. On the other hand, social and economic indicators usually derive from signs tracked through human behaviour. To develop them, it may be necessary to use special equipment, techniques and access conditions. For example, to assess the number of vessels which use an AR in a given period of time, it is necessary to use radar and/or binoculars. To establish users' satisfaction when using a given AR, it may be necessary to use techniques such as the Likert-scales. To know the quantity of fish landed by a given vessel in a certain period of time the researcher has to have access to the respective selling records. The simplest indicators may use qualitative scales whether they are text, pictures or colours (Figure 3.7).

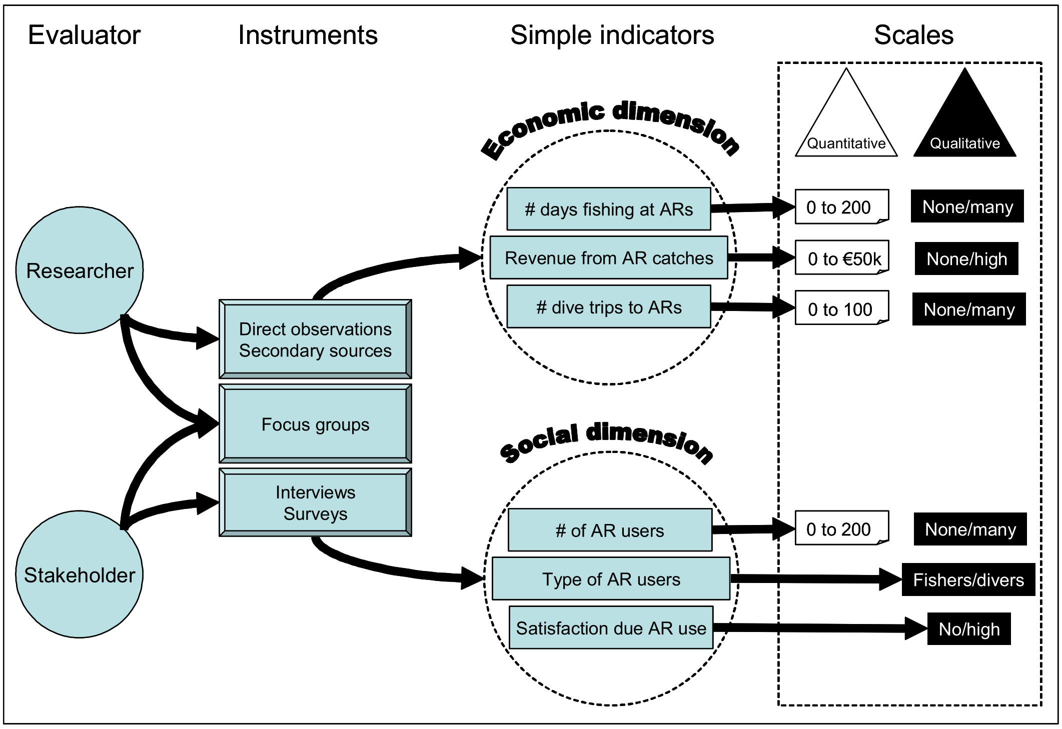

Figure 3.7 – Examples of the use of simple indicators.

3.6.2. The Analytic Hierarchy Process

<u>Introduction</u>

Many decision-making problems in our daily life involve a number of factors. In cases where people have difficulties in accurately quantifying their preferences for various criteria and alternatives, a technique called analytic hierarchy process (AHP) can be used. The AHP is essentially a basic mathematical approach to decision making using pairwise comparisons. The technique considers both qualitative and quantitative aspects of related decisions. It reduces complex decisions into synthesized results easing the decision process.

This process was developed by Thomas Saaty in the 1970s (Saaty and Rogers 1976) and was published in the book 'The Analytic Hierarchy Process' in 1980. The technique has been used in a wide range of disciplines (Saaty and Vargas 2001). Many studies using the AHP technique operate with the help of Expert Choice™ software.

The potential of AHP is enormous and it is possible to use it in multi-criteria decision making, planning, conflict resolution, forecasting and in nearly all the areas of knowledge (Saaty and Alexander 1981, Triantaphyllou and Mann 1995, Ananda and Herath 2003, De Steiguer et al. 2003). In economics the problems can be formulated by using ratio scales. In the social sciences the AHP can be used to quantify and derive measurements for intangibles. In other areas the methodology is used to link hard measurements to human values, by interpreting what the measurements mean. The technique has been applied to a range of problems involving natural resource management (Herath and Prato 2006), and in a few instances to fisheries and aquaculture (Leung et al. 1998; Mardle and Pascoe 2003a,b; Whitmarsh and Wattage 2006). One study of site selection for artificial reefs (Tseng et al. 2001) has made use of AHP.

This process consists of modelling a problem, by using a hierarchic structure. In its essence, the AHP has a sequence of different steps (Saaty 1990): (1) the problem outline, (2) definition and selection of the elements for evaluation, (3) pointing out a set of alternative outputs, (4) defining a set of relevant criteria where alternatives are judged, (5) constructing the hierarchical structure, (6) gathering information and eliciting the priorities, and finally (7) preparing recommendations for action.

In its simplest form, a hierarchy consisting of three levels is used: the goal of the decision represented at the top level, the criteria by which the alternatives will be evaluated represented respectively at the second and third (or lower) level. However, the process can involve several other intermediate levels for the establishment of comparisons, depending on its intrinsic complexity.

Usually the AHP model is represented by a schematic tree, where level zero is for the goal aimed to be achieved in the decision, level one establishes the criteria, and then other sub-levels can be developed as sub-criteria, and so forth. The lower level of the tree is represented by the alternatives to the decision[6]. Then, a number of pairwise comparisons are done, in order to establish the factor weights and evaluations. At the end, the alternative with the highest total weight score is selected as the best one.

The decision to make

Probably one of the best ways to explain how the methodology works is through the use of an example. So from now on in this section the AHP will be explained by using an imaginary example.

Let us imagine that incentives were given to deploy ARs in a given country. After preliminary studies carried out by specialists, the best location was selected and the task of choosing the appropriate AR was given to a research institution. To evaluate the choices, decision-makers (DMs) have determined that the most important overall criteria are safety, durability, and costs, where the first and second are aimed to be maximized and the latter minimized. For the AR types they selected three possible options (alternatives). They have placed the criteria in the level one of the tree and the alternatives at the lower level (Figure 3.8).

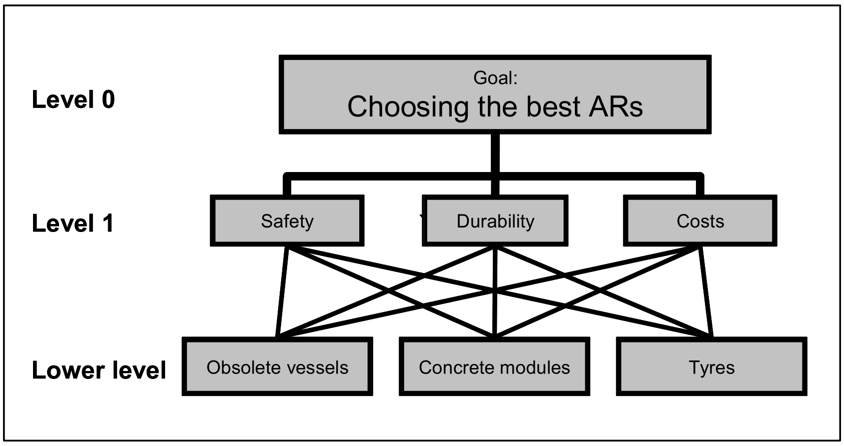

Figure 3.8 – The schematic AHP tree.

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[6] Both for criteria and alternatives the advisable number should be 7 ± 2. The reasons for this are based on the human capacity to make reliable comparisons (Saaty and Vargas 2001).

In this example the decision hierarchy has only three levels, but could have more (e.g. safety could include stability, toxicity, porosity, etc.). It is important to remember that the top level describes the overall decision. The overall decision here is that the DMs have to select the best type of ARs.

After organizing all the criteria and options, it is time to start the selection process. To make the pairwise comparisons, the DMs use a 9-point scale[7] where by convention the value of one is chosen to indicate that two items are of equal importance, while nine indicates that one item is absolutely more important than the other (Table 3.2). The scoring process is based on the judgements made by the panel of DMs.

Table 3.2 – The AHP scale represents an intensity of importance.

Score	Pairwise comparison	Explanation
9	Significantly more important	One item is favoured in the highest possible way
7	Much more important	Dominance of one item in relation to another
5	More important	One item is strongly favoured to another
3	Moderately more important	One item is slightly favoured in relation to another
1	Equally important	Two items contribute equally to the goal
2, 4, 6, 8	Intermediate values	Used to compromise between two comparisons

The pairwise comparisons

The DMs begin the comparisons by looking at each of the criteria for the AR alternatives and by comparing ‘Obsolete vessels’ with ‘Concrete modules’ (Figure 3.9). Using the preceding scale, the DMs determine that ‘Concrete modules’ are moderately more ‘Safe’ than ‘Obsolete vessels’. The number 3 on the right hand side of the scale is used for the choice. Next it is decided that ‘Obsolete vessels’ are

[7] This 9-point scale is used due to human cognitive limitations that have been established by psychologists. The human brain is limited both in its short-term memory capacity and its discrimination ability (channel capacity) to a maximum of nine items.

somewhere between moderately safe to safer than ‘Tyres’, attributing a score of 4, this time on the left side of the scale. Finally, for the ‘Safety’ criterion ‘Concrete modules’ to ‘Tyres’ are compared, and it is agreed that the former are somewhat more than much more important but less than significantly more important than ‘Tyres’, resulting a score of 8. The pairwise comparisons continue for all the criteria[8]. With all of these pairwise comparisons the DMs can construct a pairwise comparison matrix for ‘Safety’ (Table 3.3).

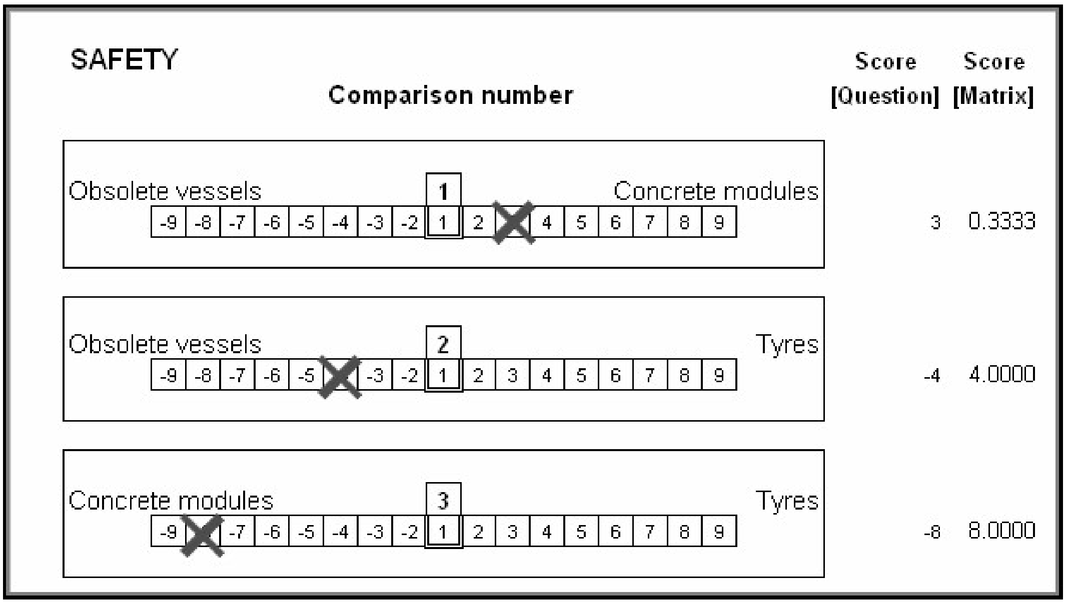


Figure 3.9 – The comparisons between criteria.

To construct the scale it is essential to take into account that the matrix construction should be based also on reciprocals [e.g. w2/w1 and w1/w2 or 1/(w2/w1)] and rational numbers (1 to 9 and their respective reciprocals) (Matrix 3.1).

Matrix 3.1

$$A = \begin{bmatrix} w1/w1 & w1/w2 & .. & w1/w9 \\ w2/w1 & w2/w2 & .. & w2/w9 \\ : & : & : & : \\ w9/w1 & w9/w2 & .. & w9/w9 \end{bmatrix}$$

[8] Having n criteria, [n x (n - 1) / 2] paired comparisons can be made. In this example [3 x (3 – 1) / 2] = 3 comparisons, once both the criteria and the alternatives are 3.

In our example, the results from Figure 3.9 are expressed in Table 3.3.

Table 3.3 – Construction of the matrix for Safety.

Safety	Vessels	Modules	Tyres
Vessels	1	1/3	4
Modules	3	1	8
Tyres	1/4	1/8	1

This pairwise matrix reveals the preferences for 'Safety' concerning the three AR options. In this matrix the diagonal always has the value of 1, which means that comparing anything with itself, the evaluation is equally preferred. In any pairwise comparison matrix the upper left-lower right corner diagonal has the value of 1. The matrix also shows that for example if an item X is twice as preferred to item Y, then Y is only preferred half as much as the item X. This logic is used to complete the cells under the diagonal.

Evaluations for 'Safety'

After completing the matrix of pairwise comparisons, it is time to calculate the evaluations for 'Safety'. The numbers in the matrix of pairwise comparisons are converted to four decimal places to work the matrix (Table 3.4).

Table 3.4 – The matrix for Safety with the elicited values.

Safety	Vessels	Modules	Tyres
Vessels	1.0000	0.3333	4.0000
Modules	3.0000	1.0000	8.0000
Tyres	0.2500	0.1250	1.0000
Column Sum	4.2500	1.4583	13.0000

After determining the column totals, the values in each cell are divided by their column totals, in order to get a normalised matrix (where each column sums one) (Table 3.5).

Table 3.5 – The matrix for Safety with the normalised values.

Safety	Vessels	Modules	Tyres
Vessels	0.2353	0.2286	0.3077
Modules	0.7059	0.6857	0.6154
Tyres	0.0588	0.0857	0.0769

To determine the priorities for 'Safety' in each AR alternative, the geometric mean or eigenvector of each of the rows in the matrix is found (Table 3.6).

Table 3.6 – The normalization of a row.

Row geometric means	Geometric mean calculations
0.2548	=(0.2353*0.2286*0.3077)^(1/3)
0.6678	=(0.7059*0.6857*0.6154)^(1/3)
0.0729	=(0.0588*0.0857*0.0769)^(1/3)

The above results can then be represented in the following manner (Table 3.7):

Table 3.7 – Priorities for the criterion 'Safety'.

Criterion	Vessels	Modules	Tyres
Safety	0.2548	0.6678	0.0729

These results show that in terms of 'Safety' the preferred choice is the option 'Modules', whereas the least preferred is 'Tyres'. The same procedure is carried out with all the other criteria (i.e., 'Durability' and 'Costs'). However, it is important to know how consistent the answers are. In order to do this the 'Consistency Ratio' is calculated.

<u>Determining the consistency ratio</u>

To compute the consistency ratio it is important to determine first the weighted sum vector. To do this the criterion evaluation for the first alternative is multiplied by the first column of the pairwise comparison matrix. Then the second criterion is multiplied by the second column, and the third criterion times the third criterion of the matrix of pairwise comparisons. All these values are then summated over the rows (Matrix 3.2).

Matrix 3.2

$$\begin{bmatrix} (0.2548)(1.000) + (0.6678)(0.330) + (0.0729)(4.000) \\ (0.2548)(3.000) + (0.6678)(1.000) + (0.0729)(8.000) \\ (0.2548)(0.250) + (0.6678)(0.125) + (0.0729)(1.000) \end{bmatrix} = \begin{bmatrix} 0.7691 \\ 2.0156 \\ 0.2201 \end{bmatrix}$$

Then it is necessary to calculate the consistency vector. To do this it is necessary to divide the weighted sum vector by the criterion evaluation values determined previously (Matrix 3.3).

Matrix 3.3

$$\begin{bmatrix} 0.7691 / 0.2548 \\ 2.0156 / 0.6678 \\ 0.2201 / 0.0729 \end{bmatrix} = \begin{bmatrix} 3.0178 \\ 3.0181 \\ 3.0189 \end{bmatrix}$$

The above is the consistency vector, and it is necessary to calculate the values for two other terms, lambda (λ) and the consistency index (CI), before calculating the final consistency ratio. Lambda corresponds to the average of the consistency vector, as follows:

$$CI = \frac{\lambda - n}{n - 1} \qquad \text{Equation 3.1}$$

Where n corresponds to the number of ARs compared. In this example n = 3, because three different types of ARs are being compared. The results for the calculations are the following:

$$\lambda = \frac{3.0178 + 3.0181 + 3.0189}{3} = 3.0183 \qquad \text{Equation 3.2}$$

Note that there is an infinite number of ways to derive the resultant priorities vector. But due to the importance of consistency, it is fundamental to calculate the value of lambda[9].

$$CI = \frac{3.0183 - 3}{3 - 1} = 0.0091 \qquad \text{Equation 3.3}$$

[9] To calculate the normalised priority weights there are two methods: (1) the geometric mean, and (2) the eigenvalue (Whitmarsh and Wattage 2006). In the literature λ is often referred as the λ_{max}, where λ_{max} is the largest eigenvector or eigenvalue (Saaty and Vargas 2001). To calculate this λ_{max} it is necessary to raise the matrix to a certain power until reaching a constant value.

Finally to calculate the consistency ratio (CR) it is necessary to divide the consistency index by the random index (RI) which can be tabulated[10]. The expression takes the following form:

$$CR = \frac{CI}{RI} = \frac{0.0091}{0.58} = 0.0157 \qquad \text{Equation 3.4}$$

The value of CR can be both used in the decimal form or in percentage. In this case by converting the CR to a percentage we obtained the value of 1.57%. It is this ratio that indicates the consistency given in the answers. It is generally accepted that if the consistency ratio is greater than 10% then re-evaluating some of the answers that are inconsistent should be considered. If the consistency ratio is below 10%, it means that the answers are consistent, the maximum consistency possible (and desirable) being 0%. This also means that it is not necessary to make much adjustment to the actual values of the eigenvector entries.

In this analysis the DMs have been consistent in their evaluations. The consistency ratio is fundamental to giving credibility to the AHP. However, there is usually some inconsistency within judgements. In the real world, people and phenomena are rarely 100% consistent. The causes of inconsistency may vary; for example, computing a wrong value in the matrix (e.g. the reciprocal), lack of information (if one has limited information about what is being compared, the chance of inconsistency is higher), and lack of concentration during the judgement process.

Evaluating the other criteria

After evaluating the criterion ‘Safety’ it is necessary to evaluate also the criteria ‘Durability’ and ‘Costs’. The calculations are similar, and the steps the same. The final matrix is the following (Table 3.8):

Table 3.8 – Matrix showing the final scores of the criteria for each alternative.

	Vessels	Modules	Tyres
Safety	0.2548	0.6678	0.0729
Durability	0.1661	0.7374	0.0935
Costs	0.0837	0.7666	0.1462

[10] The average random consistency index (RI) is obtained from a sample of randomly generated reciprocal matrices using the scale 1/9, 1/8 to 9.

The consistency ratios for all the criteria and the alternatives converted to percentage are the following:

CR= {1.57%, 1.22%, 1.58%} {0.11%}

Since all of the CRs are under 10%, it means that the DMs were consistent with all their responses to the evaluation.

Determining the factor weights

So far we have demonstrated how AHP may be used to evaluate the options against each of the criteria. What the DMs also need to do is to establish the relative importance of the criteria. Exactly the same AHP procedure is followed, except that now the paired comparisons are in respect of the three criteria (Safety, Durability and Costs), not the AR options. Suppose that this has generated the following priority weights, as shown in Table 3.9:

Table 3.9 – Priority weights for criteria.

Criterion	Total weighted evaluation (priority)
Safety	0.615
Durability	0.319
Costs	0.066

After calculating the criteria weights it is necessary to multiply criteria evaluations by the factor weights. This procedure will give the overall ranking for the three AR options (Table 3.10).

Table 3.10 – Priority weights for the alternatives.

AR options	Total weighted evaluation (priority)
Vessels	0.215
Modules	0.696
Tyres	0.084

The best option, as the table above shows, is the 'Concrete modules' which received the highest final ranking and the DMs should then select it as the best AR solution.

Comments

The AHP is a method that has both strengths and weaknesses, the latter being a source of some controversy.

In terms of strengths, the AHP allows to: (1) easily explain graphically the problem, (2) achieve rational results because there is a logical decomposition of the problem, (3) transform subjective qualitative information into objective quantitative data that can be easily analysed and used in the decision making; this is because the results are presented in the form of a percentage and are easy to interpret, (4) be a viable means of rapid decision-making, (5) to gather people from different viewpoints and working in different areas; and also facilitating the pursuit of an optimal solution in a transparent manner (by including all people), (6) find a general acceptance of the results within the people involved, (7) minimize emotion-like judgements when these judgements are made by several individuals or in groups.

In terms of weaknesses: (1) the use of different methods of constructing the AHP which analyse the same problem may result in completely different results, (2) the researcher may perceive the problem in a very objective way, whereas it may be perceived in a subjective way by individual participants in the research, (3) the method can use the answers of a few or many participants in the judgement process; however, when it comes to the task of aggregating opinions, the rating can be done by separating individuals or putting them all together, which may lead to different results, (4) whilst mathematically sound, the technique is still criticized on the grounds that its results are used when very different alternatives cannot be compared, (5) very complex problems are unlikely to be analysed, since the AHP is limited to as few pairwise comparisons as possible[11], (6) many comparisons may be seen as tedious for those individuals that are involved in the rating process.

[11] This makes it difficult to use the process with more than 9 criteria or options for comparison with each other. For example if there are five criteria, there are ten pairs to compare. However, if there are 25 criteria, 300 comparisons would have to be made.

3.7. Conclusions

In the methodological approach it is important to identify and define the dimensions to study, as well as which stakeholders are or should be involved and their degree of involvement in the socioeconomic tasks covered. Since this thesis aims to be an exploratory approach on the subject of AR socioeconomics, it seems reasonable to decide for a flexible design such as the case study method. The challenge here, that can be interpreted as the advantage is that the flexibility of the method allows to use and combine different instruments for the data collection process and build up information from that.

Adapting the case study method in the Algarve AR context depends then on the availability of data. Some of the primary and secondary data is available through different sources, but other has to be completely built up from scratch. Besides that, sometimes it is only possible to collect data quite locally, and then the trend is to narrow the case study to a simple case; whereas where the data collected is more diversified, the case study tends to be broader. In order to fulfil the requisites of the case study it is necessary to get help from instruments of data collection. In the present study there were considered the following instruments in order to focus on the AR subject: direct interviews, direct observations, surveys, and additional instruments. However, it is important to note that the difficulties to study ARs are related to the fact that the structures are not so easily accessible and visible, since they are located in the sea and submerged. For these reasons ARs are sometimes compared to the Petrarch's Principle (Pitcher and Seaman 2000), which states that it is possible 'to know things unseen'. The quality of information obtained from the study of ARs is consequently of fundamental importance to support the role and utility of ARs.

The use of measurement techniques seems of particular relevance as a reliable and easy understandable way of translating usually qualitative information into a more measurable or quantitative form. The use of summated rating scales were deemed appropriate as a means of collecting a broad range of data from different dimensions and evaluated it in terms of stakeholders' perceptions and attitudes. Other simple indicators can be used as a starting point for comparisons of AR sites along time and in terms of varied perspectives.

As a measurement technique there is a particular focus in this study to use the AHP. In the context of socioeconomics the rationale for its use is basically due to three main factors: (1) it is important to be focused on the nature of the problem and to define the main goal, (2) it is vital to have a broad knowledge about the problem in order to include all the fundamental aspects that relate to it in the development of the hierarchical structure, and (3) it is important to have access and to gather enough knowledge to assess the priority of influence of each item being analysed. The use of the AHP method as a measurement technique highlights some important points. The technique is far from perfect, and because of this there are some conflicting views over the relative strength and weaknesses of the AHP.

Part two

Results

Chapter 4

Monitoring and Description

Contents

Word Count: 11,365

4.1. Introduction

Monitoring ARs use can be defined as a scientifically designed process of standardised observations (continuing or in a specific period of time or at specified intervals), including activities such as routine counting, observing, testing and measuring to determine whether set standards or requirements have been met or to determine reef status or condition. It is used especially to detect and give warning of change. 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 ARs use can be applied in two different ways: (1) ARs may receive a monitoring visit to check on progress (by measuring certain variables), or (2) carry out regular reports on the progress of the reefs' program as a whole and notably on the extent to which it is meeting targets. 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: 123).

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). This author focuses on the importance of the standardisation of data sets to better facilitate the sharing of monitoring information in a broader scope.

There are numerous works about monitoring reefs but mainly considering biological or other natural variables. Few works consider monitoring the socio-economic variables of reef. There are some studies carried out in the Southern and Gulf of Mexico States of the US (e.g. Ditton and Graefe 1978, Milon 1991, Murray and Betz 1994, Ditton et al. 1995, Ditton and Baker 1999, Seaman 2004). Some research has been carried out in Florida where around half of the US's ARs are placed. In one of these works, Milon (1991) refers to and criticises a work by Ditton and Graefe (1978) in Texas, where the goal for those deployed reefs was 'fisheries enhancement'. However, the concept of enhancement was not clearly stated in terms of user groups and species, and monitoring information was not used to identify reasons for the different usage rates. Comparatively, it has been stated by Monteiro and Carvalho (1989) and Monteiro et al. (1994) that the Algarve AR program was to be used for ‘fisheries management’, and in this example the concept of management is too vague or at least somewhat slippery. Monitoring of the Algarve ARs currently focuses mostly on the physical-chemical and biological aspects, specifically assessment studies of benthos (Moura et al. 2004, 2006, 2007; Boaventura et al. 2006) and ichthyology/fisheries (Santos 1990, 1997, Santos and Monteiro 1997, 1998, 2007; Santos et al. 1996a,b, 1997, 2005, 2006). Both are monitored on a regular basis.

For Milon et al. (2000), monitoring is the most fundamental type of socio-economic evaluation because it can provide information to answer several basic questions needed to give a view of the whole picture about ARs (Box 4.1).

Box 4.1 Monitoring questions to answer

Monitoring questions are usually descriptive by nature and focus on the dynamics of artificial reef use. However, a single *a priori* question that should be answered is related to the demand of the AR(s): Is(Are) the target group(s) actually using the habitat?

Having an affirmative answer to the above, it is important to have answers to the following questions: a) Who uses the AR and its resources, b) Where does that use occur, c) When does that use occur, and d) Why does that use occur?

<u>Objective</u>

Based on Seaman’s (2004) work, we tried 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 chapter will focus on two primary data collection techniques used to monitor ARs. The first was based on interviews with potential users along the Algarve coast to obtain answers to the main questions related to socio-economic reef use. The second focussed 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.

4.2. Potential AR Users in the Algarve

To date, ARs in the Algarve's coast have been used for research purposes, but no information has been produced concerning the socio-economic potential of such structures in Portugal. The very starting point of this research was to obtain information about who uses the reefs. It was supposed that commercial fishermen and recreational individuals were making use of the reefs. For both types of individuals, an attempt was made to find out if they were aware of the AR structures deployed in the Algarve, and get their feedback concerning their potential use.

4.2.1. Settings

Commercial fisheries

The Algarve despite being the most active region in Portugal where fisheries is concerned, has been suffering reductions in terms of employed fishermen. There is a decreasing trend in both fishermen and vessels, but technology upgrading facilities allows more efficiency in their activity. Fish resources, however, are dependent on the adequate management and control.

The regional Directorate of Fisheries (DRPASul) keeps a record of fishermen and vessels, and based on its information it is possible to estimate the total number of vessels registered. However, there is the risk that an unknown fraction of those vessels might be already decommissioned or under the decommissioning process. It seems that fisheries activity, despite being widespread by the regional coastal area, has been somewhat replaced by tourism. This has grown up in parallel with some of these fishing communities, but where it seems to attract more young people than fisheries. The first attempt of this study was then to go towards those people, briefly characterize them and investigate what might be their interest in using the AR structures. Commercial fishermen skippers were then the priority target population to interview, since it is supposed that they 'use' the sea as no one else.

Recreational activities

The Algarve, since the 1960s, has been one of the main international tourist destinations worldwide. Even among the Portuguese people, the Algarve is the region that attracts more resident tourists. These facts are a factor in attracting investment, not only in the construction and food/catering industries, but also in the recreational and amusement ones.

Sea related recreational activities are on the increase. Two of those activities are recreational angling and diving. The actual number of recreational people varies with the season (higher in the summer and lower in the winter). This fact makes it difficult to estimate the number of recreational anglers and divers and the consequent number of angling and diving trips. Additionally, recreational vessels can be used for a diversity of purposes other than supporting sea angling and diving, and for this reason their vessel numbers are not a reliable way to estimate recreational users. The only knowledge which can be obtained is from vessels used by diving operators and charter boats hired for several purposes where sea angling can be included.

4.2.2. Methodology

Instruments

- *Interviews* – Semi-structured questionnaire-based interviews constructed by the researcher were conducted (Figure 4.1a). Pre-determined questions were included in eight sections for commercial fishermen and six for recreational users: (a) Identification information (both), (b) Professional activity (just commercial), (c) Activity characterization (both), (d) Activity site (both), (e) Upgrading (just commercial), (f) Effort (both), (g) ARs consequences (both), and (h) Investment and costs (commercial and recreational boat owners). Questions posed 'range from structured responses, which provide descriptive and comparative information, to unstructured responses which allowed for some qualitative investigations'. For the purpose of this chapter the analysis of just some of the questions was useful to answer the monitoring research questions posed in the introduction.

- *Secondary Sources* (Box 4.2) – These instruments can be useful as a starting point to know more about our object or subject of study and also to cross-check information collected from other sources (Figure 4.1b-e). They serve also to add data that is not possible to collect from the instruments where just primary data is collected.

Box 4.2 Secondary sources available

Despite limited knowledge of AR structures in Portugal, it seems that the most reasonable sources from which it is possible to collect information include:

(a) *Commercial sea-fishing boat licence records and landings information* – To find out how many licences are issued to vessels that have a commercial number plate. For monitoring AR purposes it is important to know eligible commercial fishing vessels that are still in operation. Records on wrecks can be sometimes found, but they are not useful for this study's aims. This source of data can be requested from the Fisheries Directorate (DGPA), where there is an electronic version available that can be provided for each year.

(b) *Saltwater fishing licence records* – These differ from the above source, since each vessel can have at least one gear to operate. Therefore this is not a reliable source from which to study fishing effort, due to the fact that most of the vessels have several gear licenses. In the Algarve it is common to find vessels having five or more gear licences, even if some of them are in a non-operational state. However, the fisheries directorate now has tighter control over the aspect of renewing or attributing new fishing licences.

(c) *Diving operators* – It is possible to find out how many clubs are working on a regular basis, and for some of them how many people dive during a year period. Other information such as: diving sites location and their respective approximate depths, annual diving trips, etc.

(d) *Sport anglers clubs and associations* – This source can provide partial information about numbers on boats and users that fish for recreation or competition. For this category of potential users it is difficult to find out the concrete figures. These venues work rather as a meeting point than a place where quantitative information can be gathered or is accessible. However, it is possible to have access to whom and how many people enter in a given competition, place of competition, their catches, etc.

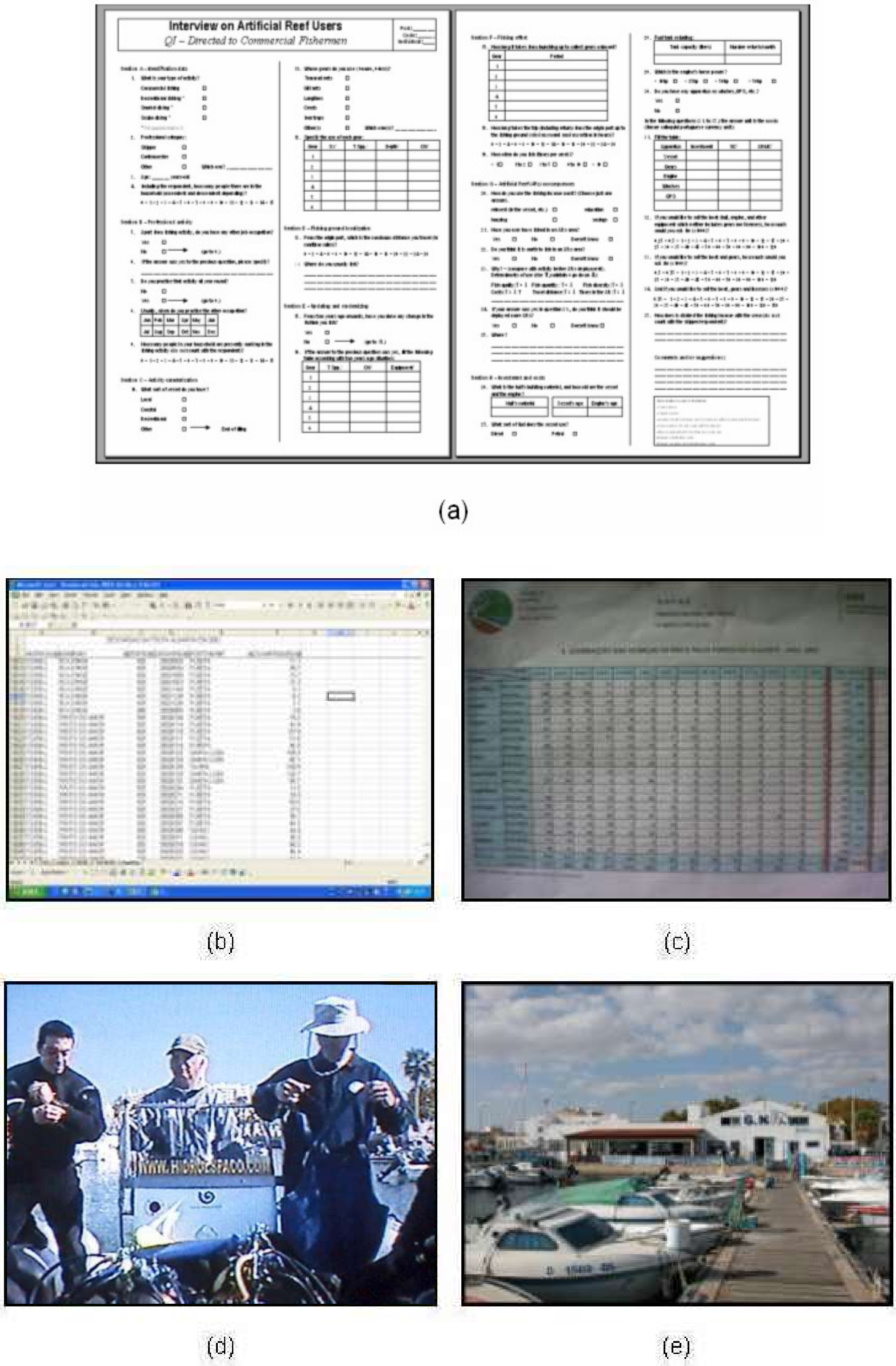


Figure 4.1 – Primary and secondary sources to collect data: (a) Semi-structured questionnaire-based interviews, (b) Commercial sea-fishing boat licence records (electronic), (c) Saltwater fishing licence records (paper or electronic), (d) Diving operators, and (e) Sport anglers clubs and associations.

4.2.3. Data Collection

The subjects for this research were divided into two groups: professional fishermen and recreational users (Figure 4.2), divided in turn into four categories (local/coastal segmented and anglers/divers, respectively) as potential AR users. It was found useful to carry out interviews at several different places and times, according to the activity: (a) fishermen – fishing ports, ramps and beaches throughout the Algarve and mainly in the morning until lunchtime, according to the place; (b) anglers and divers – angling, sailing and diving clubs; the contact hours were mainly after 6 p.m. during weekdays or mornings up to lunchtime at the weekends.

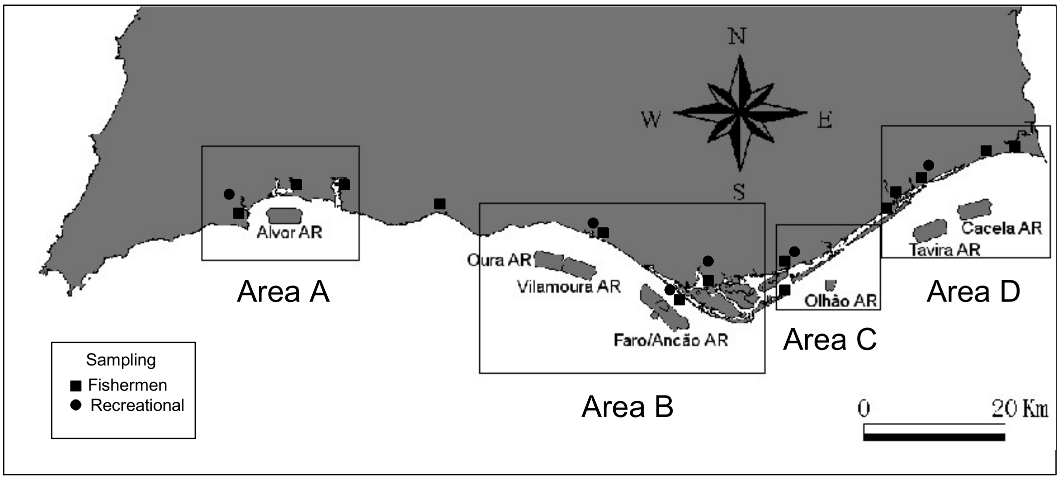


Figure 4.2 – The sites where sampling was carried out. The areas considered were useful as a reference point to carry out the interviews.

A total of 118 interviews were carried out covering both commercial and recreational potential AR users. The interviews were direct and opportunistic and took approximately between 20 to 30 minutes. However, due to limited resources available it was decided to focus more on the commercial fishermen rather than recreational potential users. Interviews were conducted by two interviewers from mid July to 5th September 2002.

<u>Fishermen</u>

The commercial fishermen's population for this survey was defined as all local and coastal vessel skippers who steer a fishing vessel with apparently eligible gear to be used in the ARs (Figure 4.3).

(a)

(b)

Figure 4.3 – Professional fisheries that can use the ARs if operating with eligible gear: (a) Small-scale fishermen ('local'), (b) Commercial fisheries ('coastal').

After ascertaining the total number of eligible vessels in the Algarve region (through records on registered vessels) it was possible to estimate a reliable sample size to take in each port delegation area (interviews). It was decided to use a quota sampling strategy concerning fleet segments, where 76% and 24% of the sampled vessels belonged to local and coastal fleets (70% and 30% according to DGPA 2002a).

After establishing the position of all ports and ramps on the south coast of the Algarve, fourteen were selected according to their dynamics. For sampling purposes it was decided to cover 5 to 10% of the coastal and local vessels for each of the five DGPA regional areas (Table 4.1).

Table 4.1 – Total number of vessels registered by segment and sampled in 2002 for this study in the Algarve. Sources: DGPA (2000, 2002a).

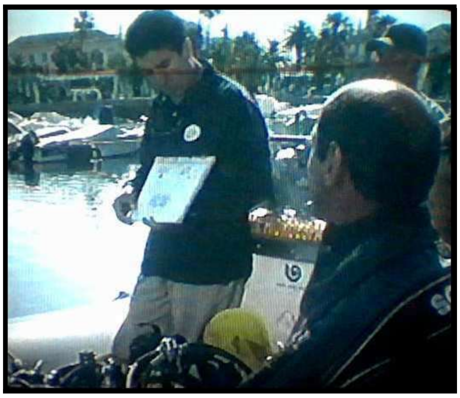
Area and ports or ramps sampled	Fleet segment	Total by segment	Total vessels	Sample by segment	Vessels sampled	Sampled %
VRSA	Local	113	160	12	12	7.5
(Two sites)	Coastal	47		0		
Tavira	Local	52	101	5	9	8.9
(Three sites)	Coastal	49		4		
Olhão	Local	389	498	24	30	6.0
(Five sites)	Coastal	109		6		
Portimão	Local	195	248	17	21	8.5
(Three sites)	Coastal	53		4		
Lagos	Local	80	111	1	6	5.4
(One site)	Coastal	31		5		
Total		1 118	1 118	78	78	7.0

Data collection derived from these sources was used to get an idea of the fishermen profile and related fishing activity. The data and their analysis provides general information about fishing times throughout the day, gear used according to each season, and species preferences (see results).

<u>Recreational</u>

For recreational potential users the first approach chosen was to get information from the regional telephone list and internet about recreational activities related to sea angling and SCUBA diving (Figure 4.4).

(a)



(b)

Figure 4.4 – Recreational users eligible to use the ARs: (a) Sea-anglers (vessel segment 'recreational', (b) Scuba-divers (vessel segment 'recreational').

It was found that there is in the region one association of recreational fishing composed of seventeen regional clubs, where more than 230 associated anglers that take part in competitions can be found (ARPDA 2004). There are also clubs that do not belong to the association, and even sea anglers that are not affiliated to any of these entities.

Concerning diving, there were thirteen affiliated entities operating in the Algarve according to the Portuguese Association of Sub-aquatic Activities (FPAS 2001). Amongst them there were at least four operators active all year round. The remaining ones are freelancers operating for tourist purposes during the summer and local clubs promoting diverse diving activities.

Since it was difficult to establish an exact overall population of recreational users to study, it was decided to survey people in the sailing, naval and angling clubs of Olhão and Faro as well as nearby diving operators. The reason for this decision was due the fact that in such clubs there is a higher chance of finding anglers who simultaneously use recreational boats to go fishing. These are the targets for this study, due to their higher eligibility as potential AR users. These sites were chosen because they are the nearest places where ARs were deployed for the first time; and for that reason it seems reasonable to think that it is where people's knowledge about the structures might be higher than elsewhere (Table 4.2).

Table 4.2 – Number of people sampled that have regular habits of practising angling or diving activities[12].

Activity	No. Individuals	%
Sea Angling	18	45
Diving (SCUBA, snorkel or both)	22	55
Total	40	100

4.2.4. Results by Activity

Characterising AR eligible fishing: quantitative and qualitative

It was established that there are some characteristics specific to commercial fishing. Usually smaller vessels have around two people on board, whereas the coastal ones are crewed by around five people (Table 4.3). The maximum distance to fish is usually dependent on the trade-off between the average daily costs (fuel cost for local vessels and fuel and personnel costs for coastal vessels) and a reasonable amount of fish caught to sell. Time of trips is variable as well.

[12] Note: There were some people (4) that considered practicing all the activities. Due to the fact that they were found in diving related environments, they were considered as divers.

Table 4.3 – Characterization of vessels eligible to use the ARs.

Variable (by vessel)	Fishing vessels			
	Local		Coastal	
	Mean	C.I. 95%	Mean	C.I. 95%
Crew (number of people)	1.8	1.58 – 2.02	4.8	3.80 – 5.89
Maximum distance to fish (nautical miles)	9.6	8.00 – 11.28	14.9	11.32 – 18.47
Average trip time including return (hours)	2.3	1.93 – 2.65	3.5	2.23 – 4.72

Species preference is probably dependent on the area where fishermen are located (sand, mud, and/or rocky bottoms). However, overlooking these potential local differences, in the interviews skippers stated their preferences concerning desired species to catch. These are shown in Table 4.4. The reasons for such preference seem to be related to two factors: (a) species market price and (b) species abundance.

Table 4.4 – Percentage of preferred species referred to by respondents. Prices are according to Olhão retail fish market in August 2002.

Preference	Group or species	Common name	Percentage	Price (€/Kg)
1	Soleidae	Flatfish	73%	Up to 20,00
2	*Sepia officinalis*	Cuttlefish	71%	6,00
3	Sparidae	Breams	54%	Up to 12,00
4	*Octopus vulgaris*	Octopus	37%	7,00
5	*Mullus surmuletus*	Red mullet	20%	20,00

According to the interviews, gear use may vary with season and haul size characteristics. We were told that for example, in Monte Gordo, there is a predominance of using nets since the main target is flatfish, whereas Santa Luzia is well known as a port where most fishermen use pots and traps to target specifically octopus. The number of gear in use varies from fishermen to fishermen and the licences they keep whatever the segment (Table 4.5).

Table 4.5 – Gear in use by professional fishermen.

Number of gear	Frequency	%
1	24	31
2	38	48
3	13	17
4	3	4
Total	78	100

One approach that can help to understand who uses the ARs is related to the presence of technologies on board, since they represent investment in the fisheries showing that fishing is a worthwhile activity. At the present time, all the coastal fleet and many of the local vessels are already equipped with radar, GPS or echo sounders. This fact means that equipped vessels are potentially better prepared to take advantage of the AR use. As shown in Table 4.6, almost half of the people who were interviewed have a reef area nearby his shelter port/ramp/beach, and of these around 83% has technology onboard. Despite this, just 41% have ever fished in AR areas, and only 2% of all those interviewed (i.e. 5% of the ones that fished there) did not have any type of navigation or detection technology onboard.

Table 4.6 – Dichotomous variables: ARs near vessels' shelter site, fishing practice in AR area and navigation/fish detection technology onboard. The plus and minus signs represent the presence or absence of the variable in analysis, respectively.

Variable combination			%
Area with AR	Fishing on AR	Technology onboard	
+	+	+	25
-	+	+	14
-	-	+	31
+	-	+	15
+	-	-	8
-	+	-	2
+	+	-	0
-	-	-	5
Total			100

In brief Table 4.7 summarises qualitative and quantitative results from the interviews. These briefly describe the type of potentially eligible AR users. The following characteristics are applied to every single fishing location (which may or not include ARs).

Table 4.7 – Brief characterization of fishermen potential users of ARs

Questions	Type of potential user	
	Local skippers (n=59)	Coastal skippers (n=19)
Who	Male, usually from 44 to 51 years old. They use less than 9 meter-long non-bridged vessels powered by an outboard petrol engine. The vessel number plate is identified by a 'L', followed by a one-to-four digit number and one or two letters for the registration port code. Usually with a comrade onboard (sometimes alone, rarely three). Some have parallel activities such as shellfish gathering or tourism.	Male, usually from 42 to 51 years old. They steer longer bridged vessels powered by onboard diesel engine with much higher capacity and autonomy. The vessel number plate is identified by a 'C', followed by a one-to-four digit number and one or two letters for the registration port code. Usually with more than three comrades onboard (can reach a dozen or even more for longer purse seines). Usually are fulltime fishermen.
Where	Skippers usually take advantage of the entire area they are allowed to fish. Some said that sometimes they incur in the risk of fishing beyond their eligible areas (less than 3 nmi off-shore). Usually do not fish more than 8 to 11 miles from the shelter port.	Preferred areas seem to vary widely and be according to their own experience. However, if more sought-after fish have been caught in a certain area, more fishermen go there as a result. Usually to fish do not overtake 11 to 18 miles from the shelter port.
When	On a daily basis, but constrained by weather conditions. In a year rarely attain 150 fishing days.	Most go fishing six times in a week. In a year they usually have around 180 to over 200 fishing days.

Why	They catch commercial fish species, preferably high priced to sell in the local market (just a certain amount to keep their licences). They also sell to restaurant dealers or keep the artisanal fishing tradition by selling directly to the public in the beach.	They catch commercial fish species to sell in the main official markets. Some may be marketed in parallel with restaurant dealers.

<u>Characterizing AR eligible recreational activities: qualitative</u>

The results collected from the forty interviews show that in general anglers are older than divers, probably because diving requires good physical health and annual examinations (Table 4.8). Angling is almost exclusively practised by men, although some clubs have affiliated some women as well (ARPDA 2004). Local people practise both activities during the weekends throughout the year with an increase in numbers during the summer. During this season, many other people come to the region, which greatly increases the practice of both activities. Some anglers said that they are dependent on fishing for their livelihood as well. People in these conditions are usually (but not always) retired fishermen who have low pensions. Where divers are concerned, most practise the activity just for fun. However, there are the ones that earn money from the activity both by non-extracting activities (tourist diver operators), and extracting activities (both SCUBA and snorkel divers who sell fish and shellfish to the catering industry).

Table 4.8 – Brief characterization of recreational potential users of the ARs

Questions	Type of potential user	
	Anglers (n=18)	Divers (n=22)
Who	Male, usually older than divers (most over 50).	Both sexes, usually younger than anglers (most under 40).

	Sea-anglers may hire a charter boat to go fishing for a day. Charter boat operators may offer services where sea-angling in shallower waters is included. The boat owner has a qualification just to steer the boat. No qualification is required for practising the activity. Most retired people practice it alone, when angling becomes a commercial activity. Interviewees said that participants are mainly nationals. Retired fishermen depend upon angling on a regular basis (commercial purposes).	Some SCUBA divers practice it alone, when it becomes a commercial activity. Diver operators usually have their own boat(s) to carry their customers. Divers usually take upgrading qualifications by developing skills as night diver, sea currents diver, rescue diver, underwater video and photography, and marine flora and fauna identification. These are usually provided by diver operators. Interviewees said that many sportspersons are foreigners (mainly British, Spanish, German, or Dutch).
Where	Many anglers fish from the shore most of the time, and for that reason are non-eligible as AR potential users. Others that fish from on board do not know about ARs or do not know their whereabouts. Probably just few have ever fished in an AR.	Divers usually prefer natural reefs or sunken structures such as old vessels instead of manmade modules. Due to the Algarve ARs depth range, snorkel divers are excluded as potential users.
When	Around twice a week. More in the weekend for non-retired people. More people in the summer time.	Around twice a week. More at the weekend, and slightly more in summer due to better weather conditions.

Why (rank preference values)	Catch fish for self consumption, just for pleasure, competition, and to earn money (extractive).	Just for pleasure, to catch fish for self consumption, earn money (non-extractive), earn money (extractive), and photography/video or scientific purposes.

4.2.5. Combined Quantitative Results

Who uses the ARs?

The first question concerning the impact of ARs' deployment was to find out who is actually using the concrete made ARs. Therefore people were asked if they already used any of the ARs in the Algarve coast.

Coastal fishermen who said 'yes' usually had no doubts about their attempts. However, most said that they used the structures just to try them out, but that they do not use the ARs regularly. Most said that they go there from time to time, but never on a regular basis. Some interviewees who answered negatively said that they never used any AR in the Algarve, or at least did not realise they were using them.

All dive operators and regular divers contacted already had experience of diving on the AR concrete blocks. Diving operators do not seem very confident about taking their clientele to the ARs areas, because the ARs are not so attractive to the 'dive spirit' and because some are in depths that have other diving requirements (experience or time limitations). Other divers whether collaborators with diving operators or other, responded that they had experience of diving on ARs just in foreign countries or on other type of ARs (such as sunken vessels).

Of all the 118 people interviewed, 51 (43%) said that they were aware of using ARs at least once, whereas 67 (57%) said that they had never used or did not know or realise if they already had (Figure 4.5).

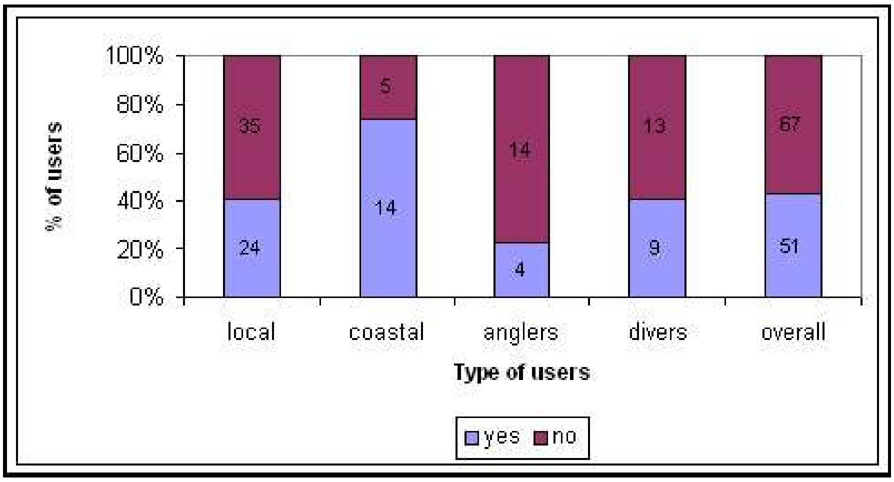


Figure 4.5 – Results from the interviews: Number of people who used or not the ARs at least once.

To explore further the previous question and determine who actually was interested in the AR issue, people were asked if they were in favour of the deployment of more ARs in the Algarve coast. Their answers suggest peoples' degree of satisfaction/happiness with the structures. However, the interviews were carried out when most AR systems were already in place, and respondents at this stage were probably not well aware of extent of the program. However, when confronted with the question if they were in favour of further deployment of ARs, most seemed to have a positive attitude towards the man-made blocks. Most were in favour of modules, however some supported the idea that, in addition, other structures should be deployed. Many local fishermen stressed that instead of blocks, old scrap-yard vessels and quarry rock should be deployed, since the purposes and results must be similar but with the added advantage of lowering the overall construction and deployment costs. There were also those who supported the idea that there are other structures that should be got rid off, such as tyres and car bodies.

Figure 4.6 shows that, of the 118 people interviewed, 78 said they were happy with the blocks deployment (66%), whereas 28 said that probably use other materials could be a better idea (24%), and 12 said that they had no opinion or were against the idea (10%).

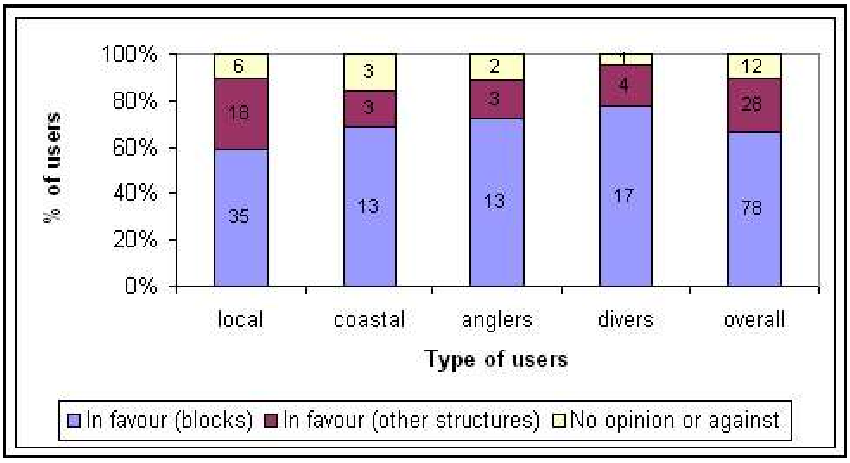


Figure 4.6 – Results from the interviews: Degree of satisfaction with the ARs.

Where does that use occur?

The second major question to be answered is to know 'where' people practise their activity. Here there are at least two directions that can be followed: (a) the depth range (latitudinal) and (b) the distance from the origin port or area covered to carry out the activity (longitudinal). For the first, the results are presented in Figure 4.7, where it seems that coastal activities are the ones that have more depth flexibility.

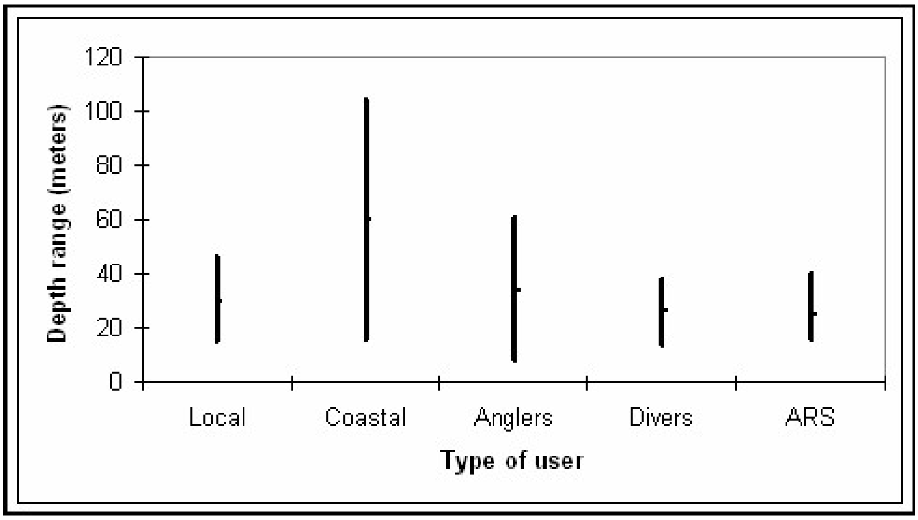


Figure 4.7 – Depth range where the potential users operate and where ARS are placed.

Nonetheless, all the activities are in the range of the ARs deployment depth. Taking into consideration the distance from the coast, it seems that most of the potential users tend not to move far away from the origin port. Commercial fishermen are limited by vessel characteristics and licences to operate. Coastal vessels are the ones that have more distance flexibility to operate (Figure 4.8).

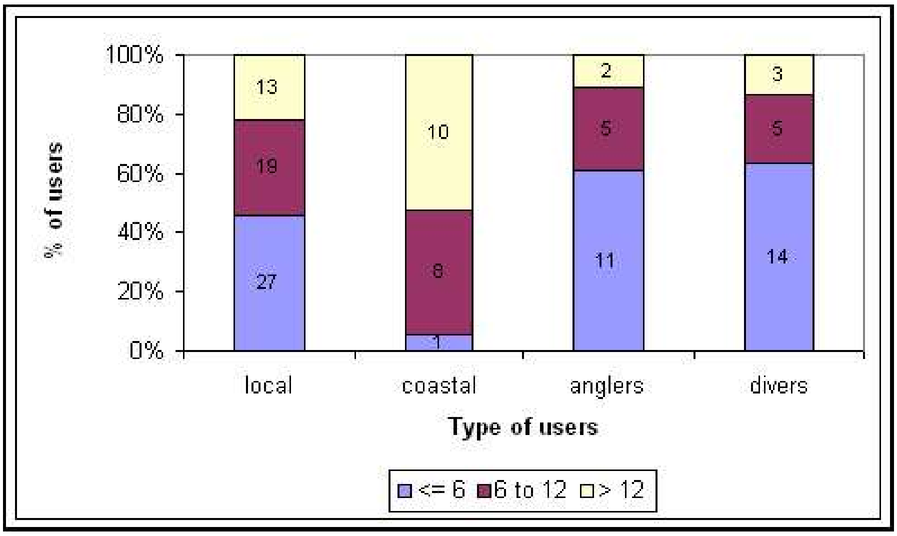


Figure 4.8 – Maximum longitudinal distance (in nautical miles) where the potential users usually operate.

When does that use occur?

The question of 'when' people practise their activity can be explored in several ways, such as: (a) day/night, (b) days of the week (and extrapolate annual frequency), and (c) type of gear/activity according to seasons (see section 4.3). Here just one of them is given, because it was the one that resulted in better data collection. A note can be added to the seasons' direction where most of users said they practise their activities all year round, only being constrained by the weather/sea conditions. However, there might be a seasonal effect for the recreational activities, since especially in the summer season (but also during other holiday periods) there is an increased demand for sea activities. Figure 4.9 shows clearly a division between recreational and professional activities. It shows that professional users have a higher effort and tend to work the whole week. Some local users said they work two days per week in fishing; this response is an indicator of part-time activity. Recreational users have an effort of one or two days, the exception being for professional divers who dive around three days/week.

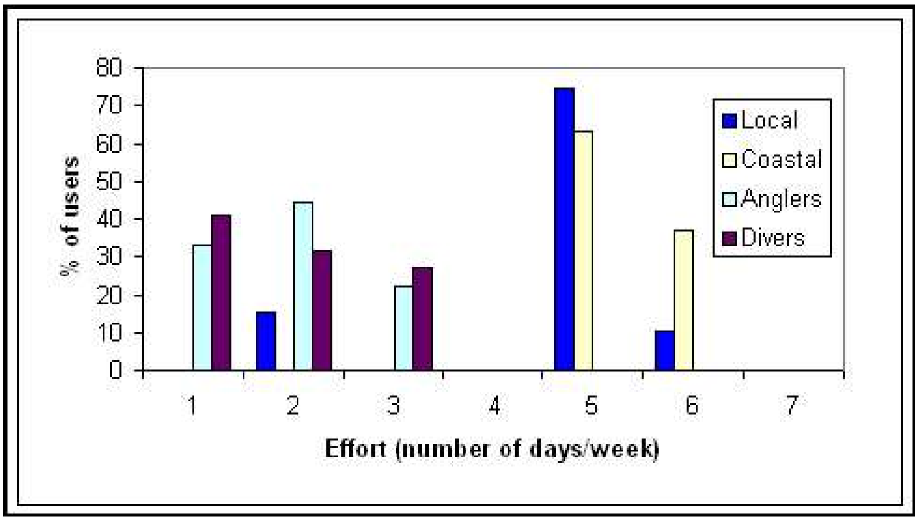


Figure 4.9 – Number of days per week the potential users exert their activity whether in the ARs area or not. Effort is sub-estimated because is just measured in fishing days per week.

Why does that use occur?

Although many people interviewed responded that they had never used an AR before, it was important to ascertain which incentives may make them use the blocks in the Algarve, or in other words, why use the ARs. To help them in such a decision they were given a list composed of five different incentives (or factors), where they were asked just to say if there was any change (increase, decrease or no change) in them after reef deployment (Figure 4.10). This question was completely based on the expectations of those who claimed to have never used the ARs and was supported by previous experiences of those who already used them. All user types said that the largest incentive to become an AR user in contrast to similar sites (sandy bottoms) is related to the higher amount of fish that can be expected to be found there (almost all divers were unanimous about this point). The second incentive to use an AR seems to be related to the expected probability of finding a wider diversity of fish after reef deployment. Concerning the quality of fish (larger size and better aspect), around half of the respondents said that fish from ARs may have slightly higher quality. Concerning distance and costs to use ARs, it seems that ARs are not an important contribution to solve the incentive problem, since there are other non-reef or natural reef alternatives that potential users may choose instead.

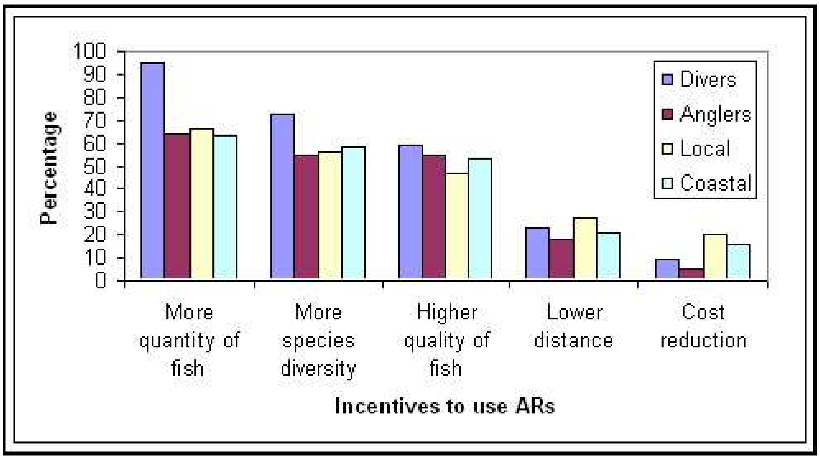


Figure 4.10 – Results from the interviews: Type of incentive to use or not the ARs.

<u>Hypothesis testing using chi-square tests</u>

To test whether there is a difference in the variables and the potential/actual users, a value of chi-square was calculated and tested to see if it was statistically significant. The hypotheses tested if the distributions were the same (H_0) or not the same (H_1), when comparing frequencies on: (1) the number of interviewees that have or have not experienced the ARs, (2) the opinion they had about the deployed structures, (3) the maximum distance they usually consider in practising their activity, and (4) the days they spent at sea.

We would reject the null hypothesis of no relationship between the variable in analysis and stakeholders type. So, it was verified that 'days at sea' and 'distance' show a high level of significance with a probability of equal or less than 0.0001, whereas for 'experienced ARs' the level of significance was equal or less than 0.025. In each of these we reject the null hypothesis. So, we can say that the different types of stakeholders: (1) have different experiences concerning AR use, (2) travel different distances from their origin ports, and (3) spend unequal days at sea. The P-value for any of these variables is very small, indicating that the pattern of having homogeneous distributions among the different user groups is very unlikely to occur.

For the case of 'AR opinion' the test shows that the distribution is not significant. This means that the null hypothesis is not rejected, and we can say that the different stakeholders interviewed have a similar opinion in terms of their support towards the ARs. An observed chi-square value of 4.54 or higher would occur about 60% of the time (Table 4.9).

Table 4.9 – Chi-square statistics.

Variable	d.f.	X^2	P-value
Experienced ARs	3	10.62	≤0.025
AR opinion	6	4.54	0.603
Distance	6	27.24	≤0.001
Days at sea	3	86.59	≤0.001

4.2.6. Discussion

The interview analysis tries to make distinctions and find out what people know, what they do, and what they think or feel. The results of this are dealing with facts, with behaviour, and with beliefs or attitudes.

Concerning the potential use of reefs by fishermen, it was perceived that skippers steering eligible vessels equipped with any sort of navigation/detection technology on board have the operational facilities to fish on reef areas. In this respect it seems that coastal skippers are better informed than local ones, and their better equipage is also an advantage for potential use of ARs.

Results related to recreational activities showed that diving operators and their closest collaborators admitted to have already experienced the concrete blocks; however, other divers usually did not have that experience. The reasons for that could be: (a) reefs' depth is not accessible to every scuba diver, since most are placed deeper, and (b) reef blocks lack of diving interest, and for that reason diving operators do not take their clientele there as often as to other sites. By contrast, anglers claimed to be rather uninformed about the deployment of the reefs.

This study shows that coastal skippers are the ones highly aware of the structures, where more than half of them have had some AR experience. All the other stakeholders have less knowledge of the structures, with less than half of all the interviewed people having experienced the structures. The quality of the reefs is not questioned, however their deployment costs are. It is found that most of the interviewees were happy with the structures as they are, even considering their higher manufacturing costs (when compared with materials of opportunity). Fewer people have stated a preference in favour of using derelict structures instead. The benefits from reefs are perceived to be mainly related to the higher quantity of fish available; AR influence on activity cost reduction only seems to be relevant to a small percentage of potential users. Reefs were demanded some time ago, since a number of people said that they should be deployed before.

These *prima facie* results show that the involvement of different types of stakeholder with the ARs is already considerable. However, it is difficult to quantify precisely the actual number of users without *in situ* observational studies. From the results presented previously it has been shown that it is possible to address reef related main questions (who are the stakeholders, where they usually operate, when that use occur and why are the incentives to do so), but it is difficult to separate effectively their use from non-use. This fact shows that, while it is relatively easy to find ‘potential’ users, it is difficult to collect data resultant from ‘actual’ AR users.

4.3. Actual Users in the Olhão AR

The section 4.2 covered the entire Algarve region where reefs were deployed, whereas the present section is an observational study focusing on just one small AR system. It is intended to shed some light on and contribute additional information to the previous study. If previously there was no clear line between 'potential' from 'actual' AR user, here the line is disclosed.

4.3.1. Settings

AR location

The Olhão artificial reef system (OARS) was the first reef to be completed in the Algarve reef program. It dates back to 1989 when first studies were commissioned, and it was completely deployed in 1990. As a pilot reef many questions were posed *a priori* concerning the amount of concrete made modules, their type, and which shape the entire system should follow for both groups. In the end the AR system acquired an arrow-shaped form constituted by two different groups. A first group, where the small cubic module sets take the tip and are positioned closer to shore (16 to 25 meters depth); and a second group, where the larger module sets are positioned at a greater depth range (26 to 41 meters depth). Its geographic positioning is off-shore the Armona sandy barrier island occupying approximately its middle area (60 ha), and having a parallel orientation to the shore, i.e. northwest-southeast direction (Figure 4.11).

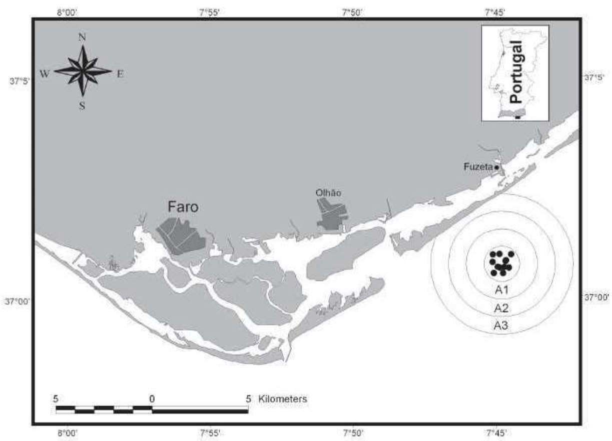


Figure 4.11 – Location of the OARS (black spots). Reef geographic point is 37º 00' 35.082' N and 007º 44' 38.641' W and was obtained by ArcView GIS 3.2a.

Curiosity about the structures

In 1989 at Olhão an AR building area could be seen next to the fishing port (eastwards). Initially local residents probably did not know the immediate purpose of barges carrying such structures daily to the area. Despite the absence of recorded data, it is supposed that such AR structures were obviously noticed by former users of that area, whatever their purpose (commercial fishing, angling, etc.). At that time the GPS was a novel technology, but once it was more widespread, fishermen (and probably other users) were adding new information about grounds to their empirical knowledge and experience. The OARS modules were probably for the first time detected and recorded.

Cross-checking observational and documents data

Olhão, Culatra and Fuzeta are the nearest fishing communities, where their fleets are mainly locally segmented. Observations in the Fuzeta fishing and recreational corridor-port show that resting gear found nearby are mainly traps, pots and nets. However, their proportions may vary (i.e. more traps comparatively to pots and nets). Observations in the early mornings show that some fishermen when they arrive in the port do not always land their fish in the official fish market, but take them to the local restaurants. It is also possible to buy fish directly from fishermen, as in the former days. Despite being illegal, it is still a common practice nowadays.

In an analysis of landings of electronic files, it can be seen that many vessels have irregular records on selling events in the local official fish market. By cross-checking the information obtained by identified vessels operating in the OARS, there is no evident match with the selling days for most of the times (see section 6.2.). This means that it is difficult to analyse catches related to the OARS.

Socio-economic setting

With regard to recreational activities, the division is not completely clear. Brandão (1923) referred to Fuzeta as the homeland of many '*bacalhoeiros*' (cod-men), who fished in the North Atlantic waters. That fishing activity remained until the 1980s. However, with the adhesion of Portugal in 1986 to the EEC, a new common policy on fisheries was gradually adopted, and long distance fishing opportunities were reduced drastically. Due to the fact that many fishermen never declared their taxes to the social security, they consequently received low pensions during retirement. One account of low income, many fishermen use their recreational registered vessel to go fishing. Since surveillance is not tight, many fishermen use the pretext of recreational fishing to practise a parallel economic activity to add some revenue to their low pensions, and in this way to obtain a better standard of living without paying any sort of tax. Beneficiaries are those retired fishermen and restaurants. Losers are fishermen who sell in the official fish market and the government. Fishermen in such a situation are losers since they get lower revenue due to tax deductions and are also subject to oligopoly buying prices. However, there are also several other people that have their own job and benefit from the same flaw in the system, to take economic benefits from what was supposed to be recreational activity.

In 2003 in the Fuzeta area leaflets could be found from tourist operators offering services to fish and dive to the OARS and other grounds. Despite some potential for recreational marine activities, there are no diving operators based in the town of Fuzeta.

4.3.2. Methodology

Instruments

To make the data collection more systematic, for monitoring and description purposes the following instruments to collect data were designed and used:

- *Direct Site Observations (DSOs)* – Through non-participant direct site observation by collecting data from inside a research vessel (Figure 4.12a) via filling in a specific form (Figure 4.12b). The form entries consisted of information derived both from vessels operating near a given AR area and gear already deployed prior to the observation period. GPS, radar and binoculars are essential devices to gather accurate observational information.

- *Secondary Sources* – These additional instruments of secondary data were based mainly on Electronic Archival Analysis (electronic files on landings – DGPA 2002b). This sort of instrument can be useful to cross-check or to support information collected from DSOs sources.

(a)

Direct Site Observations

Observation n.º ____ Site location: ________ Day: ___ Date: ___/___/___ Hour: ____ and ___.

ARs Fishing Effort Monitoring RV _______ Observer: ________.

#	Vessel's name	Number plate	User	Gears	Catches (Species)	Amount	During time	Crew
1								
2								
3								
4								
5								

#	Submerged gear type	Buoys number	Approximate extension	Relative positioning to ARs	Notes:
1					
2					
3					
4					
5					

(b)

Figure 4.12 – Direct site observations: (a) Inside the research vessel; and (b) The DSO form to be filled in.

Desired reliability of the data

Data collected from DSOs are relatively accurate. 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. Data on demographic, social or economic issues cannot be obtained via direct observation.

Resources available and research skill of the evaluator

Since 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 was necessary to take advantage of research vessels. However, there is the disadvantage of being constrained by its operational period, which is usually just during the daytime. 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. Taking this into account it was decided to take advantage of the CRIPSul research vessels' routine activities to work as a basis for on board direct site observations. Due to the fact that it was necessary to identify deployed gear, which generally needs a highly skilled person in fisheries issues, RV skippers were chosen to perform the task.

Physical characteristics of the sites

A smaller AR might be easier to monitor than a large one. A larger AR can be monitored via aerial photography, but can become very expensive if it is intended to carry this out for a long period of time (Milon 1991). The choice for the socio-economic monitoring should be the reef system which is more or less systematically visited. This point is important to consider because observational limitations will influence the specific use of other instruments as well.

4.3.3. Data Collection

Sampling

Due to limitation of available resources, data collection from observation focussed solely on one AR. Sampling days for observations were chosen randomly, derived from routine activities of the research vessels in the OARS. Fishing vessels operating solely at night (e.g. purse seines) were underestimated since all observations were done during the daylight period. However, it is difficult to monitor vessels and gear during the night because of the lack of light. This lack of representative samples for the entire diurnal period may influence and limit the validity of results obtained and consequent analysis. Notwithstanding that fact a monitoring analysis was pursued.

Sampling was done by a trained observer through systematic DSOs with the use of binoculars (8x40 magnification) from the research vessels (RVs) *Donax* and *Puntazzo*, in the OARS and surrounding areas, up to a distance of 1.5 nautical miles (nmi) from its geographic centre (the observational areas are represented in Figure 4.11 by the concentric circles). A pre-test period was taken from September until December 2002. Afterwards it was decided to carry out a sampling period involving the operational vessels and gear anchored in advance for a two-year period, i.e., from January 2003 to December 2004.

Sampling in 2003 covered almost the whole year (missing September and December), whereas for 2004 samples were not collected for five of the months (Table 4.10). The month of December in either year had no samples collected because usually the sea is rough due to weather conditions and the vessels go to the shipyard for repairing and painting.

Table 4.10 – Sampling strategy for 2003 and 2004 according to each month.

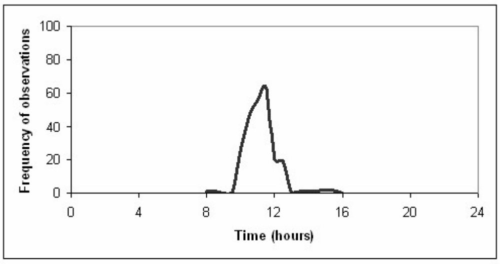
2003			2004		
Month	# samples	Average time (min)	Month	# samples	Average time (min)
January	9	83’	January	0	-
February	13	109’	February	0	-
March	5	78’	March	0	-
April	12	68’	April	2	60’
May	9	93’	May	11	102’
June	11	106’	June	10	96’
July	7	103’	July	4	105’
August	4	105’	August	1	120’
September	0	-	September	4	90’
October	3	120’	October	0	-
November	6	66’	November	2	105’
December	0	-	December	0	-
Total	79	-	Total	34	-
Average	-	92’	Average	-	99’

Observational period

Observational periods were divided by periods of 30 minutes. After counting all of these periods, it can be seen that most of the observations took place between 10 a.m. and 12 p.m., despite the fact that the period samples occurred always during the daytime between 8:00 a.m. and 4:00 p.m., as shown in the Figure 4.13. Sampling took a minimum of half hour to a maximum of around three hours.

Due to technical reasons a lower number of samples were collected for the year 2004 than for 2003. On average samples in 2004 were taken earlier in the day.

2003 2004



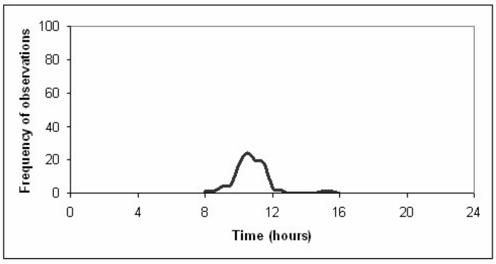


Figure 4.13 – Comparative observational periods sampled for years 2003 and 2004.

Standardised variables according to time

The number of observations and their time may vary somewhat, and this variation may increase bias in the results' interpretation. To reduce that bias, observational variables were standardised according to time. For year t, standardised number of occurrences observed in a given month (SO_i), was given by the following equation:

$$SO_i = \frac{O_i}{s_i} \times \frac{\overline{T}}{\overline{T_i}}$$ Equation 4.1

Where:

O_i – is the number of occurrences observed in a given month (i) in year (t);

s_i – is the sample size for a given month (i) in year (t);

$\overline{T}$ – is the average observational time in year (t);

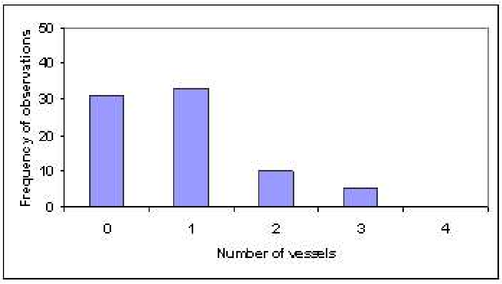
$\overline{T_i}$ – is the average observational time in a given month (i) in year (t).

4.3.4. Results

General vessel patterns

Observations collected show a pattern with regard to the presence of vessels in the surroundings of the OARS (half nautical mile) during the observational periods (Figure 4.14). In 2003 it was observed that for most times at least one vessel was operating, whereas for 2004 most of the observations had no vessels.

2003 2004



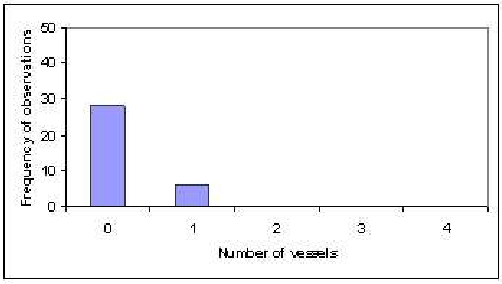
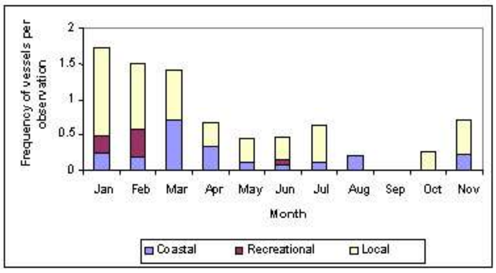


Figure 4.14 – Vessels observed during sampling for years 2003 and 2004.

Monthly pattern: average number of vessels by segment

It was observed that the commercial fishermen's vessels are the main users, the local fleet being the one that takes more advantage of the structures (Figure 4.15). Considering a standardised observational period, for 2003 it is in January where more vessels can be seen operating, whereas for 2004 it is not possible to find a reliable pattern due to the low number of observations. The number of vessels occurrence was 68 for 2003, and solely 6 for 2004.

2003 2004



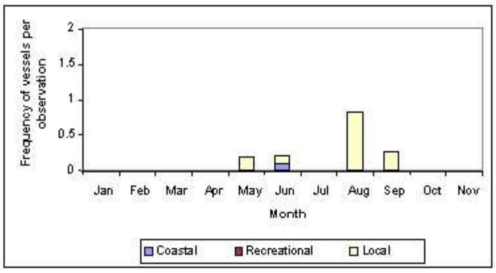


Figure 4.15 – Occurrence of vessels by comparing observational periods in years 2003 and 2004.

Monthly pattern: average number of vessels by registration port

It was also observed that the majority of the vessels for both time periods came from nearby ports (i.e. less than 10 nmi), or at least they were registered in nearby port authorities[13] (Figure 4.16).

2003 2004

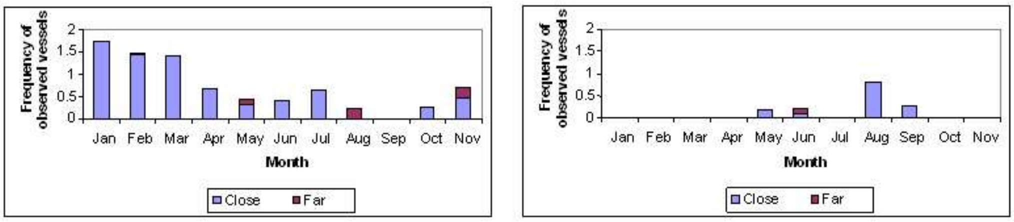


Figure 4.16 – Provenance distances of observed vessels for years 2003 and 2004.

General crew patterns

Concerning the patterns of on board crew (Figure 4.17), observations show that most users belong to vessels crewed with only one person on board. However some records exist of vessel trips with five people onboard, which can be a sign of larger vessels effort.

2003 2004

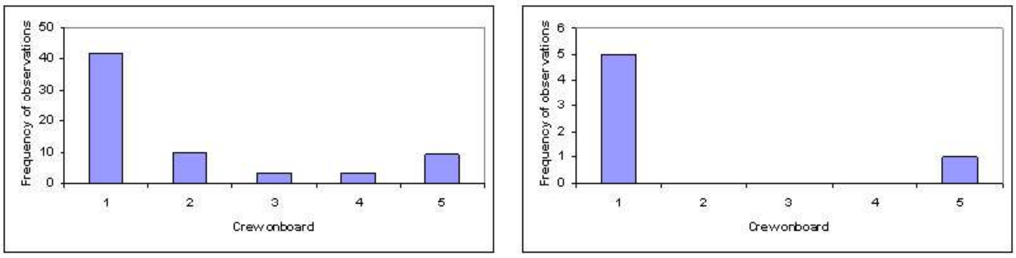


Figure 4.17 – Number of crew onboard observed vessels for years 2003 and 2004.

Monthly pattern: average crew number

[13] In Portugal is not compulsory to register a vessel in the same fishing area.

Throughout the year there are variations in the pattern of on board crew (Figure 4.18). For the year 2003 it seems that at least 128 people took advantage of using the AR (people can be the same since vessels are seen more than once). March was the month where more people per observation were seen, and since there were less than 1.5 vessels per observation, it can be concluded that most of the effort came from the coastal fleet. For the year 2004 only 10 people were seen in operating vessels. The number of vessels per observation was too low, which means few people were observed by sample.

2003 2004

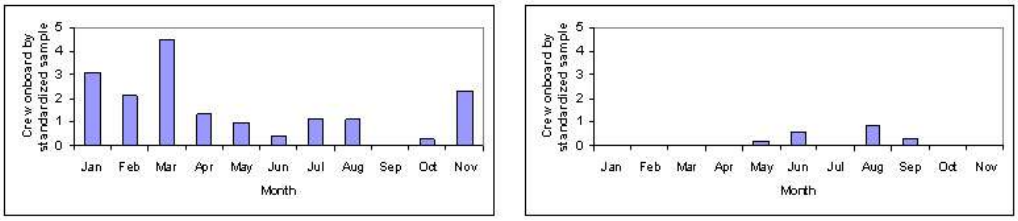


Figure 4.18 – Crew observed onboard for comparative observational periods for years 2003 and 2004.

Up to five people crewed vessels, but in the majority of observations the vessels had only one person onboard, which usually corresponded to the local or recreational segmented vessels. Recreational vessels had a crew of one person, and despite being the second most common segment in terms of vessel numbers they were the least frequent in terms of observations. The recreational vessels observed were exclusively engaged in fishing, i.e., there was no diving or other recreational activity observed during the sampling period. Local fleet vessels were the ones with highest frequency of appearance in the OARS area, contributing approximately half of the total observations. Coastal fleet vessels accounted for fewer observations, however, they more than doubled recreational vessels in terms of frequency of occurrence and given their larger crew numbers contributed significantly to overall OARS users.

As a whole, at least 75 different people were seen on board using the OARS during the sample period. However, it can be estimated that between 1.5 and 2 people are observed in a standardised period of time (92’ for 2003 and 99’ for 2004) for one third of the day, all of them are related to fishing. Assuming a constant effort along the day, it can be said that daily the reef area up to 0.5nmi is used by around 4.5 to 6 people that take the advantage of the reef as a source of income.

General gear patterns

The average number of gear also diminished over the years of 2003 and 2004 (Figure 4.19). In 2003 a total of 425 gear deployed was observed during the sampling period, which means 5.4 gear per standardized period of time. In 2004 a total of 138 gear deployed was observed, and only 4.0 gear for the same comparable period of time. This shows a negative trend for gear.

2003 2004

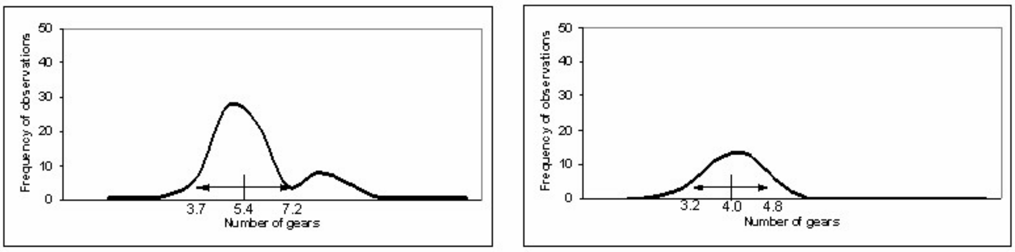


Figure 4.19 – The number of gear distribution for comparative observational periods for years 2003 and 2004.

Monthly pattern: average gear number

When taking into account the months, it was verified that April is the month when a greater number of gear is found (higher effort) for both years being compared, where around eight gear per observation was seen on average (Figure 4.20). No other pattern can be visualized with the data.

2003 2004

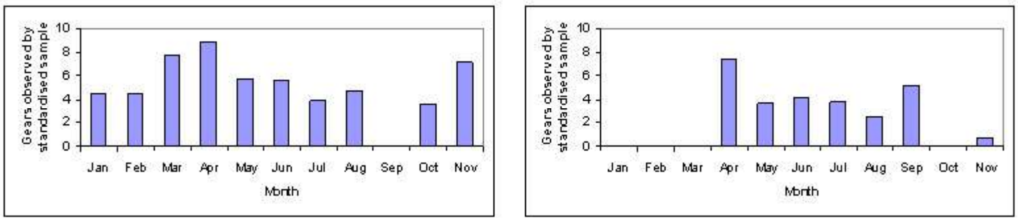


Figure 4.20 – Monthly average number of gear observed for years 2003 and 2004.

Monthly pattern: average gear distance from the OARS

It seems that despite the existence of gear deployed over the reef, the distances of 0.5 and 1 nmi are the ones preferred by fishermen to deploy their fishing gear (Figure 4.21). Throughout the year the pattern does not vary greatly and it is constant for both compared years.

2003 2004

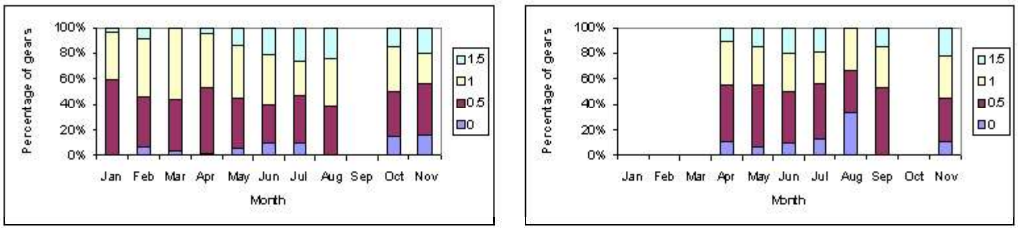


Figure 4.21 – Comparative distances between signalled gear and OARS for years 2003 and 2004. In the legend distances are measured in nautical miles.

By contrast, the type of gear used changes over the year (Figure 4.22). For 2003 there is an increase in pots from January till June, and a decrease afterwards. It seems that when pots are not in use, they can be compensated for by the use of traps. Nets seem to be independent of this, and have two peaks of use for the months of April and July, probably due to the post spawning season for target species. The year 2004 has a similar trend if we discount the month of August which is certainly biased due the fact that just one sample was collected for that month.

2003 2004

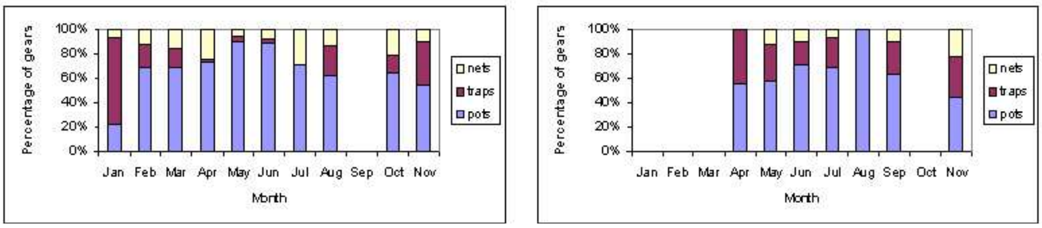


Figure 4.22 – Comparative proportion of the number of gear in the OARS for years 2003 and 2004.

Information from reported landings (electronic documents)

Vessels observed in the OARS show a pattern of their landing ports preference (Figure 4.23). The total number of landings reported was 6,135 and 5,762 for years 2003 and 2004, respectively. The most chosen landing port is Olhão with almost three quarters of the landings, followed by Quarteira. However, for the comparative period of 2003 and 2004 there seems to be a slight change in the pattern where there is a shift characterized by a decrease in landings at Olhão and an increase at Quarteira.

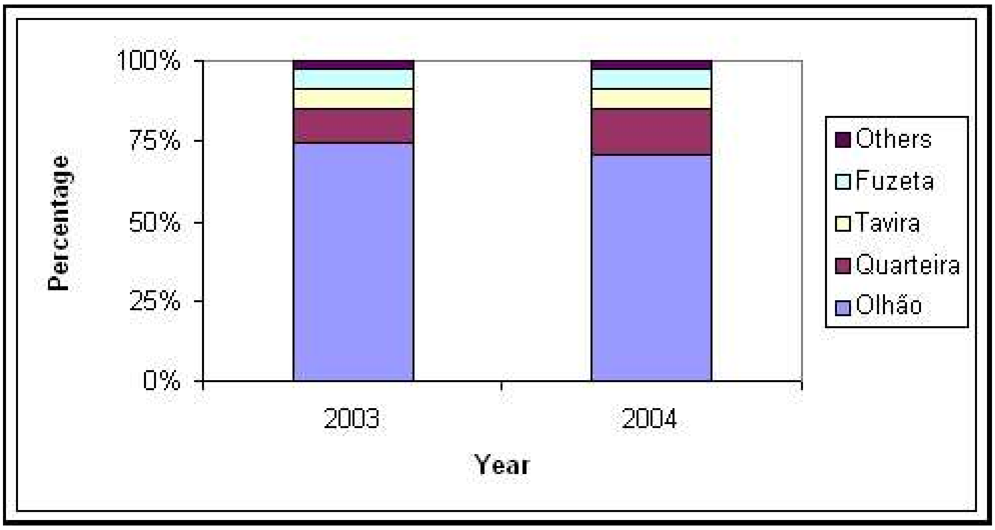


Figure 4.23 – Percentage of landings from vessels seen in the OARS in the official market ports.

When considering the species that those vessels landed, there is also a clear pattern (Figure 4.24). Octopus is the most caught species in both years, followed closely by cuttlefish. The difference between both species is attenuated in 2004. Overall it seems there is a decrease in landings for the main species balanced by an increase in the percentage of the 'others' species. Just two species showed a slight percent increase in landings: hake and sole. In 2004 the increase in the class 'others' can be related to higher usage of less selective gear.

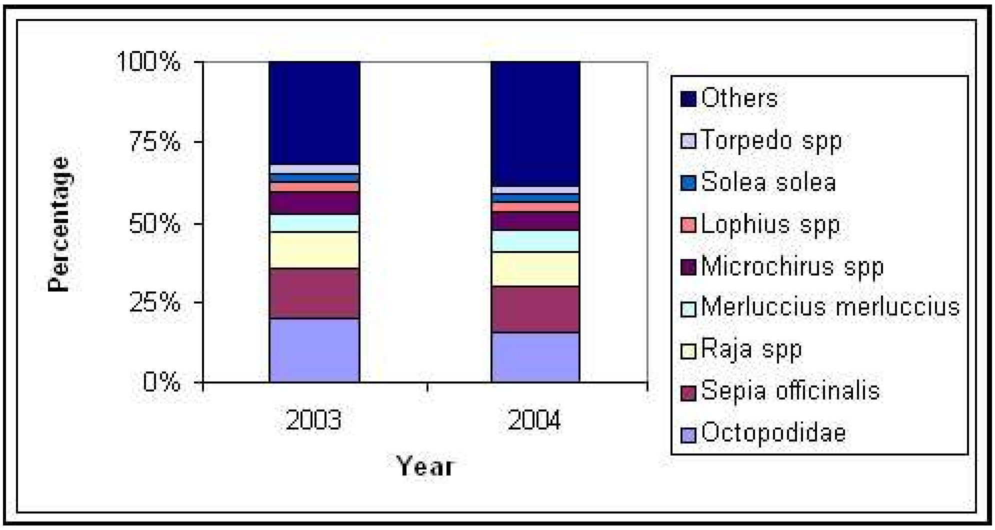


Figure 4.24 – Percentage of the most important species caught by vessels seen in operation in the OARS landed in the official market ports.

Hypothesis testing using chi-square tests

To test whether there is a difference in the variables and the actual users, a value of the chi-square was calculated, and tested to see if it was statistically significant. The hypotheses tested considered if the distributions were the same (H_0) or not the same (H_1), when comparing frequencies on 2003 with 2004 concerning: (1) the number of DSO samples, (2) the number of vessels observed in the reef area, (3) the crew on board the vessels seen, (4) the number of gear found, (5) gear distance from the reef, (6) ports chosen to land catches, and (7) species landed.

We would reject the null hypothesis of no relationship between the variables under analysis when comparing both years. So, it was verified that 'number of vessels', 'number of gear', 'ports chosen to land fish' and 'species landed' show a high level of significance with a low level of probability. The null hypothesis is rejected for all of these variables. So, we can say that the distribution of vessels and gear number, as well as the ports and species landed changed in 2004 relative to 2003. The P-value for these variables is very small, indicating that the pattern of having homogeneous distributions between both years is very unlikely to occur.

In the case of 'DSO samples', 'crew onboard' and 'gear distance from the AR' the test shows that the distributions are not significant. This means that the null hypothesis is not rejected for these cases, and it can be said that it makes sense to compare samples from April to August and November, the vessels observed in both years have a similar distribution in terms of crew, and the pattern of fishing gear over and around the AR did not alter. An observed chi-square value of 7.90 or higher occurred about 16% of the time in the case of DSO samples, an observed chi-square value of 0.11 or higher occurred about 75% of the time in the case of crew onboard, whereas an observed chi-square value of 3.84 or higher occurred only 28% of the time in the case of gear distance (Table 4.11).

Table 4.11 – Chi-square statistics.

Variable	d.f.	X^2	P-value
DSO samples[14]	5	7.90	0.162
Number of vessels	1	8.26	≤0.004
Crew onboard	1	0.11	0.746
Number of gear	3	12.81	0.005
Gear distance from the AR	3	3.84	0.280
Ports chosen to land fish	4	55.88	≤0.001
Species landed	8	1,797.65	≤0.001

Use of indicators as a synthesis of monitoring information (site: OARS)

The use of indicators can be seen as a simplified and effective way to present results. It can be useful to managers and decision makers. Below in Table 4.12 there are presented most of the results shown in this section, but abbreviated in the quantitative aspect. In brief the table shows that in 2004 less than half of the observation/monitoring trips were done. The months covered were reduced as well. However, the average sampled time increased slightly and the average time period changed to the earlier sampling period. As a consequence of the above reduction, the related crew onboard reduced in numbers as well. However, it seems that the proportion of vessels from greater distances increased slightly. Total gear anchored

[14] For the purpose of chi-square test there were used data from April to August and November. All the other months were rejected because they were not in accordance with the chi-square test rules.

reduced. However, traps number per observation increased. Gear distance from the OARS centre for 2004 is slightly closer. Additional electronic data DGPA (2002b) shows that the observed vessels tend to sell in the same ports. Most of the catches and their selling prices increased their percentiles in 2004, whereas in the case of the main species (Octopus) landed percentage decreased in detriment of other species.

Table 4.12 – Comparison of OARS use based on indicators. ↑ - if > 10% of positive variation; ≈ - if < 10% variation; ↓ - if > 10% of negative variation.

	Indicator	2003	2004	Δ (2004/2003)
	DSOs: sampling			
1	Number of sea trips (samples)	78	34	↓
2	Months sampled	10	7	↓
3	Average sampled time (minutes)	92	99	≈
4	Average sampled time period (hours)	11 – 11.30 a.m.	10.30 – 11 a.m.	≈
	DSOs: vessels[15]			
5	Average number vessels observed	0.9	0.2	↓
6	Local vessels observed	0.51	0.2	↓
7	Coastal vessels observed	0.23	0.01	↓
8	Recreational vessels observed	0.07	0	↓
9	Crew onboard	1.88	1.67	↓
10	Vessel trips from far distances	0.05	0.03	↓
11	Vessel trips from close distances	0.82	0.15	↓
	DSOs: gear[15]			
12	Total gear anchored	5.4	4	↓
13	Pots anchored	3.93	2.56	↓
14	Traps anchored	0.86	1.09	↑
15	Nets anchored	0.8	0.41	↓
16	Gear distance from the OARS centre	0.79	0.77	≈
	Electronic documents			
17	Landings (%L) in closest main port	74.8	70.8	≈
18	Closest port (position)	3rd	4th	↓
19	Closest port (%L)	6.5	6.0	≈
21	Main species (Octopus) landed (%L)	19.6	15.8	↓

[15] This information is a standardised number per observation.

4.3.5. Discussion

The use of descriptive statistics to summarise study results obtained helps to clarify and answer the monitoring questions posed in the introductory section: (a) who uses the ARs (commercial and recreational, occasional and regular, number of users), (b) when does the use occur (high and low yearly seasons in terms of numbers of boats and gear), (c) where does the use occur (the preferred area to set up fishing gear in relation to the AR distance), (d) why does the use occur (reasons pointed out to justify reef use).

Reef limitations

The OARS, despite being mature in terms of colonization of commercially exploitable marine resources, is small in scale because of its initial purpose as a pilot project, limiting not only fish concentration, but also any potential users' interest in its exploration. There were no observations concerning diving operators; the reasons for this may be related to the fact divers seldom use the reef and (if at all) mainly during the weekends (few DSOs), due to diving accessibility difficulties (depth, visibility or sea currents), or due to limited or low interest of the reefs. Miguel N. Santos (IPIMAR personal communication 2005) says that OARS' divers are resident in Olhão or its neighbourhood area. Nevertheless, through the collected information it is clear that there is significant activity around the AR, as evidenced by the occurrence of vessels fishing in more than half of the DSOs.

Observed activities

The activities perceived so far in the AR and surrounding areas are commercial and recreational fisheries. This fact can be corroborated by the presence of different types of vessels during the sampling period. The observed user vessels often belonged to commercial operators and the majority used pots to target specifically octopus. We have the same evidence for observations with reference to gear anchored.

It was observed that more than 75 different users have enjoyed the benefits of OARS and the surrounding zone during the sampling period. Due to the fact that previously anchored gear act as additional indicators to help in the identification of the type of reef users, and while there is the chance that some of these gear belong to some of the observed users, it is also possible that other vessels fish on different occasions. It is important to highlight that with regard to gear launching and retrieving times, these may vary according to each skipper's empirical knowledge and target species. We need to add a caveat, however, since the samples were always carried out between 8 a.m. and 4 p.m., i.e., corresponding to eight hours of observational spectrum, and taken mainly during weekdays. This limited observations of vessels fishing during other schedules, (e.g. purse-seines) or during weekends (e.g. recreational users).

The declining trend in the number of vessels observed for the year 2004 can be linked to several factors. However, our inferences are necessarily speculative. Since there is a limit to the comparisons that can be made based on the DSOs' data results, the analysis of secondary data sources (electronic file on landings) can shed some light on the trend. We assume that in each fishing trip, vessels tend to sell their catches in the nearest ports. The slight increase observed for landings in Quarteira and Tavira (ports further from OARS) in detriment of Olhão and Fuzeta (ports closer to OARS) can be partially justified by lower use of the OARS in 2004 when compared with the previous year.

Gear patterns

In general, gear is usually anchored slightly outside the AR area up to one nautical mile away. Gear densities in each area show that the greater the distance from the AR, the fewer anchored gear is found. This demonstrates empirically that fishermen have higher motivation to fish in areas closer to the AR, essentially because of the certainty of more fish, and less possibility of loss or damage to their gear. In addition, any vessel equipped with GPS is able to mark the OARS' position and anchor gear in a safe and strategic position within the reef zone.

Due to the fact that most of the vessels observed operating had several gear licenses, one can assume that the gear used changes throughout the year, according to the season. Many fishermen have several gear licenses and change their use only when the gear they are using does not catch a stipulated amount of the target species they intend, or just because their empirical knowledge leads them to change gear. This phenomenon gives rise to a greater use of nets during certain months (peaks of over 20%) when the occurrence of the associated target species is perceived to be higher.

The choice of gear positioning patterns may be related to the sea currents that have a drifting effect, or even due to the fact that it seems that depth distribution is rather longitudinal than latitudinal (i.e., accompanying the continental shelf steepness). However, over the OARS it seems that the preference for West and East positioning exceeds any gear preference; there being no well-established gear preference evident. In noting this however, it is evident from observations that fishermen have already acquired experience about how to operate in the reef area.

Fishing patterns

The observation that there is a spatial pattern to commercial fishing activity is evidence that the ARs have impacted on behaviour, suggesting that fishermen have expectations of higher returns. The decline observed concerning the deployment of gear and vessels operating might be related to attitudes. For fishermen, if there is a sign of more fish being caught in a given area, most of them move their effort to that area (example from OARS to Faro/Ancão artificial reef system). Another factor is related to the closed seasons, where some gear targeting certain species is forbidden. For instance, in 2004 there was a closed season with regard to the octopus species for the entire Algarve; this fact has resulted in changing fishing strategies by fishermen, and could be one of the main reasons for the observed decrease in vessel and gear patterns near the OARS since this species is the main target for the vessels seen in operation in this AR. In addition, the official data results also show a decrease in octopus landings which might be related to this fact.

Finally, it is perceived that the number of gear deployed is probably a better indicator of reef use than the number of vessels observed. The reason for this lies in the fact that the research vessels may have a dissuasive effect on commercial and recreational vessels. Users may tend to use other area in such circumstances.

4.4. Conclusions

A preliminary step to monitoring ARs is to identify potential users. During this process it is also important to identify and answer basic questions that may lead people to use the reefs. Answers to these questions are useful because they can be used for proving reef utility. The description of potential or actual users can be used to support direct observation.

Direct observation is of fundamental importance because it allows us to find out who really uses the structures, as well as their characteristics and patterns of use. However, it is difficult to implement a structured direct observation schedule. The reason for this is that direct observation is not only a time consuming task, but also because a place has to be selected where the observations can be taken without being seen, otherwise reef users may be deterred and as a consequence the results biased.

According to Milon (1991) and Milon et al. (2000), monitoring techniques can be used individually or in combination, in order to verify and/or cross-check the data collected. After collecting monitoring data, the application of several types of frequency and/or statistical tests is helpful to summarize important results in the study.

There are probably many stakeholders that may have their own interests in the Algarve reefs. However, thus far it seems that the ones that take most advantage of reef use are fishermen. The distance from the port of origin is an area of concern for small-scale fishermen (local fleet), but it is not so important for larger operators (coastal fleet). Monitoring data also show that AR modules are probably not considered as an important choice for recreational activities. However, the demand for these structures may vary from place to place.

So, after identifying AR potential users and finding out who in fact uses them, it seems of fundamental importance to know the broad range of stakeholders that may be affected by reefs' deployment. It is also imperative to get the involved stakeholders' 'vision' of the AR subject, as well as to find out their interest in the structures, their power in helping to accomplish reefs' policy objectives and to discover what sort of impact the structures have.

Chapter 5

Social Analysis

Contents

Word Count: 11,033

5.1. Introduction

Since the Algarve AR deployment, users have been accumulating greater empirical knowledge of the effects of ARs. This has undoubtedly influenced both their attitudes and behaviour (e.g. fishing patterns) towards the reef program as a whole. 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. In this respect, the technology matters and all those who update their equipment are one step ahead (Figure 5.1). 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, even though they do not use them as much as commercial fishermen. All these insights are important to take into account when asking stakeholder group representatives about their perception of impacts.

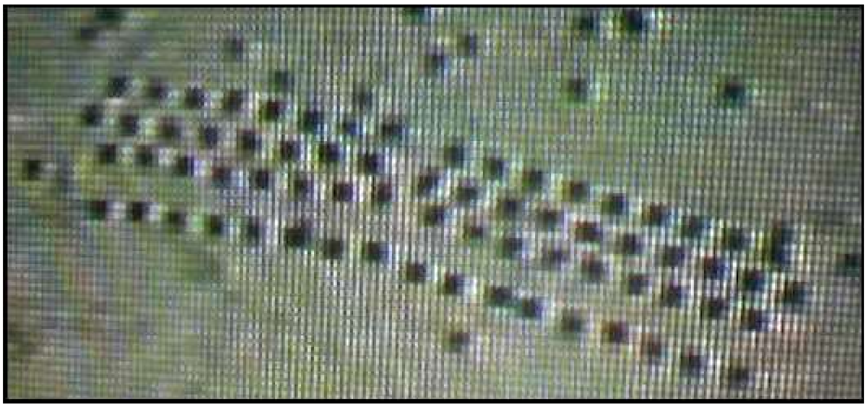


Figure 5.1 – The Faro AR system detected by GPS.

In the next sections four methodological approaches are presented in order to find out about stakeholders' and media perceptions of reef deployment and its consequences (impacts). All the social approaches asked about impacts derived from reef deployment, the aim being to assess the perceptions of the different stakeholders involved.

5.2. Stakeholders' Perception of AR Impacts

5.2.1. Rationale

It is important to investigate the local community's perceptions of the Algarve 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 socio-economic as well as environmental objectives need to be considered, and this sort of data typically has to be collected via surveys (Milon et al. 2000). To carry out this sort of study it is important to consult properly all the local stakeholders and interest groups. Studies which have examined the impact of artificial reefs, particularly where they involve stakeholders, have commonly considered the 'rigs-to-reefs' conversion of obsolete oil platforms to other uses (Reggio et al. 1986, McGurrin and Fedler 1989, Reggio 1989, Aabel et al. 1996, Cripps and Aabel 2002).

In this section, a simple analysis of perceived impacts is carried out by consulting a panel made up of different key stakeholders involved in the AR deployment process and its use. The panel's overall perception of the effects resulting from AR deployment in the Algarve south coast may help resource managers who can use the findings to work out trade-offs between policy objectives.

5.2.2. Material and Methods

Though the reef deployment program was only completed in 2003, the presence of artificial habitats since the early 1990s is acknowledged to have had a biological impact. While it is essential to explore the economic implications of this, particularly with regard to measurable quantities such as catches and incomes, it is also important to find out how far people regard the reef program as successful across a wide spectrum of performance criteria. A number of techniques may potentially be used to measure stakeholder attitudes (Robson 2002), and the particular approach adopted here is outlined below.

Questionnaire survey

As a first step in the study, three dimensions expected to be impacted by reef deployment were selected: environmental, social, and economic. For each dimension, factors likely to be affected by deployment were identified, and from these an item-pool was constructed (Bell 1999, Robson 2002) which included all the perceived predefined impacts. The item-pool consisted of fifty-four ambiguous-free relevant items to be included in the survey of respondents' opinions (Table 5.1). The item-pool was then adapted to a specific questionnaire addressed to a range of people with different perceptions and educational levels. The questionnaire was pre-tested and adjusted. Prior contact was established both by post or e-mail. This was accompanied by an introductory letter explaining the objectives of the proposed work, and an informative memorandum (INIAP/IPIMAR 2003) explaining the purposes of the ARs and their structure, organisation and location along the south-coast. The questionnaires were sent directly to each representative by hand or via post mail, and were addressed to the highest representative of each body/institution, or to the person used to dealing with fisheries or environmental issues.

Table 5.1 – Brief description of each of the twelve factor-sets and the number of impacts addressed to the key stakeholders.

Dimension	Factor-set	Brief description	No. items
Environmental	A. Deployment area use	To assess stakeholders' perception of the use that can be found in the area.	4
	B. Ecological impact and bio-diversity	Effects caused to the species, namely their aggregation and protection after deployment.	5
	C. Pollution	The contribution of the structures to pollution of the environment (water or sediment).	3
	D. Fishery and management	ARs as a management tool for fisheries (traditional fishing, off-shore aquaculture, etc).	6
Social	E. Demography and employment	Signs of changes in social aspects (people migration, employment, and social benefits).	3
	F. Enforcement and communication	The need to establish sea use rules and communication between the different players.	4
	G. Opinion	How is the AR deployment perceived by stakeholders and the public in general?	5
	H. Conflicts	Possibilities of conflicts occurring between the different stakeholders involved.	6
Economic	I. Production and benefits	To evaluate the chances of extra catches and returns after reef deployment.	4
	J. Costs to society	Awareness of the costs involved in the reef deployment process.	5
	K. Changes in local economy	Signs of changes in the local economy in all the sectors of activity after reef deployment.	5
	L. Safety at sea	Reefs contribution to promote safer fishing activities in their deployment area.	4

Conceptual framework and stakeholders

Though the consultation was 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 newly-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 were pre-selected from a key-stakeholder database created from the regional yellow pages and from a fisheries event's invitation list. The panel was constructed from key stakeholders based on their agreement to take part in the survey.

The survey was addressed to representatives of: (a) fishermen associations; (b) anglers' clubs and associations; (c) divers' clubs; (d) environmental and fisheries administrations; (e) natural, social and economic scientists; and (f) others, such as borough council representatives in the environmental and/or fisheries areas. The key-stakeholders panel consulting approach was similar to the one described by McKinnon and Forster (2000), where: (i) items were kept simple, and members' views were averaged to reach a consensus within the same institution; (ii) information was collected by questionnaire, without using interviews or subject discussion; and, (iii) anonymity was guaranteed to the members of the panel.

From each one of the six stakeholder groups there were chosen six to eight representatives. In order to understand stakeholders' involvement with the ARs, representatives were divided into two groups: those who knew the structures either by using them or by being involved since the pre-deployment process, and the others whose knowledge was solely by other means (e.g. through the media). The first three types of panel members (a, b and c above) represent the direct or potential users (primary stakeholders), whereas the other three (d, e and f) are usually involved in the ARs process mostly as institutional representatives (secondary and external stakeholders).

The impact assessment validation

Key-stakeholders used 5-point Likert scales[16] to state their positions about impacts (Murray and Betz 1994, Cripps and Aabel 2002, Kennish et al. 2002). Perceptions/attitudes were then measured using summated rating scales. Items were graded according to the probable perturbations in the marine system caused by reef deployment as well the effects on the fishing communities nearby. After collecting all questionnaires, impacts of the AR deployment were assessed according to their scores and the analyses carried out by dimension, stakeholder type, factor-sets, and the most meaningful items (the latter were decided upon their relative scores). To evaluate the level of the impact, it was important to define *a priori* what constituted a 'positive impact', since this underlay the whole concept and measurement of success in policy terms.

The survey made use of an AMOEBA plot, which is a graphical device that uses a 'radar' diagram. Though the approach is simplistic it has the advantage of representing to respondents (usually managers and policy makers) the impact of an intervention in a clear and easily understandable manner (Ten Brink et al. 1991). In the current study, an AMOEBA plot was used consisting of three areas: inner (negative impacts), middle (no evident impact), and outer (positive impacts). The AMOEBA reading shows that the perception of the AR complex impact assessed over twelve factor-sets is not expressed as a function of others (discrete variables). 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 results obtained concerning ARs' impacts after deployment have particular significance for stakeholders. The analysis was undertaken by separating the panel of stakeholders according to the group interests. To demonstrate the differences in stakeholders' positioning, hypotheses were tested for the whole impact using a simple t-test (Zar 1996). The t-test was carried out for the analyses on dimension, factor-set, and stakeholder type. It was decided to work on a percentage basis, where the overall score had three critical thresholds:

[16] Using these scales, the respondents indicate their level of agreement to a list of statements presented in a questionnaire, expressing their favourable or unfavourable attitude. The higher numbers express a favourable attitude. Rensis Likert invented the scales in 1932.

scores over 66.7 implied that the effect was positive, those falling between 33.3 and 66.7 signified that the impacts were largely neutral, while those below 33.3 were interpreted as negative. For each item, individually summated rating scales were also used showing the top and bottom impacted ones.

5.2.3. Results

Key stakeholders' characteristics

The total number of stakeholders contacted representing regional entities was 53. Of these, 9 stakeholders explicitly declined to collaborate, did not answer the calls, did not fill the questionnaire by the stipulated time, or simply filled out the questionnaire in an invalid way (Table 5.2). The final panel consisted of 44 respondents, where 28 knew already the structures, and 16 just knew a little bit about the artificial reefs built off the Algarve's coast. The most knowledgeable group was fishermen, and the least knowledgeable was the group of borough council representatives.

Table 5.2 – List of the key-stakeholders contacted and their relationship with the ARs.

Contacted (n = 53)				
		Agreed		
Stakeholder type	Denied	Total	AR experience	
			Heard	Known
Fishermen	2	7	0	7
Anglers	2	7	2	5
Divers	1	6	1	5
Administrators	2	8	2	6
Scientists	1	8	5	3
Others	1	8	6	2
Total	9	44	16	28

Key stakeholders' perception

In terms of impact perception, the majority of stakeholders were positive in their attitude towards the environmental impact caused by ARs. Stakeholders who had first-hand experience of the structures were even more optimistic than those who had simply heard about them. In environmental terms, around 60% of the answers showed that reef deployment had made a positive contribution, as opposed to 20% believing the impact was negative. By contrast, for social and economic effects, both types of stakeholders were more cautious in making statements about the potential impacts. The areas corresponding to the neutral position reflected, to some extent, stakeholders' difficulty in formulating judgements. Around one third of the social and economic dimensions are in this position (Figure 5.2). For the economic and social dimensions, less than 50% of the answers were accounted as positive and more than 20% negative.

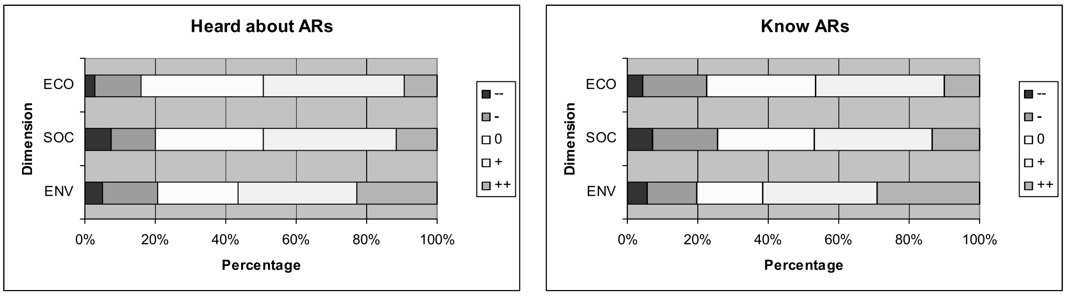


Figure 5.2 – Stakeholders' perception of impacts: a) Stakeholders who had only heard about ARs (n = 864 answers), b) stakeholders who have experience of (know) ARs (n = 1,512 answers). 'Minus' signs represent the percentage of impacts perceived as negative. 'Plus' signs represent the percentage of impacts perceived as positive. Double minus/plus mean respectively high improbability/probability of occurrence. The 'zero' represents answers with no clear position taken or perceived by stakeholders. Legend: ENV – environmental, SOC – social, ECO – economic.

Key stakeholders' general positioning and dimension analysis

Despite the differences found between those stakeholders who knew the reefs from first-hand experience and those who had only heard about them, it can be seen that the entire panel thought that the most important positive impacts belonged to the environmental dimension (Figure 5.3).

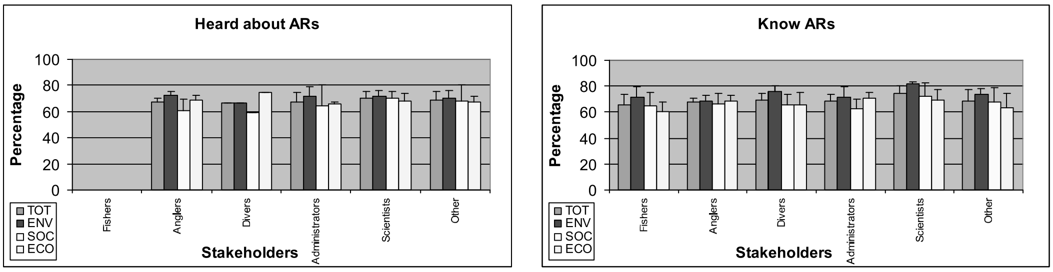


Figure 5.3 – Stakeholders' positioning about impacts caused in each dimension. Legend: ENV – environmental, SOC – social, ECO – economic, TOT – all previous three dimensions together.

The results of the hypotheses tested showed that only fishermen and anglers were not sure about the environmental overall impact of the ARs. By contrast, divers and scientists were the most optimistic (Table 5.3). Anglers, divers, and administrators considered that economic impacts overshadowed social impacts, whereas scientists and others claimed the opposite. In addition, fishermen representatives were the most sceptical of all about the economic dimension of the reefs, in contrast to administrators who strongly supported their economic role. Scientists were the most favourably inclined towards the social role of the reefs.

Table 5.3 – Statistical results using t-test for impacted dimensions. '++' for $p < 0.01$, '+' for $p < 0.05$, and the 'n.s.' for non-significant results.

Stakeholder	Dimension			
	Environmental	Social	Economic	All
Fishermen	n.s.	n.s.	n.s.	n.s.
Anglers	n.s.	n.s.	n.s.	n.s.
Divers	++	n.s.	n.s.	n.s.
Administrators	+	n.s.	n.s.	n.s.
Scientists	++	n.s.	n.s.	+
Others	+	n.s.	n.s.	n.s.

<u>Factor-sets analysis</u>

By disaggregating each dimension into their factor-sets through an AMOEBA plot, it was possible to perceive important impacts detected by the entire panel of stakeholders (Figure 5.4).

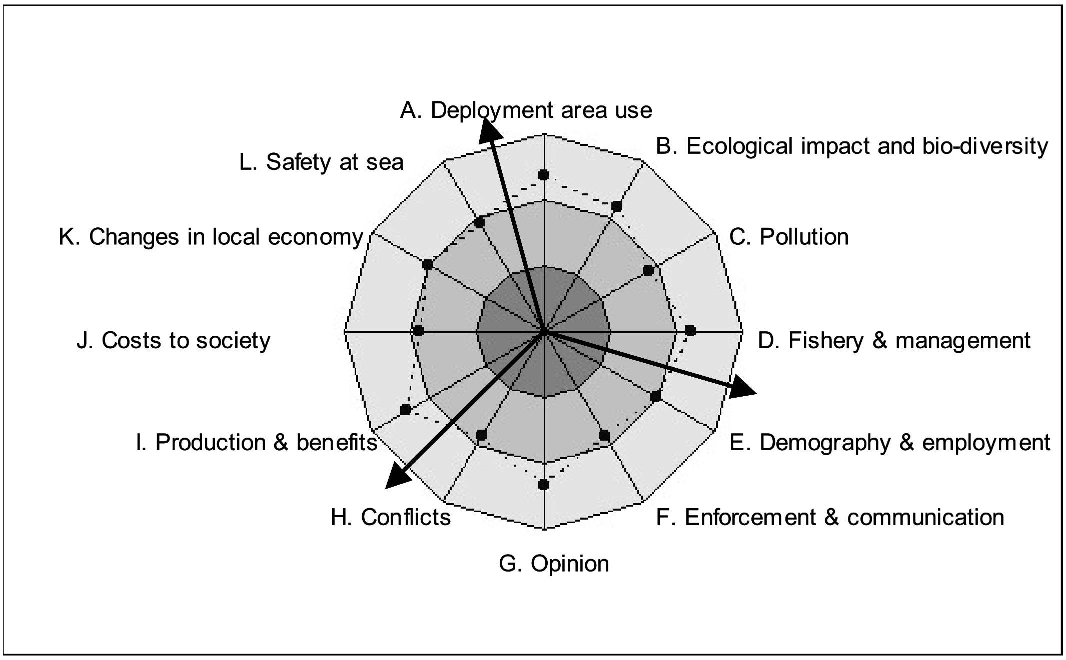


Figure 5.4 – The AMOEBA plot showing the twelve factor-sets of impacts.

A refinement of the AMOEBA plot showed that among the twelve factors, only four can be considered as positively significant (Table 5.4). In the environmental dimension, the only factor not having a visible positive impact is related to 'pollution', whereas all the other factors are positively accepted (however, 'ecological impact and bio-diversity' was rejected by the t-test). The social dimension, by contrast, showed only a strong positive factor related to the 'opinion', demonstrating that these structures were generally welcomed. For its part, the economic dimension seemed to have factor-sets perceived sceptically in terms of some factors (for example 'costs to society' and 'safety at sea') but more favourably in terms of others (e.g. 'production and benefits').

Table 5.4 – Simple t-test statistics for the AMOEBA-approach refinement. '++' for $p < 0.01$, '+' for $p < 0.05$, and the 'n.s.' for non-significant results.

Dimension	Factor-set	Statistics

Environmental	A. Deployment area use	++
	B. Ecological impact and bio-diversity	n.s.
	C. Pollution	n.s.
Social	D. Fishery and management	+
	E. Demography and employment	n.s.
	F. Enforcement and communication	n.s.
	G. Opinion	++
	H. Conflicts	n.s.
Economic	I. Production and benefits	++
	J. Costs to society	n.s.
	K. Changes in local economy	n.s.
	L. Safety at sea	n.s.

Key stakeholders by factor-set

The disaggregating of the dimensions by factor-set and the entire stakeholder panel by stakeholder types shows that groups are not identical in their assessment of the impacts (Table 5.5). After putting together all stakeholders' results by factor-set, it appears that fishermen were the most sceptical concerning evident positive impacts. For their part, administrators were positive about just two fundamental socio-economic aspects of the reefs: the structures' acceptability and their role as revenue generators. In contrast to the previous groups, divers were the ones who believed that four out of twelve impacted factor-sets are positive.

Table 5.5 – Simple t-test statistics showing stakeholder type by factor-set. '++' for $p < 0.01$, '+' for $p < 0.05$, and the 'n.s.' for non-significant results.

Stakeholder	Dimension

	Environmental					Social			Economic			
	A	B	C	D	E	F	G	H	I	J	K	L
Fishermen	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Anglers	+	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+	n.s.	n.s.	n.s.
Divers	++	n.s.	n.s.	++	n.s.	n.s.	++	n.s.	++	n.s.	n.s.	n.s.
Administrators	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+	n.s.	++	n.s.	n.s.	n.s.
Scientists	+	n.s.	n.s.	n.s.	n.s.	n.s.	+	n.s.	+	n.s.	n.s.	n.s.
Others	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+	n.s.	+	n.s.	n.s.	n.s.

The most positively impacted factor-set was within the environmental dimension and related to the ‘deployment area use’, where three of the stakeholder types supported the suggestion that ARs will attract more users to sites. Another factor-set showing a favourable result in the social dimension is related to the ‘opinion’ about AR deployment. Here four out of six stakeholder types were found to have a confident attitude/opinion, while only fishermen and anglers remained unconvinced. The factor-set believed to have had a demonstrated positive effect was the ‘production and benefits’, with five out of six stakeholder types being strongly favourable to it. Fishermen alone were sceptical or did not reveal their position.

Factor-sets that do not show any significance can also give some clues about AR impact. For instance, environmentally it seems that ARs are regarded as a tool to improve ‘fishery and management’, since apart from divers no other group revealed an attitude that was either strongly positive or negative. Socially it seems that AR deployment is not a significant contributor to regional ‘demography and employment’.

<u>Key stakeholders agreed impacts</u>

The survey results enable us to produce a hierarchy of items most significantly affected by the deployment of the reefs (Table 5.6). Ratings are indicators of stakeholders’ sensitivity to impacts.

On the positive side, the overall perception is that: ARs promote a specific habitat enriched with several different species, promoting bio-diversity; they are also able to aggregate marine fauna, and the structures are more likely to attract local fishermen than other users. The use of local fishing vessels at the reef area was considered an environmentally positive impact, since it is recognised as a more sustainable way of fishing, in comparison to using larger vessels. There are other positive impacts perceived, such as having the potential to augment catch rates when fishing in the ARs.

Negatively, the worst impact is the lack of perceived enforcement measures to keep sea use rules in the deployment area. Other negative impacts relate to the uncontrolled augmentation of fishing pressure on the reefs, associated especially with the activities of non-local boats having more powerful fishing capacity. Other perceived adverse impacts include the belief that ARs cause a loss of fishing gear which in turn entails additional costs in their replacement.

Table 5.6 – The greatest and least impacts due to the existence of the ARs. Stakeholders' rating averages are indicators of their sensitivity to each item. Ratings vary between 1.0 (minimum), and 5.0 (maximum). Legend: CF – commercial fishermen's associations, RF – anglers' associations and clubs, DV – divers' clubs, AD – administration bodies in fisheries, environment, and fisheries funds managers, SC – natural and social scientists, and OI – other institutions, such as local council representatives in the fisheries and/or environmental sectors).

Rank	ARs' positive impacts	Dim	Score	Stakeholder rating averages						
Top 10				All	CF	RF	DV	AD	SC	OI
1	To promote bio-diversity	ENV	204	4.6	4.1	4.4	4.7	5.0	4.6	4.6
2	To contribute to the success of fish enhancement actions	ENV	192	4.4	4.6	3.9	4.3	4.3	4.5	4.6
3	To assemble marine fauna	ENV	190	4.3	4.0	4.1	5.0	4.3	4.1	4.1
4	To increase the numbers of local fishing vessels in the AR area	ENV	188	4.3	4.3	4.3	4.5	4.4	4.1	4.1
5	To increase the numbers of recreational anglers in the area	ENV	187	4.2	4.0	4.3	4.2	4.4	4.4	3.9
6	To protect juveniles from inshore waters	ENV	186	4.2	4.6	4.3	3.7	4.4	4.1	4.3
7	To demonstrate to users that the program is worthwhile	SOC	182	4.1	4.0	4.1	4.2	4.0	4.3	4.3
8	To augment the catch in the AR area	ECO	181	4.1	4.3	4.0	4.0	4.0	4.1	4.3
9	To protect some marine life species	ENV	178	4.0	3.7	4.1	4.2	3.4	4.5	4.4
10	To increase the numbers of divers in the area	ENV	175	4.0	4.1	4.0	4.3	3.8	4.4	3.4
10	To attract users to the nearby area	SOC	175	4.0	4.0	3.6	4.0	4.1	4.3	3.9

Rank	ARs' negative impacts	Dim	Score	Stakeholder rating averages						
Bottom 10				All	CF	RF	DV	AD	SC	OI
1	To increase the need of sea rules	SOC	83	1.9	2.7	2.0	1.5	1.6	1.9	1.6
2	To increase fishing pressure over the AR	ENV	94	2.1	2.0	1.9	2.3	2.3	2.3	2.1
3	To increase fishing gear loss near the AR	ENV	109	2.5	1.9	2.1	1.8	2.8	2.9	3.1
4	To contaminate or pollute the water	ENV	110	2.5	3.0	2.7	2.3	2.3	2.8	2.0
5	To increase local authorities enforcement	SOC	115	2.6	2.6	2.6	2.5	2.6	2.3	3.1
6	To cause more fishing gear damage	ECO	116	2.6	2.0	3.1	2.0	2.6	2.8	3.1
7	To find other less expensive options	ECO	120	2.7	3.1	2.9	2.2	3.3	2.6	2.3
8	To make no contribution to social benefits	SOC	123	2.8	2.6	3.0	3.0	2.3	3.4	2.6
8	To generate conflicts between fishermen and anglers	SOC	123	2.8	2.6	3.0	2.3	2.6	3.3	2.9
8	To realise that there were better sites to deploy ARs	ECO	123	2.8	2.7	2.9	2.8	3.1	2.6	2.6

5.2.4. Discussion

This study shows that the deployment of the Algarve's reef structures has resulted in perceived changes. The program can be considered successful since, apart from a few sceptical views, in general key stakeholders are not opposed to it and indeed there is an overall positive attitude. For the purposes of this study, key stakeholders can be considered as valid 'judges' of the AR program by virtue of their experience, use or knowledge of these structures. Among the key stakeholders' panel there is agreement that, compared to the economic or social dimensions, the environmental dimension seems to be the one impacted most positively. The social dimension can be seen as the one that still remains relatively unaffected by reef deployment, either for better or worse. Moreover, it seems that there are no highly adverse (i.e., impacting negatively) factor-sets, whatever the dimension. The negative effects are specific and relate to the risk of losing gear, conflicts between users, and problems of enforcement. Arguably these can all be overcome through awareness campaigns on how to use the ARs. A slightly unexpected result is that, despite the scientific evidence of increased economic abundance, some stakeholders take a cautious position regarding the economic impacts, holding the belief that there are no strong signs of visible positive results.

Biological findings show that AR structures are intensely colonised and attract fish assemblages. Monitoring data show that there is an average increment in catches (Santos and Monteiro 1997, 1998). However, some potential users consider the ARs' location to be generally either unknown or of no interest. The latter situation may arise where, even if the underwater structures are detected by vessels, the quantity of harvested fish is deemed inadequate or the species composition unsuitable; consequently, the site fails to be accepted as a 'hot spot' ground amongst other fishermen. A further constraint on the effectiveness of ARs is that their use may be limited to commercial fishermen who use passive gear (such as pots, traps, trammel and gillnets, etc.). Eco-tourism based around charter boats and diving is an activity that could take some advantage of reef deployment, and in particular the depth and range, since they are additional features to charter boat passengers and to divers. Due to the ARs' depth range, the structures can be used for several levels of divers.

A joint collaboration between several key stakeholders is important in order to establish to what extent the impact of the ARs is perceived. A problem that is being faced is the specificity of the AR program. Many stakeholders were consulted before and during the deployment phase, and even after deployment many of the results seem to be based on expectations. This study demonstrates how the key stakeholders' perceptions of the impacts may be empirically measured. By using a summated rating scale and appropriate simple statistics, it is possible to make a selection of the most important positive and negative impacts from the entire item-pool. The panel members who took part in the survey emphasised that in the future they would like to be consulted in similar surveys. This is a sign of positive interdisciplinary interest and participation in solving fisheries management problems. Finally, it can be added that these types of survey can provide some information to fisheries managers about stakeholders' positioning, which can be used as indicators for management. It is important to get more people involved with the reefs' use and awareness campaigns targeted at each specific user type should be carried out in the future.

5.3. Content Analysis: Regional Newspapers

5.3.1. Rationale

In AR assessment it is important to have systematic and comparative monitoring of social variables (Milon et al. 2000). The variables have to be relevant to the program's objectives.

One way to find social variables and the way they vary is by searching in the national or regional newspapers. Since the Algarve ARs' program is particularly directed towards fisheries, off-shore aquaculture, and eco-tourism/species protection, it was necessary to research these subjects in the regional 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 this simple content analysis was to ascertain the importance attached to sea-related news, with respect to each of the three subjects chosen. The aim also was to find out if AR-related news featured in the newspapers.

5.3.2. Material and Methods

For sampling purposes, the Algarve periodical press was consulted, bearing in mind two important aspects: (1) each title had to have a general regional scope, and (2) each title had to be from sea-related towns. It was intended to find out the impact and importance of the news relating to: (1) aquaculture and shellfish gathering, (2) fisheries, and (3) other sea-related news. In addition to this, it was also important to know how many times the ARs were mentioned, as well as the importance attached to them, or at least the potential issues that the ARs can address.

The method consisted of a time-series sampling, selecting newspapers every five years starting from the year of the first AR deployment - 1990. A structured sampling was carried out for the four periods of time selected: 1990, 1995, 2000, and more recently (2004 and 2005). Newspapers were selected according to their periodicity as well, but focusing more on the weekly and bi-weekly ones. Three different libraries were chosen because the first one had just one title with potential sea-related news and only 2000 onwards titles, the second had few issues from 1990, and since it was proposed to sample a reasonable number of titles per year (around 40 to 50), it was decided to go to a third library.

All the news items/articles were selected according to their reference to sea subjects. The news items were divided into three categories: (1) aquaculture and shellfish gathering, (2) fisheries, and (3) other sea-related news. Excluded were: sailing activities, and pollution to the sea. Included were: marina-related news, angling competitions, and sand barrier-islands management.

The importance of the subjects was then evaluated through the use of ratios. Each ratio consists of the number of times each subject appeared 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 aspects/impacts of the activity. To carry out this social impact analysis based on this type of media, fishing newspapers were 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 were divided into four categories: (1) one page, (2) half a page, (3) quarter of a page, and (4) one eighth of a page or less.

5.3.3. Results

Not even a single news item was found that referred to the AR development or any impact caused by it, whether in the aquaculture, fisheries or other sea-related subject. Despite that fact, the results were explored in order to find out what the contents of each news item were and to categorize them. There were more news items found relating to fisheries in the last two time series (2000 and 2004/5), where more than one news item could be found in every two issues (Table 5.7). With regards to fisheries in the first two time series, it was found that to find a news item about fisheries it was necessary to consult more than four newspaper issues. These results provide evidence that fisheries issues have become more important in the last decade.

Table 5.7 – Regional periodical newspapers sampled according to four different years of publication.

Time series	Periodical title	Periodicity	Sampled	Aquaculture	Fisheries	Other sea news
1990	O Algarve	Weekly	25	0	3	8
	O Olhanense	Bi-weekly	7	4	4	0
	Barlavento	Weekly	13	0	1	1
	Algarve Região	Weekly	7	0	4	5
	TOTAL		52	4	12	14
1995	Jornal do Sotavento	Bi-weekly	18	0	0	0
	O Algarve	Weekly	27	0	10	6
	TOTAL		45	0	10	6
2000	Postal do Algarve	Weekly	27	2	30	16
	Correio de Lagos	Monthly	12	0	3	6
	O Olhanense	Bi-weekly	8	0	6	8
	TOTAL		47	2	39	30
2005	Postal do Algarve	Weekly	19	0	12	21
	Correio de Lagos (04/05)	Monthly	15	0	9	12
	O Olhanense	Bi-weekly	8	0	7	5
	TOTAL		41	0	28	38
	OVERALL TOTAL		185	6	89	88

The analysis of the news by subject reveals that there are few articles about aquaculture and shellfish gathering. For the 185 newspapers sampled, only six had news related to this topic. Most of the news items refer to fisheries or other sea-related issues. Especially for these two latter subjects, one article could be found for every two newspaper issues for the years of 2000 and 2005. The highest ratio was found for other sea-related news in the 2005 time series (an average of 0.93 articles per newspaper). It also seems that other sea-related news items increase in their coverage, whereas fisheries news items feature slightly less (Figure 5.5).

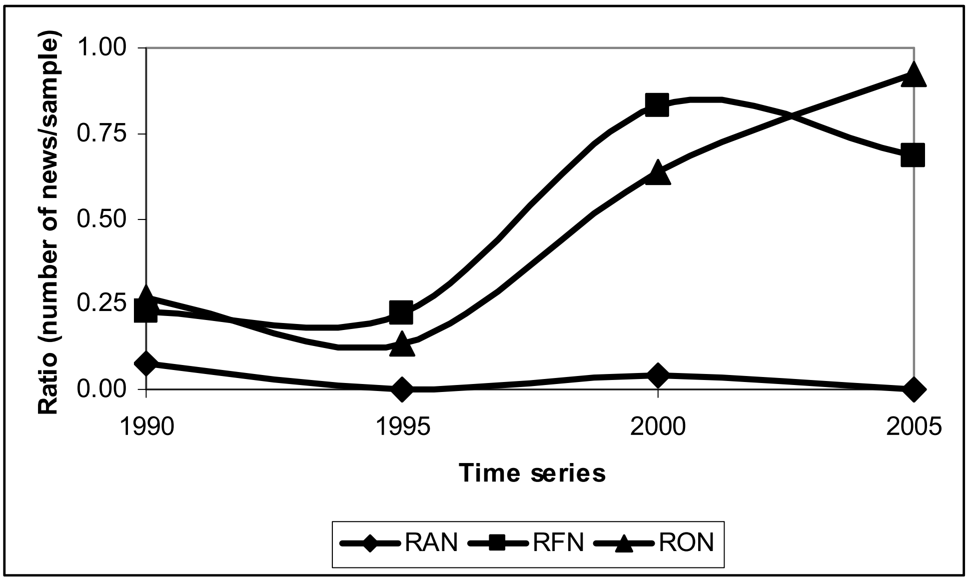


Figure 5.5 – Ratio of news items found by newspapers' issue throughout the time series selected. The ratios correspond to: aquaculture and shellfish gathering news (RAN), fisheries news (RFN) and other sea-related news (RON).

It was found that as the number of the news items increases, the space used by the newspaper decreases. Both news items covering subjects with negative and positive impacts of perceived changes on the three subjects considered were found. In general, amongst the newspaper issues sampled, it seems that there is a preponderance of the positive impact news. The number of small-sized newspaper articles seems to be more related to the positive impact in the most recent time series issues (Figure 5.6).

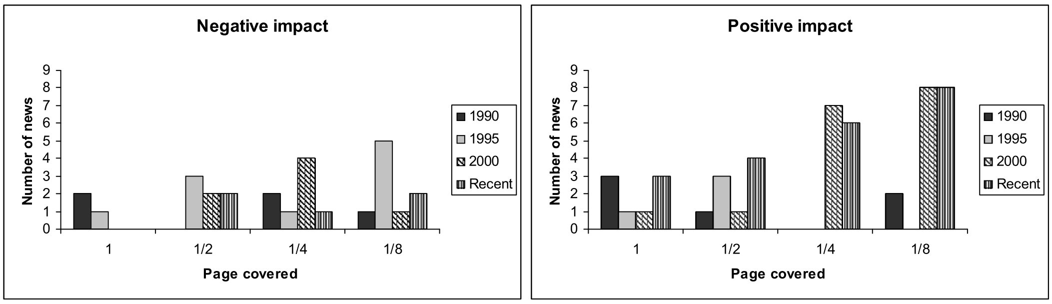


Figure 5.6 – The importance given by the regional press: news according to title and size of the news item.

Examples of regional news items that were highlighted in the regional press (i.e., covering one page or more) related to the subjects are presented in Table 5.8. Most of these headline news were about the fisheries subject (seven out of 11). Aquaculture and shellfish gathering were not an issue of importance at all, since no single news item had a high impact.

Table 5.8 – Issues of higher impact occurring in the sampled newspapers.

Time series	Type of impact	
	Negative	Positive
1990	Fisheries – fishing conflicts between small-scale fisheries and managers (All regions)	Fisheries – border negotiations between Portugal and Spain (All regions)
	Fisheries – delay in the construction of a fishing port (Quarteira)	Other – sand removals from navigation channel (Lagos)
		Other – anniversary of an angling club (Faro)
1995	Other – enforcement of coastal management (Faro)	Other – anniversary of a navigation club (Faro)
2000	None	Fisheries – fishing port enhancement (Olhão)
Recent	None	Fisheries – fishing port enhancement (Olhão)
		Fisheries – insurance for fishermen (All regions)
		Fisheries – past female canning factory workers (Lagos)

5.3.4. Discussion

In general, it seems that the AR deployment and related subjects did not evoke a high impact in the regional press. The reasons for this may be related to the fact that the institution commissioned to deploy the ARs in the region did not put much commitment into issuing press releases to the information media (Neves dos Santos IPIMAR personal communication 8 July 2005). However, there are some relevant news items. To this study's author's knowledge, a single news item was published in the regional newspapers, but this was not revealed by the sampling plan, because of the random strategy used. This news item referred previously was published by the regional newspaper Barlavento (Löfgren 2003).

Present content analysis just focused on the regional newspapers. Setting that methodological approach aside, it should be noted as curious that the ARs deployed in the Algarve sometimes attracted national interest. The reason for this may be related to the newness of the program. Therefore, there are a few other news items about this subject. Some of these can be found in the national printed press, as in the case of Expresso (e.g. Vieira 2000) and in the European digital press (e.g. Europa 2000). Both news items were released in April 2000 because of the great interest aroused by the visit of Franz Fischler (European Commissioner for Agriculture, Rural Development and Fisheries at that time). During this visit he took part in the launching of two fisheries projects in the Algarve co-financed by the EU (the second phase of the AR project cost €784k, and a new fish auction and related infrastructure cost €2.2 million).

However, larger audience media, such as television, may have a different impact on stakeholders and the public in general. Since the 1990's, the different generalist channels of the Portuguese TV covered some short features highlighting the ARs (Neves dos Santos IPIMAR personal communication 8 July 2005). Recently (18th December 2005), a 30-minute TV program was dedicated exclusively to the Algarve ARs. The program called *Bombordo* usually attracts approximately 6% of the audience of Portuguese TV, and this program was repeated two weeks later. The TV program tried to show that different groups of stakeholders (e.g. commercial fishermen and diving operators) have been positively affected by the deployment of the ARs. People who were interviewed on TV explained the benefits provided by utilizing the structures. *Bombordo* may have presented to a large audience much information about the Algarve ARs.

5.4. Document Analysis: Internet Sources

5.4.1. Rationale

It is difficult to collect data relating to the social impact caused by the deployment of ARs in the Algarve. From direct observation, there is no sign of changes that can be directly attributable to the reefs. Collecting data from the printed media in the region again showed no signs of changes brought about by the reef deployment.

Another approach to the social analysis could be the focus groups methodology. However, there were some institutional difficulties in proceeding with arrangements to conduct focus groups. Faced with these problems of lack of registered information about the specific subject of 'Artificial reefs of the Algarve' with regard to socio-economic aspects, it was decided to use internet documents and to proceed with their content analysis. This unobtrusive measure was then used to carry out the data collection. The advantages of this methodology are: (a) to observe without being observed, (b) the data are readily accessible (available on the internet to everyone), with reanalysis and replications easily being done, and (c) it is a low cost method of getting data without inconveniencing the host institution with special arrangements (e.g. inviting stakeholder representatives for focus groups). The disadvantages are: (a) the documents available are limited, some are partial (e.g. newspapers' notices), (b) the documents were written for purposes other than this study, and some distortions and other bias can occur, (c) causal relationships are difficult to assess (e.g. is there any influence on the demand for ARs presented in some diving forums as a result of the IPIMAR's information or diving operators' sites?).

5.4.2. Material and Methods

Research question

It was intended to establish the importance that the sources of data found gave to each of the subjects (codes) in order to evaluate the social importance of the ARs to date. The main research questions were: 'How have the ARs been perceived by potential stakeholders, and what is the relative importance they attribute to the structures according to different terms used in the discourse?' To this end it was intended to find internet documents that could be used as indicators of human use of the 'Algarve ARs', and in which dimensions and categories they match according to a predefined list.

Sampling strategy

Using the 'Google' search engine, the terms 'recifes artificiais' and 'Algarve' (literally *artificial reefs* and *Algarve – region of Portugal*) were entered, as shown in Figure 5.7, and 487 entries (by 30th November 2005) were found. The next step was to sample all the first 150 documents, ignoring all the 'PDF' files and the ones that were repeated (cited by another source or simply occurring two or more times, but with different addresses). All the documents produced in Portuguese specifically related to the searched terms (i.e. a non-scientific scope) were selected. In addition to this, the analysis focused solely on the contents relating to the AR subject found in the Algarve, even if there were other subjects in the document. Documents were found on the internet dating from the late 1990s until recently. By the end of the search, 23 documents were found for content analysis. However, due to software analysis limitations only 20 were chosen.

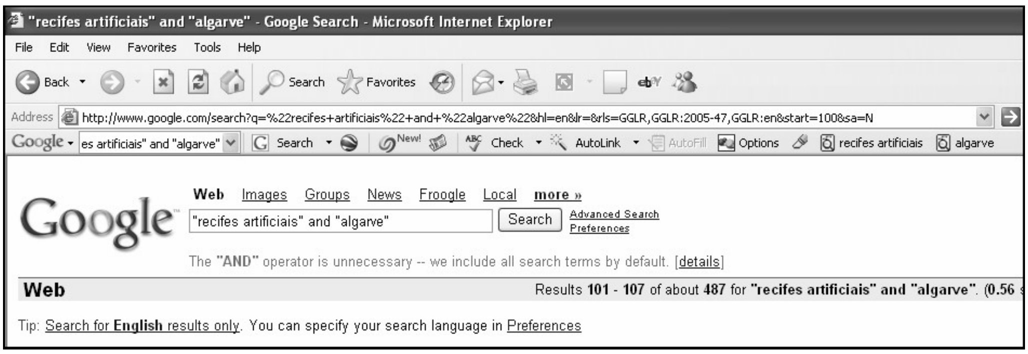


Figure 5.7 – Google search for terms '*recifes artificiais*' and '*Algarve*'.

Another method that could be used in document analysis is the optical character recognition (OCR) software that translates documents directly into an electronic file without the necessity of typing (Figure 5.8). However only two documents were found using this method (newspaper notices), and for that reason all the document analysis done here does not include them.

Figure 5.8 – Using OCR software as a tool for digitalising documents that can be used by document analysis software.

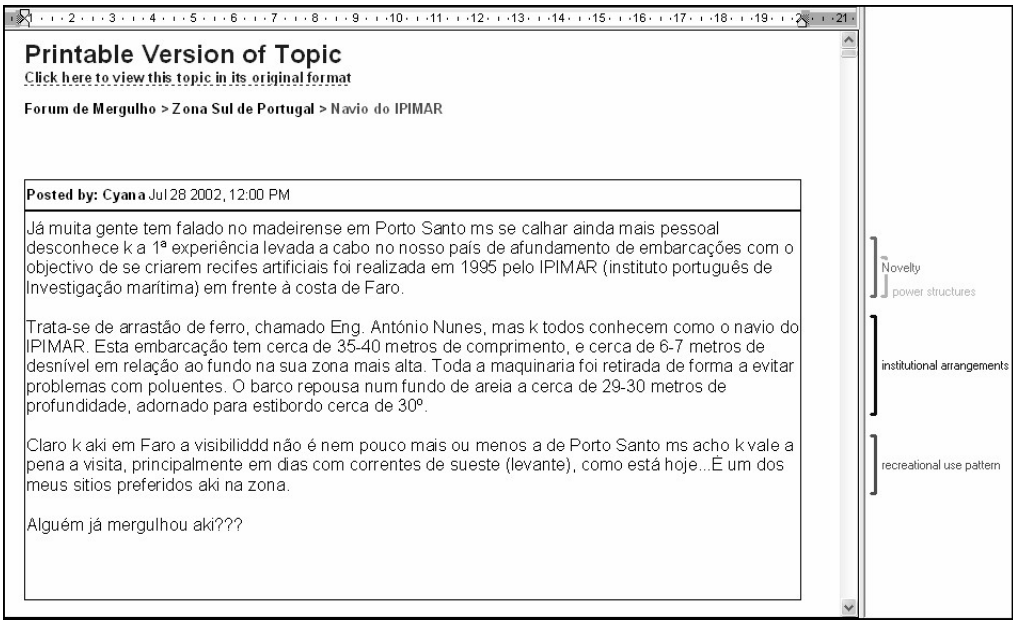
<u>Qualitative data analysis software</u>

To carry out the qualitative data analysis a free version of the QDA Miner 1.3 (unregistered copy) was used. The developers of this software say that '*QDA Miner is a qualitative data analysis software package for coding textual data, annotating, retrieving and reviewing coded data and documents. The program can manage (…) documents combined with numerical and categorical information. QDA Miner also provides a wide range of exploratory tools to identify patterns in codings and relationships between assigned codes and other numerical or categorical properties. Documents are stored in Rich-Text Format and support font and paragraph formatting, graphics and tables. Documents may be edited at any time without affecting the existing coding. QDA Miner can import* *and export documents, data and results in numerous file formats (MS Word, WordPerfect, RTF, HTML, MS Access, Excel, Paradox, dBase, etc.). It also provides unique integration with advanced quantitative content analysis, text-mining (WordStat) and statistical analysis (Simstat) tools, providing easy combination and integration of qualitative and quantitative methods.*'

Recording unit

In this particular content analysis study, the focus was 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 Algarve. Basically, the number of times that particular concepts (codes) appeared in the selected texts was counted (Figure 5.9). 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 Algarve.

The text size varied from sample to sample, as well as the size of each recording unit. The recording unit consisted in part or whole of selected sentences and paragraphs from the document text that matched the different codes chosen in advance. To do this, it was necessary to examine the context where the recording unit was set in order to code it accordingly.


Printable Version of Topic
Click here to view this topic in its original format

Forum de Mergulho > Zona Sul de Portugal > Navio do IPIMAR

Posted by: Cyana Jul 28 2002, 12:00 PM

Já muita gente tem falado no madeirense em Porto Santo ms se calhar ainda mais pessoal desconhece k a 1ª experiência levada a cabo no nosso país de afundamento de embarcações com o objectivo de se criarem recifes artificiais foi realizada em 1995 pelo IPIMAR (instituto português de Investigação marítima) em frente à costa de Faro.

Trata-se de arrastão de ferro, chamado Eng. António Nunes, mas k todos conhecem como o navio do IPIMAR. Esta embarcação tem cerca de 35-40 metros de comprimento, e cerca de 6-7 metros de desnível em relação ao fundo na sua zona mais alta. Toda a maquinaria foi retirada de forma a evitar problemas com poluentes. O barco repousa num fundo de areia a cerca de 29-30 metros de profundidade, adornado para estibordo cerca de 30º.

Claro k aki em Faro a visibiliddd não é nem pouco mais ou menos a de Porto Santo ms acho k vale a pena a visita, principalmente em dias com correntes de sueste (levante), como está hoje...É um dos meus sitios preferidos aki na zona.

Alguém já mergulhou aki???

Figure 5.9 – Sample of text from a 'Forum' where codes are used to characterize the terms used in the text.

Categories for analysis

There is a wide range of potential categories that can be analysed. The contents of the 20 samples were assigned to two different types of AR-related categories: demand and supply. Each of them was subsequently divided into four sources of data: administrative (AD), forum (FO), news (NE), and political (PL). Additionally, they were divided into four topics: fisheries, ARs, general, and diving (Figure 5.10). The direction (i.e., favourable or not) of the treatment was not considered. The categories were treated as exhaustive, i.e., presuming everything relevant to the AR study could be categorized in at least one category.

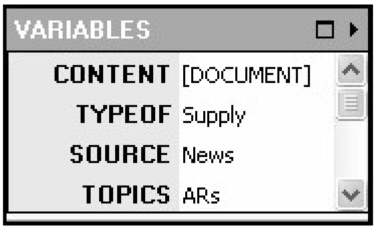


Figure 5.10 – Example of categories (or variables) used for document analysis.

The coding strategy consisted of the selection of four main dimensions (cultural, demographic, historical, and other), further divided into 11 different categories (Figure 5.11).

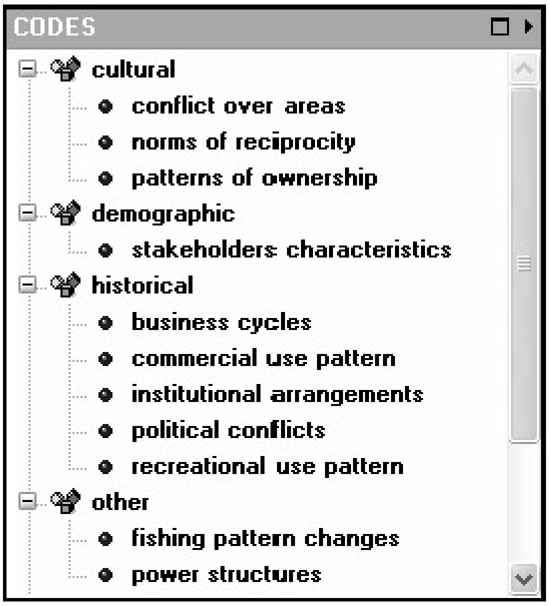


Figure 5.11 – Coding strategy used for content analysis.

Test coding and assess reliability

The process of coding the documents should be done by at least two people. Tests of reliability should be done, and the process should be repeated until reliability is attained.

5.4.3. Results

Codes co-occurrence analysis

A first question to be analysed is whether there is any similarity between the co-occurrence of Algarve AR-related codes when analysing texts from different internet sources. By using hierarchical clustering[17] from QDA Miner presented in a dendrogram (Figure 5.12), we can see the codes that tend to appear together.

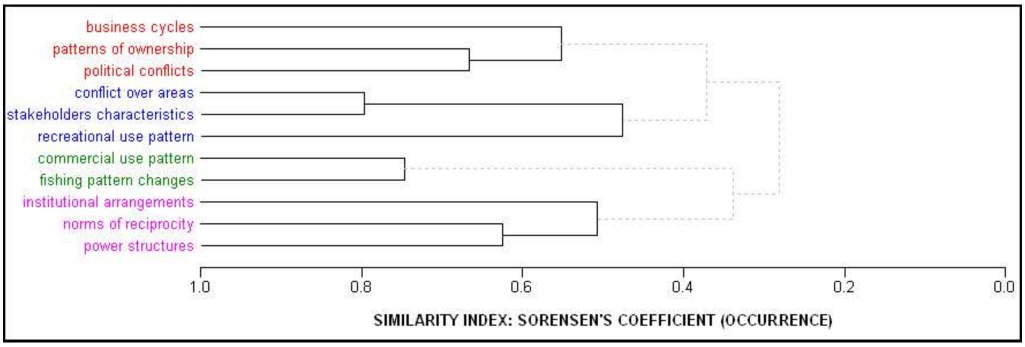


Figure 5.12 – Dendrogram showing the similarity between codified terms.

By using the Sorensen's coefficient[18] for the occurrence in the discourse of all the cases analysed (independent sources), when choosing a similarity index of

[17] Data clustering is a technique used for statistical data analysis. Clustering is the classification that refers to the partition of a given data set into several subsets (i.e. the clusters), where it is supposed that the data in each subset share some common features, expressed by proximity according to some defined distance measure.

[18] This coefficient is calculated from a fourfold table, such as 2a/(2a+b+c), where 'a' represents cases where both items occur, and 'b' and 'c' represent cases where one item is found but not the other.

around 0.5 co-occurrence difference, codes can be divided into four different clusters.

The first code combination presenting more similarities in the discourse texts analysed is ‘conflict over areas’ and ‘stakeholder characteristics’. Due to the absence in the analysis of the direction of treatment (i.e., favourable or not), the similarity of occurrences just denotes that there is a concern about conflicts when characterizing stakeholders. For instance in a sandy beach area, where there are some artisanal fishermen and also many recreation stakeholders enjoying the beach, there is the possibility of conflict over the area (beach and coastal surrounding zone). This explanation is corroborated by the fact that in this cluster the ‘recreational use pattern’ also appears.

The second combination of codes relates to fishing, namely commercial fishing pattern and extractive fish pattern changes. This similarity found in the discourse denotes a potential that fishing activities have to adapt to the structures.

All the other codes of co-occurrence appear less frequently. In future research it would be desirable to have a larger number of samples.

Coding variables

The number of documents by source varied: news (9), forum (5), administrative (4), and political (2). The documents were divided by type of document according to the topic. The representativeness of each category varied somewhat (Table 5.9). Half of the documents focused exclusively on the Algarve ARs. There were no documents that referred to supplying ARs for diving purposes. However there is an old trawler which was sunk for that purpose (the text presented in Figure 5.9 states that fact but on the demand side). The document produced by fisheries people about the ARs relates to the demand for recreational usage (forum), since professional fishermen usually do not use internet.

Table 5.9 – Documents found by source type categorised according to the topic.

Topic	Number of cases									
	Demand					Supply				
	AD	FO	NE	PL	Total	AD	FO	NE	PL	Total
ARs	1	2	1	0	4	3	0	3	0	6
Diving	0	2	2	0	4	0	0	0	0	0
Fisheries	0	1	0	0	1	0	0	1	2	3
General	0	0	1	0	1	0	0	1	0	1
Total	1	5	4	0	10	3	0	5	2	10

The frequency of codes associated with ARs and the Algarve vary considerably in the documents analysed (Table 5.10). Sometimes their content is analysed in implicit terms. There is a rank of occurrence for subjects (codes) for each type of source.

Table 5.10 – Frequency of codes associated with ARs and the Algarve.

Label	Frequency
Recreational use pattern (RUP)	29
Norms of reciprocity (NOR)	23
Institutional arrangements (IA)	20
Business cycles (BC)	15
Power structures (PS)	13
Fishing pattern changes (FPC)	7
Political conflicts (PC)	7
Stakeholder characteristics (SC)	5
Commercial use pattern (CUP)	4
Conflict over areas (COA)	3
Patterns of ownership (PO)	3
Total	129

These frequencies have some significance. The most common code detected is RUP. It suggests the interest of the structures for both diving and angling. The most frequent codes might be connected with the most important issues faced by the ARs. Codes that appear few times are usually related to less tangible reef-related topics. The code frequency varied also between the different sources analysed (Figure 5.13).

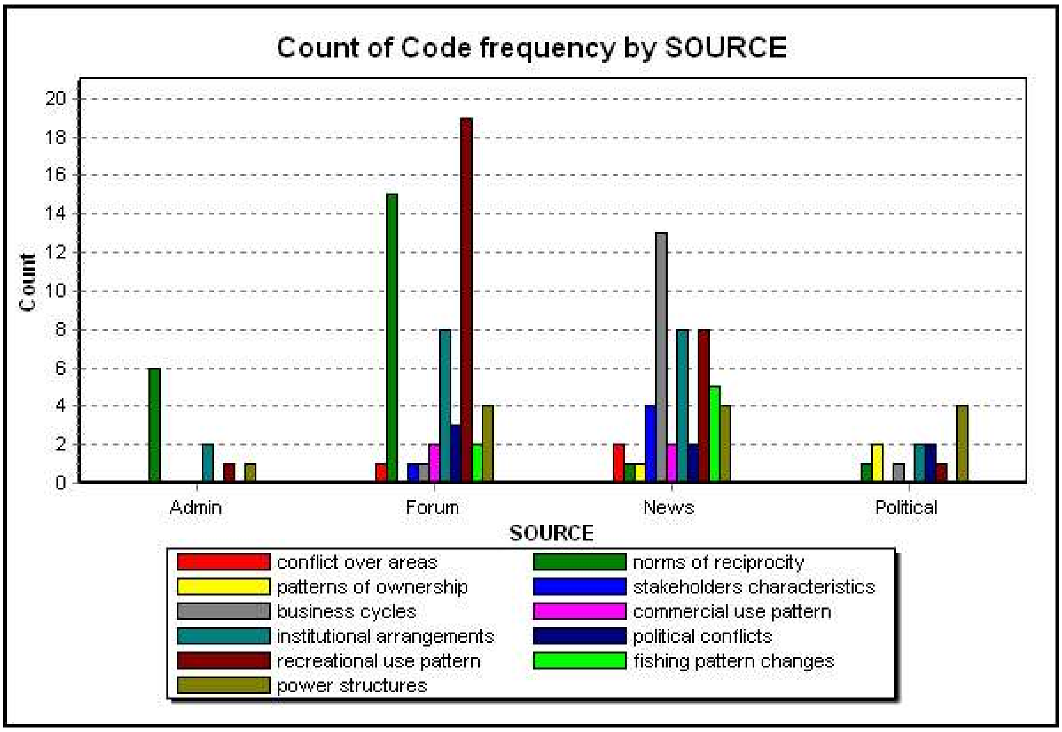


Figure 5.13 – Code distribution among four different sources of internet documents.

Concerning the type of source, it seems that coded areas may differ both in terms of frequencies of occurrence for each code and number of codes covered by each source of information:

Administration – The most frequent code used is the 'norms of reciprocity' (NOR); a brief mention is also given to three other issues. NOR in this source refers to the supposed interaction that can be developed between stakeholders. It is usually used in a somewhat vague manner based on future expectations.

Forum – Usually aimed at demand, it is very widespread, covering 10 out of the 11 codes, with relevant code frequencies for 'recreational use pattern' (RUP) and 'norms of reciprocity' (NOR), and also 'institutional arrangements' (IA). RUP is usually used in this source to demonstrate that there is some knowledge about the AR structures concerning users' characteristics (type of user, target species, etc). NOR features question-and-answer dialogue usually between the more experienced AR' user to an inexperienced one requiring information. IA focuses mainly on the facilities, and rules related to AR use.

News – This source is the only one covering all codes, with the issues being fairly evenly distributed by code categories. Nevertheless, there are three issues that emerge more frequently: ‘business cycles’ (BC) and less often ‘institutional arrangements’ (IA) and ‘recreational use patterns’ (RUP). BC is probably a ploy to sell the notice easily and is also more consumer-oriented, bearing in mind that regional newspapers are directed to a minor audience. The other two codes (IA and RUP) may appear as a consequence of the ease with which journalists can obtain this sort of information. They might be used to inform people from the Forum source.

Political – This source touches on seven codes but no high value is attributed to any of the codes. ‘Power structures’ (PS) is the one that is most used in the political internet documents though this code obtains similar results for Forum and News sources.

Heatmap

The heatmap plot[19] (Figure 5.14) shows that political discourses analysed for the Algarve ARs represent the extremes: the ‘power structures’ content is present in all the cases studied, yet at the same time this content never revealed knowledge or interest in issues such as ‘stakeholder characteristics’. News is the only source that presents an even distribution of discourse, i.e. many subjects are treated in each case. Administrative and forum discourses have a similar pattern, probably due to the fact that forums are always related to supply and follow (or not) any measures launched by the administrative bodies. Their main focused terms are concerned with ‘power structures’ and ‘norms of reciprocity’.

[19] It is a graphical device where relative frequencies are represented by different colours and on which a clustering algorithm is applied to reorder rows and/or columns. When used in qualitative analysis it eases the identification of functional relationships between related codes and group of values (Provalis Research no date).

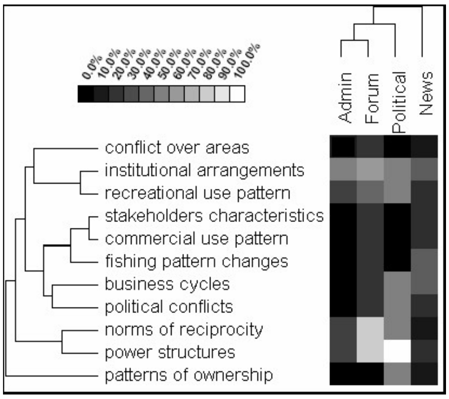


Figure 5.14 – Heatmap code occurrence (% of cases).

5.4.4. Discussion

The starting point and perhaps the most important point of this analysis was to select a few search terms that could be embedded in the subject of analysis. The prompted terms used in the search have some particular characteristics. The first term refers to '*recifes artificiais*' which is the Portuguese expression for ARs and can only be found in Lusophone countries, and so that narrows the search to approximately eight different countries. The second search term refers to '*Algarve*' which is an expression which is universal to all languages. The combination of both search terms show results to Portuguese speakers who are looking for or writing about the ARs in the Algarve region of Portugal. The present document analysis reveals evidence that the Algarve ARs are known to some extent by some of the internet users who provide more or less reliable information to other people who are looking for information about the reefs.

All the documents analysed here were written in Portuguese, which suggests that most, if not all, of the Algarve reef users are Portuguese. The reefs are not usually the main topic of the discussions, but come up when some subjects are raised. The most commonly occurring group of people who talked about the Algarve ARs via the internet were divers, but since virtually every single person who has access to the internet can potentially find out about this subject, a wider range of different people can be reached via these simple records on the World Wide Web. However, using this means for analysis has a big drawback since it excludes the most important reef stakeholder group, i.e., the ones with extractive use of the structures – fishermen. The main reason for that is simply because fishermen usually do not use internet.

5.5. Stakeholder Analysis: Winners and Losers

5.5.1. Rationale

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, Jennings and Lockie 2002). According to MacArthur (1997) there are three main aspects associated with a stakeholder analysis: (1) to allow stakeholders participation and involvement with the project, (2) to use the methodology in order to assure the implementation of policy makes sense to those involved in the project, and (3) to use the methodology as a means of understanding the processes underlying the AR system and its natural resource management, so that it can be applied in a beneficial way.

The participation of stakeholders in the case of the ARs is concerned with the problem of sustainability of its resources. There are many degrees of participation (De Lopez 2001). More recently (mid-1980s), participation includes an element of empowerment in the project planning and decision-making, since the project will affect people's lives. The involvement of the stakeholder may also be dependent on the degree of ownership felt and attributed to the activities of the development and the outputs generated by it (Varvasovszky and Brugha 2000, Lim et al. 2005). This raises the question of who should be involved (Brugha and Varvasovszky 2000). 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, Ramirez 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 recognised, whether they are supporting the AR structures or opposing them. The stakeholder analysis allows that the policy objectives stated by the IPIMAR can be addressed and scaled to each stakeholder and their position can be evaluated. The overall stakeholder position can give important clues in the evaluation of the AR program risk.

5.5.2. Methodology

The approach used here 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 [in this case they are the policy objectives stated by the INIAP/IPIMAR (2003)]; (2) list all the different parties that may have any interest in the developments, where these will be the stakeholders (i.e. primary, secondary and external stakeholders); (3) determine the interests of the different stakeholders concerning the different policy objectives of the program, 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.

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[20], and 4th showing the importance of each stakeholder influence on a ranking scale from 1 to 5[21] 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 behaviour towards it; and (4) participation matrix, which is a description of the different types of participation that stakeholders have throughout the project development, their level of participation being expressed in a tabular ranking scheme.

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[20] Where -2 means the AR policy objectives have had a moderate negative impact and 5 means that the AR policy objectives have had an outstanding positive impact.

[21] Where 1 means the stakeholder has very little influence and 5 means the stakeholder has very great influence.

5.5.3. Results

Stakeholders can be listed and categorised in different ways. The selection of stakeholders puts them into three categories: primary (I), secondary (II), and external (III). They can interact with the structures through having private, public or cooperative interest (Table 5.11).

Primary stakeholders are all those people and groups that are affected by the project. This includes intended beneficiaries or those negatively affected (for example, fishermen that do not have eligible gear to fish in the ARs).

Secondary stakeholders are the intermediaries in the process of delivering the program to primary stakeholders. In the current situation they are represented by the central government and local public administrators (including funding, implementing, monitoring and advocacy organisations, or governmental).

External stakeholders are other individuals or institutions which have personal interests at stake, as well as formal institutional objectives. Here I have identified and listed all those stakeholders who are perceived as participating in the Algarve AR program throughout the different stages.

In terms of stakeholder class there were found: twelve primary, six secondary, and three external. Their main interests (which can be more than one) are described as well as the degree of impact the ARs may have on each stakeholder according to the policy objectives of the program (whether positive or negative); and finally, the relative influence that each stakeholder has on the project in order to meet their own interests is shown.

The impact of the project on stakeholders and their relative power to influence AR outcomes can be represented in a scatter diagram (Figure 5.15) where their position in the different quadrants may show where their interests lie. In this particular analysis it is possible to establish whether: (1) the program is meeting the interests of the primary stakeholders, and (2) there are strong negative interests that may put the success of the program at risk. Stakeholders' interaction with the ARs may lead them to attribute different values to the structures which will affect their attitudes and behaviour (Table 5.12).

Table 5.11 – Stakeholder table for the Algarve ARs program.

#	Class	Stakeholder	Institutional sector	Interest(s) in the project	Impact	Influence
1	I	'Local' fleet users	Private (firms)	ARs close to save time, safety onboard, catch certainty	+5	2
2	I	'Local' fleet non-users	Private (firms)	Hope that some species can be protected in the ARs	-1	2
3	I	'Coastal' fleet users	Private (firms)	Catch certainty	+5	2
4	I	'Coastal' fleet non-users	Private (firms)	Hope that some species can be protected in the ARs	-1	2
5	I	Fishermen associations	Cooperative	Create more fishing opportunities for their associates	+4	3
6	I	Fishermen producers org	Cooperative	To increase fishing production	+4	3
7	I	Charter boat anglers	Private (firms)	Catch certainty or just recreation	+3	2
8	I	Onshore anglers	Private (individuals)	Catch certainty or just recreation	+1	1
9	I	Anglers clubs and associations	Cooperative	To diversify fishing sites for their associates	+2	3
10	I	Diver operators	Private (firms)	Creation of extra diving sites	+4	2
11	I	Spear-fishing divers	Private (individuals)	Catch certainty	+1	1
12	I	Off-shore aquaculture	Private (firms)	To get a viable ground to produce their species	+4	2
13	II	Fisheries research institute	Public (local administration)	Demonstrates AR potential, onsite observations, data collection	+3	4
14	II	Directorate for fisheries	Public (local administration)	Keep stocks, avoid user conflicts	+2	4
15	II	Directorate for the environment	Public (local administration)	Stability of the materials	-1	4
16	II	Ports authority	Public (local administration)	Contribution to sort out fisheries management	+1	4
17	II	Financial institutions (EU + Pt)	Public (central government)	Good acceptability by those involved	+1	5
18	II	Navy	Public (local administration)	Contribution to sort out fisheries management	+1	4
19	III	University of the Algarve	Public (local administration)	To diversify their knowledge base	+2	4
20	III	City councils	Public (local government)	Creation of jobs related (both AR construction and use)	+2	4
21	III	Environmental agencies	Public (NGOs)	Coastal and stock protection, correct selection of materials	-1	3

Table 5.12 – Stakeholder interaction table with the ARs and likely attitudes and behaviour towards it.

#	Class	Stakeholder	AR interaction	More likely attitudes and/or behaviour
1	I	'Local' fleet users	Extractive value	To use the ARs if they are close and if their target species can be found there
2	I	'Local' fleet non-users	Diversion effect	To be slightly discontent because ARs do not provide them with a direct income
3	I	'Coastal' fleet users	Extractive value	To use the ARs mainly in their corridors
4	I	'Coastal' fleet non-users	Diversion effect	To be slightly discontent because ARs do not provide them with a direct income
5	I	Fishermen associations	Conservation value	To preserve ARs because they are associates' common fishing grounds
6	I	Fishermen producers organizations	Future availability value	To catch only the necessary and sizeable fish species
7	I	Charter boat anglers	Extractive value	To try the ARs to see if there is potential to obtain large specimens
8	I	Onshore anglers	Non-users	To think ARs were not deployed for shore anglers
9	I	Anglers clubs and associations	Conservation value	ARs are an additional angling spot
10	I	Diver operators	Non-extractive value	ARs are an additional dive spot, but due to their similar design shapes their use will be only occasional
11	I	Spear-fishing divers	Extractive value	ARs are an additional spot, but snorkel divers have physiological limitations to use them
12	I	Off-shore aquaculture	Extractive value	The structures may provide the physical and biological support to establish a business
13	II	Fisheries research institute	All values	Trying to get data from more ARs
14	II	Directorate for fisheries	Non-users	Do not bother much if there are no or few signs of conflicts among users
15	II	Directorate for the environment	Indirect use value	May be slightly discontent due to probable sand retention around the structures
16	II	Ports authority	Non-users	They are involved in the consultation process
17	II	Financial institutions (EU + Pt)	Conservation value	To be happy if the investment shows signs of success
18	II	Navy	Non-users	They are involved in the consultation process
19	III	University of the Algarve	Conservation value	Trying to get data from more ARs
20	III	City councils	Non-users	Partial social and economic problems solved if ARs are contributing to increase jobs and economic benefits of users
21	III	Environmental agencies	Conservation value	To oppose to ARs if there are any signs of pollution or species over-fishing derived from congestion

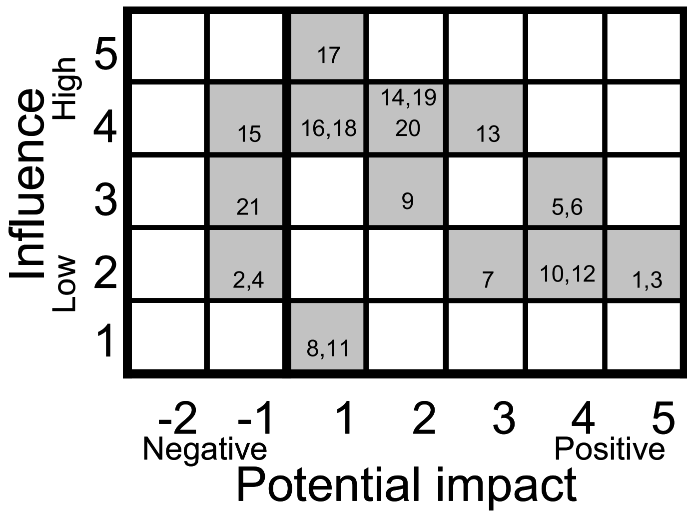


Figure 5.15 – Stakeholder classification matrix. The figures in each cell represent each of the stakeholder numbers found in Tables 5.11 and 5.12.

During the different stages of AR development there are different levels of stakeholders' inclusivity. In the earlier stages of the program few stakeholders are involved, whereas in the later stages some other stakeholders appear. The aim is to include all the stakeholders with increasing level of participation (Table 5.13).

Table 5.13 – Participation matrix for the development of the Algarve ARs program. The figures in each cell represent each of the stakeholder numbers (1 to 12 primary, 13 to 18 secondary and 19 to 21 external).

Stage	Degree of involvement				
	Inform	Consult	Partnership	Delegate	Control
Identification					13
Planning	5,6,14,15,16,18, 19,20,21	17			13
Implementation	1,2,3,4,7,8,9,10, 11,12,20,21	5,6,15, 16,18	14	17	13
Monitoring and evaluation	1,2,3,4,7,8,11, 17,21	9,12,15, 16,18	5,6,10,19,20	14	13

5.5.4. Discussion

There are groups of interested people from the moment they participate in the AR project or 'discover' the structures. In the case of reef users, their interest is triggered by the experiences they encounter when using the reefs. If they enjoy good outcomes when they used the reefs, they will wish to repeat the experience. Empirically they are judging the structures in their own interests and evaluating them according to their needs. However, as Milon et al. (2000: 172) highlight, stakeholders are all those involved with reef deployment even if they oppose it. This can be the case of certain environmentalist groups or entities having opposing interests.

Worldwide there is a general consensus that usually after reef deployment the benefits will outweigh the costs. However, in this scenario there are not only winners, but also losers. From an economic perspective, winners might be all those who can use the reefs and achieve higher incomes from this action. Winners are also those who, even if they do not get higher revenues, can gain in time-saving, catch certainty or safety. Losers may be the ones that due to reef deployment are expelled from the reef area or have operational limitations (e.g. dredge owners).

In this stakeholder analysis it seems that the program is meeting the interests of most of the primary stakeholders. It also seems that those stakeholders to whom AR deployment has impacted negatively do not pose a threat to the success of the AR program.

5.6. Conclusions

For the social analysis, it is very important to identify all the relevant stakeholder groups involved in the reef development, as well as their relationship to the structures. Stakeholders' interaction with the ARs varies according to many factors, such as their level of knowledge about the structures, their degree of use or non-use and likely attitudes and behaviour, interests/expectations and satisfaction, and also their involvement and inclusion in the process.

These issues can be studied by using different analytical techniques. Such studies are important because of their potential to identify research priorities that managers and policy makers need to know. To the best of our knowledge, the different methodological approaches employed in this chapter have not been used in the AR context before now. In addition, once stakeholders are involved in the reef analysis they should give some feedback contribution and the information collected in such a social analysis can be very valuable to managers so that they can address appropriately the different AR policy objectives.

From this social analysis, it can be concluded that in general there are positive attitudes towards the Algarve ARs deployment. However, there is little widespread printed or electronic information available on the subject, though enough to stimulate the curiosity of some potential or actual users. An additional conclusion is that the Algarve AR policy objectives may affect many stakeholders, but few of them may have direct benefits from their economic activities in the reef areas. For example, Seaman (2004) highlights that initially ARs are probably peripheral to users' interests since they have their own preferred sites (i.e. fishing and dive spots). In addition, in the case of fisheries in the Algarve region, it seems that the activity is more competitive than cooperative. Fishers usually choose sites that they do not wish their direct competitors to know about. However, in the case of the ARs, it seems that their competitive view alters somewhat, since they are aware that the structures were deployed with the objective of enhancing catches (amongst other things) and that all eligible fishermen have the right to use them. So, they usually share the information about the productivity and efficiency of the ARs. This sharing of information is half way to cooperation, as pointed out by Salas and Gaertner (2004). It is perceived as a synergistic overall benefit derived from cooperative actions where the resultant effect is greater than the sum of all individual actions (Guttman 1996). However, there is not cooperation among all fishermen, because among some of them there is a sense of independence. This is the limiting factor in pursuing cooperative activities.

Chapter 6

Economic Assessment

Contents

Word Count: 15,792

6.1. Introduction

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 the Algarve. Focusing on economic efficiency, it is important to establish whether effectively, the AR program is a good or bad project. In order to do this, it is important to find answers to some questions. As regards economic efficiency, it is important to know: (1) If the socio-economic objectives of the project have been met, (2) If the economic benefits derived from reef use have been satisfactory, (3) If the users have been attracted to ARs because of the increased opportunity for better revenue expectations, and (4) If reefs' signs of performance throughout time have a pattern.

Basically these questions serve to establish whether the monetized value from project benefits exceeds the project costs and to what extent. To investigate the above questions three approaches will be adopted. One of them is based on scientific survey catch records and also information about fish landed in official fish markets. The second approach aims to find out about maximizing benefits from fishing by prioritizing criteria and alternatives through the use of the AHP methodology. Identical information is used to find out more about diving activities. Finally, the third approach is a cost benefit analysis (CBA) on the deployment of a pilot reef and its use by small-scale commercial fisheries.

6.2. Analysis of Artificial Reef Productivity

6.2.1. Rationale

Stakeholders may have different opinions about the effects derived from AR deployment. They can easily qualify impacts by ranking a list of possible items, but cannot actually quantify AR impacts. To do so it is necessary to collect quantitative data. 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 obtained variations can be seen as desirable if it is demonstrated that ARs have influenced positively the activities under analysis in a given community or region. Unfortunately it seems difficult to estimate employment variations.

The aim in this section was to see whether variations in euros (€) per unit of effort could be explained statistically by 'reef effects'. In order to verify this, reef effects are subsequently divided into four categories and tested statistically.

6.2.2. Material and Methods

Instruments

To carry out this efficiency analysis based on productivity approaches, it is necessary to obtain information from the following sources:

- *Scientific fishery trials (SFTs)* – RV surveys from October 1990 until December 2005 were carried out using traditional fishing gear to simulate commercial fisheries.

- *Direct site observations (DSOs)* – All the fishing vessels having regular patterns of use (RPU) based on data from the direct site observation forms collected in the 2002-2004 period were selected.

- *Electronic data (ED)* – Detailed data on observed vessels fishing in the OARS were collected from DGPA. Data reported official landings and respective selling market prices and were used to cross-check DSOs.

Study sites

The SFTs were carried out both in the Olhão and Faro areas as described by Santos and Monteiro (1997, 1998, 2007). The pilot reefs in the structures called protection modules (FPR and OPR) and exploitation (FER and OER) were sampled. Control sites for each reef type were also used, whether protection or exploitation (C*PR and C*ER, respectively). Control sites were located 1.8 to 4.6 km east and west of each artificial reef, at the same range of depths and similar distance from the coast. This helped to avoid or minimize the possibility that they might be affected by the presence of the man-made reefs. The artificial reef systems are located off the Ria Formosa lagoon (Algarve, south Portugal), deployed 2.0 to 3.0 km offshore from Olhão on a sandy-muddy bottom and 2.6 to 4.8 km off Faro on a flat sandy bottom (Figure 6.1).

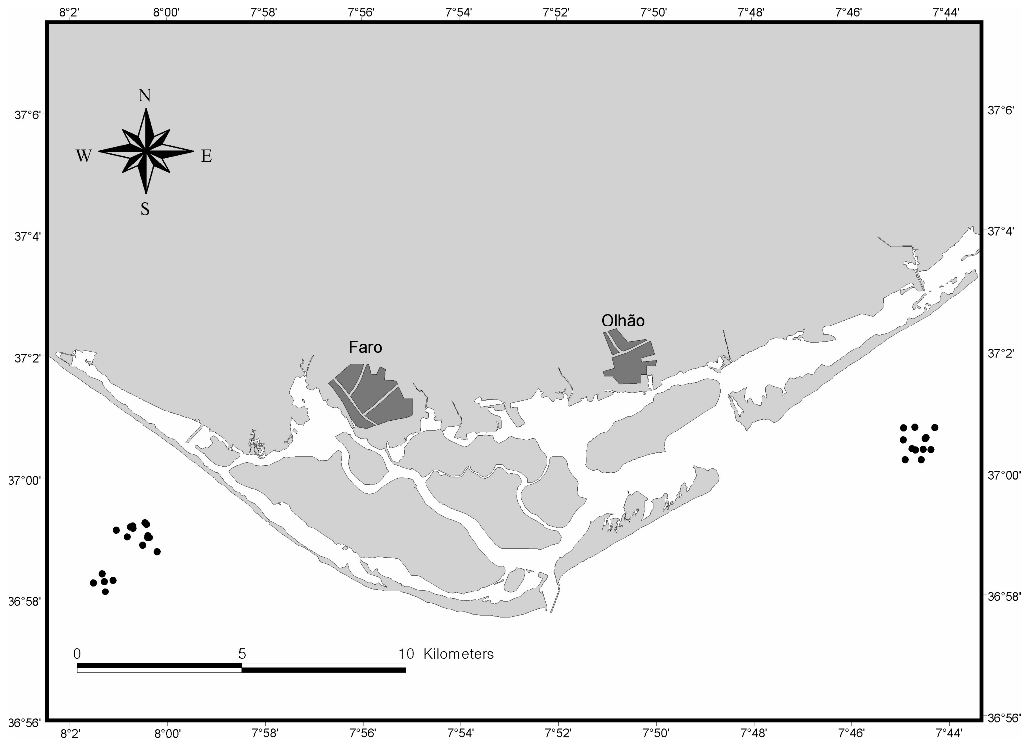


Figure 6.1 – Location of the pilot reefs (Faro and Olhão).

For the DSOs there is just data from the Olhão AR area (OARS). Once the data was collected from direct observation, control areas are assumed to be like any other area with the exception of the ARs. In order to find out if a given vessel effectively fished in the OARS, the days it was observed were recorded. By cross-checking this information with official landing data, catches in the reef zone are obtained. It is assumed that a vessel did not fish in the OARS if in the DSOs there is no record of that vessel, whether this vessel had or had not landed on that day (Figure 6.2).

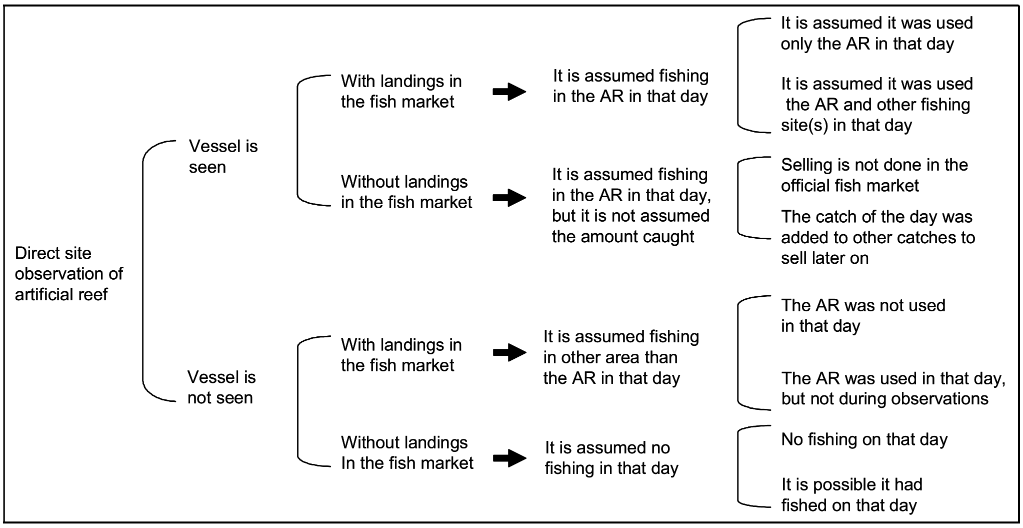


Figure 6.2 – Assumptions derived from cross-checking data from direct observations with fish market landings.

Statistical techniques

In order to perform an economic analysis based on AR productivity approaches it becomes important to make a judgement 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. submitted and under review). Therefore, in this study the calculations for the productivity approaches were based on:

(1) Paired samples t-test of mean - It was important to test if there were differences between: (1) reef versus control catches, (2) the different types of reef structures, (3) the location of reefs, and (4) time periods. The results derived from testing hypotheses may be relevant to finding out whether there was a reef effect in terms of catches and correspondent revenues (variables). To that end, there were carried out paired samples t-tests of mean catches and revenues at the reef and corresponding control sites. The hypotheses to test were:

$$H_0 : \overline{X_i} = \overline{X_j} \ ; \ H_1 : \overline{X_i} < \overline{X_j}$$

Where: ‘i’ represented the variable in the analysis when in the control site and ‘j’ when in the reef.

Sample means for the type of reefs (exploitation and protection) were also compared:

$$H_0 : \overline{X_k} = \overline{X_l}\ ;\ H_1 : \overline{X_k} \neq \overline{X_l}$$

Where: ‘k’ represented the variable in the analysis when in the exploitation reef and ‘l’ when in the protection reef.

There were also compared the sample means for the geographic location (Faro and Olhão):

$$H_0 : \overline{X_m} = \overline{X_n}\ ;\ H_1 : \overline{X_m} \neq \overline{X_n}$$

Where: ‘m’ represented the variable in the analysis when in the Faro area and ‘n’ when in the Olhão area.

Finally, there were compared the sample means for time between reefs and control sites:

$$H_0 : \overline{X_p} = \overline{X_q}\ ;\ H_1 : \overline{X_p} \neq \overline{X_q}$$

Where: ‘p’ represented the variable in analysis for observations at the reefs in October 1990, increasing over time in monthly units through to September 2005; and ‘q’ is used for observations at the control sites.

(2) Multiple regression econometric model – A model was developed using qualitative variables to test value of fish per unit of effort (VPUE). The model accounts for the separate effects of reef versus control sites, type of reef (i.e. exploitation or protection), location (i.e. Faro or Olhão), and time (in months). The variable time is used as a proxy for any underlying change in productivity over the whole area (as might be expected if effort had changed). Four binary (i.e. dummy) explanatory variables were included in order to calculate their influence on revenues as seen in Equation 1.

$$VPUE_i = \beta_1 + \beta_2 E_i + \beta_3 C_i + \beta_4 L_i + \beta_5 T_i + u_i \qquad \text{Equation 6.1}$$

Where: 'VPUE' is the outcome score for the value per unit of effort for the i^{th} observation; β_1 is the coefficient for the intercept; β_2 , β_3 , β_4 and β_5 are the coefficients for the slope when considering the dummy variables 'reef effects, 'reef configuration', 'reef location', and 'time', respectively; E_i , C_i , L_i , and T_i are the dummy variables for reef effects, configuration of the reef (1 if the i^{th} observation is at the exploitation reef, 0 otherwise), reef location (1 if the i^{th} observation at Faro, 0 otherwise), and time (1 if the i^{th} observation for months at the reef since November 1990 to September 2005, 0 otherwise), respectively; u_i is the residual for each i^{th} observation. It should be noted that reef effects were included in the analysis in two ways: (i) as a shift dummy (i.e. 0 for observations at the control site, 1 for those at the reef), and (ii) as an interaction dummy between reef observations and time.

For the statistical analysis fishing hauls were grouped by month in each year. The economic value of caught fish is assumed to be the same along the time-series.

6.2.3. Data Collection

<u>Scientific fishery trials</u>

For the SFTs artificial reefs and control sites were chosen for sampling. Samples were taken using bottom gill nets as described by Santos et al. (1996b). The sampling period covers 16 years (October 1990 to December 2005). In the statistical analysis fishing hauls were grouped by month in each year, resulting in 256 fishing events distributed evenly by each of the eight locations under analysis (Table 6.1).

Table 6.1 – SFTs in four areas (two reefs and two respective controls) along a temporal series where each cell represents the average number of species caught by sample and fish species biodiversity.

Location	Faro				Olhão			
Reef type	Protection		Exploitation		Protection		Exploitation	
Site	Control	AR	Control	AR	Control	AR	Control	AR
1990	12	7	12	12	3	13	13	12
1991	38	60	33	47	40	40	29	34
1992	32	37	20	41	32	37	23	34
1993	52	56	50	54	49	55	43	49
1994	25	26	22	32	14	38	23	19
1995	18	22	18	22	14	13	16	23
1996	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-
1998	15	30	19	32	23	28	24	29
1999	12	13	7	10	4	8	6	13
2000	18	35	15	33	7	33	8	29
2001	18	15	18	17	10	24	12	19
2002	19	28	14	31	14	25	12	30
2003	3	10	7	24	7	20	7	18
2004	14	24	18	38	13	35	8	22
2005	13	22	10	23	10	16	12	18

According to Santos et al. (1996b) ‘gill nets were utilised because they are an efficient method for investigating the reefs on a regular basis, are widely used in this region, and are the most effective individual sampling technique’. The technical procedure is described by Santos and Monteiro (1997, 1998), where ‘the standard net was 750 m long and 2.8 m wide, with a stretched mesh size of 60 mm, set for 3 h. The 60 mm mesh was chosen because it is the legal size and it may be the most adequate from a management perspective. Each fishing operation consisted of setting three standard nets. Four fishing operations were conducted per year (one every three months) at each site, corresponding to 72 fishing operations (216 net sets). The reefs and the control sites were sampled simultaneously, in order to reduce fish variability due to weather and sea conditions. The nets were set at night (2±3 h before sunrise) and retrieved about 1 h after sunrise, to provide 3±4 h of fishing. This is the usual procedure of local fishermen.’ It is important to highlight that for SFTs a unit of effort (UE) corresponds to a standardized gill net 750 m long by 2.8 m wide with a 60 mm mesh size fishing for a period of 3 hours.

Small-scale fisheries

All days vessels were seen operating in the AR area were recorded. A list of thirty different commercial fishing vessels was attested. Through data triangulation (via ED) it was possible to check on which days those vessels sold their catches in the official market. From the initial list of 30 vessels, the results of data triangulation showed that only one vessel had a reliable number of fishing days in the reefs and concomitant fish sales in the official fish market (Table 6.2). The type of gear that best characterized the vessel corresponded to the use of pots. All the other vessels that had a regular pattern of reef use were not considered in this analysis due to lack of observations and respective fish market landings. There is no standardized figure for the units of effort applied in the case of small-scale fisheries (recorded via DSO and ED).

Table 6.2 – Small-scale fishery vessels observed operating in the OARS area at least 5 times in the observational period 2002 – 2004[22].

Vessel	Gear	2002		2003		2004	
		O	L	O	L	O	L
A	Pots	0	0	17	15	1	1
B	Pots	4	2	2	0	0	0
C	Nets	0	0	6	-	0	0
D	Pots	1	0	10	1	0	0
E	Pots	1	-	4	-	-	-

Fish price attribution

More than 100 different species were recorded, with approximately two-thirds having commercial value. However, the economic value of caught fish is always considered the same throughout the time-series. The prices for each species were based on surveys in the market of Olhão for the year 2004.

In the case of commercial fishing results, fish prices vary according to the official fish market price. This means that the same species is subject to variations in the price throughout the year due to several factors such as: (1) the demand for each species,

[22] Data represent observations (O) and corresponding landings in the same day (L). The sign '-' (hyphen) means no data available, whereas '0' (zero) means no recorded landings in the observed day.

(2) the supply either by the amount of fish landed in the port or by the competition effect from other substitute products, (3) the size, weight and condition of fish landed, and (4) intermediary buyers and their influence.

6.2.4. Results

Statistics

(1) Paired samples t-test of mean – This was carried out as a preliminary to the regression analysis. Table 6.3 shows the t-test results for the variables catches and economic benefits in terms of differences between: (1) site reef versus control, (2) type exploitation versus protection, (3) location Faro versus Olhão, and (4) time post-deployment versus time control sites.

Table 6.3 – Results obtained from the t-test. The signs used are: '+' when $P < 0.05$, '++' when $P < 0.01$, and 'n.s.' for non-significant results.

Comparison	Compared parameter	Catches	Revenue
Site (AR vs control)	FER – CFER	++	++
	FPR – CFPR	++	++
	OER – COER	++	++
	OPR – COPR	++	++
Type of reef (exploitation vs protection)	FER – FPR	n.s.	n.s.
	OER – OPR	n.s.	n.s.
	CFER – CFPR	n.s.	n.s.
	COER – COPR	+	+
Location (Faro vs Olhão)	FER – OER	++	+
	FPR – OPR	+	n.s.
	CFER – COER	n.s.	n.s.
	CFPR – COPR	++	++
Time (AR vs control from Oct. 1990 increasing over time in monthly units through Sep. 2005)	$FER_{(t+1)-t}$ – $CFER_{(t+1)-t}$	++	++
	$OER_{(t+1)-t}$ – $COER_{(t+1)-t}$	++	++
	$FPR_{(t+1)-t}$ – $CFPR_{(t+1)-t}$	++	++
	$OPR_{(t+1)-t}$ – $COPR_{(t+1)-t}$	++	++

From the information summarized in the above table, it can be seen that the reef effect is present because at least two of the independent variables (i.e. site, and time) are statistically significant in both catches and revenues in all situations. In addition, it seems that the distinct reef types do not present significant differences. Finally, geographic location seems to be significant for some situations.

Catches

A graphical analysis of the reef effect is shown in Figure 6.3. It can be observed that catches can vary according to the reef location, but do not vary according to the type of reef.

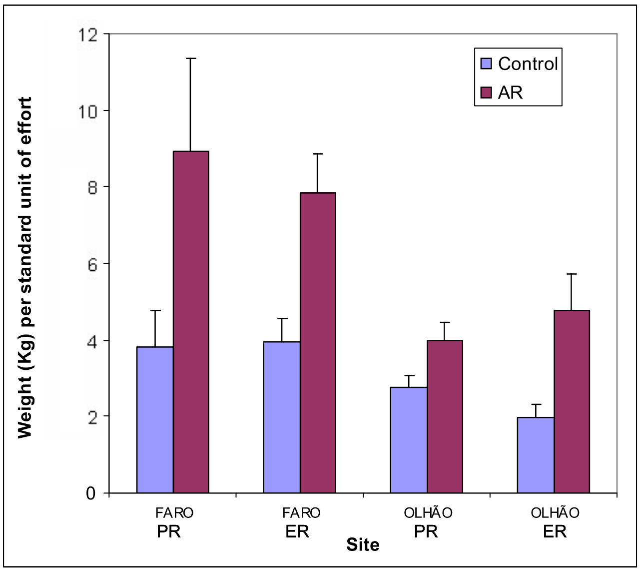


Figure 6.3 – Catch effects of the Faro and Olhão ARs, based on a RV fishing trials (n = 256).

According to the analysis, small-scale commercial fisheries seem to be more productive when using the AR (Figure 6.4). However, this conclusion has to be regarded as tentative, since the analysis is based solely on one vessel targeting exclusively one species in a single year.

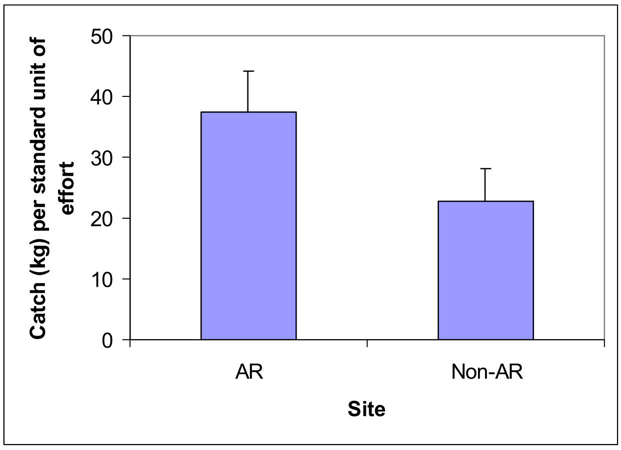


Figure 6.4 – Economic effects of the Olhão AR (OARS), based on a small-scale commercial vessel (n = 30).

Revenues

Looking at revenues for the fishing experimental trials, it seems that there is a similar pattern for the expected sales of the overall catch. For instance, the Faro exploitation reef (FER) was more profitable than the corresponding control site per unit of effort. This is true also for the Faro protection reef (Figure 6.5).

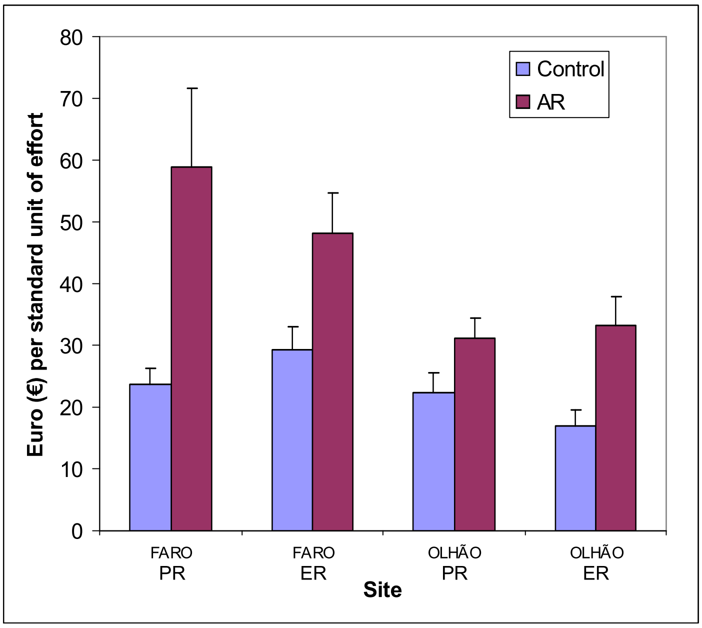


Figure 6.5 – Economic effects of the Faro and Olhão ARs, based on RV fishing trials (n = 256).

When considering the average revenue derived from SFTs by group of species (pelagic, demersal and benthic), the reef effect can be noted (Figure 6.6). The effect is more evident in the case of the revenue derived from demersal and benthic species rather than pelagic ones. The results over this 16-year period of observations show that an average catch in a control area can be worth between €18 and €29 by UE, whereas in a reef area that figure rises to €42 and €66 by UE. The results also show that in the Faro reefs the average revenue is higher for demersal species, whereas in the Olhão reefs the highest value is for benthic species. The average value of pelagic species for any reef is around 5% of the total revenue obtained. However, this figure is masked because the fishing gear used does not aim to target pelagic species.

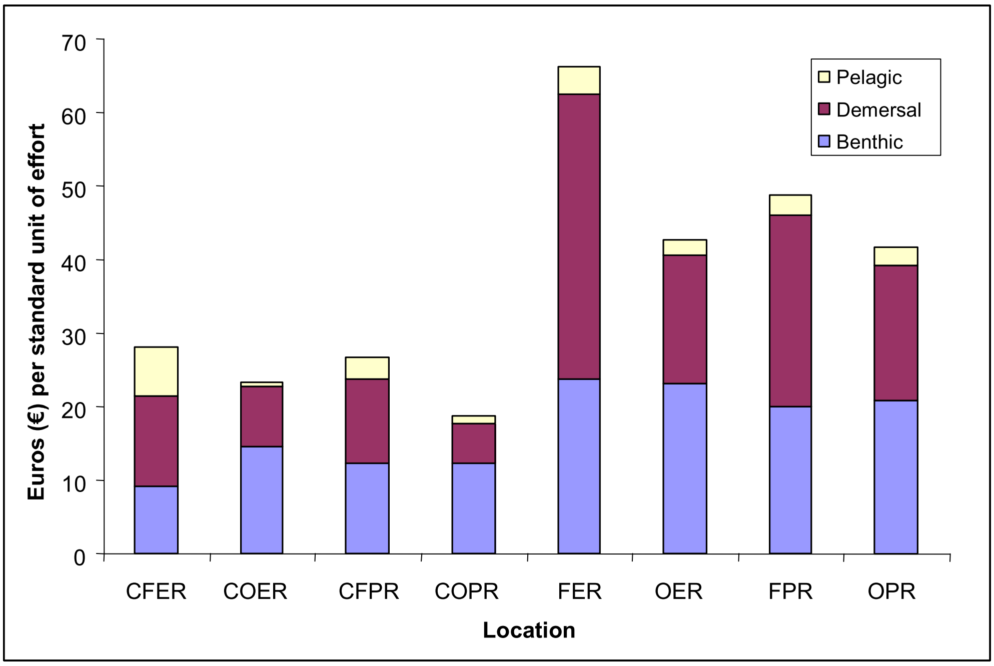


Figure 6.6 – Average commercial species value observed in catches in the reefs of Faro and Olhão and respective controls (based on SFTs where n = 256).

Small-scale commercial fisheries' results similarly show that there is a higher economic return when fishing in the AR when compared to fishing elsewhere (Figure 6.7).

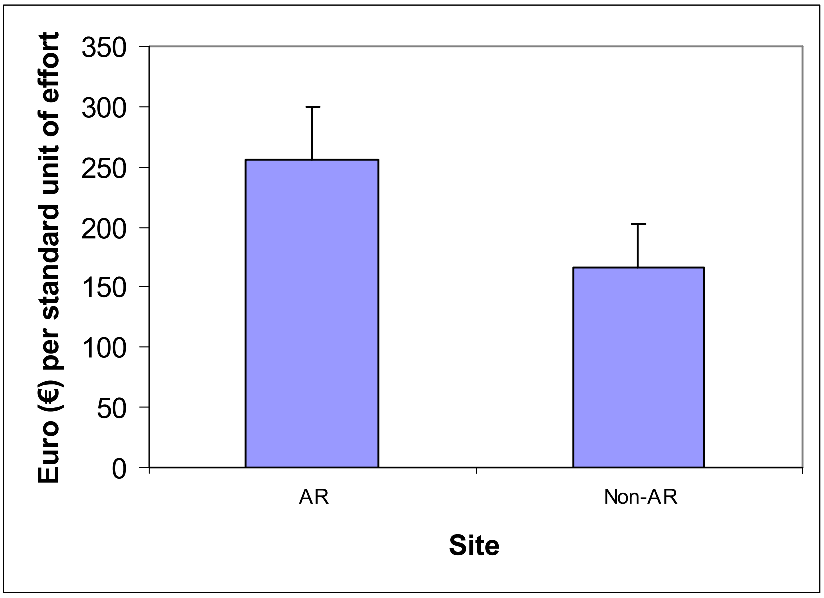


Figure 6.7 – Economic effects of the Olhão ARs, based on data cross-checking derived from a small-scale commercial vessel (n = 30).

Comparative indicators

Overall, these results show that catches and revenues at the reefs can be expected to catch/earn more per unit of effort than they would at the corresponding control sites, *ceteris paribus* (other things being equal). Table 6.4 shows the results obtained.

Table 6.4 – Reef effect results per unit of effort by comparing catches in ARs with catches in control (scientific trials) or elsewhere (small-scale fisheries) sites.

	Scientific fishery trials	Small-scale fisheries
Catches (quantity in Kg)	+3.73	+14.83
Revenues (selling price €)	+24.66	+88.89
Reefs studied	Olhão and Faro (pilot)	Olhão
Source of revenues	Market surveys	Daily market price
Number of samples	256	30
Unit of effort	750 m of 60 mm mesh size gill net and 3 h set	Clay pots web per fishing day
# species caught	Over 100	1

(2) Multiple regression econometric model[23] – The regression analysis confirms the evidence indicating a positive 'reef effect'. Table 6.5 presents the results of the linear model.

Table 6.5 – SFTs regression results (linear model): comparison between revenue (VPUE) in ARs and control sites (n = 256, R^2 = 0.227, D-W statistic = 1.795, F = 18.4).

Performance indicator (ind. variables)	Regression coefficient	*t*-statistic	Significance
Average revenue (€) due to effect of:			
Constant	13.833	3.653	0.000
Reef	13.089	2.551	0.011
Type	5.243	1.385	0.167
Location	11.240	2.968	0.003
Time	0.177	3.824	0.000

[23] All data comes from the paper Whitmarsh et al. (submitted and under review).

The results of the linear model indicate that three of the independent variables 'reef', 'location' and 'time' are statistically significant. From the coefficient of the independent variable 'reef' (13.09) catches at the ARs would be expected to earn around €13 per unit of effort more than they would at the control sites, *ceteris paribus*. In the same line of thought 'location' implies that VPUE would be €11 higher at Faro than at Olhão; and 'time' implies that over time VPUE on the reefs (but not at the control sites) increases by approximately €0.18 per month.

By its turn, the log-linear model also indicates the significances of the variables 'reef', 'location' and 'time' by substituting in the expression 'e^{x}' each of the 'x' values presented on Table 6.6.

Table 6.6 – SFTs regression results (log-linear model): comparison between revenue [Log(VPUE)] in ARs and control sites (n = 256, R^2 = 0.255, D-W statistic = 2.065, F = 21.5).

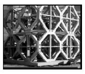
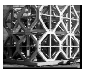
Performance indicator (ind. variables)	Regression coefficient	*t*-statistic	Significance
Effect on revenue (e^x):			
Constant	2.652	28.893	0.000
Reef	0.548	4.406	0.000
Type	0.087	0.946	0.345
Location	0.298	3.243	0.001
Time	0.003	2.502	0.013

From the log-linear model it is also obtained that 'reef', 'location' and 'time' are statistically significant, but the coefficients have to be interpreted differently. The coefficient for the REEF variable, means that catches at the artificial reef sites would be expected to earn 1.73 (= $e^{0.5481}$) times more than they would at the control sites when first installed. Similar analysis can be done for the remaining variables, where the figure of variable 'location' shows that each unit of effort spent at Faro would expect to earn 1.35 (= $e^{0.2977}$) times what it would at Olhão, considering a control over the effect of the other factors, and the coefficient of the variable 'time' shows that the rate at which VPUE on the reefs changes month by month is 0.0028. It was also found that in neither of these models the type of reef (i.e. whether protection or exploitation) is statistically significant.

Catch by reef volume

As shown above, the 'type of reef' does not seem significant in terms of surplus catch/revenues. Thus, if we consider that reef volume occupied by 'protection' and 'exploitation' reefs is different, catch should differ between the unit of volume found for the different types of reef as well. Table 6.7 shows that the reef effect is considerably higher per unit of volume in the protection reefs for both locations analysed. However, it is noted that in terms of average catches and their corresponding revenues, geographic location effect reflects higher importance in terms of economic efficiency than the reef type considered.

Table 6.7 – Fish catch and corresponding revenue calculations by AR cubic metre by unit of standardized effort unit.

Reef	Average catch (g/m^3)	Average revenue (€/m^3)
Faro		
 PR	3.92	0.025
 ER	3.27	0.021
Olhão		
 PR	2.74	0.020
 ER	1.56	0.012

At first sight it may be concluded that modules having the same size can have an identical contribution to fish production/attraction. Thus, geographic location and fishing effort can be influential factors in that contribution.

6.2.5. Discussion

Both for scientific fishing trials and small-scale fisheries, there seems to be clear evidence of a reef effect. Scientific fishing trials revealed that the value per unit of effort (VPUE) in the ARs is generally higher than at the control sites. In that sense we can say that economic benefits derived from reef use are positive, though whether the deployment of these structures represents a good investment in terms of net present value (NPV) remains to be seen.

Site may have also effects on catches, since over the time series studied, Faro ARs are overall more productive than Olhão ones. Biologists record that there are different surrounding environments at each site, where Faro AR is near some rocky outcrops compared to the Olhão AR, which is completely surrounded by sand or mud bottoms. That fact alone may greatly influence the results obtained, where it is believed that areas with higher rate of rocky substrates (Faro) are richer than others where these features are scarce (Olhão).

The type of reefs, i.e. ‘protection’ versus ‘exploitation’ modules, may have some influence but it does not seem clear what this influence is. The difference exists if we consider reefs’ volume. Here it is clear that fishing in the protection reefs has a higher positive impact in terms of weight catch per reef unit of volume. The higher number of interstitial surfaces found in the ‘protection’ reef type modules are probably related to the creation of higher biomass at any level.

6.3. Analysis of Fishing and Diving Reef Priorities

6.3.1. Commercial Fisheries

Rationale

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 fulfil a fisheries function (Jensen 2002). As a public investment, it is important to establish their role in terms of feedback and economic return in the medium term. In the fisheries sector, ARs are expected to facilitate vessels that operate with suitable gear, namely by saving time and assuring greater catch certainty (Simard 1996). In the Algarve (South Portugal), since AR deployment it is necessary to find out whether the investment has been worthwhile in terms of fisheries management or not.

However, 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. Fishermen use their empirical experience to ensure the highest catch possible. However, converting catch into profits is highly dependent upon the demand, especially by species' prices found in the market. By determining which criteria (and sub-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).

A site's 'value' can give rise to problems, particularly if there is evidence that a given AR is much more productive than grounds elsewhere. This can result in extra effort and overexploitation if no management measures are taken. Not all gear is suitable for use in the ARs. In the Algarve, the areas that were previously 'pure' open access have ceased to be so since the ARs' deployment, due to the fact that gear restriction was imposed by the structures of the ARs themselves.

It is intended in the first instance to consider the AR program as a management measure to maximize commercial fisheries benefits. The 'decision problem' or main goal to achieve is then to get consistent support for the management of fishing grounds through the data provided by commercial fishermen (both via logbooks and their own perceptions). Here the efficiency analysis is conducted by using the analytic hierarchy process (AHP).

Material and methods

The collaborators

In April and June 2003 and May 2004, seminars in three different local communities were conducted with fishermen regarding ARs (Figure 6.8). Overall about eighty participants were present. At the end of each presentation some skippers decided to collaborate in this survey, and we adopted a focus group-like approach to talk to fishermen who were potential/actual AR users. The groups had in total twelve fishermen (15% of all participants). This qualitative method was used on the grounds that it is an acceptable way of bringing about a group of people from the same community to discuss a research question (Robson 2002). *A priori* four goals were selected for the groups: (a) to gauge interest stimulated by the presence of the ARs on the nearby coast; (b) to get feedback about their actual use; (c) to get collaborators (or key-informants) to fill out our logbooks, both in the ARs and outside of them; and finally (d) to conduct a brief questionnaire survey on collaborators' details.

Logbook sheets (n=76) already filled in by fishermen were collected approximately one year later and also an AHP questionnaire was conducted with 12 skippers (half in each fleet type, i.e., six from the local vessels and the other six from the coastal vessels).

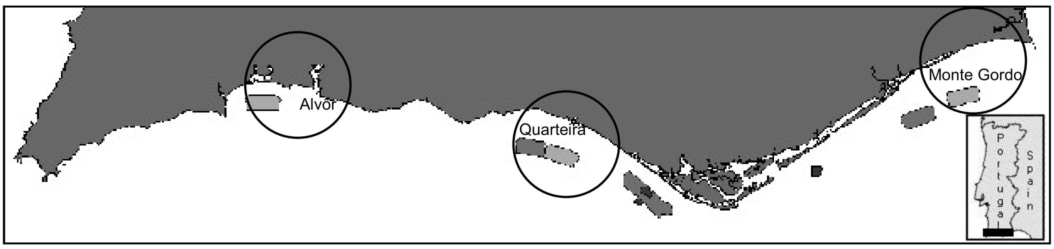


Figure 6.8 – The ARs' location area and the origin ports for the vessels studied.

The collaborators usually use multipurpose gear and adapt it according to the time of year or for some other reason related to the actual circumstances of their fishing operations. The findings they reported in the observations will provide valuable information about how the fish resources can be managed in the future.

It was proposed to make a comparison between data collected via logbook sheets and those collected via a questionnaire in order to find out what the main differences between both methods are. Logbook sheets provide fishermen's quantitative data that are subsequently used to elicit weights by the researcher, whereas the AHP questionnaire asks fishermen directly to elicit weights.

Developing an AHP tree structure

In this particular study, the AHP approach is used to find out which criteria the skippers usually choose to go fishing. So, at the top of the AHP tree stands the main goal skippers choose in order to maximise benefits from fishing in the long run (Figure 6.9). It is important to study the problem of measuring fishing efficiency in each of the sites contemplated. The next step was to establish the criteria taken into account in the decision to fish at one site rather than another, and what makes this site more attractive than the others. In this study we assumed that fishing efficiency is a function of three main factors or criteria: 1) Biological, 2) Economic, and 3) Technical. Since it is very difficult to elicit values for these criteria, they were subsequently divided into sub-hierarchies in order to facilitate comparisons. This AHP step is sometimes recommended (Saaty and Vargas 2001: 2) in order to make the analysis easier.

The biological sub-goal is further divided into two criteria: by-catch, and catch weight (measured in kilograms). Both criteria include catches in the ARs and elsewhere. By-catch includes non-target commercial species landed and takes into account their number. It is important to keep this indicator relatively low, by minimizing by-catches. In contrast, catch weight objective should be maximized.

The economic sub-goal takes into account two criteria: revenue and employment. The revenue category in turn is divided into vessels' average daily revenue when fishing in an AR ground and when fishing elsewhere. This objective should be maximised. Revenue also includes the ratio of high valued species, because they can contribute more to fishing efficiency. The higher the value of the species, the higher will be the relative revenue. Employment refers to the number of people that take part in the fishing process, such as full-time employees for the vessels analysed. In the questionnaire the employment category is divided into part-time or full-time work. The objective of this category is to maintain approximately the same number of people in the activity.

In the technical sub-goal two criteria are also considered: one related to the preferred fishing grounds, and another one related to the effort produced by the vessel. Grounds relate to the potential yield that the ground is able to produce according to the stage of its maturity and the biological habitats' establishment. Finally, the effort category takes into account the catching power generated by gear, including the likely damage inflicted on the available resources, and also how selective a gear is.

For the remaining analyses, two different approaches were adopted which differed slightly: (a) A survey asked skippers' preferences for fishing grounds' characteristics and their main fishing grounds; (b) The logbooks indicated the exact location of fishing grounds used by each skipper who provided them.

Six fishing grounds were selected as the sites to achieve the main goal: five ARs (Alvôr, Oura, Vilamoura, Faro, and Windward), and one non-AR site ('Elsewhere'). It is believed that these fishing grounds play an influential role in many of the small-scale coastal fisheries in the Algarve. It was deemed necessary to compare the sites amongst themselves as well as their overall influence on fisheries in the region.

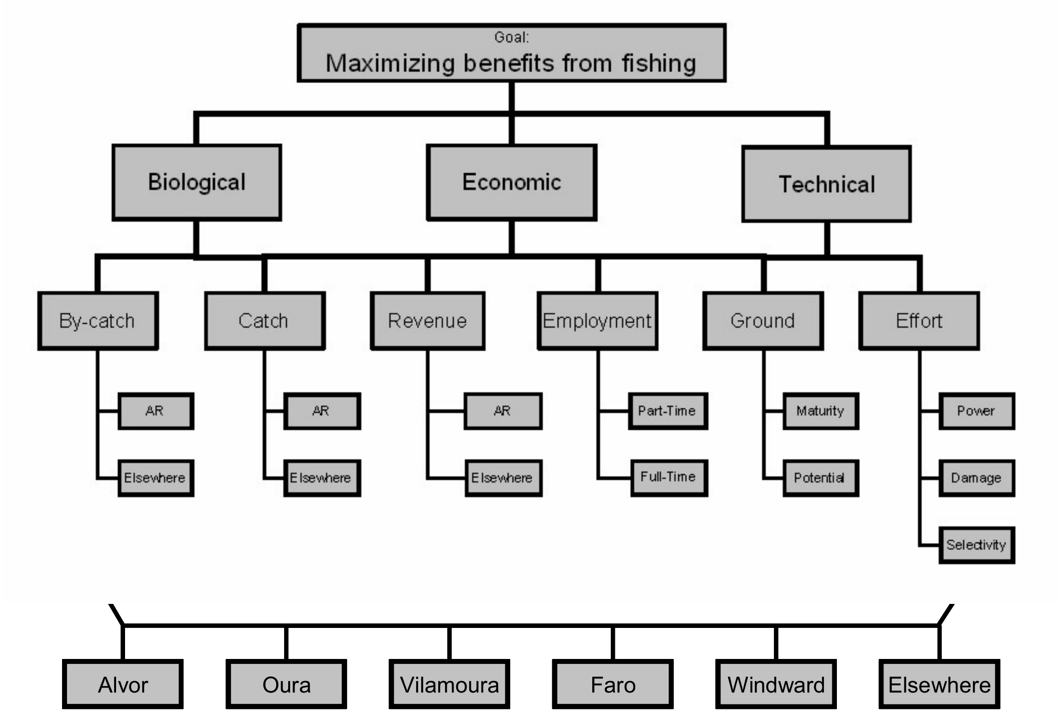


Figure 6.9 – The AHP tree: maximizing benefits from fishing objectives. In the upper part of the tree at the top there is the main goal, on the second level there are the sub-goals, on the third level the criteria, and then on the fourth level the sub-criteria. The lower part of the tree presents the fishing grounds (options/alternatives).

Weights elicitation

The application of the weighting process to the levels of the hierarchy starts at level two. After that the normalised priority weights (eigenvector) are calculated for the efficiency analysis objectives. In making the judgements about the power or importance of each criterion, the help given by those who are knowledgeable about the fisheries situation was fundamental. In this study, the elicitation of weights was done by the author both through the interpretation of the fishing logbooks provided by skippers, and also by fishermen answering the questionnaire.

The elicitation of weights is a necessary but time-consuming interactive procedure. A common AHP -9/9-point scale converted all the information collected in the logbooks, and the weights were derived by pair-wise choices. Whereas in the first part of the tree the elicited values were based on each of the logbook observations, the second part took into consideration facts related to the ARs known in advance. When data collected were not sufficient, mechanistic elicitation was done by judgements based on a background study, without any empirical justification. Saaty and Alexander (1981: 154) highlight that the former procedure is obviously preferable, but that it is not always possible. Finally a sensitivity analysis was carried out for each of the criteria and alternatives.

Results

Criteria

Figure 6.10 shows the results derived from skippers. Figures for the upper part of the AHP tree were obtained by comparing the priorities of the 3 sub-goals, 6 criteria, and 13 sub-criteria, giving a total of 25 comparisons per skipper (survey) or vessel (logbooks). The figures correspond to the base case that best represents the analysed data for the lowest inconsistency ratio obtained by changing only one variable.

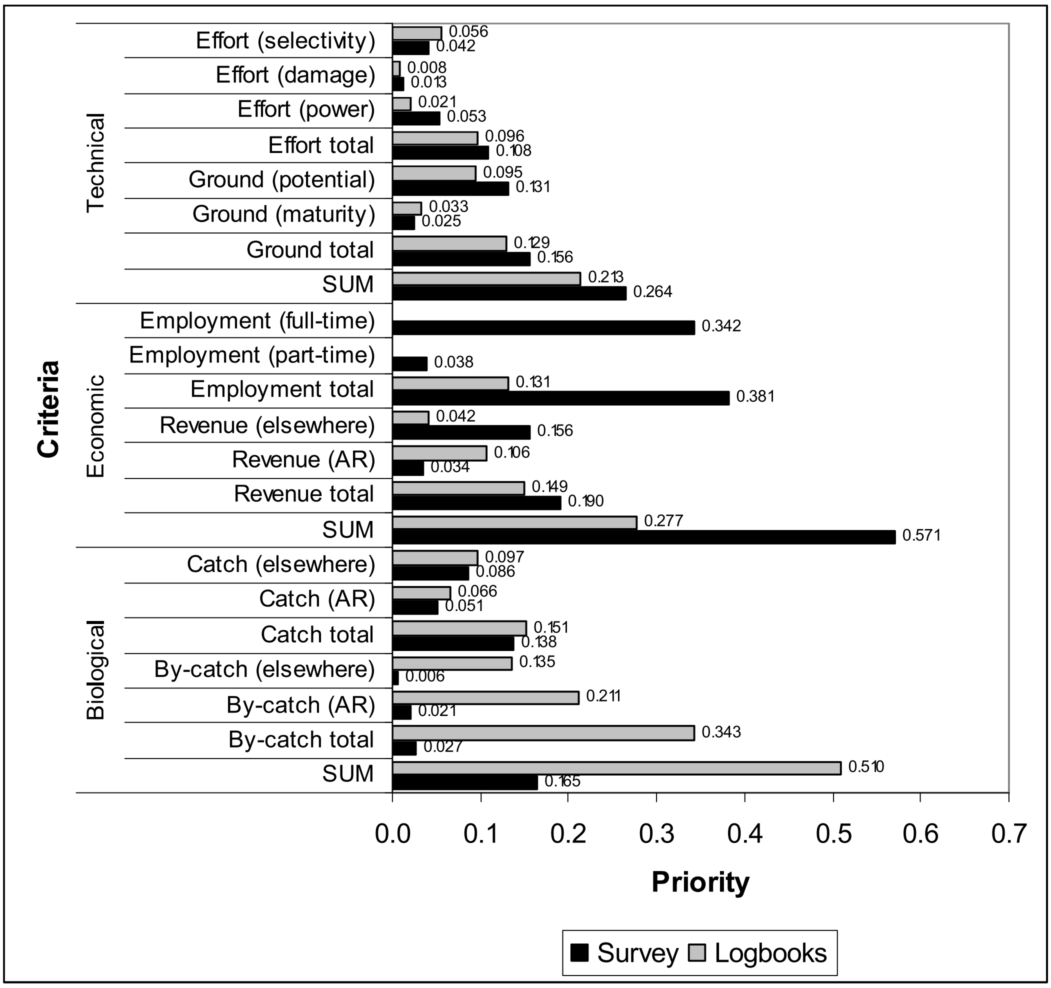


Figure 6.10 – Priorities chosen over the criteria and sub-criteria.

When considering the results obtained from the two approaches, many differences can be found. Looking at the logbooks information analysis, we see that the biological sub-goal has the highest priority (0.510), greater than the other two put together. The same cannot be said when fishermen elicit directly; here the priority is the economic sub-goal (0.571).

At the 3rd level criteria comparison under all the sub-goals, the highest priority when analysing logbooks is for minimizing by-catch everywhere (0.343), but especially in the ARs' area (0.211). However, fishermen's preference is for keeping employment (0.381), mainly as a full-time job (0.342); followed by maximizing revenue (0.190), especially in their favourite grounds other than ARs (0.156). There is a clear difference in the attribution of weights. Not surprisingly, they state the following: whereas the researcher thinks reducing by-catch based on logbook data is a priority, fishermen consider safeguarding their jobs as the most important criterion to consider.

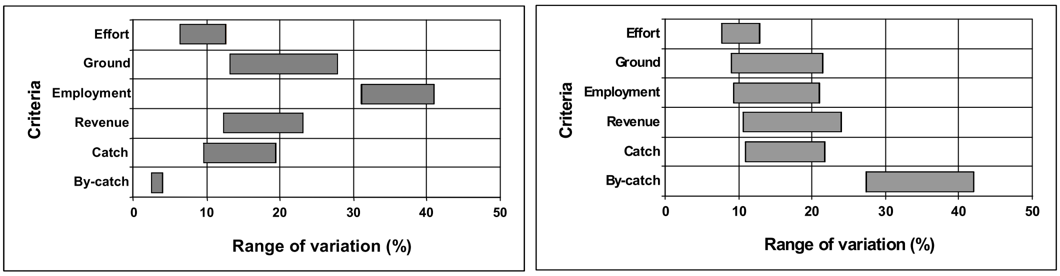
Previous biological surveys have found that higher biodiversity occurs where these artificial structures were deployed (Santos and Monteiro 1997, 1998). This can explain the higher level of by-catch rates found there. At the first sight, it seems that in order to counteract this problem it is important to have more selective fishing gear operating in these areas. However, it was found that selectivity is not a major priority for any of the methods used (only 0.056 and 0.042 for logbooks and survey, respectively).

Despite catch and revenue having similar priorities in logbook analysis, when performing analysis of the fishermen's responses there is a somewhat greater preoccupation with revenue than with catches. It was found that catch in 'Elsewhere' areas is always slightly greater than in reef areas for both approaches, where similar figures were obtained.

The technical sub-goal presented identical results for both elicitation approaches, with the ground potential being the most important aspect to take into account (maximize). Ground maturity seems not to be as important as its potential for fisheries. This means that a given reef already can be well-established, but if it attracts many non-commercial species, it is of little interest to fishermen. Effort seems to be the lowest priority amongst all the sub-goals. For this criterion, the engine power is somewhat influential since the most powerful engines usually operate more active gear. Damage inflicted by gear is the least important of all the sub-criteria evaluated. This means that the type of gear used in the study was not found to be destructive, in comparison to others that potentially can cause more damage but which are not allowed to be used in these areas (e.g. dredges and trawlers).

Sensitivity analysis for criteria

A sensitivity analysis was performed for each of the criteria, the results of which are shown in Figure 6.11.



a) b)

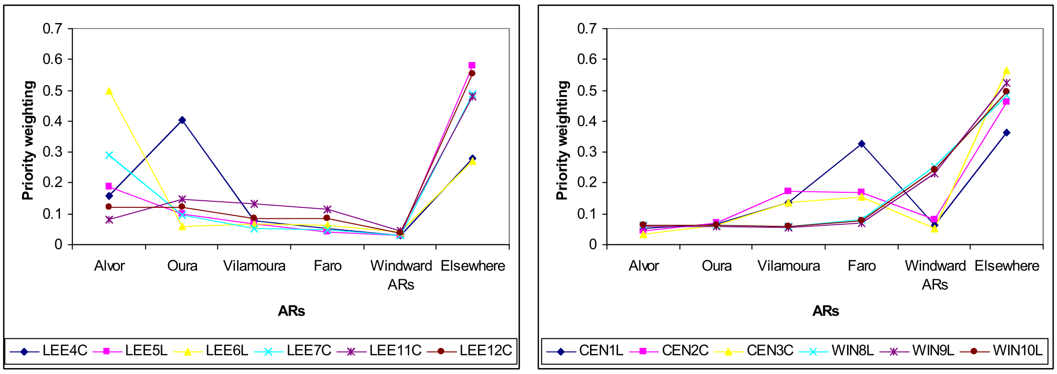
Figure 6.11 – Sensitivity analysis for each of the criteria: a) Elicitation was done via a questionnaire given to fishermen, and b) Elicitation was done via fishing logbook sheets.

It seems that the major differences between both elicitation methods concern the criteria of 'Employment' and 'By-catch'. By their turn, both methods also show that 'Effort' and 'Catch' have a similar pattern of preference. It seems that for fishermen the most important factor in maximizing benefits from fishing is to keep their job. The second factor that most affects the goal is the ground selection. This is also the most sensitive factor for achieving good results. Maximizing revenues is the third most important criteria to consider. Reducing effort is not considered important and by-catch species are almost neglected. Logbook analysis shows that reducing 'By-catch' is the most important criterion to consider and also the most sensitive.

Fishing options

For the lower part of the AHP fifteen pair-wise comparisons were also made amongst the six differing options.

In terms of preferred sites, most fishermen stated 'Elsewhere' as the best option to maximize benefits from fishing (Figure 6.12). It seems that fishermen usually have a preference for the ARs in their shelter port. Just two (out of 12) favoured ARs equally with other non-AR sites. Individual preferences are in that sense highly variable according to geographic position (i.e., fishermen prefer ARs located nearby).



a) b)

Figure 6.12 – Fishermen's individual priority weighting for the six ground options in order to maximize fishing: a) Leeward skippers, and b) Central and windward skippers.

From the logbooks' elicitation, the Faro AR is greatly preferred even to 'Elsewhere' options (Figure 6.13). The second best site to fish appears to be 'Elsewhere'. By contrasting the information provided by both approaches, one may consider that this may mean that the fishing 'Elsewhere' priority may be underestimated. 'Elsewhere' fishing grounds can be a natural reef or other natural feature that attracts target species, depending on fishermen's previous positive experiences.

The factor that contributes most to use a given ground is the number of times it is chosen. The empirical reason skippers use to choose a given reef could be connected with the knowledge that the reef is already well-established. The Alvôr reef is not seen as a priority because only a few observations could be made, and all of these were from just one vessel.

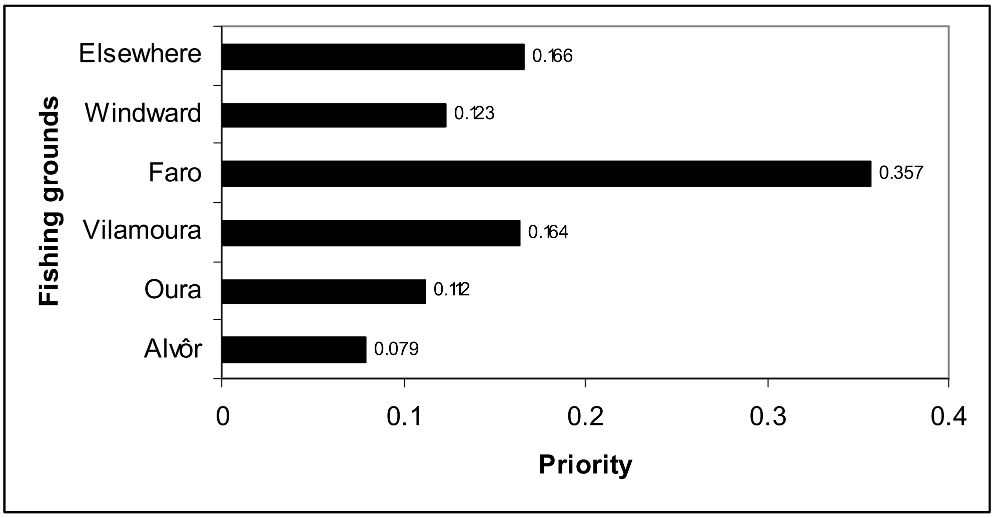


Figure 6.13 – Logbook priority weighting for the six ground options in order to maximize fishing.

Sensitivity analysis for the different options

Identically, a sensitivity analysis for the options was also carried out. The results for the sensitivity analysis of the alternatives are shown in Figure 6.14.

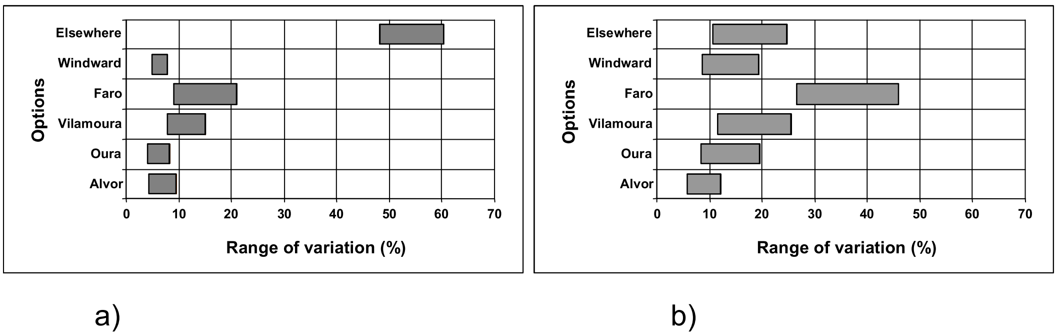


Figure 6.14 – Sensitivity analysis for the options: a) Represents priority weightings based on elicitations from fishermen, and b) Represents priority weightings based on elicitations derived by the author from the analysis of logbook sheets provided by fishermen.

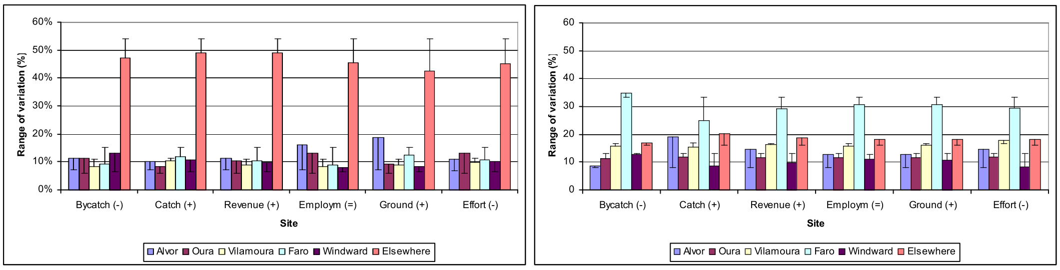
It can be perceived from the above analysis that there are some differences in the results between both approaches. In general, the range of variation of the different options when elicited by fishermen is relatively small when compared to logbooks. In both approaches the Faro AR seems to be the one presenting the larger range of variation (i.e. it is the most sensitive ground concerning maximising benefits from fishing).

Criteria and options together

The priorities for the six fishing ground options are presented in Figure 6.15. The upper part of the tree takes into consideration the results based upon observations both when fishing in the ARs or elsewhere. Although all fishermen questioned have already fished in some of the 'Elsewhere' sites, this does not mean that they are preferred over any of the ARs. 'Elsewhere' sites are used as a comparison and positioned at the same level as a 'commonly chosen' fishing ground.

The questionnaire survey data treatment shows that a pattern is detected when looking at site options. For the Alvôr, Oura and Windward reefs it seems that the observed values always go beyond the expected ones. Bearing in mind that skippers stated employment as their main priority, it seems that the sites that are contributing most to this are Alvôr and Oura.

In the case of elicitation via logbooks, the Faro reef takes higher priority over 'Elsewhere' sites. The Faro reef option displays the highest priority for all the criteria, while the priorities for the alternatives Vilamoura and 'Elsewhere' are quite close to each other in respect of by-catch, ground, and effort. Considering that by-catch was the most important priority in the logbook approach, the reef of Oura showed relatively low by-catch values.



a) b)

Figure 6.15 – Priorities for the criteria: a) Elicitation was done via a questionnaire given to fishermen, and b) Elicitation was done via fishing logbook sheets. The signs represent the aim of each criterion and stand for: Minus (–) to minimize, equal (=) to maintain, and plus (+) to maximize. The bars represent the base case, whereas the '⊤' and '⊥' represent the expected values.

Comparing the overall results by both methods, it seems that there are differences in terms of the evaluation of the objectives. Fishermen may think that maintaining employment and using sites other than reefs may be their best choice to maximize their fishing benefits (or at least this is what their questionnaire responses indicated). However, their logbook information alerts one to the fact that by-catch should be considered as the main criterion to prioritize and be minimized. Thus there are no great differences between expected and observed values, which is a good sign.

<u>Brief discussion</u>

This chapter sub-section shows that the use of the AHP can be very useful for analysing the fishing sector. The use of the same methodology in two different ways (questionnaire and logbook sheets) can be very valuable in determining which priorities are elicited according to different sources.

Portuguese fishermen do not cooperate if the AHP questionnaire is sent by post. Furthermore, it is sometimes difficult to ask questions about fishermen's jobs. However, the use of the AHP questionnaire on a one-to-one basis eased the task.

Not surprisingly, skippers' main priority is safeguarding their job. This priority is even higher if skippers work as full-time employed people in the fisheries extracting sector. Usually they do not indicate ARs as their main preferred sites to fish. However, they admit that the structures can provide a good contribution to enhancing their fishing efficiency and keeping their jobs safer for the future.

6.3.2. Diving

Rationale

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 (1989a, 1991), Glenn et al. (1994) 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).

Van Treeck and Schuhmacher (1999a) have highlighted the contrasting negative and positive impacts. On the one hand, the degradation of natural reefs (NRs) by mechanical damage (divers) is high but is accepted because of the income generated by diving tourism in countries well supplied with NRs. On the other hand, there is evidence that any 3-D structure (such as a wreck) can provide a sufficient attraction for divers. Given these findings, it should be possible to divert diving activities from the vulnerable NRs (such as coral reefs). Van Treeck and Schuhmacher (1999b) claim that a change in the reef demand options can be achieved through divers' education, alongside other active measures aimed at mitigating the destruction of NRs.

The main objective of this section was to test the usefulness of the AHP in establishing the conditions determining divers' choice concerning sites. Diver-type opinions are split into two: consumers and producers. In this analysis, the respective demand and satisfaction level for each of the five site types is examined. Finally, as part of the 'decision problem', we also attempt to find out if concrete blocks are as interesting to divers as other types of reef.

Material and methods

The data set used

To understand what sort of decision-making processes enter into a diving trip choice, it is important to know: (1) which factors are taken into consideration by divers when choosing a site to dive, (2) what in fact attracts divers to specific sites, and (3) in order to address these questions adequately, it is necessary to choose the variables to study. To do this in this survey, a prior data set was provided to IPIMAR by a collaborating full-time diving operator. The first objective was to analyse which sort of dive sites were chosen by the operator to take their customers. The data covered temporal information (morning/afternoon trips, day of the week, month, year), as well as specific information (site location) and reef type (five different alternatives). In this study, the diving sites are presented in five categories (options or alternatives).

Site locations were chosen from three areas in the Algarve region (Figure 6.16): (1) Faro (where the diving operator is based, and more facilities are available, but it is further to go to the nearest diving sites), (2) Lagos, and (3) Sagres (well known in the region as providing the best natural reef spots). These latter two areas, despite being further away for most of the potential dive consumers are usually considered worthwhile from the point of view of the diving opportunities they offer.

The data used in the analysis were collected from the last 5 years of the operator's activity and were taken from their own records. We also used a questionnaire involving the AHP, in order to find out which criteria are most important in choosing a diving spot, and which type of spot attracts most diving activity. The research question concerning which priorities should be surveyed can be structured at different levels: (1) the beneficiaries (SCUBA divers), (2) the goal (choosing the best diving spot), (3) the criteria (relative factors to take into account during the choice process), and finally (4) the options (the different types of reef sites, which are prioritized).

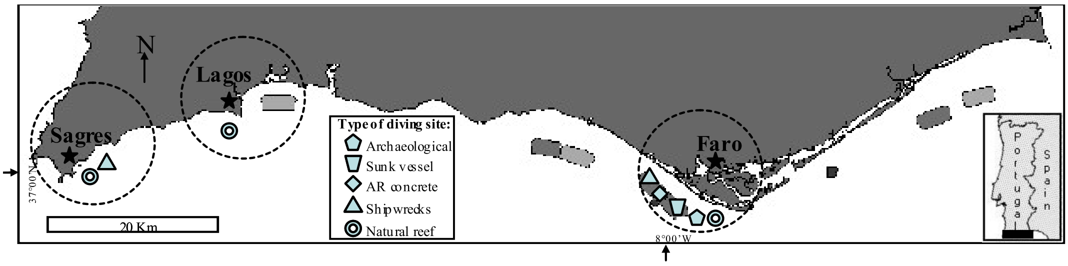


Figure 6.16 – The study areas (circles) represent the diving sites. Geometrical shapes indicate the diving spots.

Developing the AHP tree structure

As part of the methodology, it is important to divide the research questions into two parts: (a) the upper part of the tree, where it is important to establish which criteria are taken into account by divers in order to decide where to go diving, and the relative importance of these criteria in order to achieve the main goal; and (b) the lower part of the tree which identifies the choice options amongst five different diving sites (Figure 6.17). So for the upper part of the tree there are five criteria to take into consideration: (1) biological, (2) geographic, (3) atmospheric, (4) economic, and (5) incentive.

The biological criterion comprises three sub-criteria: biodiversity, conservation, and the presence of unusual species. Biodiversity is related to the satisfaction obtained from the different species that can be found in a certain diving place. Conservation takes into consideration a site's maintenance of and/or active participation in preserving the unspoiled status of high beauty/importance sites. The last sub-criterion is to ensure the presence of unusual species or behaviours in resident species. All of the above sub-criteria are sought to be maximized.

The geographic criterion comprises three sub-criteria: access or location, topography, and depth. Access is related to the ease of locating and diving in the site (a function of currents and/or topography, or of the distance from main inland water sources such as river deltas and lagoons). Topography takes into account the features and the ground materials the site possesses, whereas depth refers to the water column from the surface which can be somewhat limiting in terms of dive time and divers' expertise. Topography is the only sub-criterion that is intended to maximize, since the flatter the seabed the more monotonous the dive trip, and so a site with plenty of 'accidents' has more character and appeal.

Atmospheric condition is a criterion with three sub-criteria: currents, visibility, and water temperature. Currents refer to surface and deep sea currents occurring at the dive spot. Visibility is connected with the occurrence of storms and bleaching phenomena through the sea, especially in the autumn and winter seasons. If there is a great deal of rain, this results in more fresh and seawaters being mixed, as well as mud and silt. But low visibility can also be linked to plankton blooms, especially in the spring season. The high biomass productivity occurring during this season makes it difficult to achieve a good dive. Visibility is something that significantly affects the quality of a dive. Water temperature has an important bearing on divers' comfort below the surface; the lower the temperature the shorter the dive and less comfortable it is (unless the diver has a dry suit). Visibility and water temperature are two sub-criteria sought to be maximized, whereas currents are desired to be minimised.

The economic criterion consists of two sub-criteria: price, and facilities. The price of the dive trip is the monetary value a diving club asks for a given spot, taking into consideration hire equipment and services (boat, guidance and auxiliary crew, and the spot itself). Facilities refer to the equipment and services provided by the school in terms of giving the safest and most enjoyable dive for customers' complete satisfaction. Price is a trade-off between producers and consumers. Facilities are intended to be maximized (i.e., producers will tend to provide maximum facilities and consumers to enjoy from this offer).

Lastly, the incentive criterion refers to the various motivations that people have to dive. Three sub-criteria are defined: diversifying diving sites, exploring a known site better, and updating diving skills (for scientific purposes or purely for additional knowledge). To diversify the diving sites implies that the diver seeks the adventure of exploring other diving spots in order to get more diving satisfaction. Exploring a given site further means that there is the need to explore the same site in order to understand it better, due to factors such as the size and richness of the diving spot. Updating skills is associated with the need to enhance/update diving skills through course progress, or to satisfy curiosity or for scientific study purposes. All of these are intended to be maximized.

In the lower part of the tree, the diving spot options are taken into consideration, where the criteria to be considered for each site correspond with the criteria used in the first part of the tree that have been discussed above. The diving options are: (1) artificial reef modules, (2) sunken vessel, (3) natural reefs, (4) wrecks, and (5) archaeological sites. Artificial reef modules are deliberately deployed cubic or octagonal structures made of concrete. Sunken vessels are those deliberately submerged for a reef purpose after decontamination. Natural reefs are any natural formation, usually rocky intrusions. Wrecks are any type of manmade structure, which was not deliberately sunk (e.g., vessels, planes, or their parts). Archaeological sites refer to any place having archaeological or historical interest, which are not included in the previous alternatives.

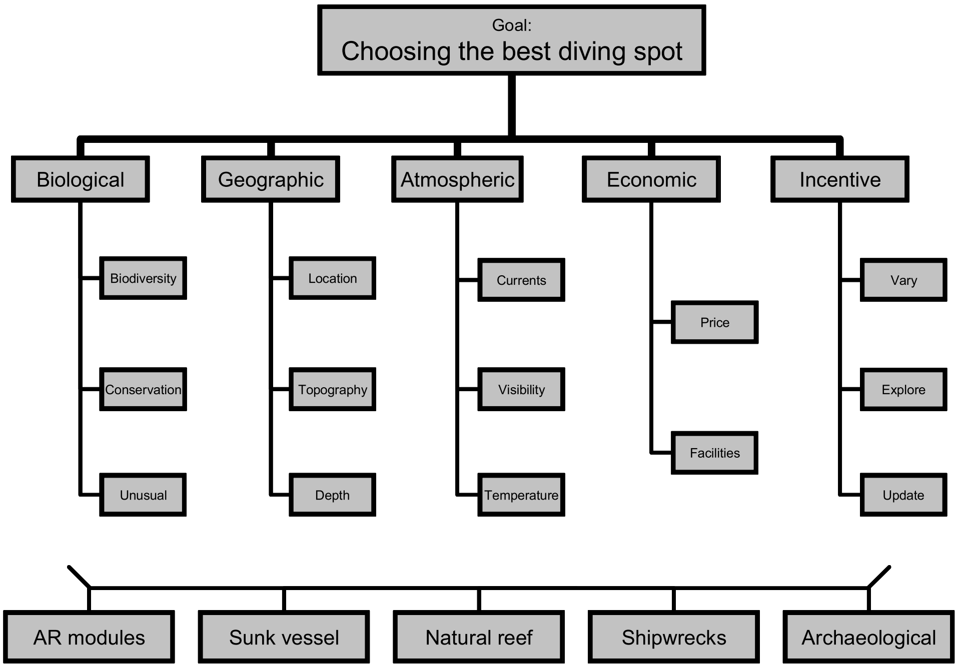


Figure 6.17 – The AHP tree: choosing the best diving spot. In the upper part of the tree at the top there is the main goal, followed by the criteria that are found at the second level, and the sub-criteria at the third level. The lower part of the tree shows the different reef-type options.

Weights elicitation

The AHP technique applied to decision-making is based on pair-wise comparison preferences and in this study data are derived from a questionnaire and prior knowledge about the sites. The weighting process for this analysis starts at level two. After that the normalized priority weights (eigenvector) are calculated for the efficiency analysis objectives.

In making the judgments about the power or importance of each criterion, the assistance given by those knowledgeable about the differences between each of the diving spots was fundamental. In this study, the elicitation of weights was carried out by a set of 32 divers, half of whom are dive consumers and the other half dive producers.

The elicitation of weights is a necessary procedure. A common AHP -9/9-point scale is used to elicit weights derived from pair-wise choices. Whereas in the first part of the tree the elicited values were based on the divers' experience and values of the incentives and limitations about going diving, the second part took into consideration the empirical and scientific (where appropriate) experience of the different diving options. Finally, to adjust divers' choices to an inconsistency ratio, i.e. the degree of divers' inconsistency in their judgment was measured through an inconsistency rate of 10% or less which is considered acceptable.

Results

Criteria

In order to better understand divers' choices, one has to take into account the different factors that may affect each person's decision and then to determine their average choices, represented as a 'vector'. In Figure 6.18 the results obtained for each type of diver are shown.

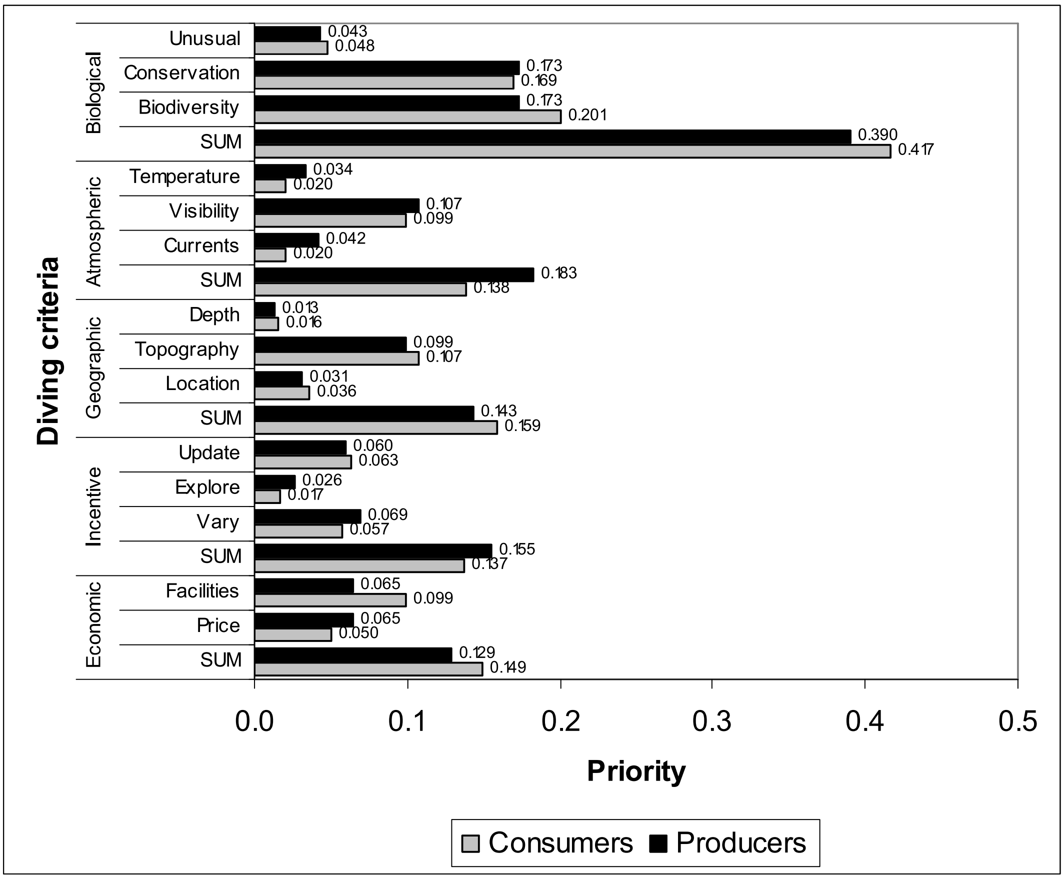


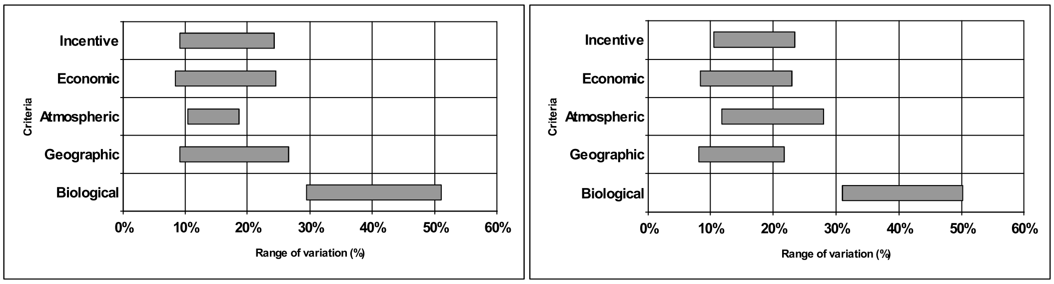
Figure 6.18 – Divers' priorities elicitation.

Whichever type of diver, the most important criterion in choosing the best diving spot is the biological one. Secondly, dive consumers attach more value to the geographic conditions, whereas dive producers believe the atmospheric conditions are more important. The economic criterion is the third most important for consumers, whereas for producers it is the least important one. This outcome may be based on the fact that consumers are concerned about a fair price and good diving facilities available, whereas producers are confident that they practise fair trade and offer good diving facilities to their customers.

In fact, the highest priority weights go to the biological criterion where great biodiversity and the conservation of the dive spot are highly ranked in both types of divers' choices. However, greater biodiversity is more valuable to dive consumers. The next prioritizations in the case of consumers are topography (0.107), followed by visibility and facilities (both 0.099). In the case of producers, there is a shift between topography and visibility, where the latter is considered more important than the former. Facilities are not considered important to dive producers, probably because they are confident that they offer good diving facilities.

Sensitivity analysis for criteria

When a sensitivity analysis is carried out (Figure 6.19), it seems that both diver types attach the highest importance to the biological criterion (around 30 to 50%), which is also the most sensitive one in terms of the diving decision. The atmospheric criterion is the second most sensitive in the producers' opinion, whereas for consumers it is the least sensitive one. Consumers' second most sensitive criterion is the geographic characteristics of the dive spot.



a) b)

Figure 6.19 – Results from the AHP analysis representing the upper part of the tree (criteria and sub-criteria): a) Left hand graph shows dive consumers, and b) Right hand graph shows dive producers.

Diving options

For the lower part of the tree it seems that divers have their preferences clearly stated (Figure 6.19). There is no doubt when considering the five dive choices available; divers' preference is for natural reefs, followed by shipwrecks and archaeological spots. All the others rank below, with the AR concrete modules being the last choice (as well as being seen as less demanding in terms of diving). It seems that dive consumers' choice for non-natural reefs has elicited a preference of around 1/2, which means that they are willing to be diverted from natural to artificial reefs. By the contrast, dive producers' choice seems to be strongly in favour of natural reefs, rather than man-made ones. This fact may be connected to the ease producers have to promote natural reef sites because of their high abundance in terms of different sites to dive, when compared to the man-made ones, which are scarcer.

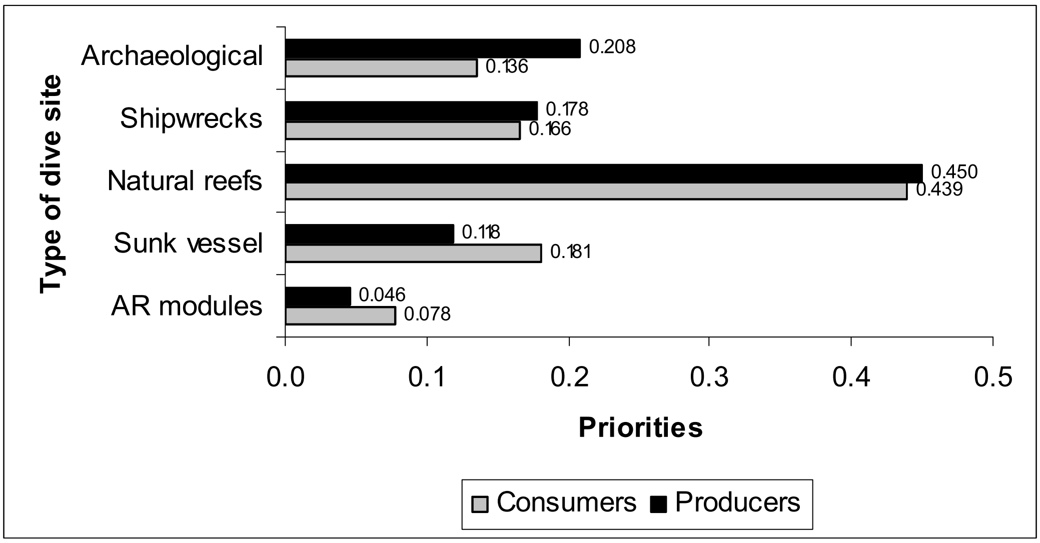
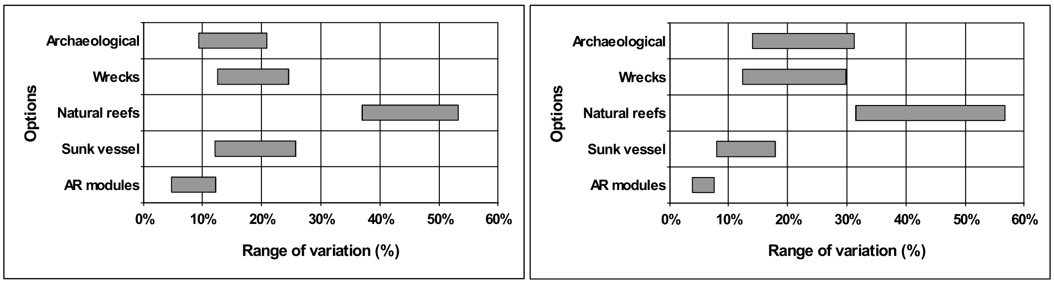


Figure 6.20 – Results for the lower part of the AHP tree. Here is presented a comparison of the differing sites' priorities.

Sensitivity analysis for the different options

Identically, a sensitivity analysis for the options was also carried out. The results for the sensitivity analysis of the alternatives are shown in Figure 6.21.



a) b)

Figure 6.21 – Sensitivity analysis for the options: a) Represents priority weightings based on elicitations from dive consumers, and b) Represents priority weightings based on elicitations derived from dive producers.

It can be perceived from the above analysis that there are some differences in the results between both types of divers. For instance, there is a strong evidence that whatever the diver type, the preferred option to dive is in ‘Natural reefs’, which is also the most sensitive dive option. By contrast, ‘AR modules’ seem to be the least preferred choice, and concomitantly the least sensitive one. However, dive consumers seem to be willing to dive more often in the ‘AR modules’ than the trips offered by dive producers. From the sensitivity analysis it can also be seen that dive producers are able to supply more ‘Natural reefs’ than it is actually demanded by consumers.

Brief discussion

In this study the results show that divers’ preference is for the biological sub-criteria. Given that these attributes are not unique to natural reefs, there may be scope in the future to divert diving choices (as suggested by Seaman and Jensen 2000: 11-12) towards artificial habitats, whether these be accidental (e.g. shipwrecks) or intentional structures (e.g. sunken vessels), in order to avoid mechanical damage to natural reefs. The rationale for this conclusion is based on the evidence that eco-tourists’ satisfaction is achieved by any artificial 3-D structure (Van Treeck and Schuhmacher 1999a) and less environmental impact results in less damage to coral reefs and other natural habitats (that need a long time to ‘mature’ and can be destroyed in a few seconds).

Much has been said about the ARs and especially the concrete blocks. It is generally accepted that they can be beneficial for local and recreational fishing, though as this pilot study has highlighted, there are still questions about their importance for diving purposes and the reasons why divers are attracted to them. It is necessary to understand the use of ARs for diving purposes, since this affects the performance of the fishing system as a whole. Divers usually choose grounds with more random topography, whether these are natural (such as coral reefs) or artificial (old sunken vessels). However, this criterion is only one amongst several that play a part in divers' choices. An important consideration is the 'efficiency' of a dive site in being able to divert people from natural to artificial structures, given the benefits that may accrue from mitigating or preventing habitat degradation. In this study we have taken a step towards understanding some of the factors that affect divers' location choice, but more research is clearly needed and we recommend it as a worthwhile future line of enquiry.

Due to the limitations cited above regarding the data set, the results described herein do not necessarily reflect the opinion of all scuba divers in the Algarve region. However, the AHP seems to be a feasible and useful technique to help decision- makers understand divers' choices about the use of the artificial reefs (namely concrete-made modules) in the Algarve for eco-tourism purposes.

6.3.3. Discussion

This section has highlighted the importance of the analytic hierarchy process (AHP) as a robust multiple-criteria decision analysis technique, one which is very useful in solving problems that have a certain degree of complexity. Despite the fact that the resultant rankings of criteria and options cannot be tested for statistical significance, the technique's strongest point is that it addresses the problem solving in a straightforward way.

<u>Commercial fishing</u>

It seems that the use of AHP can be a useful tool in defining fishermen's criteria and option preferences in order to maximize their benefits from fishing (usually expressed in a form of tangibles, e.g., catches). Fishers' preferences in terms of criteria do not vary widely; they may have some potential differences due to the fleet type or geographical area, since these factors can be somewhat limiting. In terms of preferred fishing sites, their options vary widely, especially in terms of ARs. However, this might be expected, since fishermen show a greater preference for those ARs that are located closer to their port of origin or at least for the ones that they visit more regularly. Most fishers said that their preferred sites to fish are usually located elsewhere. 'Elsewhere' is a more vague description than giving the precise location of an AR, but simultaneously it is understandable, because skippers usually do not reveal their preferred fishing grounds. However, skippers stressed that most of the preferred elsewhere sites can usually be found in their local areas rather than further away. Despite this fact, fishers go to fish where they believe there are fish, no matter the distance. However, it seems that there is always a preference for closer sites to fish and in these benefits from fishing can be maximized also.

Diving

The use of the AHP method can be very valuable for prioritising divers' choices in terms of the criteria and the options for their best dive spot. More meaningful results can be found if divers are split into two sets, i.e. the ones that pay for hiring a dive service, and the ones that receive money for hiring diving services. On the one hand, the results show in general the prioritization of the criteria and sub-criteria are in accord. On the other hand, knowing both divers' preferences for the dive site options, it is easy to see which are the most popular dive sites. Any eventual adjustments that dive producers can make in order to increase the satisfaction of their clientele (expressed in a form of intangibles, e.g., satisfaction), will result in a more efficient activity. Since it was found that overall 'non-natural habitats' have a high demand rate, it could be concluded that these structures can also contribute to divert divers from natural to non-natural habitats and from this perspective they have an effective role to play in terms of protecting natural reefs.

6.4. Cost-Benefit Analysis of the OARS Project

6.4.1. Rationale and Background

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). In order to explain how the CBA is used in the OARS project, it is necessary to describe briefly its context.

In the present section it was decided to use a CBA 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 1997b, Milon et al. 2000). The present CBA counts only the direct impacts on income of small-scale fishermen benefits that result from the AR project. All other beneficial impacts, including the more widely defined socio-economic effects discussed earlier in the thesis, are not considered.

OARS context

Fuzeta is a small fishing community mostly associated with small-scale fishing. Most of these fishermen target demersal or benthic species. Reefs are highly populated by these species, so the deployment of such structures off the flat sandy coast of Fuzeta was proposed to function as a contribution to ease the access of these fishermen to such stocks. The main fishing gear shows some variation during the year, but pots to target octopus are the most common. Despite being third in terms of tonnage, octopus is the fish resource that provides the highest income in the Algarve region, approximately 21% of the revenues from fisheries (DGPA 2004). The fishing port of Fuzeta is not an exception, and octopus is the main fish resource been landed by local fishermen.

The deployment of reefs has not only attracted fishermen, but also anglers and scuba divers. However, there is no diving school based in the town, but there is an operator that advertises diving activities to the ARs. Dive trips to the reefs occur a few times a year (José Salvador dive operator personal communication 2004).

Some considerations related to AR resources and their management

ARs can host many different species, not only fish, but also other living organisms. Many of these species have commercial value. However, apart from fishing ARs can also provide other amenities such as: coastal protection, water quality, diversion effect, etc. While these are important, in this exercise we ignore them and focus solely on the economics of traditionally marketed fish species.

However, sea-based fisheries are quite difficult to deal with when defining ownership. This is because usually property rights at sea are not well defined. This is a generalized problem that plagues fisheries, commonly called open access. The absence of well-defined property rights makes difficult to harvest fish at adequate times in order to maximize profit (Arnason 1999). The absence of well-defined property rights is a problem that also makes difficult an adequate stock assessment. In fisheries it is not easy to discriminate between older and younger fish when nets are cast into the water. As a consequence of this, there are no optimal harvesting rules concerning catch sizes.

There are several species of fish living in the OARs (Santos et al. 1996a, Santos and Monteiro 1997). Thus, without specific property or user rights, AR fish will be caught at a relatively high indiscriminate level (e.g. risk of catching fish that have inadequate sizes). In addition, there is some degree of 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.

Objective

In the present section, a CBA will be carried out using data only from fisheries. CBA makes use of a wide range of methods for estimating values of market and non-market goods and services. Here the method used is a productivity approach (results from previous sections), but the analysis will now be extended to 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.

6.4.2. Methodology and Estimations

Rationale for the economic calculations

The economic benefits engendered by the reefs have accrued over several years (i.e. since their deployment in 1990), 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. The data and assumptions used in this calculation are outlined below.

OARS resources growth

However, before answering the above point, it is important to show AR yield in terms of biomass. We begin with a biological growth function (sigmoid function). The function shows 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.

The deployment of ARs is considered to have a substantial economic advantage over areas without any sort of rocks or other 3-D features in areas subjected to some degree of fishing pressure. As AR ages, it adds biomass. The total exploitable biomass of fish at any age (time) is given by the yield function (potential). As AR ages, biomass continues to increase. At some point, however, AR biomass is no longer increasing. At this point fish resources achieved their maximum potential yield for the AR site. The point where net annual growth declines to zero, it corresponds to AR carrying capacity.

In 1990 an artificial reef system was deployed off Fuzeta (OARS). After deployment, it was assumed that the area would be devoid of life, but that after a short while demersal and benthic 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 area show fish species composition (Santos and Monteiro 1997, 2007). Assuming that the fish that are sold in the local fishing market are caught by local fishermen and that the catches have similar species composition, we can obtain the average fishing market price. For the purposes of this exercise, externalities whether positive or negative, are not taken into account.

Costs and benefits description

In this CBA, project costs only include the investment made in the construction and deployment of the structures. There are not accounted any costs related to reef maintenance (e.g. cleaning fishing gear lost over the AR or reef removal). It is supposed that the AR structures may last for at least a 50-year period. However, CBA calculations represent a 25-year period.

Indirect costs represent the opportunity cost of fishing at the AR on a full-time basis. During the times fishermen use other places than OARS, 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 include fuel, insurance, inspections, and licences for both fishing gear and vessel.

Explaining the independent variables

The monetary benefits that commercial fishermen may receive are estimated from the data collected in the scientific fishing trials, the direct observations, and interviews with fishermen. The monetary benefits and costs are a function of: (1) enhanced yield derived from reef deployment, (2) average fish market price of the species caught, (3) fuel costs, (4) harvesting costs, and (5) the discount rate used. These estimations are presented in Table 6.8.

Table 6.8 – Estimates of the independent variables to be used in a CBA in the OARS. The reference year is 1990.

Estimates of the independent variables	Sign	Value	Unit
Reef investment	I	249,399	€
Average fish price	p	2.40	€/Kg
Fuel costs	f	8.62	€/day
Harvesting costs	h	1,274	€/year
Discount rate	r	5	%

Reef investment – This variable includes all costs related to the OARS. Costs in this category also include preliminary research (mainly related to engineering, reef design and proper choice of materials of construction), reef construction, reef transport and deployment.

Average fish price – It is the average price obtained from the whole species composition that it is sold in Fuzeta's fish market. It is assumed that fish prices in real terms are constant over time.

Fuel costs – This figure is based on estimations from fuel consumption local segmented fleet fishermen declared to have (i.e. from the data collected in the semi-structured questionnaire-based interviews). Costs are based on petrol price times the amount of litres fishermen said to spend.

Harvesting costs – These costs include all expenditure local segmented fleet fishermen declared to have in: vessel, engine and gear maintenance or repairing; fishing gear and vessel licences; insurance and inspections.

Discount rate – The discount rate of 5% was chosen based on the reference given by Anonymous (2003) for the projects co-financed by the European Union.

Explaining the dependent variables

For the calculations it is assumed that: (1) there is a constant effort, i.e. the number of fishermen and/or the number and catchability of their fishing gear in relation to the amount of catchable fish available is constant along the time horizon of the project, and (2) the reef needs about six years to become mature and fishermen's catches are dependent on this according to a sigmoid function (Equation 6.2).

$$Y(t) = \frac{0.1}{0.1 + e^{-t}} \qquad \text{Equation 6.2}$$

Where: Y is the potential yield in the AR, t is time in years and e is the mathematical constant used as the base of the natural logarithm (~2.718).

The sigmoid function used as a proxy of reef 'production' is shown in the curve represented in Figure 6.22. The function describes what it is supposed to happen with the potential yield derived from reef deployment. In the deployment phase (i.e. year zero), it is assumed that reef production is low and only attains one tenth of its maximum potential. The experience accumulated from observations (Santos 1997) allows the supposition that the maximum potential for these ARs is attained approximately at year six. From year six onwards it is assumed that the AR keeps its maximum potential along its lifetime.

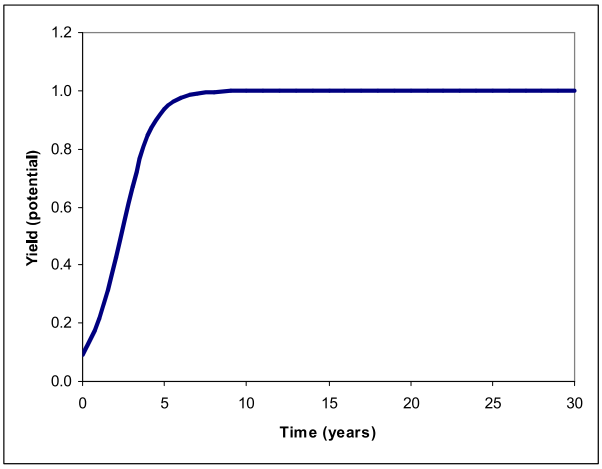


Figure 6.22 – The sigmoid function is used as a proxy for fish ‘produced’ at the reef site.

In this analysis of the AR fisheries economics, it is assumed that property rights are not well defined, and fishermen act in self-interest (i.e. individually) will attempt to maximize profits. Beyond the yield function, there are other dependent variables that need to be calculated for the purpose of CBA. These variables are presented in Table 6.9.

Table 6.9 – Base case estimates of the dependent variables to be used in a CBA in the OARS.

Estimates of the dependent variables	Sign	Value	Unit
Fishing days	d	250	Days
Reef users/day	u	3	Number
Average UE per user	z	5	Number
Catch outside the reef (control sites)	c(o)	2.5	Kg/UE
Catch within the AR	c(i)	7.0	Kg/UE
AR yield function over time	Y(t)	varies	
Unit of AR enhanced yield	S(i)	4.5	Kg/UE
AR enhanced yield per day	S(d)	67.5	Kg/day
AR enhanced yield quantity per year	S(q)	16,875	Kg/year
AR surplus catch value per year	S(v)	40,500	€/year
Revenues	R	varies	€/year
Net benefits	NB(i)	varies	€/year
Net benefits discounted	NB(@)	varies	€/year

Fishing days – This variable accounts the maximum number of fishable days. Because it is an average figure, then it is for a single representative vessel. Usually, due to higher stability larger vessels are able to be in operation more days. It is common that vessels go to repair/painting once a year or every two years during the season that corresponds to rough weather.

Reef users/day – This variable is calculated based on DSOs records and according to the OARS capacity. Technically it is not feasible to have more than 10 – 11 Km long of passive fishing gear (e.g. gillnets) fishing simultaneously (Figure 6.23). If one presupposes that this 'reef limit' is divided equitably amongst users, and each fishermen is considered to take advantage of the maximum fishing effort allowed by law (Portaria 1992); then the maximum number of reef users per day is three (which is in accordance with DSOs). These calculations are based on the supposition that AR users are basically small local vessels (where each vessel counts as one user). However, local vessels can have more than one user (as seen before in section 4.3), and it is also possible that other larger vessels use the reefs.

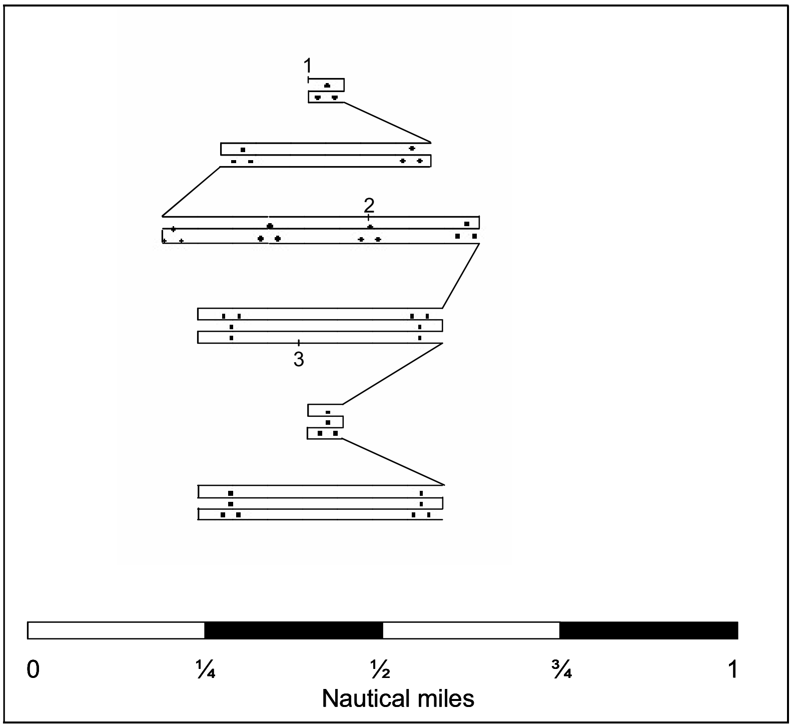


Figure 6.23 – Olhão AR system: dots are representing AR module positions, whereas the lines show one possible way to set up the nets. In total, horizontal lines represent around 11 Km of nets (i.e. equivalent to three fishermen operating with small-scale open deck vessels).

Average UE per user – To estimate the variable unit of effort (UE), there are used three conditions: (1) it is assumed that each vessel operates with the maximum fishing effort allowed by law (Portaria 1992), (2) UEs are estimated based on comparisons with some pre-defined known effort, i.e., as explained in section 6.2, and (3) based on previous regulation and the patterns of use on the observed fleet (see section 4.3), it is averaged the UE per user.

Catch outside the reef (control sites) – It is the average catch per standard UE. This figure is based on data experimental trials using gillnets in a non-reef area nearby the AR structures as explained in section 6.2.

Catch within the AR – It is the average catch per standard UE. This figure is based on experimental trials using gillnets in the AR structures as explained in section 6.2.

AR yield function over time – It is the AR potential in terms of commercial fish. The function was already explained earlier in this section.

Unit of AR enhanced yield – Fish caught that is believed to be a consequence of AR production.

$$S(i) = c(i) - c(o) \qquad \text{Equation 6.3}$$

Where $S(i)$ is a dependent variable that represents the enhanced yield in the AR area (i.e. unit of output catch due to AR deployment). It is measured in kilograms per standardized unit effort (i.e. it is assumed that one unit effort is the one presented in section 6.2). $c(i)$ is fish caught within the AR subtracted by the catch outside the AR area $c(o)$.

AR enhanced yield quantity per day – Potential fish caught at AR in a single fishing day.

$$S(d) = u * z * S(i) \qquad \text{Equation 6.4}$$

In this equation $S(d)$ represents the enhanced yield in the AR area in a fishing day. u represents fishing pressure in terms of users found in a day, z represents the average total effort in terms of fishing gear that each fisherman applies to fish stocks in the AR area (it is assumed 3,750 metres of net, which is based on the maximum established by law according to their type of vessel).

AR enhanced yield quantity per year – Potential fish caught at AR in a year.

$$S(q) = d * S(d) \qquad \text{Equation 6.5}$$

Here $S(q)$ is a similar equation but intends to estimate AR surplus catch weight in a year. d represents the number of fishing days.

AR surplus catch value per year – This variable represents fishing market value of the quantity of fish caught in an AR.

$$S(v) = p * S(q) \qquad \text{Equation 6.6}$$

In this equation $S(v)$ it is estimated the monetary value of the AR surplus catch in a year. In the equation p refers to the average fish price per kilogram in the fish market of Fuzeta in the year base 1990.

Revenues – The amount of money that all fishermen who use the AR receive from their activities in an annual basis mostly derived from fish sales.

$$R = S(v) * Y(t) \qquad \text{Equation 6.7}$$

In the above equation, R represents the total revenue obtained by all fishermen that use the AR. Y is the fishing yield that varies according to the function explained by Equation 6.2.

Net benefits – Net benefits $NB(i)$ represents gross revenues R subtracted by costs.

$$NB(i) = R - \left[(f * d) + h\right] \qquad \text{Equation 6.8}$$

Where: f is fuel cost, d are fishing days, and h represents harvesting costs.

Net benefits discounted – This equation shows the process of finding the present value of net benefits $NB(i)$ along a 25-year period, and along with compounding cash forms the basis of time value of money calculations.

$$NB(@) = \frac{NB(i)}{(1+r)^t} \qquad \text{Equation 6.9}$$

Net benefits discounted at a given discount rate $NB(@)$ represents net benefits gross revenues $NB(i)$ subjected to the time value of money, where r is the interest rate that would be compounded for each period of time in years t.

6.4.3. Results

Due to the fact that in the OARS surrounding area there are no rocky outcrops and in order to facilitate understanding in the present case study, it is assumed that all the surplus fish stock is due to AR production. Monetary benefits obtained by fishermen through the OARS were calculated using the estimates presented in previous tables. If the sum of net discounted benefits (i.e. NPV) from commercial fishing over a period of 25 years for the project in analysis would be greater than zero, it is supposed that AR investment would add value to society and the AR project should be accepted.

NPV and IRR calculations

The Net Present Value (NPV) here is calculated for a 64 ha AR for current management strategy, assuming sustainability and complete renewability of fish resources. NPV estimate is based on patterns of use data for the system and considers local fishermen as the users. Table 6.10 shows the results obtained for the actual situation in the OARS. Using an opportunity cost of capital (discount rate) of 5%, the benefit-cost ratio (BCR) over a period of 25 years is approximately 1.64. This means that for each euro spent on the project sixty-four cents were produced. The net present value (NPV) of the project was €98,453. It is taken into account the single case where the costs of the ARs are purely the investment costs (Figure 6.24). The costs imply an initial investment of approximately €249,399 (at 1990 prices) and no maintenance costs on the project are considered.

Table 6.10 – Benefits accrued from the investment in the Olhão AR system without maintenance costs.

Year	Project lifetime	Investment	Annual fuel costs	Harvesting costs	Revenue	Net benefits	Net benefits discounted at 5%	IRR
1990	0	249,399	6,464	3,822	3,682	-256,003	-256,003	
1991	1	0	6,464	3,822	8,656	-1,630	-1,553	
1992	2	0	6,464	3,822	17,209	6,923	6,280	
1993	3	0	6,464	3,822	27,038	16,752	14,471	
1994	4	0	6,464	3,822	34,230	23,944	19,699	
1995	5	0	6,464	3,822	37,943	27,657	21,670	
1996	6	0	6,464	3,822	39,520	29,234	21,815	-18%
1997	7	0	6,464	3,822	40,134	29,848	21,212	-12%
1998	8	0	6,464	3,822	40,365	30,078	20,358	-8%
1999	9	0	6,464	3,822	40,450	30,164	19,444	-4%
2000	10	0	6,464	3,822	40,482	30,195	18,537	-2%
2001	11	0	6,464	3,822	40,493	30,207	17,661	0%
2002	12	0	6,464	3,822	40,498	30,211	16,823	1%
2003	13	0	6,464	3,822	40,499	30,213	16,023	3%
2004	14	0	6,464	3,822	40,500	30,213	15,260	4%
2005	15	0	6,464	3,822	40,500	30,214	14,533	4%
2006	16	0	6,464	3,822	40,500	30,214	13,841	5%
2007	17	0	6,464	3,822	40,500	30,214	13,182	6%
2008	18	0	6,464	3,822	40,500	30,214	12,554	6%
2009	19	0	6,464	3,822	40,500	30,214	11,957	6%
2010	20	0	6,464	3,822	40,500	30,214	11,387	7%
2011	21	0	6,464	3,822	40,500	30,214	10,845	7%
2012	22	0	6,464	3,822	40,500	30,214	10,329	7%
2013	23	0	6,464	3,822	40,500	30,214	9,837	8%
2014	24	0	6,464	3,822	40,500	30,214	9,368	8%
2015	25	0	6,464	3,822	40,500	30,214	8,922	8%

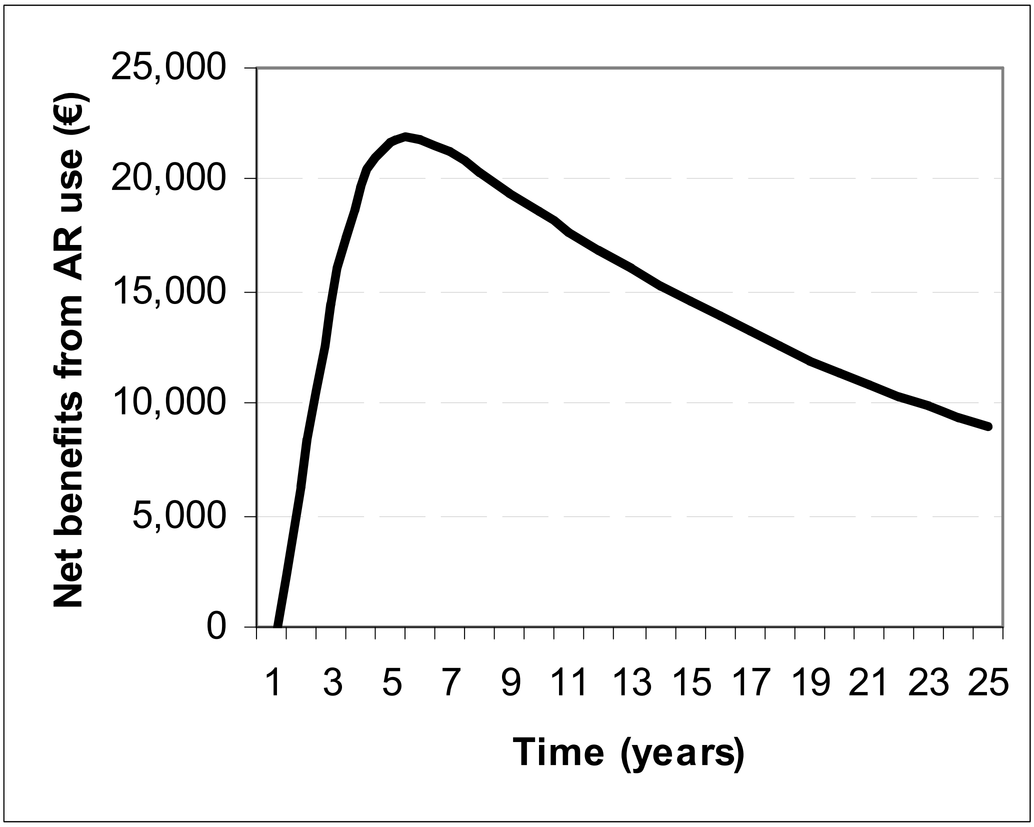


Figure 6.24 – The profile of net benefits from the OARS over the lifetime of the project. The discount rate used is 5%.

The scatter plotted in Figure 6.25 below shows that the internal rate of return (IRR) is approximately 8%, i.e. the point on the x-axis where the discount rate makes the NPV equal zero.

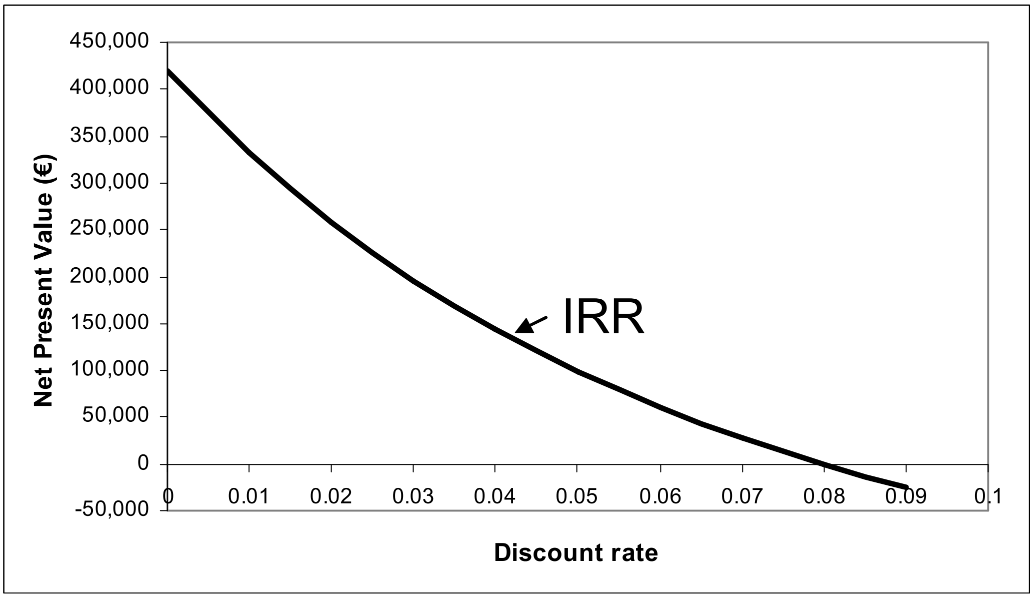


Figure 6.25 – The NPV curve of the net benefits from the OARS according to different discount rates. At the discount rate of 0.7966, NPV is approximately zero.

Since the calculated NPV over a 25-year period for the project in analysis is greater than zero, it can be presumed that AR investment would add value to society and the AR project should be accepted. The basic principle for this is that AR deployment becomes worthwhile where the rate of return is greater than the rate of interest.

Sensitivity analysis

One way we have to understand uncertainty in this model is by conducting a sensitivity analysis (SA). SA developed here results from a ±10% change on each of the independent variables over the time series (i.e. 25-year period). Changes are made on one variable at a time. Such changes in the variables (revenues and costs) will alter the NPV. The objective of a sensitivity analysis is to identify critical variables of the model and how the variability of each of the inputs impacts NPV result. Here the results of the sensitivity analysis are represented by a tornado diagram (Figure 6.26). The y-axis of the diagram shows the effect of five variables on the result, where the most sensitive variable is the largest bar at the top, which means that it has the maximum impact on the result;

and with each successive lower bar having a lesser impact being depicted towards the bottom of the diagram. There is a vertical line that shows base case NPV for each of the variables.

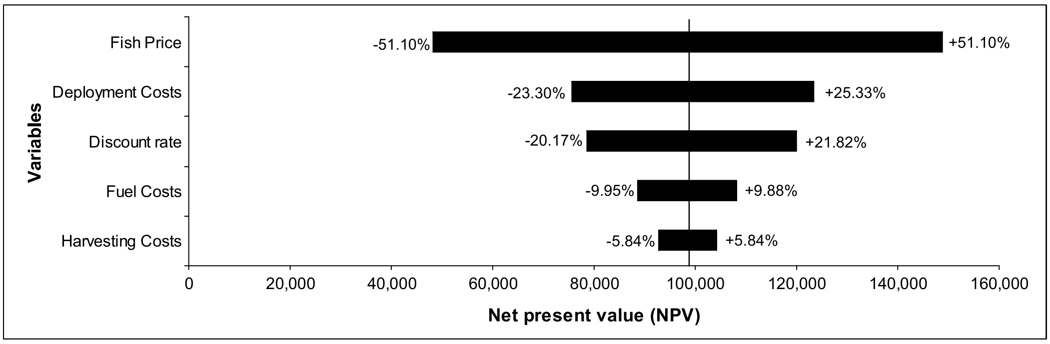


Figure 6.26 – Sensitivity analysis represented by a tornado diagram. The vertical line represents base case NPV. A ±10% change in each of the independent variables correspond to a NPV change represented in % in the left and right of the bars.

The SA represents a measure of the elasticity of project worth in terms of each independent variable. The results show that the most sensitive independent variable in terms of changing NPV is fish price. This means that if fish prices were to rise by 10%, *ceteris paribus*, NPV would rise by ~51%. The second most sensitive variable is deployment costs, where if they were to rise by 10%, *ceteris paribus*, NPV would fall by ~23%. The least sensitive variable is harvesting costs. These results enable us to understand the dynamics of the independent variables, and consequently to know how to decrease the overall risk of the project.

Risk analysis

It is not enough just to present the results of the project in a single-figure based on a threshold of acceptability (via NPV and IRR results). Moreover, it is not correct to state that the AR project in analysis is a complete success or failure without appraising its results in a probability distribution of likely outcomes (Whitmarsh and Pickering 1995, 2000). In order to address that issue, risk analysis is undertaken. In this particular case study, a risk analysis is carried out in order to identify and assess how independent variables endanger Olhão AR project of achieving its goals. Here it is considered that there are four variables that have the most influence over AR success, which are presented next in a decreasing order: (1) fish price in the market, (2) AR deployment costs, (3) fuel costs, and (4) harvesting costs.

Variables were assumed to have either a normal distribution (fish price) or triangular distribution (related to costs), as seen in Table 6.11. Prices of commodities such as fish are subjected to inflation, but since the analysis is conducted in real terms then we have assumed no time trend, and any variations in price are around a constant mean. However, in this case study it is assumed a normal distribution for simplicity reasons. The variables on costs are assumed to have triangular distribution because there is limited sample data. Their values are based on guesses of smallest and largest in each cost variable.

Table 6.11 – Independent variables used in the risk analysis.

Variables	Distribution	Expected level	Variation
Average fish price	Normal	2.40	S.D.=0.40
AR costs	Triangular	249,399	224,459; 249,399;274,339
Fuel costs (year)	Triangular	2,155	1,940; 2,155; 2,371
Harvesting costs	Triangular	1,274	1,147; 1,274; 1,401

Uncertainty over events (i.e. as a result of the random combinations of variables) may put the OARS project at a certain degree of risk. In this way it is possible to predict risk and evaluate the degree of threat[24] .

In order to know the likelihood of events, four independent variables were randomly sampled via the Latin Hypercube Sampling technique (LHS). LHS was selected because according to Saliby (1997) it 'preserves a minimum random variability on the sample values selection' which does not occur with some other

[24] Threats may come from diverse sources: (1) *human* due to excess effort exerted by individuals or groups on reef resources; (2) *operational* if OARS is limited by damage due to excess gear loss, and the alike that may lead to a loss of access to the reef; (3) *project* due to over investment on the OARS and low returns from fishing and other reef amenities; (4) *financial* if there is a risk of too low fish prices, or to high discount rates, unemployment, etc., (5) *technical* due to obsolete use or lack of fishing technology, etc.; (6) *natural* if ARs are disturbed due to rough weather, natural disaster as pollution, any sort of accident or disease, etc.; and (7) *political* if there are changes in the AR management structure, public opinion, government policy, etc.

common sampling methods (e.g. Descriptive Sampling, which is a Monte Carlo Sampling technique). Figure 6.27 depicts the results of the risk analysis using the LHS algorithm.

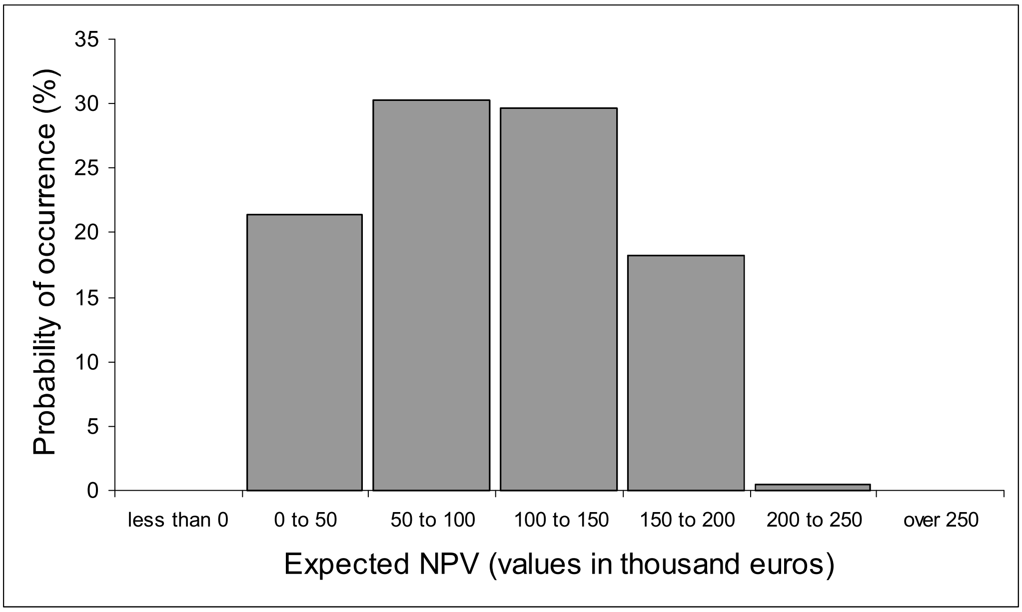


Figure 6.27 – Risk analysis. There were conducted 192 iteractions. The expected NPV result is €99,408.

In this risk analysis it is assumed that all four independent variables change over time according to the above sources of threat. Figure 6.27 shows that, even given an unfavourable combination of parameter values (i.e. low fish price and high costs), there appears to be little or no chance that the AR project would come out with a negative NPV.

6.4.4. Discussion

From the policy objectives stated by IPIMAR, the main priorities for OARS would be to protect juvenile fish and promote biodiversity. Due to the fact that both factors are not easily tangible (i.e. it is difficult to estimate their monetary value), in this CBA there are only accounted the benefits from commercial fishing derived from reef deployment. Other benefits, such as for example scuba diving trips to ARs are not calculated.

In economic terms, the results presented here show that BCR is greater than 1.0, NPV is positive, and the project IRR (8%) is greater than the assumed cost of capital (5%). This means that this is a worthwhile investment. Thus, it has to be emphasized the importance of the project in social terms. It is extremely important and politically well-accepted to invest in such a project in order to maintain fishermen and their livelihoods. One example of that can be highlighted here, when the former European commissioner Franz Fischler visiting the IPIMAR in 2000 had referred to the reef project in the following way: 'It is through such creative initiatives, which associate scientific ingenuity with practical participation of the fishermen, that we can improve the situation of fish stocks in our coastal areas and thus help ensure the future of small-scale fisheries'.

However, some precautions have to be taken. The calculations presented here are over-simplistic, since maintenance costs of the reef are not taken into account. In fact, the institution responsible for the reefs is not considering spending money on maintenance costs. All the calculations are based on small-scale commercial fishermen who have a certain fishing effort and pattern throughout the year. For simplicity it is supposed that the above users fish only with gillnets, however nets operating account for less than 20% of total fishing gear used. There are also not considered larger vessels that use the reef, and have larger fuel and harvesting costs as well as more people onboard (Ramos et al. 2006a). It should be added though, that other people may benefit from the use of this reef, namely divers and anglers.

The CBA presented here can measure the best (most efficient) management strategy from a range of options. The decision to proceed with reef deployment was based on the expectation that the reef was to create positive effects on the environment and the public attitudes to it would be favourable. The area where the reefs were deployed was previously quite unproductive in terms of fish or other resources. The deployment of the reefs altered the habitat in the area. It is expected that after reef deployment there will be a higher fishing pressure over the reef, but it is not known how much. To the extent that this occurs, however, then the enhanced yield assumptions on which the NPV calculations are based may turn out to be optimistic, since CPUE would be lower than projected. This is yet another aspect of what Milon (1989) has referred to as the 'paradox of artificial habitat development'. It is also not known whether some congestion externalities will arise. There is no certainty that the species caught in the ARs are going to be the same as before reef deployment. In fact, Santos and Monteiro (1997, 2007) reported the enhancement of the total number of species in the area, as well as the mean number of species caught per standard catch. However, the balance between the different components (groups) of the fish assemblages was kept.

The sustainable development of the project is subject to certain conditions such as: (1) non-declining consumption of fish resources produced over time, (2) non-declining utility over time, (3) non-declining stock of total capital over time, and (4) non-declining stock of natural capital over time.

There are similar projects elsewhere where the sustainability is guaranteed if certain conditions are safeguarded (e.g. adequate management). However, there are also records of complete failure. The challenge here is to provide conditions to guarantee that the resources exploited can be maintained for a longer period due to the project's development. Since property rights are not established, the distribution of income from fishing is not maximized. As seen before, a sensitivity analysis is useful in determining what role key variables play, especially those related to costs.

Since we have seen that the OARS as a pilot project has been a worthwhile investment, it is believed that all other Algarve AR projects following similar deployment patterns, will have at least as good results as this project. Furthermore, it is believed that deployment costs for all other projects will decrease due to economies of scale, and as a consequence economic indicators such as NPV, BCR and IRR will have a higher acceptability level.

In terms of risk analysis, it is important to know the likelihood of the occurrence of events as well as their impact. In this particular risk analysis it is assessed the type of impact (i.e. the NPV change derived from a random combination of the independent variables) by frequency of occurrence in possible scenarios. Here we defined risk as the probability of event (expressed by a random combination of the variables) that may lead to a possible loss over time, i.e. what is the frequency of NPV loss after a 25-year period from the base case NPV.

Another issue that it is important to consider is managing risk. This study can help decision makers to know which are the main threats to the OARS project and address ways to accept and minimize risks.

6.5. Conclusions

The productivity approach shows how effectively measures of reef production along a time series can be obtained. It has been shown that there is clear evidence of a reef effect. The bulk of the catch value in the reef areas goes to demersal and benthic species. It was also shown that in the smaller reef modules the biomass and value of fish caught was higher than larger ones, probably because, for the same reef volume, more interstitial surfaces can be found.

In terms of priorities, fishermen believe that in order to maximize their benefits from fishing the most important factor is to keep their jobs within the fisheries sector. The resources come second, with less than half of the importance attributed to them. This sort of attitude may pose serious problems for resource management in terms of communal or privatisation use of the fish resources. In the case of diving producers, they do not seem very convinced that AR modules are an outstanding contribution to the services they provide. However, they think that these structures help to offer a diversity of diving sites.

The CBA shows that the deployment of the OARS is a benefit from at least the fishermen's perspective. This means that the resources committed to reef deployment can improve fisheries efficiency in providing extra benefits in terms of revenues. However, the very success of the reefs in raising productivity and fishing revenues may undermine these benefits if effort is attracted to the reef sites. The results presented in this chapter confirm again that AR deployment is not a substitute for fisheries management to control harvesting pressure. Indeed, the economic efficiency of this technology increases, not reduces, the need for management.

Part three

Implications and Final Considerations

Chapter

7

Final Remarks

Contents

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7.1. Summary

A brief review of the main issues covered in each of the thesis' chapters is summarized in the paragraphs below:

Chapter 1 – The introductory chapter presented, in brief, the whole picture behind the interest in the development of ARs in the last few decades. The focus was on some of the major comparative information on fisheries and aquaculture production and consumption between countries. The chapter drew attention to the increasing pressure over the coastal areas from a plethora of human activities. It suggested, however, that there were differing views on the severity of the problem, and as regards the prospects for fisheries it was possible to identify an 'optimistic' and a 'pessimistic' perspective. It also described in brief the origin of ARs and some Portuguese fishing facts and trends, highlighting expectations on the potential of an AR program to mitigate some perceived problems in that scope. Also presented were the main problems concerning reef deployment and some of the related questions that need to be answered. The research framework for the thesis was outlined, and a brief description given of what it is intended to achieve in each chapter. The main objectives of this piece of research were laid out.

Chapter 2 – An in-depth review of the available literature on ARs showed the relevant theory and direction worldwide research has taken when dealing with this subject. In Portugal there is still very limited research and literature about ARs. From the literature search it was found that the concept of ARs has been changing through time and has currently a specific definition. In addition, it can be said that not all types of man-made structures that are deployed in the water should be considered as ARs, but some controversy persists around this issue. ARs serve different purposes, which may vary according to different locations around the globe or even different policies. For ARs to fulfil a specific function not all construction materials are suitable, and there are also other characteristics such as design and adequate location that have to be followed in order to achieve adequate AR functioning. From the perspective of worldwide importance, it was found that ARs became an issue focussing international attention after

1974 (at the time of the 1st international conference on ARs) and reached their peak of interest in scientific research terms in the early 1990s (when there were presented and published most papers at a time). From the perspective of all peer-reviewed literature, it was found that there is an increase in terms of papers published on the AR subject in the last five years (period from May 2001 to May 2006), when compared to earlier periods. These findings may lead us to conclude either that authors are publishing their papers in journals other than the conference proceedings and/or that there is an increase of interest for the subject, which did not occur after the early 1990s. There are some subjects of study (i.e. defined as key-terms in combination with wildcards) that are increasingly been found in the AR literature. Examples of these are the cases of 'rig*', 'impact*', and 'environ*' issues. Other subjects that have been less used recently are 'fisher*', 'enhanc*', and 'natural reef*'. In Portugal there are no specific arrangements for management of AR use, but some may be found to promote their deployment. Concerning the ARs deployed in Portugal, namely in the Algarve, there is an increasing trend in terms of scientific research, particularly due to the fact of available funding to support a project in the AR program (during 2002 – 2007 period). Currently, there are five main domains of research in the Algarve AR team: oceanography, ichthyology, benthos, socio-economics and restocking. In Portugal there are other regions that have already started to develop some AR deployment and related technical studies as in the cases of the Madeira archipelago, Centre, and Lisbon and Tagus Valley regions.

Chapter 3 – Some of the most important concepts relating to the ARs were introduced. Such concepts are related to the: dimensions of the present study, adequate management strategies to be adopted in the case of the AR structures, and stakeholder involvement with ARs. In this thesis a conceptual bio-economic model is developed in order to integrate important elements, and establish the basis of the research problem – which is to evaluate the impact and efficiency of AR structures on involved people (i.e. stakeholders). The conceptual bio-economic model is used as the main engine to generate research questions and hypotheses. To address the problem from a supply side, it is necessary to consider two dimensions: social and economic. The challenge of the research problem is to link the different stakeholders both in social and economic terms, aiming to maximize AR economic value. In this piece of research an exploratory methodology was adopted, since no previous studies on the socio-economics of the Algarve reefs have been conducted. In order to carry out the study, a flexible design was chosen, namely using a case study approach. The support of this research needs people's information (expressed as attitudes). This type of information prevails in qualitative data. Face-to-face interviews, direct observations, surveys and other instruments were used as means to collect information. To give the necessary degree of rigour to the analysis, scales were used as an empirical metric. These included traditional techniques such as Likert scales, but more sophisticated multi-criteria measures (specifically, AHP) were introduced and discussed.

Chapter 4 – The focus here was on monitoring, which addressed questions such as who are the potential AR users, as well as where, when and why the reefs are used. In order to obtain answers to these questions, 118 semi-structured questionnaire-based interviews were conducted in 2002 with potential AR users (fishers, divers and anglers) throughout the Algarve region. The findings showed that, despite being eligible to use the ARs, most of the interviewees had never used an AR before or admitted that they were not familiar with the structures. It was found that skippers of larger commercial vessels were the ones who had most experience of the ARs. Skippers' operational distances were estimated, and found to be around ten miles for local vessels and fifteen miles for coastal ones. Crew onboard numbers were estimated at approximately two people for local vessels and five for coastal ones, while average return trip times were approximately two hours for local vessels and three and a half hours for coastal ones. There was also collected information on the target species (73% of skippers said they target flatfish, 71% cuttlefish, 54% breams, 37% octopus and 20% red mullet). Most fishermen declared to use two fishing gear (48% of them), and no one declared to use more than four fishing gear. Patterns for both commercial and recreational users were observed in the Olhão AR and it was noted that the most common fishing gear used was the pot type (to target exclusively octopus). It was considered that the potential involvement skippers may have with the ARs depends upon: the fishing community to which they belong (i.e. closer the reef, more often it is used by locals), their knowledge and incentive about the structures, and the technology they have onboard their vessels. The results of this were: 31% of the interviewees declared that they have detection technologies onboard, but have no ARs nearby and do not use the ARs to fish; 25% of the interviewees live in an area with ARs, fish there and have detection technology onboard; whereas there were 5% that have none of these three conditions. The profile of potential skippers' of Algarve ARs is described: male, in their 40s or early 50s, mostly fulltime fishermen, usually they fish in a daily basis (up to six days a week in the case of coastal vessels). As regards recreational users, the information provided by the interviewees was used only to construct their profile: divers are usually younger than anglers, divers are both domestic and foreign people whereas anglers are mainly domestic, and in both activities there can be found some free-riders (i.e. people that catch fish to sell). Data from secondary sources was used to cross-check results. The combination of results from both types of users was analysed. ARs are perceived as a good option for enhancing fish stocks, namely by giving them some degree of protection and provision of food. Most of the interviewees were in favour of the AR blocks (66%); but some (24%) claimed that the use of materials of opportunity (e.g. old vessels, car bodies, boulders) could be a cheaper solution for the same purposes; the remaining (10%) did not have an opinion or were against the idea of ARs. Benefits of ARs are perceived to be related to higher quantity of fish available at reef sites. Cost reduction to use the reefs does not seem to be a benefit of ARs. The results for potential users show that there is some involvement with the structures, but it is difficult to separate who actually uses or does not use the reefs. This information on potential reef users provides *prima facie* evidence as to the scope for genuine socio-economic benefits to the local community. Through the use of chi-squared tests it was found that independently of the type of user, opinions are favourable to AR deployment. Other variables as: experience concerning the use of ARs, distances travelled to practise their activity, and days at sea; vary considerably among users.

Direct site observations (DSOs) are an effective way to determine who actually uses the ARs. However, the technique also discloses some caveats mainly related with operational hours, and effective catch. The Olhão AR was monitored in terms of use. Comparisons between 2003 and 2004 were made despite some differences in samples. In order to obtain results about actual users of the ARs 123 direct site observations were made of the first AR deployed and 128 reef users and 563 fishing gear were identified. The average observation time in each sample was around 90 to 100 minutes, and most of the observations took place in the morning (10 a.m. to 11.30 a.m.). The number of vessels operating simultaneously in the AR area is usually low (less than four), and in many observations there were not observed any vessel. There were seen vessels from three segments: local, coastal and recreational. Most of the vessels in operation were local from the nearby fishing communities of Fuzeta, Olhão and Culatra. This finding also means that most of the vessels have just one or two people onboard. The average number of fishing gear observed in the OARS area was around five (2003) and four (2004). Comparisons using a chi-square test were used to find that for comparable months, samples have the same distribution. From the chi-square test it was also found that the observed number of crew onboard the vessels, as well as the fishing gear distance from the AR, do not alter in both periods. However, other variables such as number of vessels, number of fishing gear, ports chosen to land fish and species landed varied for the periods under analysis. It was suggested that the above and other variables can be used as indicators of AR use. The differences found may indicate changes in terms of patterns of use. Those changes are represented in a table of indicators, where arrow signs show the variations between both periods of time compared. In the monitoring studies it can be concluded that some people are affected by AR deployment. The patterns of use are a sign of that reef contribution. However, not all stakeholder types are affected in the same manner and it is suspected that affection may vary from place to place.

Chapter 5 – Several different approaches to the social analysis were adopted. Firstly, the perceptions of a panel of 44 stakeholder representatives with differing levels of knowledge about the ARs were collected. Likert scale questionnaires were used to analyse answers. There was an overall perception that the structures had a positive effect on the environmental dimension, but no relevant effects were perceived on the social or economic ones. The most significant results show that: in environmental terms, reefs are regarded as non-destructive, in social terms there is a favourable opinion about the presence of structures when compared with their absence, and in economic terms it is believed that ARs increase production and benefits amongst users. This last response was the one that gathered most agreement between the different stakeholder groups in the analysis (five out of six). Divers were the group that presented the most optimistic view (four out of 12 sets of impacts having a significance level of 99%, whereas the most sceptic group was fishermen where not a single set of impacts had significant results). Using this approach, it was also possible to construct a ranking of the most important questionnaire items. From an item-pool of 54 questions surveyed, respondents said that the three major benefits from AR deployment were: promoting biodiversity, contributing to the success of stock enhancement, and assembling marine fauna. There were also found the major threats derived from AR deployment: increasing the need of sea rules, increasing fishing pressure over the ARs, and increasing fishing gear loss near the ARs.

Other approaches, such as looking at regional periodic newspapers and the internet, were used to investigate the sort of information concerning the Algarve ARs available in the public domain. Investigating the media and in particular, regional newspapers, it was found that there is little information about the AR issue. Despite the absence of news items related to ARs for the time-series sampling search considered, it was decided to find out which were the most relevant news items related to aquaculture, fisheries or other sea issues. In terms of issues having higher impact, there were found more news items on the positive side than the negative. According to the issuing dates, the positive impact news items related to fisheries were: 1990 – border negotiations between Spain and Portugal, 2000 – fishing port enhancement at Olhão, 2005 – fishing port enhancement at Olhão, insurance for fishermen, and past female canning factory workers. In their turn, the negative impacts were: 1990 – (fishing) conflicts between small-scale fishermen and managers, delay in the construction of a fishing port at Quarteira, and 1995 – enforcement for coastal management. In addition to this, it seems important to highlight that more recently, a television broadcast was made with the intention of widening their audience's knowledge about the AR subject in the Algarve region. In this program, fishermen and divers who had experienced the structures at least once and who testified to their benefits were interviewed. It was believed that this information would stimulate other people to use the ARs in the future.

In the case of the document analysis, it focused on a qualitative study on internet documents. In the analysis, documents were classified according to four sources of information (administrative, forum, news and political) and four topics (ARs, diving, fisheries and general issues). There were also defined 11 codes to categorize sentences in the texts analysed. From that analysis, it was found that most of the documents had AR information on the category of 'recreational use pattern', and there were discovered few documents attesting signs of 'conflicts' or 'patterns of ownership'. It was found that there is some knowledge and demand for more knowledge about the structures, namely from the diving community. However, for divers, it seems that artificial structures other than the concrete modules generally hold more interest. It is believed that this method of analysis has a big drawback, because it seems to exclude fishermen (who are so far the most important reef stakeholder group). The rationale for this is based on the grounds that stakeholders' contribution, namely in internet forums is an important research input from the AR demand side. This is explained because people state their degree of satisfaction and happiness with the structures, and the researcher can collect this information in an unobtrusive manner, i.e., user's feelings, attitudes and behaviour are not distorted because there is no direct contact with the researcher.

The final approach adopted in this chapter was to carry out a stakeholder analysis in order to find out winners and losers connected with the reef deployment. In the stakeholder analysis there were identified 21 different stakeholder classes, who were listed according to their relationship to the AR program. In this type of analysis, stakeholders can be classified as: primary, secondary or external. There were identified 12 primary stakeholders (i.e. those intended to be the beneficiaries or those negatively affected by the AR program). There were also identified six secondary stakeholders (i.e. those who are intermediaries in the process of delivering the AR program to primary stakeholders). Finally, there were identified three external stakeholders (i.e. all other individuals and institutions that have interests at stake). It was also found that in this study stakeholder interaction with the structures can be of private, public, or cooperative interest. In the analysis there were also identified the impact of the projects on stakeholders and their power to influence the AR program outcomes. Most stakeholder groups may be affected positively, but there are four groups supposed to be affected negatively. However, it is believed that those that may be affected negatively do not pose a serious threat to the expected AR development along its lifetime. In addition, it was also defined which are stakeholders' interactions with the ARs and their likely attitudes and behaviour towards the structures. Finally, a stakeholder participation matrix was developed where all stakeholder groups were allocated in terms of their expected degree of involvement throughout the different AR stages over time (i.e. stakeholders' inclusivity). The degree of involvement stakeholders have with the AR program varies over time depending on the stage of the program. If at the earlier stages (e.g. planning process) most of the stakeholders just have a low inclusivity (e.g. they are just informed), at a later stage (e.g. monitoring and evaluation), it is desired that the degree of inclusivity is much higher (e.g. partnership or even delegation of responsibilities on ARs).

Chapter 6 – Economic efficiency analysis was undertaken, using productivity approaches to fishing trials' data collected over a 16-year time period. The results showed that the presence of ARs, as well as their location and time effects over catches, are statistically significant, in terms of both catches and revenues. Because of a combined effect of these variables, vessels on reef areas are expected to earn approximately twice as many euros compared with nearby control sites. Similar results were found for data collected from one commercial fishing vessel, though the magnitude of the 'reef effect' was not quite so great. These results suggest that higher economic returns can be achieved when fishing in the reefs rather than in the surrounding control areas. The analysis also revealed evidence that there was an increase in catches in reef areas over time, whereas catches in control sites remain constant. This finding supports the contention that there is a positive reef effect on fish resources. This finding can also contribute to the 'attraction' versus 'production' controversy. In that scope, it was found that reefs that were completely surrounded by sandy substrates usually had less fish biomass than other reefs with rocky substrates nearby. Because both systems analysed (i.e. pilot artificial reefs of Olhão and Faro) have similar design and size, just differing their location and surrounding area these results suggest that the reefs may have an exclusive production role in sandy areas (as the case of Olhão ARS), whereas there is a production and attraction role to be played in rocky ones (as the case of Faro ARS).

A separate analysis using the AHP was conducted of data from logbooks and individual questionnaires from a sample of 12 commercial fishing fleet skippers from different areas of the Algarve region that used the ARs. From the questionnaire's results it was found that the criterion that fishermen declared that have contributed most for maximizing benefits from fishing is the economic reason (57.1%), namely the contribution from keeping employment (38.1%) and increasing revenue (19.0%). By their turn, the information provided by similar AHP analysis but on fishermen logbook records lead the researcher to prioritize the biological instead of the economic criterion as the main priority in order to maximize benefits from fishing. There are sources of evidence attesting to the fact that reef development can indeed be considered as an alternative choice for fishing. However, in areas where there is the 'competitor' natural reef, fishermen do not seem to switch to ARs. The reasons for this may lie in the fact that most fishermen are still attached to their favourite grounds. This means that it is difficult to change their views, and also, if they believe their favourite ground provides good catches, then there is no reason to change fishing sites. So, the use of the ARs may be only occasional. Fishermen placed a higher value on keeping their jobs in fisheries and did not pay much attention to factors such as by-catches. They also considered fishing elsewhere to be more important than fishing in specific ARs.

From a questionnaire survey of 32 divers (distributed evenly within the consumers and producers categories), AHP results showed that they placed a high value on biological resources, whether they are dive consumers or producers. Specifically, it was found that from a set of 14 sub-criteria to take into account in choosing the best diving spot, what is more important is to have ‘high biodiversity of the site’, followed by its ‘good state of conservation’ (both account for more than 1/3 of the preferences stated). By contrast, other sub-criteria as ‘depth range’ or ‘explore a given site more times’ do not contribute much to the decision (less than 2% and 3%, respectively). Divers generally choose natural reefs as the most interesting place to dive, whereas AR modules offered the least interesting site. AR modules alone may provide little contribution to diverting divers from the more attractive natural dive spots. However, they do contribute to diversifying divers’ options in terms of sites. AR modules seem to be very effective as a last resort when there are unfavourable visibility conditions at other sites. The reasons may be related to the service AR provides in terms of improving water quality, derived from the sessile fauna that is aggregated there and contributes to the re-mineralization of particles from bio-fouling. These facts can be explored from an economic standpoint by looking at nearby diver operator businesses. The AR modules together with other artificial structures can indeed help to mitigate divers’ negative impact on the fragile natural reefs (i.e. coral reefs), if there is a shift from natural to artificial reefs.

Finally, a brief cost-benefit analysis (CBA) showed that there were some economic benefits attached to the commercial exploitation of a pilot reef (including only fishermen). In order to conduct the CBA there were identified five independent variables that affected fishermen’s net economic returns from the reef investment. The variables are: average price of fish in the market, reef investment costs, fuel costs, harvesting costs and discount rate. In order to define AR yield, a sigmoid function was used as a proxy for fish produced at the reef site. In the case analysed (Olhão artificial reef system), it is believed that the approximately €250,000 invested in 1990 will result in a net present value (NPV) of approximately €100,000 after 25 years from deployment. The benefit cost ratio (BCR) of the project is 1.64 (i.e. for each euro spent on the project, sixty-four cents were produced). The internal rate of return (IRR) is around 8%, which is higher that the 5% discount rate used. Since the return from the investment is higher than the cost of capital, this is a worthwhile project. A sensitivity analysis shows that the most sensitive variable to project worth is fish price, where a ±10% change would cause a ± 51% change on NPV. A risk analysis was also conducted and it was obtained that for 60% of the occurrences NPV will fall within the range of €50,000 – €200,000. Less than 1% of the occurrences will fall over the figures referred previously, and there were no occurrences having a negative NPV.

7.2. Discussion of the Results of this Study

At this stage of the thesis it is important to recapitulate the four objectives stated at the end of first chapter. These were to:

- Examine the main reasons that lead to the adoption of ARs;

- Review the literature in terms of the state-of-the-art on ARs, their purpose and functioning, and identify the gaps on the socio-economics aspects;

- Adapt appropriate methodologies to the study of the AR human use, namely on: monitoring, social perceptions and attitudes, and economic efficiency;

- Integrate this knowledge of ARs with that of the wider area of marine resource management.

In order to justify the accomplishment of the above objectives, it seems important to structure this section in the following way: (1) Contribution to knowledge, (2) Toolbox for management, and (3) Further research.

7.2.1. Contribution to Knowledge

There are many studies attesting the increasing demand for fishing resources and saturation of supply from the wild. Pessimistic views tend to focus on fish catch reductions and impacts on species composition, while optimistic views claim that aquaculture and adequate management strategies are the solutions for such ‘dramatic’ problems. The deployment of artificial reefs is seen as a partial solution for the fishing problem. Historically, what first engendered an interest in ARs may probably have events that occurred by chance. Over time fishermen found some evidence that more fish was caught in void areas where objects were accidentally or deliberately sunken. At the present time there is sufficient scientific evidence supporting the contention that fish in general are structure-dependent, and seek shelter or/and food in such structures. In terms of reef usefulness for people this evidence is of interest for fishermen that usually are able to find more fish in any kind of reef (i.e. whether natural or artificial), and divers who like to dive in any structure presenting tri-dimensional relief. These are strong arguments supporting AR deployment for human use. However, some doubts still persist concerning the real potential ARs have in ‘producing’ biomass, instead of just ‘attracting’ or ‘re-distributing’ species from elsewhere.

The accumulated knowledge about ARs leads to the conclusion that their deployment generates both positive and negative impacts. For example, some decades ago, there existed (wrongly) the perception that materials of opportunity could serve both as a way of getting rid of unwanted equipment and at the same time enhancing habitat for many species. However, it soon became clear that this was not always the case. It was found that well planned long-life structures, having material stability were more successful than most of the materials of opportunity which are usually unstable. More recently, literature shows evidence that in many places around the world the positive effects of ARs deployment are perceived to be at least as important as the negative impacts. This perception favours the deployment of ARs in areas where there is a scarcity of rocky formations or other geographic accidents. The majority of past and current AR project policies have tended to focus on values and benefits related to fishermen, anglers and divers (whether professional or recreational), as well as the mitigation of the degradation of marine habitats.

Following the perception that ARs have more positive than negative impacts, in 1989 it was decided to reproduce the experience in Portugal. At that time there were several conditions that facilitated the process to create such structures. The chosen location to proceed with the deployment was the southern coast of Portugal mainland (Algarve). The main reasons pointed out as supporting pilot AR deployment and a further larger scale program in this region as against other Portuguese regions were:

- *Geographic and natural conditions* – The region presents an abundance of estuarine and inland waters (rivers Guadiana and Arade, and the lagoons of Ria Formosa and Alvôr), which confers some degree of protection to marine species. The presence of sandy bottoms and some scarcity of rocky formations (particularly noticed in the windward area), are necessary conditions to AR deployment.
- *Biological* – There is scientific evidence indicating that the lagoons of Ria Formosa and Alvôr are important nursery areas. ARs located nearby these lagoons are seen as a platform for younger fish when in transition from inland

waters to the open sea. ARs in that sense serve as a ‘friendly’ transitional environment, providing not only shelter for protecting, but also food and habitat.
- *Oceanographic* – It is important to have weak to moderate sea conditions of waves and currents, because these are indispensable for AR module stability, which in its turn is a *sine qua non* condition for AR deployment. The coastal waters of southern Algarve present these requirements, having the advantage of being calmer when compared to the ones from West Atlantic due to the influence of Mediterranean waters.
- *Demographic and human pressure* – In the Algarve there is an intense exploitation of the coastal fishing resources. The reasons for this may be due to the high rate of fishermen per resident inhabitants. This high rate may be also sustained by the high willingness to pay for fresh fish products (due to much higher rate of tourism when compared to other Portuguese regions). This high demand for fresh fish products in the region is a stimulus to keep many traditional small-scale fishing activities supplying fish within the local market.

The AR program developed in the southern coast of Portugal is currently the largest of its kind in Europe. In previous studies the structures deployed in the Algarve have already proved to be successful in biological terms, namely in the protection of juvenile fish and promoting biodiversity. Former studies also considered the importance of adequate management of ARs but have so far just focussed on that aspect solely by studying the structures in respect of their biology. Other policy objectives related to the multiple effects of ARs namely in terms of small-scale fisheries, diving and angling as well as other commercial activities (e.g. supporting off-shore aquaculture), remained largely unexplored.

The above objectives are beyond the biological dimension of the structures and relate to the human (i.e. anthropocentric) aspects of reef deployment. In addition, to address adequate management strategies for the structures, it is important to consider not only the biological resources, but also all stakeholders involved and their interactions (with the resources and between themselves). Therefore, by taking into consideration the important work by Milon et al. (2000), where it is referred that a ‘reef that is not useful to people is not a successful reef’, we addressed in this thesis the multiple effects generated by reef development in order to consider the success of these structures from a socio-economic perspective. In this thesis the above statement was taken to be a core theme of the enquiry, and as such it was essential to establish an empirical basis for any statements relating to the human impacts of reef deployment. To that end, the present thesis focussed on methodologies to collect and analyse data that examined and reflected the opinion, attitude and behaviour on preferences that users and other stakeholders had in relation to their interaction with ARs as an exogenous change in the marine ecosystem. In this study it was inquired about the utility users give to these new structures as a matter of not only habitat change, but also impacts on their livelihoods. That sort of new information on the socio-economic effects of ARs is important to decision-makers, who in turn can use such information in AR management strategies where the aim is to improve societal welfare.

The review of the literature showed that worldwide what is available on the socio-economics focuses mainly on recreational aspects of reef use, specifically diving and angling satisfaction. In Portugal there is some scientific knowledge of the effects of ARs, but apart from the present study there is a complete absence of literature concerning AR socio-economics. Since the deployment of the pilot reefs in 1990 until 2007 there were published less than 20 peer-reviewed papers on Portuguese ARs. From the state-of-the-art perspective, the scientific literature shows that ARs have been deployed worldwide, but the most important examples come mainly from Japan, southern coastal states of US, and the Northern Mediterranean coast. From the three geographical areas referred to above there is also a distinct purpose. In the first geographical area (Japan), ARs are usually carefully designed modules used by or attributed to fishing cooperatives. In the second geographical area (the US), there are used mainly materials of opportunity as obsolete structures (e.g. oil-rig jackets, vessels and armoured vehicles) for diving and angling purposes. In the third geographical area (Mediterranean) purposefully designed AR modules usually serve to protect kelp habitats and mitigate the effect of more destructive fishing devices.

The case of the Algarve, ARs benefited from the technical and scientific experience developed elsewhere. So, there was carefully considered a precautionary reef design using long-lasting materials (i.e. concrete-made modules). In an initial phase there was a pilot project consisting of two AR systems. Meanwhile, there were some ongoing monitoring schemes mainly aiming at biological (ichthyological and benthic fauna) and oceanographic purposes. Following some perceived AR ‘success’ from pilot reefs deployed, six years afterwards it was decided to extend the program by deploying more AR systems in a larger scale. All of these features considering the Portuguese experience of ARs are fairly described in the scientific literature. The Portuguese AR policy intends primarily to enhance fish (namely by protecting juvenile fish stocks and promote biodiversity) and support small-scale fisheries (by creating fishing areas). Portuguese reefs' policy objectives state that other AR benefits are welcomed, such as diverting effect of more destructive fishing practices, eco-tourism and off-shore aquaculture projects associated to ARs. The last ones are speculatively viewed as an activity with great potential, but which is still in an incipient phase.

Considering the purpose of ARs, it can be emphasised that despite some evidence of reef success, there still persist doubts about real effectiveness of ARs. Not only is the evidence fragmentary (and in some cases contradictory), but the effects of a particular reef system may only show up gradually and over an extended period. In the last three decades or so, there has been evidence demonstrating that, notwithstanding the fact that materials of opportunity are an obvious cheap solution, they not infrequently turn out to be disastrous (e.g. use of ballasted tyres resulted in debris scattered in beaches after storms). Due to these negative experiences, more recently it has been acknowledged that long-lasting structures such as planned modules have shown to be more effective, despite their higher costs. Likewise in the past, it was generally perceived that ARs could not only be made of different materials, but could also serve a range of purposes. However, recently that view has modified and it has been demonstrated that adequate choice of materials, as well as satisfactory design and acceptable location are the most fundamental considerations to take into account for AR deployment. In that scope, the structures tend to be used for specific purposes (e.g. to restore fish species, to provide easy and safe access for fish resources), despite the potential they have to provide a wider range of services. It has been emphasised that continuous evaluation of AR functioning is important in order to verify if the policy objectives defined are being met. Multi-purpose evaluations should desirably start before reef deployment and last as long as possible (i.e. during estimated AR lifetime). Thus, in this aspect some criticisms may occur by the fact that under current knowledge of ARs, their policy objectives should be clearly defined at the pre-deployment phase and should not try to serve all purposes. Rather, they should concentrate on a few functions or ecosystem services in order to maximize AR benefits to society. The reason to keep focused in few functions is to prevent potential conflicts from developing in which one service negates others (e.g. fishing practices may be incompatible with diving safety and inquisitiveness).

In the case of Algarve ARs, policy objectives stated a set of pursued goals. These are multi-purpose goals and focused mainly on fish protection, biodiversity promotion, and integrated coastal management (with special focus on fisheries). There are some studies attesting that AR deployment in the Algarve region has been useful for species protection because many small fish species are found there, and have been at least neutral in terms of biodiversity because there is a stable number in terms of species. It is believed that the structures also contribute to the management of coastal activities (namely fisheries), despite the incipient studies on the subject.

In terms of AR functions the deployment of such structures presupposes some changes in the marine environment. Some of those changes are desirable (e.g. ARs can mimic natural rock outcroppings) and others not so desirable (e.g. changes on the pattern of species abundance and dissimilar ecological chains). In order to reach adequate functioning of the structures the materials' choice and their design have fundamental importance, as well as their location. The knowledge of reef functioning is of fundamental importance namely in the focal point of distinguishing between what is production or attraction of the reefs.

In the case of Algarve ARs there were chosen long-lasting materials (the structures are made of concrete) and their design followed the rationale that modules deployed closer to the shore should invoke a 'protection' role, while those located deeper should have an 'exploitation' role, i.e. smaller and larger shaped according to their deployment depth. In terms of location, these ARs were placed according to criteria such as rock scarcity and far away from inlets. In the Algarve a single experience with a sunken vessel has been shown to be of particular interest through its effect on demand, notably because it serves as an additional diving spot choice (and hence widens the range of options to dive), as it was pointed out by Ramos et al. (2006b). Worldwide and specifically in the Southern coast of US, there are cases in the literature citing the examples of this type of reefs' success namely for diving and sea angling.

Considering the gaps on socio-economics, one that is easily perceived in this theme relates to the cause-effect of AR deployment. Apart from the generalized view usually supported by biologists that in AR areas there is an increment in terms of biomass (biological effectiveness), there are some controversies on the issue. Despite the documentary evidence, principally the scientific literature on the 'production versus attraction controversy', the fact is that immense doubts still persist on the subject. These doubts make difficult the correct understanding of the socio-economic effects of ARs, because this is a core concept for such evaluation.

The assertion about real functioning of ARs is important to take into account, because the success sought depends upon the interaction between people and the structures. So, the explanation for what in fact is AR effectiveness may vary amongst authors and according to their subjects of study. From a social and economic viewpoint it is important to have answers to questions concerning AR use: who are the users, where and when use occurs, and why ARs are used. In its turn, economic analysis of ARs should focus on impact and efficiency. It is important to perceive how the presence of ARs contributes to increase professional and/or recreational activities. In that sense it is extremely important to find out an objective answer to the value of benefits derived from reef development (whether monetized or not), in order to claim about reefs' success in socio-economic terms.

According to the reviewed literature, socio-economic research on ARs has been initiated in the 1980s, and since then some methodical approaches have been applied to calculate reef impact and efficiency. However, there is still a lack of rigorous techniques to assess wider effects of ARs on individuals and communities, and the specific question of how one can measure the economic value of these structures is seriously under-researched. The methods utilized to study the contribution of ARs within the social and economic domain have focused on measuring the increase in the number of boats and expenditures in recreational activities in a given reef area. Other studies have focused on CPUE measurements, but some authors have pointed out that studies on socio-economic performance should consider not only this type of measurements, but also other type of impacts and values.

Long-term assessments especially related to monitoring, impact assessment and efficiency analysis are considered in the literature as the most important aspects to measure social performance. Thus, so far studies on these aspects remain scarce. A central but simplistic concept is the benefit cost ratio (BCR) of an AR and its calculation. Despite being considered as a good approach, it is sometimes considered excessively simplistic because usually presupposes a constant catch ratio surplus.

Other needs in socioeconomics relate to data on harvests from the ARs and associated resources, and to know if the artificial structures can be legitimately considered as resource conservation refuges needing little enforcement. Amongst other things, managers need to know if reef size and location bear any relationship to key variables (e.g. yield) or parameters (e.g. species growth, survival rates, and carrying capacity of the reef system). Lack of knowledge of this kind can gives rise to uncertainty and doubt, typified by the current feeling within the research community that the results found for pilot ARs may not apply to larger reefs - in other words, the size of a reef matters. However, so far there is no strong evidence in the scientific research endeavours attesting that fact.

Nevertheless, in AR socio-economics it is always a central point to be focused on the human effect on reefs, since this aspect may be crucial to determine if a given AR program is a success or a failure. In general, the hitherto narrow focus of the literature should be widened to encompass a fuller range of techniques to evaluate AR effectiveness. Thus, ‘AR effectiveness’ is still an arguable question especially in terms of adequate management. The social dimension is often forgotten, which represents a weakness in most of the studies. Stakeholders’ perception and attitude are fundamental but usually absent in the AR literature. The access to the AR systems and the way stakeholders share their costs and benefits are also fundamental. So, it is imperative to get more information on reef effectiveness and concomitantly to document their benefits both on the demand and supply sides.

The results found in this research support the contention that ARs in the Algarve were expected to produce a number of desired or beneficial changes in many coastal communities. In particular, ARs were empirically perceived by coastal communities as helping to halt the decline in local fish stocks by conferring them some degree of shelter or food and consequently providing habitat for the establishment of fish that would be otherwise dispersed or caught easily. It should be emphasized that coastal communities in the Algarve present different characteristics, whether they have propensity for fishing or tourism, or exhibit a mixed combination of both activities. However, the results also reveal that some fishermen and some sea anglers still have some persisting doubts when considering reef effectiveness. These doubts may be related to non-use of the structures due to people's scarcity of information about them. It was also found that there is limited interest for divers to use the reefs. Other potential uses of ARs remain to be investigated; however, there is a recent and increasing stakeholder interest related to off-shore aquaculture near the ARs. These reasons may be supportive enough to justify the adoption of ARs in the region. Higher stakeholder involvement with the structures and perception of the reefs as structures that can be beneficial, may improve the feeling of need for them.

It was against this background of expectation, particularly the belief that ARs could overcome the problem of increasing fish scarcity, that the AR program was adopted from late 1980s in the region. In fact, the deployment of these structures occurred at an opportune moment, because at that time funds were available along with the necessary scientific/technical expertise. The choice of the Algarve over other regions was also helped by the set of favourable conditions that were outlined above. Recently, due to the interest demonstrated by stakeholders keen to develop off-shore aquaculture projects, initiatives were taken to license areas for this type of fish production (located near an existing pilot AR). It is believed that the structures may help in the management of not only fisheries, but also other coastal activities. The presence of the structures also allows the development of scientific studies on this particular subject.

7.2.2. Toolbox for Management

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. In their essence the Portuguese ARs have an ecosystem-based fisheries management goal, namely because 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 as the core aspect because there are many studies on reef assessment, but usually focusing solely on biological approaches. Thus, these biological approaches are commonly not enough to prove or refute the above premise. In order to explain 'AR usefulness', it is imperative to include the involvement of people in the process. Probably the most affected people by the Algarve's reef development are fishermen. Thus, as a public investment ARs need to be considered useful not only for a particular group of people, but for people in general, whatever the services provided by the structures. The rationale for the previous sentence is based on the grounds that people need to know that the money spent in reef development has some economic return or other social benefit or important role, making the society better off. However, it is difficult to perceive AR usefulness without directly contacting potential AR beneficiaries, and without querying and perceiving their values, beliefs, attitudes, behaviours, as well as their organizational characteristics. So, it is of fundamental importance not only to consider the affected people (i.e., stakeholders), but also to involve them. This involvement of stakeholders is the core aspect of AR socio-economics.

The challenge of this doctoral research was to develop and adapt methodological tools to study ARs in their social and economic context (i.e. where it was intended to find out people's involvement concerning artificial reef's deployment). The outcome of this endeavour was, in effect, to assemble a 'toolbox' that has potentially wide applicability in other situations. Such a tool box is believed to be of value to AR managers, since it enables them to assess important components of social and economic performance. The tool box 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 instruments and measurement techniques.

Monitoring and description data collection instruments such as opportunistic direct interviewing and some secondary sources are useful on the grounds of investigating potential users and *prima facie* patterns of AR use. It is important to select *a priori* which type of stakeholders to survey and define a consistent sampling schedule. In this context, the use of a semi-structured questionnaire-based interview seems to be very practical for several reasons, as such: it delimits the interview timings, it points out the main questions to be addressed without specifically following a given order, and it presupposes a known terminology by the interviewee where there used both closed and open-ended questions. The main weaknesses of this instrument are related to the veracity and subjectivity of the given data. In their turn, direct site observations and secondary sources (e.g. electronic files on fish caught landings) are instruments that offer a further way to get information on actual AR users. The main strengths of this methodology are related to observing stakeholders directly in action in their environment, and get the overall picture in the AR surroundings during the observational period. There is the drawback of being a somewhat intrusive method, which may result in biased data collection if the observed people suspect they are been observed. Another drawback to this particular methodology is when there are limited resources, which restricts observations to a relatively small reef area. The secondary sources collected are based on landings' records, boat and fishing gear licence documentation, as well as information from diving operators and anglers' clubs. Secondary sources are useful to cross check information both from interviews and direct site observations, but have the drawback of being subjected to some degree of confidentiality. In the 'Monitoring and description' context simple indicators represent general information about people using ARs. These indicators can provide summary numerical data describing (i) who uses the reefs, (ii) where and when does that use occur, and (iii) why are ARs used. In the present study, most of the measurement techniques used in the DSOs can be considered as simple indicators that mainly relate to standardised variables in terms of comparing patterns (i.e. vessels, crew onboard, fishing gear) in two or more different years. Data selected from secondary sources can be used as simple indicators in a similar way (e.g. percentage of landings by port and percentage of landings by most important species).

Social approaches may include the possibility of diversifying the range of stakeholders' inquiry by using a methodology where they are distributed into different groups, contacting directly the key ones and not focusing only on AR users, but also in other stakes. In the present piece of work the approach developed to study stakeholders' perception of AR impacts is designed to account for the multiple dimensions of reef performance - environmental, social, and economic. In this methodology key-stakeholders are invited to evaluate perceived impacts provoked by AR deployment by means of a questionnaire survey using attitude scales. In the research design of such analysis it was necessary to address most important issues on AR deployment both related with the pre- and post-deployment phases. The AMOEBA plot and ranking of items can be used as indicators of social perception of AR impacts. The strength of this methodological approach seems to be gathering people from different groups and backgrounds in order to evaluate reefs' impact according to their own perceptions in an objective manner. The corresponding drawback that it oversimplifies the results, because all items are analysed in the same mode and gather altogether whatever the dimension they come from. In addition to these techniques, it is also important to develop unobtrusive methods where there is no direct contact with stakeholders. The rationale for using such methodologies is based on the importance of investigating in an unbiased manner stakeholders expressed values, beliefs and attitudes either by the supply and demand sides of AR deployment. In the present work these methods focus on media such as newspapers and internet sources, which are believed to be essential to reach the above results. In the newspaper analysis, a ratio was used to compare the importance of sea-related subjects found (three different categories) over time. In this type of analysis, qualitative information was also used to classify the most important impacts by type of news (negative and positive). For its part, the internet when compared with printed media has the drawback of presenting relatively recent information (because the internet only became ubiquitous from late 1990s), but enjoys the advantage of being able to gather inputs from a wider range of people and is now accessible virtually everywhere. The analysis of internet sources is basically qualitative, though the data analysed can often be presented in quantitative forms (e.g. co-occurrence analysis, frequency of codes, and heatmap). Finally, a stakeholder analysis approach makes it possible to group all the perceived intervenient people into different clusters (i.e., primary, secondary, and external), and find out their interests in the AR projects. In such analysis, it is also possible to perceive their interaction and more likely attitudes and behaviour towards reef development and use. In the stakeholder analysis the measurement techniques used can also be expressed by indicators. They are both qualitative (stakeholder interest, AR interaction, likely attitudes and behaviour, stake and degree of involvement through the project stage) and quantitative (discrete variables for impact and influence of AR projects). The strength of this method is its holistic presentation where it is easy to pinpoint the main subjects and relate them with the object of study. The main weakness of this approach is that in order to be adequately detailed is a time consuming task.

In terms of economic efficiency, the useful methods often take as their starting point the analysis of fisheries yield and productivity. These allow the understanding of the surplus production of fish in an AR, when compared with non-reef control areas. In the current thesis there were developed some approaches where it is possible to determine the value per unit effort (VPUE) of reef areas, by attributing market values to the fish caught. Comparative indicators are used (i.e. comparing control or non-reef versus ARs) for scientific fishery trials and small-scale fisheries. In parallel with this, multiple regression was used to evaluate the influence of four variables (reef, type, location and time) on reef performance. Stakeholder elicitation methods are useful to perceive the preferences of the involved people in a given project, object, good, etc. This sort of method is very important in decision making processes. In the present study, the analysis of commercial fisheries focused on direct use values (related to productivity) and the implications of performance differences for fishing site preferences. In the case of recreation (i.e. diving), the values looked at are essentially intangible, since divers' valuation of sites is equated with the satisfaction they get from the activity at a site with specific characteristics. AHP was chosen as an adequate measurement technique that assists the analysis of fishing and diving priorities. The eigenvectors and sensitivity analysis for each of the criteria and alternatives are the results used as indicators for the decision analysis process. In the particular case of this study the main strengths found for the stakeholder elicitation technique is perhaps its straightforwardness in decision taking. The technique simplifies a complex problem involving human perceptions and judgments about a given set of elements, where the elements of the decision are difficult to quantify or compare and 'transforms' the data into an easy and perceptible solution (eigenvector). The main weakness found is related to the high variability of the results if there occur some relatively small changes in the data. The cost benefit analysis (CBA) is a generalized method of economic analysis where its usefulness is found when it is necessary to anticipate if a project is above or below a defined threshold of monetary acceptability (e.g. based on NPV or IRR). This process is commonly used as a support in decision analysis processes. In the present study a CBA approach is developed for a pilot AR and the relative BCR is calculated. In the approach there is the empirical problem of how to satisfactorily monitor and obtain consistent 'producer surplus' measures that arise from reef deployment. Sensitivity and risk analyses are used as indicators for acceptance or rejection of a given project. CBA used in the context of ARs is useful because it is a high-quality way to show the potential of an AR in economic terms by gathering the most important variables. However, by the same token CBA has at least one important limitation, because in the absence of any data it may be necessary assume a constant catch surplus while fishing at reefs. This assumption is likely to be violated if, as might quite likely happen, fishing pressure at an AR builds up over time and catch rates fall.

The main argument of this thesis is that it is of crucial importance to know stakeholders' perception and attitude concerning the ARs and include them in the management process of the structures. By using a tool box of techniques for obtaining evidence on the human impact of artificial reefs (i.e., by means of knowing who uses the reefs and to what extent), and specifically to get information on the benefits derived from them, a contribution can be made to the identifying the social and economic implications of reef deployment in the particular case of south Portugal.

In terms of management, AR structures should not be considered as an effective fisheries management method on their own, if there are not also other control measures in place. This is because the deployment of ARs is just one measure taken to try to mitigate the negative externalities associated with open-access fisheries. It is of fundamental importance to establish ways to control AR access and provide strategies to accomplish monitoring schemes. In this context, it is necessary to consider the behavioural consequences likely follow from the new incentives and opportunities resulting from an intervention of this kind (Hardin 1968, 1998, Ostrom 1990). This was the rationale in the thesis for collecting and analysing information related to the behaviour of AR users. It was found that there are different behaviours, and interactions with the reefs, and consequently reefs may be affected in different ways by stakeholders and these may jeopardise reefs' biological effect. This result is fundamentally important for management: if decision-makers are aware of the different interests of stakeholders, and understand how the behaviour and activities of such groups may be impacted, they can potentially make the best use of ARs while at the same time recognising that these structures are not a panacea for all the problems of the fisheries.

However, at the present time it has to be considered seriously that AR resources are still subjected to a quasi-open access like most of the other marine areas in Portugal. The problem with this is because, if there are no special protection or concession jurisdictions concerning the ARs, congestion and stock externalities over AR fish resources will be created. These externalities basically mean that competition for fish will saturate the AR ground and over-harvesting of fish will occur as a result of the ease of finding fish in the reefs' area. The above problem can attain dramatic proportions for fishing communities, notably in AR areas where there is a substantial attraction of fish from the vicinity. In such a circumstance as a result of inadequate reef management, over-exploitation of fish resources can occur in both reef and non-reef areas, leaving the society worse off. In such cases the utility of the reefs is condemned to vanish before the life expectancy of the project (at least by the fisheries point of view), and the AR project fails.

This study tries to show that, while there are real social and economic benefits of artificial reefs, the very existence of these benefits (notably increased profits from fishing) engenders a risk of failure. This will occur if the social utility of the structures is dissipated due to ineffective management measures to control fishing activity. In turn this may be more likely to happen if the strategies chosen by decision-makers are erroneous (e.g. based on simplistic 'command and control' measures) or ignore the preferences and aspirations of stakeholders. Therefore, it is of fundamental importance to understand the circumstances in which such failure can arise and thus be prevented. If the problems are satisfactorily overcome then there is a wider scope to deploy more ARs in other parts of the country (or elsewhere) with higher expectancy of success, since the pre-conditions for AR socio-economic success can be assured.

So, it is believed that the results found in this study have a number of implications in terms of management. For example, it demonstrates that the type of information here (i.e. perceptions, attitudes, and behaviour of stakeholders) is fundamental to pinpoint user needs and adequate use of the structures. Decision-makers need to know how to use this type of information in order to best address AR management problem. It was also found that in order to have sustainable fish resources, it is necessary to collect information on AR use and resources exploited, which is only possible if there is adequate monitoring in terms of fishing, recreational and other human use. It was also found that it is difficult to control the above variables without closest stakeholders' collaboration with scientific bodies. One way to achieve that may be through restricted access to AR resources, where the establishment of use or property rights might be a necessary solution. However, this step has to be considered as an adaptive process, and again it has to be emphasised that it is only possible with closest stakeholder involvement. In conclusion, it is possible to construct an effective support for management purposes, if attention is paid to the clues of knowledge provided in this study.

7.2.3. Future Research

In the present work, as a case study there were developed many questions during its ongoing progress. All the questions raised could only be answered due to the combination of the methods used. However, there are some methodological developments in the socio-economics scope that could and should be done in order to better understand the importance of ARs in anthropocentric terms or even to contribute to the recent, but increasing concern in the eco-centric issues. The present research is essentially an exploratory approach to some of these socio-economic issues related to ARs, and as such is not only a starting point but also a baseline for further research on the socio-economics of ARs. The various lines of enquiry that might useful be pursued are discussed below.

One area in particular concerns the economic value of ARs, a topic which was touched on in the thesis but which is still in its infancy. Our knowledge of the total economic value (TEV) of ARs is then still quite incomplete, because most of their indirect, option and passive use values remain unquantified. Though controversial, the concept of TEV has been receiving increasing prominence in the scientific media, especially in terms of developing more reliable methodologies. The importance of establishing a TEV for ecosystems relates to the goal of rational resource, since arguably without some knowledge of economic value it will be impossible to decide what level of protection they should be given. One of the major challenges for adequate AR management is to know the economic value of goods and services provided by the deployment of the structures. These include not only direct use values, but also other values contributing to AR total economic value (TEV), namely: indirect use value (e.g. habitat protection for some species, fishing and diving diversion from natural reefs, contribution to coastal and shore protection by attenuating wave and current power during storms, and improving water quality), and non-use value (e.g. benefits from knowing that biodiversity has been conserved for future generations). Reef TEV is ultimately related to the importance which individuals and stakeholders attach to these multiple functions as well as the effectiveness of the management regime in capturing such benefits.

It is therefore of fundamental importance that in the future methodologies are adapted and developed which can measure the value of ARs in the broadest sense. For monetary valuation this will involve the application of revealed preference methods (e.g. the travel cost method – TCM) and stated preference methods (e.g. through contingent valuation method [CVM] or choice experiments [CE]). This seems to be the next natural step towards a fuller socio-economic knowledge of ARs. It is also necessary to investigate the scope for applying non-monetary (i.e. scoring) methods based on multi-criteria analysis. These can provide useful information to resource managers about public preferences, helping to answer the question 'what do people want from artificial reefs?' This thesis has demonstrated that one particular multicriteria method, the analytic hierarchy process (AHP) has considerable potential. However, further research is needed to refine this technique and to see how it can be combined with other valuation methods. This includes work on carrying out focus-groups and establishing protocols with key-stakeholders (namely commercial fishing associations in order to obtain meaningful information on cost and earnings of the activity). This sort of information can also be used as a means to help in the construction of TCM and CVM methods.

7.3. Conclusion

When reviewing the literature concerned with the development of ARs, it can be found that the biological aspects of the structures are those that have been extensively covered. Most of this literature suggests that, from a biological perspective, ARs can provide benefits. However, some doubts may be raised when considering the ARs' usefulness in social and economic terms. One of the main reasons for these doubts is the scarcity of relevant information and studies about the socio-economic aspects of reef deployment. Another reason is that in places where AR structures were introduced and fishing practices were allowed to operate freely, the economic benefits derived from reef deployment dissipated more rapidly and the fisheries' situation worsened. The above facts suggest that ARs should not be considered as the magic solution to fisheries' problems. Another factor to be taken into account is the classic controversy of 'attraction' versus 'production', that still exists and needs to be more fully understood. A clear understanding of this controversial phenomenon can help to solve many crucial problems related to reefs, namely in socio-economic terms.

The objective of this thesis was to shed some light on a number of the social dimensions relating to the deployment of artificial reefs. This objective could help to fill a big gap in the literature which has up till now paid little attention to the socio-economic aspects. The intention was 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 that could be used in future socio-economic studies of ARs. It is suggested that the involvement of the different stakeholder representatives in the management of AR structures is fundamental in order to achieve policy objectives. It is central to assess stakeholders' importance and their relative 'lobbying power'. One approach to achieve that is by using the analytic hierarchy process methodology (AHP). In this study it is concluded that Algarve fishing communities and stakeholders in general perceive AR benefits mainly in terms of direct value, as such: extractive resources (e.g. surplus fish they catch in the AR area) and non-extractive use (e.g. biodiversity, extra shelter and refuge provided by ARs that are valuable to recreational divers and eco-tourists).

Probably one of the most important contributions of the present piece of work is that it demonstrates that artificial reef deployment has multiple impacts within different domains. As well as the expected physical and biological effects, it has also been shown that attitudes and behaviour 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. It is the contention of this thesis 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.

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Annexes

Interview on Artificial Reef Users

QI – Directed to Commercial Fishermen

Port: ________
Code: _______
Individual: _____

Section A – Identification data

1. What is your type of activity?

   Commercial fishing ☐
   Recreational fishing * ☐
   Snorkel diving * ☐
   Scuba diving * ☐

   * *Fill questionnaire II.*

2. Professional category:

   Skipper ☐
   Contramestre ☐
   Other ☐ Which one? __________________

3. Age: _______ years-old

4. Including the respondent, how many people there are in the household (ascendent and descendent depending)?

   0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – 13 – 14 – 15

Section B – Professional activity

5. Apart from fishing activity, do you have any other job occupation?

   Yes ☐
   No ☐ ⟶ (go to 9.)

6. If the answer was **yes** to the previous question, please specify?

   ____

7. Do you practice that activity all year round?

   No ☐
   Yes ☐ ⟶ (go to 9.)

8. Usually, when do you practice the other occupation?

Jan	Feb	Mar	Apr	May	Jun
Jul	Aug	Sep	Oct	Nov	Dec

9. How many people in your household are presently working in the fishing activity (**do not** count with the respondent)?

   0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – 13 – 14 – 15

Section C – Activity caracterisation

10. What sort of vessel do you have?

    Local ☐
    Coastal ☐
    Recreational ☐
    Other ☐ ⟶ End of filling

11. Whose gears do you use (1-more, 6-less)?

    Trammel nets ☐
    Gill nets ☐
    Longlines ☐
    Creels ☐
    Iron traps ☐
    Other(s) ☐ Which one(s)? ________________

12. Specify the use of each gear:

Gear	SY[1]	T Spp.[2]	Depth[3]	CN[4]
1				
2				
3				
4				
5				
6				

Section D – Fishing ground localization

13. From the origin port, which is the maximum distance you travel (in maritime miles)?

    0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26

14. Where do you usually fish?

    ____
    ____
    ____

Section E – Updating and modernizing

15. From two years ago onwards, have you done any change in the fashion you fish?

    Yes ☐
    No ☐ ⟶ (go to 17.)

16. If the answer to the previous question was **yes**, fill the following table according with two years ago situation:

Gear	T Spp.[2]	CN[4]	Equipment[5]
1			
2			
3			
4			
5			
6			

Section F – Fishing effort

17. How long it takes from launching up to collect gears onboard?

Gear	Period
1	
2	
3	
4	
5	
6	

18. How long takes the trip (including return) from the origin port up to the fishing ground (**minimum** and **maximum** time in hours)?

0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26

19. How often do you fish (times per week)?

< 1☐ 1 to 2 ☐ 3 to 5 ☐ 6 to 10 ☐ > 10 ☐

Section G – Artificial Reef (ARs) consequences

20. How do you use the fishing income most? (Choose just one answer).

reinvest (in the vessel, etc.) ☐ education ☐

housing ☐ savings ☐

21. Have you ever have fished in an ARs area?

Yes ☐ No ☐ Doesn't know ☐

22. Do you think it is worth to fish in an ARs area?

Yes ☐ No ☐ Doesn't know ☐

23. Why? – (compare with activity before ARs deployment). Determinants of use (rise ↑, maintain **=** go down ↓):

Fish quality:↑ = ↓ Fish quantity: ↑ = ↓ Fish diversity:↑ = ↓
Costs:↑ = ↓ T Travel distance:↑ = ↓ Times in the AR:↑ = ↓

____

24. If your answer was **yes** in question 21., do you think it should be deployed more ARs?

Yes ☐ No ☐ Doesn't know ☐

25. Where?

____

____

____

Section H – Investment and costs

26. What is the hull's building material, and how old are the vessel and the engine?

Hull's material

Vessel's age	Engine's age

27. What sort of fuel does the vessel use?

Diesel ☐ Petrol ☐

28. Fuel tank refueling:

Tank capacity (liters)	Number refuels/month

29. Which is the engine's horse power?

< 10hp ☐ < 25hp ☐ < 50hp ☐ > 50hp ☐

30. Do you have any apparatus as winches,GPS, etc.?

Yes ☐

No ☐

In the following questions (31. to 35.) the answer unit is the **conto** (former colloquial portuguese currency unit):

31. Fill the table:

Apparatus	Investment	SC[6]	ARMC[7]
Vessel			
Gears			
Engine			
Winches			
GPS			

32. If you would like to sell the boat (hull, engine, and other equipment which neither includes gears nor licenses), how much would you ask for (x1000)?

0.25 – 0.5 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120

33. If you would like to sell the boat and gears, how much would you ask for (x1000)?

0.5 – 0.75 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120

34. And if you would like to sell the boat, gears and licenses (x1000)?

0.75 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120 – 150

35. How does is divided the fishing income with the crew (**do not** count with the skipper/respondent)?

____

____

Comments and/or suggestions:

____

____

____

Abbreviations used in the tables:

[1] Year season
[2] Target species
[3] Average depth in braças (used commonly within commercial fishermen)
[4] Crew number (do not count with the skipper)
[5] New equipment with less than two years age
[6] Annual substitution costs
[7] Annual repairing and maintenance costs

Sondagem em Utilizadores de Recifes Artificiais

QI – Dirigido a Pescadores Comerciais

Porto: ________
Código: ________
Indivíduo: ________

Secção A – Dados identificativos

1. Qual é o seu tipo de actividade?

   Pesca comercial ☐
   Pesca de recreio* ☐
   Mergulho de apneia* ☐
   Mergulho com escafandro* ☐

   * *Preenchimento do questionário II.*

2. Categoria profissional:

   Mestre ☐
   Contramestre ☐
   Outra ☐ Qual? ______________________

3. Idade: _______ anos

4. Quantas pessoas tem o seu agregado familiar (descendentes e ascendentes a seu cargo, contando com o inquirido)?

   0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – 13 – 14 – 15

Secção B – Actividade profissional

5. Exerce outra actividade para além da pesca?

   Sim ☐
   Não ☐ ⟶ (passar para 8.)

6. Se respondeu **sim** à pergunta anterior, qual é essa actividade?

   ____

7. Pratica essa outra actividade durante todo o ano?

   Não ☐
   Sim ☐ ⟶ (passar para 8.)

8. Em que meses pratica essa outra actividade?

Jan	Fev	Mar	Abr	Mai	Jun
Jul	Ago	Set	Out	Nov	Dez

9. Quantas pessoas do seu agregado familiar estão ligadas à actividade da pesca (**não** contar com o inquirido)?

   0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – 13 – 14 – 15

Secção C – Caracterização da actividade

10. Em que segmento a sua embarcação se insere?

    Local ☐
    Costeira ☐
    Recreio ☐
    Outra ☐ ⟶ Terminar o preenchimento

11. Quais são as artes que utiliza (1-mais, 6-menos)?

    Redes tresmalho ☐
    Redes emalhar ☐
    Palangre ☐
    Covos ☐
    Murejonas ☐
    Outra(s) ☐ Qual(ais)? ____________________

12. Especifique a utilização de cada uma das artes?

Arte	EA[1]	Spp A[2]	Calador[3]	NHC[4]
1				
2				
3				
4				
5				
6				

Secção D – Localização do pesqueiro

13. A partir do porto de origem, qual é a distância máxima que percorre (em milhas marítimas)?

    0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26

14. Em que locais costuma pescar?

    ____
    ____
    ____

Secção E – Modernização e adaptação

15. De há dois anos para cá, fez alguma alteração no modo de pesca?

    Sim ☐
    Não ☐ ⟶ (passar para 16.)

16. Se a resposta à pergunta anterior foi afirmativa, preencher o quadro de acordo com a situação há dois anos atrás:

Arte	Spp. A[2]	NHC[4]	Equipamento[5]
1			
2			
3			
4			
5			
6			

Secção F – Esforço de pesca

17. Quantas horas de trabalho tem em média desde a calagem das artes até à alagem das mesmas?

Arte	Duração
1	
2	
3	
4	
5	
6	

18. Quanto tempo dura a viagem desde a saída do porto (assinalar o **mínimo** e **máximo** em horas)?

0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26

19. Com que frequência (n.º vezes por semana) pesca?

< 1☐ 1 a 2 ☐ 3 a 5 ☐ 6 a 10 ☐ > 10 ☐

Secção G – Consequências dos Recifes Artificiais (RAs)

20. Como utiliza o rendimento na pesca? (Escolher apenas uma opção)

investi-lo (no barco, etc.) ☐ em educação ☐

utilizá-lo em arranjos na casa ☐ poupá-lo ☐

21. Já alguma vez pescou numa zona de RAs?

Sim ☐ Não ☐ Não sabe ☐

22. Acha que vale a pena pescar numa zona de RAs?

Sim ☐ Não ☐ Não sabe ☐

23. Porquê? – (comparar com actividade antes da implantação dos RAs). Determinantes de uso (subiu ↑, manteve **=** ou desceu ↓):

Qualidade px:↑ = ↓ Quantidade px: ↑ = ↓ Diversidade px:↑ = ↓ Custos:↑ = ↓ Distância percorrida:↑ = ↓ N.º X no AR:↑ = ↓

____

24. Se respondeu **sim** na questão 21., acha que se devem colocar mais RAs?

Sim ☐ Não ☐ Não sabe ☐

25. Onde?

____
____
____

Secção H – Investimento e custos

26. Qual é o material do casco e a idade da embarcação e do motor?

Material do casco

Embarcação	Motor

27. Que tipo de combustível usa na embarcação?

Gasóleo ☐ Gasolina ☐

28. Abastecimento do depósito de combustível:

Volume do depósito (em litros)	Nº abastecimentos/mês

29. Qual é a cavalagem do motor?

< 10cv ☐ < 25cv ☐ < 50cv ☐ > 50cv ☐

30. Têm aparelhos como aladores ou guinchos, sondas, GPS, etc.?

Sim ☐

Não ☐

Nas questões seguintes (30. a 33.) a unidade de resposta é o **conto**:

31. Preencha o quadro:

Aparelho	Investimento	CS[6]	CMRA[7]
Barco			
Artes			
Motor			
Alador			
Sonda			

32. Se quisesse vender o barco (casco, motor, e outro equipamento que não inclua as artes, nem licenças), quanto pediria (x1000)?

0.25 – 0.5 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120

33. Se quisesse vender o barco e as artes, quanto pediria (x1000)?

0.5 – 0.75 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120

34. E se quisesse vender o barco, as artes e as licenças (x1000)?

0.75 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120 – 150

35. Como é dividido o rendimento da pesca com o pessoal da companha (**não** contar com o mestre/inquirido)?

____
____
____

Comentários e/ou observações:

____
____
____
____

Abreviaturas usadas nas tabelas:
[1] Época do ano
[2] Espécies alvo em % aproximada de captura
[3] Calador (profundidade média em braças)
[4] N.º de homens na companha (sem contar com o mestre)
[5] Equipamento que não tinha na altura
[6] Custos de substituição anuais
[7] Custos de manutenção e/ou reparação anuais

Interview on Reef Users

QII – Directed to Recreational Fishermen and Diving

Port: ________
Code: _______
Individual: _____

Section A – Identification data

1. What is your type of activity?
   - Commercial fishing* ☐
   - Recreational fishing ☐
   - Snorkel diving ☐
   - Scuba diving ☐

   * *Fill questionnaire I.*
2. Category:
   - *Patrão de Costa* license ☐
   - *Marinheiro* license ☐
   - Snorkel diving certificate ☐
   - Scuba diving certificate ☐
   - Other(s) ☐ Which one(s)? _______________
3. Age: _______ years-old

Section C – Activity caracterisation

4. What is(are) that(these) occupation(s) you practice?
   - Angler (reed and reel) ☐
   - *Toneira* ☐
   - Spearfishing ☐
   - Recreational diving ☐
   - Other(s) ☐ Which one (s)? ______________________
5. Do you practice that (these) occupation(s) with…?
   - Alone ☐
   - Friends or work colleagues ☐
   - Members of any association or group ☐
   - Other ☐ Which one? ______________
6. Specify the use of each occupation referred in question 4.?

Occup.	YS[1]	Aim[2]	Depth[3]	CN[4]
1				
2				

7. The fishing or diving activity you practice represents...?
   - Your main economic activity ☐
   - An important economic contribution ☐
   - A small economic contribution ☐
   - Just leisure ☐

Section D – Fishing ground localization

8. From the origin port, which is the maximum distance you travel (in maritime miles) to fish or dive?

   0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26
9. Where do you usually fish or dive?

   ____
   ____
   ____

Section F – Fishing effort

10. How long it takes the journey from the moment you achieve the site for the activity(ies) referred in question 4.?

Activ.	Period
1	
2	

11. How long takes the trip (including return) from the origin port up to the fishing or diving ground (**minimum** and **maximum** time in hours)?

    0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26
12. How often do you fish (times per week)?

    < 1☐ 1 to 2 ☐ 3 to 5 ☐ 6 to 10 ☐ > 10 ☐

Section G – Artificial Reef (ARs) consequences

13. Have you ever have fished in an ARs area?

    Yes ☐ No ☐ Doesn't know ☐
14. Do you think it is worth to fish in an ARs area?

    Yes ☐ No ☐ Doesn't know ☐
15. Why? – (compare with activity before ARs deployment). Determinants of use (rise ↑, maintain **=** go down ↓):

    Fish quality:↑ = ↓ Fish quantity: ↑ = ↓ Fish diversity:↑ = ↓
    Costs:↑ = ↓ T Travel distance:↑ = ↓ Times in the AR:↑ = ↓

    ____
16. If your answer was **yes** in question 21., do you think it should be deployed more ARs?

    Yes ☐ No ☐ Doesn't know ☐
17. Where?

    ____
    ____
    ____

If you are the owner or responsible for any sort of vessel, please answer the following questions; otherwise you finish the questionnaire.

Section H – Investment and costs

18. What is the hull's building material?

Hull's material

19. How old are the vessel and the engine?

Vessel	Engine

20. What sort of fuel does the vessel use?

Diesel ☐

Petrol ☐

21. Fuel tank refueling:

Tank capacity (liters)	Number refuels/month

22. Which is the engine's horse power?

< 10hp ☐

< 25hp ☐

< 50hp ☐

> 50hp ☐

23. Do you have any apparatus as winches,GPS, etc.?

No ☐

Yes ☐ Which one(s)? ________________

In the following questions (31. to 35.) the answer unit is the **conto** (former colloquial portuguese currency unit):

24. Fill the table:

Apparatus	Investment	SC[5]	ARMC[6]
Vessel			
Engine			
Diving equipment			
Others			

25. If you would like to sell the boat (hull, engine, and other equipment which neither includes gears nor licenses), how much would you ask for (x1000)?

0.25 – 0.5 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120

Comments and/or suggestions:

____

____

____

____

Abbreviations used in the tables:

[1] Year season
[2] Aim can be target species or diving satisfaction reasons
[3] Average depth in meters
[4] Crew number (do not count with the skipper)
[5] Annual substitution costs
[6] Annual repairing and maintenance costs

Sondagem em Utilizadores de Recifes Artificiais

QII – Dirigido a Pescadores de Recreio e ao Mergulho

Porto: ________
Código: _______
Indivíduo: _____

Secção A – Dados identificativos

1. Qual é o seu tipo de actividade?
   - Pesca comercial * ☐
   - Pesca de recreio ☐
   - Mergulho de apneia ☐
   - Mergulho com escafandro ☐

   ** Preenchimento do questionário I.*

2. Categoria:
   - Carta de Patrão de Costa ☐
   - Carta de Marinheiro ☐
   - Certificado de mergulho por apneia ☐
   - Certificado de mergulho escafandro ☐
   - Outra(s) ☐ Qual(ais)?____________________

3. Idade: _______ anos

Secção C – Caracterização da actividade

4. Qual(ais) é (são) a(s) ocupações que pratica?
   - Pesca com cana ☐
   - Toneira ☐
   - Pesca com arpão ☐
   - Passeio subaquático ☐
   - Outra(s) ☐ Qual(ais)? ____________

5. Com quem costuma praticar essa(s) ocupação/(ões)?
   - Sozinho(a) ☐
   - Amigos(as) ou colegas de trabalho ☐
   - Associados de um clube ou grupo ☐
   - Outro ☐ Qual?_________

6. Especifique a utilização de cada uma das ocupaçã(ões) referida(s) na questão 4.?

Activ.	EA[1]	Objectivo[2]	Calador[3]	NHP[4]
1				
2				

7. A actividade da pesca ou mergulho que pratica, representa...?
   - A sua actividade principal ☐
   - Um importante contributo económico ☐
   - Um pequeno contributo económico ☐
   - Apenas lazer ☐

Secção D –Localização do pesqueiro

8. A partir do porto de origem, qual é a distância máxima que percorre (em milhas marítimas)?

   0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26

9. Em que locais costuma pescar ou mergulhar?

   ____
   ____
   ____

Secção F – Esforço de pesca

10. Quantas horas dura a jornada (em média), a partir do momento em que começa(m) a(s) actividade(s) referida(s) na questão 4.?

Activ.	Duração
1	
2	

11. Quanto tempo dura a viagem desde a saída do porto (assinalar o **mínimo** e **máximo** em horas)?

    0 – 2 – 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18 – 20 – 22 – 24 – 26

12. Com que frequência (n.º vezes por semana) pesca ou mergulha?

    < 1☐ 1 a 2 ☐ 3 a 5 ☐ 6 a 10 ☐ > 10 ☐

Secção G – Consequências dos Recifes Artificiais (RAs)

13. Já alguma vez pescou ou mergulhou numa zona de RAs?

    Sim ☐ Não ☐ Não sabe ☐

14. Acha que vale a pena pescar ou mergulhar numa zona de RAs?

    Sim ☐ Não ☐ Não sabe ☐

15. Porquê? – (comparar com actividade antes da implantação dos RAs). Determinantes de uso (subiu ↑, manteve **=** desceu ↓):

    Qualidade px:↑ = ↓ Quantidade px: ↑ = ↓ Diversidade px:↑ = ↓
    Custos:↑ = ↓ T Distância percorrida:↑ = ↓ N.º X no RA:↑ = ↓

    ____

16. Se respondeu **sim** na quesão 14., acha que se devem colocar mais RAs?

    Sim ☐ Não ☐ Não sabe ☐

17. Onde?

    ____
    ____
    ____

Se é proprietário ou responsável de alguma embarcação, responda às seguintes questões; caso contrário terminou o preenchimento.

Secção H – Investimento e custos

18. Qual é o material do casco do barco?

Material do casco

19. Qual é a idade da embarcação e do motor?

Embarcação	Motor

20. Que tipo de combustível usa?

Gasóleo ☐

Gasolina ☐

21. Abastecimento do depósito de combustível:

Volume do depósito (em litros)	N.º abastecimentos/mês

22. Qual é a cavalagem do motor?

< 10hp ☐

< 25hp ☐

< 50hp ☐

> 50hp ☐

23. Tem aparelhos como aladores ou guinchos, sondas, GPS, etc.?

Não ☐

Sim ☐ Qual(ais)? _______________

Nas questões seguintes (24. e 25.) a unidade de resposta é o **conto**:

24. Preencha o quadro:

Aparelho	Investimento	CS[5]	CMRA[6]
Embarcação			
Motor			
Equipamento de mergulho			
Outros			

25. Se quisesse vender o barco (casco, motor, e outro equipamento que não inclua as artes, nem licenças), quanto pediria (x1000)?

0.25 – 0.5 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 12 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 60 – 70 – 80 – 90 – 100 – 120

Comentários e/ou observações:

____

____

____

____

Abreviaturas usadas nas tabelas:

[1] Época do ano

[2] Objectivo pode ser: a(s) espécie(s) alvo ou razões para a satisfação do mergulho

[3] Calador (profundidade média em braças)

[4] N.º habitual pessoas nessa ocupação (contra com proprietário/responsável pelo barco)

[5] Custos de substituição anuais

[6] Custos de manutenção e/ou reparação anuais

Fisheries in the artificial reef zones of the Algarve's coast

Date:____/____/ 200____ Fishing place: Reef of ____________________

Latitude: ______°______' N West/East Reef of ___________________

Longitude:_____°______' W Fishing gear:___________________________

Gear size (N° of pieces, traps, etc):_________ Mesh/Hook size:_________

Caught species	Weight (kg)

Date:____/____/ 200____ Fishing place: Reef of ____________________

Latitude: ______°______' N West/East Reef of ___________________

Longitude:_____°______' W Fishing gear:___________________________

Gear size (N° of pieces, traps, etc):_________ Mesh/Hook size:_________

Caught species	Weight (kg)

Pescarias na área recifal da costa do Algarve

Data: ____ / ____ / 200__ Local pesca: Recife de ____________________

Latitude: _______°_______' N Poente/Nasc. Recife de ____________________

Longitude: ______°_______' W Arte de pesca: ____________________________

Dimensão (Nº panos, covos, etc): __________ Malhagem/Tam. anzol: __________

Espécies capturadas	Peso (kg)

Data: ____ / ____ / 200__ Local pesca: Recife de ____________________

Latitude: _______°_______' N Poente/Nasc. Recife de ____________________

Longitude: ______°_______' W Arte de pesca: ____________________________

Dimensão (Nº panos, covos, etc): __________ Malhagem/Tam. anzol: __________

Espécies capturadas	Peso (kg)

Direct Site Observations

Observation n.º [ ] Site: ______________________ Day: ________ Date: ____/____/____ Time: _________ and _________.

ARs Fishing Effort Monitoring.

RV ________________ Observer:____________________.

#	Boat's name	Number plate	User type	Gears	Catches (species)	Amount	Duration	Crew
1								
2								
3								
4								
5								

#	Type of gear	Nº of buoys	Approximate extension	Position related to ARs	Notes:
1					
2					
3					
4					
5					

Observation n.º [ ] Site: ______________________ Day: ________ Date: ____/____/____ Time: _________ and _________.

ARs Fishing Effort Monitoring.

RV ________________ Observer:____________________.

#	Boat's name	Number plate	User type	Gears	Catches (species)	Amount	Duration	Crew
1								
2								
3								
4								
5								

#	Type of gear	Nº of buoys	Approximate extension	Position related to ARs	Notes:
1					
2					
3					
4					
5					

Observações Directas de Campo

Observação n.º Local: ________________________ Dia: ________ Data: ____/____/____ Hora: _________ e as ________.

Monitorização do Esforço de Pesca nos RAs.

NI __________ Observador:___________.

#	Nome do barco	Matrícula	Utilizador	Artes	Capturas (Espécies)	Quantidade	Duração	Tripulação
1								
2								
3								
4								
5								

#	Tipo de arte fundeada	N.º de bóias	Extensão aproximada	Posição em relação aos RAs	Notas:
1					
2					
3					
4					
5					

Observação n.º Local: ________________________ Dia: ________ Data: ____/____/____ Hora: _________ e as ________.

Monitorização do Esforço de Pesca nos RAs.

NI __________ Observador:___________.

#	Nome do barco	Matrícula	Utilizador	Artes	Capturas (Espécies)	Quantidade	Duração	Tripulação
1								
2								
3								
4								
5								

#	Tipo de arte fundeada	N.º de bóias	Extensão aproximada	Posição em relação aos RAs	Notas:
1					
2					
3					
4					
5					

ARTIFICIAL REEF STAKEHOLDERS' QUESTIONNAIRE

IMPORTANT: Before starting to fill up the questionnaire read the box containing the **FILLING NOTES** instructions.

[1] **Stakeholder area:**

I	II	III	IV

[2] **Stakeholder type:**

A	B	C	D	E	F	G

[3] **Which of the AR(s) you know?**

1	2	3	4	5	6	7	All	Heard

[4] **ID Number:**

FILLING NOTES

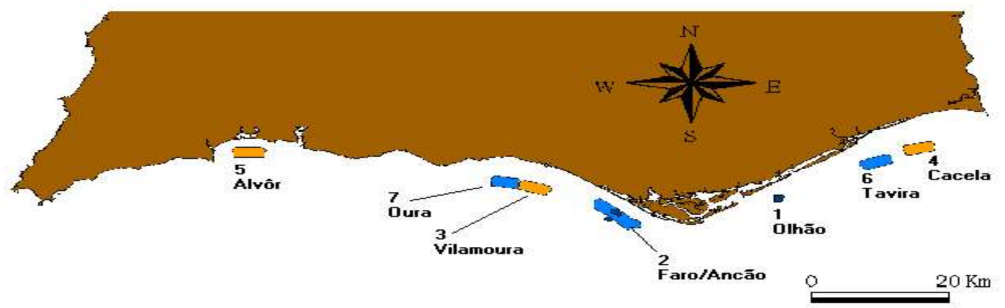
Please complete the questionnaire in black or blue ink. To score the questions simply tick ☒ the one that best describes your position. If the respondent feels relevant to defend a position that each AR is different from each other that must be stressed at the end of the questionnaire after the 54 item in the space provided.

[1] **Stakeholder area** – Is where the stakeholder is usually based at work:

Stakeholder area	Location of the stakeholder representative
I – Leeward	From Odiáxere to the west margin of the firth of Arade river (boroughs of: Aljezur, Vila do Bispo, Monchique, Lagos, and Portimão)
II – Central	From the east margin of the firth of Arade river to the eastern part of Culatra island (boroughs of: Lagoa, Silves, Albufeira, Loulé, and Faro)
III – Windward	West part of Armona island to the firth of the Guadiana river (boroughs of: Olhão, S. B. Alportel, Tavira, Alcoutim, Castro Marim, and VRSA)

[2] **Stakeholder type** – Use the code for the stakeholder type you are representing (choose **only** the one that best suits you):

Code	Stakeholder type	Eligibility
A	Small-scale fishermen	Associations of artisanal fisheries, those in local number plate fleet
B	Industrial fishermen	Boat owners, companies, or associations of industrial fisheries
C	Sport anglers	Anglers clubs or associations
D	Sport and commercial divers	Diver representatives from clubs, associations, or schools
E	Resource managers and scientists	Entities issuing licenses, scientific divers and other researchers
F	Environmentalists	Public and NGO entities
G	Other institutions	Local councils, natural parks representatives, other not stated before



Please turn page

In the next pages there is a questionnaire about the impacts of the ARTIFICIAL REEFS (ARs) deployment program in the Algarve. The questionnaire starts with a general statement where all the questions should be addressed: **'Recently deployed AR has been contributing…'** to several ('good' or 'bad') changes or 'no changes' at all. In addition, changes can also be considered and distinguished by the respondent as having a 'slight' or 'considerable' effect.

The respondent should use and interpret the information contained in the following table (5-point scale), to score the questions in the next pages. Nevertheless, do not forget that if the answer to a given question is interpreted by the respondent as "Don't know", it should be filled in as **neutral** according to the 5-point scale below:

Type of effect				
Negative		**Neutral**	**Positive**	
- -	-	0	+	++
Highly improbable	Somehow improbable	No change, or not known	Somehow probable	Highly probable

In the questionnaire three dimensions are considered, namely: Environmental, Social, and Economic. Due structural reasons, each dimension is by its turn composed of 4 groups distributed from A to L, each one containing 18 items/questions, consisting in total 54 items. **Note that all the items should be answered.**

Examples:

Recently deployed AR has been contributing…

x. to the revenue of local small-scale fishermen in Alcoutim…………………………………………… | ⊗ | - | 0 | + | ++ |

It should be interpreted as neutral because small-scale fishermen in Alcoutim solely fish in the river Guadiana, i.e., far away from the AR systems. Due that fact, it seems that there is **no change** concerning the ARs contribution to these fishermen' revenues.

y. to generate fish scarcity in the deployment area……………………………………………………… | - - | - | ⊗ | + | ++ |

Should be ticked double minus because there is empirical and scientific evidence that this item is not true. AR devices attract and aggregate **considerable** amount of fish and other species.

z. to provide shelter to some fish species…………………………………………………………… | - - | - | 0 | ⊗ | ++ |

Should be ticked plus if the stakeholder perception is that is **somehow probable** that these types of AR (concrete blocks and vessel wreck) can be used as a refuge for certain species after deployment. Thus, if the respondent perception or experience is that is **highly probable** to find many species in the AR, the answer should be **double plus** instead.

Note that the statement below should be addressed to **all** the following 54 items:

Recently deployed AR has been contributing…

I – Environmental

A: Use of the deployment area

	5-point scale				
1. To find divers in the AR since its deployment ……	--	-	0	+	++
2. To find recreational fishermen in the AR since its deployment ……	--	-	0	+	++
3. To find small-scale fishermen in the AR since its deployment ……	--	-	0	+	++
4. To find industrial vessels in the AR since its deployment ……	--	-	0	+	++

b: Fishing in the area

5. To increase fishing pressure around the area ……	--	-	0	+	++
6. To lose gears over and around the AR……	--	-	0	+	++
7. To endangering sea life due those gears lost ……	--	-	0	+	++

C: Bio-diversity

8. To bio-diversity establishment in the AR habitat……	--	-	0	+	++
9. To get a complete settlement of species in the area……	--	-	0	+	++
10. To fish aggregation in the area..……	--	-	0	+	++
11. To compete with non-reef or natural reefs in terms of fish availability……	--	-	0	+	++
12. To catch juvenile fish in the AR ……	--	-	0	+	++

D: Ecological impact

13. To sink materials environmentally friendly or at least not prejudicial……	--	-	0	+	++
14. To contaminate and/or pollute the area……	--	-	0	+	++
15. To contaminate and/or pollute the sediment ……	--	-	0	+	++
16. To sediment deposition around the area……	--	-	0	+	++
17. To the presence of debris...……	--	-	0	+	++
18. To contaminate and/or pollute the water column over the area……	--	-	0	+	++

II – Social

	5-point scale				
E: Demography & jobs					
19. To find more jobs in fishing-related activities in the nearby towns	--	-	0	+	++
20. To a decrease in the size of the population in the nearest fishing communities	--	-	0	+	++
21. To visible social benefits (if any)	--	-	0	+	++
F: Enforcement & communication					
22. To no need to enforce rules	--	-	0	+	++
23. To change enforcement by local authorities	--	-	0	+	++
To establish communication between:					
24. Managers and fishermen	--	-	0	+	++
25. Other stakeholders	--	-	0	+	++
G: Opinion					
26. To fishermen's acceptance of concrete-made AR	--	-	0	+	++
27. To change general stakeholders' opinion about the AR program	--	-	0	+	++
28. To attract users to the AR and surrounding sea area	--	-	0	+	++
29. To a unwanted change	--	-	0	+	++
30. To make people to have a general opinion about its impact	--	-	0	+	++
H: Conflicts					
To generate conflicts between:					
31. Small-scale fishermen	--	-	0	+	++
32. Small-scale fishermen and industrial fishermen	--	-	0	+	++
33. Small-scale fishermen and recreational anglers	--	-	0	+	++
34. Small-scale fishermen and divers	--	-	0	+	++
35. Small-scale fishermen and environmentalists	--	-	0	+	++
36. Other stakeholders	--	-	0	+	++

III – Economic

	5-point scale				
I: Production & benefits					
37. To increase the quantity of fish caught in the AR area………………….…………...………………	--	-	0	+	++
38. To find in the local market more high-priced species ………………….…………………………….	--	-	0	+	++
39. To users get economic benefits (if any) from AR deployment……………………...……………...	--	-	0	+	++
40. To decrease catch certainty in the deployment area…………………………………………...…….	--	-	0	+	++
J: Costs to society					
41. To think that there were less costly alternatives to build an AR in this site…….……..…………...	--	-	0	+	++
42. To think that the materials deployed were costly……………………………………..…………….	--	-	0	+	++
43. To realize that the AR is aging and need of extra cost to repair it…………………..………………...	--	-	0	+	++
44. To realize that there were no better sites to deploy the AR instead…………………………………	--	-	0	+	++
45. To realize that it take too long time to built this AR………………………………………………..	--	-	0	+	++
K: Changes in local economy					
To perceive a sign of positive change in the:					
46. A positive sign in the local economy …………………………………………………………...…...	--	-	0	+	++
47. Positive changes in the primary sector (i.e. catching, extracting activities) in local economy ...……..	--	-	0	+	++
48. Positive changes in the secondary sector (i.e. transformation activities) in local economy .....…….....	--	-	0	+	++
49. Positive changes in the tertiary sector (i.e. services) in local economy ……………………...…….....	--	-	0	+	++
50. That there are no channels to the AR production (e.g. restaurants, canning industry, etc.)...……..…..	--	-	0	+	++
L: Safety at sea					
51. For safety once it is saved time by fishing over or/and around the AR..…………………………..….	--	-	0	+	++
52. For a need to change or adapt gears to fish in the AR area……………………..……….………...….	--	-	0	+	++
53. To damage gears by fishing over or around the AR area………………………..…………...……..	--	-	0	+	++
54. To the perception of the need to establish a stakeholders' limited access to the AR…..……...…...…..	--	-	0	+	++

If you (person or institution/company representative) have any other comment(s) about the deployed ARs, including to think that each AR is different from each other, use the lines provided below to state your point.

Thank you for the collaboration.

AVALIAÇÃO DE IMPACTE DOS RECIFES ARTIFICIAIS

IMPORTANTE: Antes de começar o questionário, leia a caixa que contém as instruções das **NOTAS DE PREENCHIMENTO**.

[1]**Área geográfica do avaliador:**

I	II	III	IV

[2] **Tipo de avaliador:**

A	B	C	D	E	F	G

[3] **Qual(ais) o(s) RA(s) que conhece?**

1	2	3	4	5	6	7	Todos	Ouviu falar

[4] **Número ID:**

NOTAS DE PREENCHIMENTO

Por favor preencha o questionário em tinta preta ou azul. Para pontuar as questões marque simplesmente ☒ no espaço que melhor descreve a sua posição. No final em "Outros comentários" existe um espaço em aberto para qualquer observação adicional.

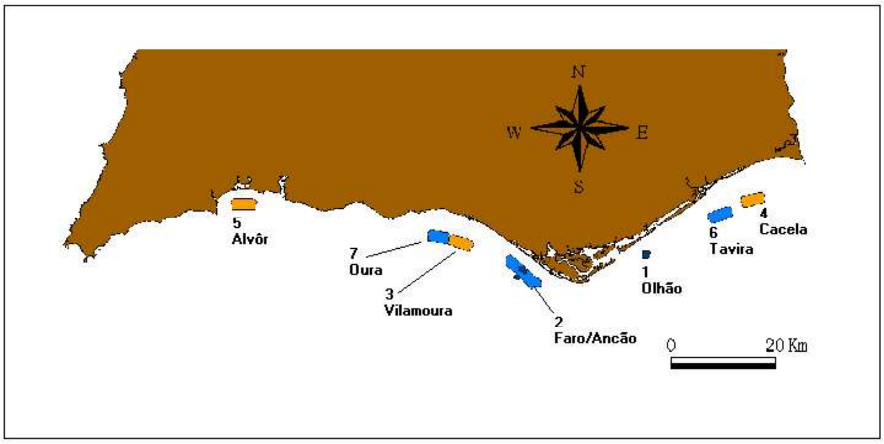
[1] **Área geográfica do avaliador** – É o local onde o avaliador trabalha ou está geralmente sediado:

Área geográfica do avaliador	Localização do representante
I – Barlavento	De Odiáxere até à margem oeste do estuário do rio Arade (concelhos de: Aljezur, Vila do Bispo, Monchique, Lagos, e Portimão)
II – Central	Da margem leste do estuário do rio Arade até à parte oriental da ilha da Culatra (concelhos de: Lagoa, Silves, Albufeira, Loulé, e Faro)
III – Sotavento	Oeste da ilha da Armona até ao estuário do rio Guadiana (concelhos de: Olhão, S. B. Alportel, Tavira, Alcoutim, Castro Marim, e V.R.S.A.)
IV – Outra	Qualquer outra área fora do Algarve

[2] **Tipo de avaliador** – Use o código para o tipo de avaliador que representa (escolha **apenas** aquele que melhor se adapta):

Código	Tipo de avaliador	Elegibilidade
A	Pescadores locais	Associações de pesca artesanal, todos aqueles que possuam a matrícula de barco de pesca local
B	Pescadores costeiros	Proprietários de barcos que possuam matrícula costeira, companhias de pesca, ou associações de pesca industrial
C	Pescadores desportivos	Pescadores recreativos, associações de pesca recreativa, empresas que prestam serviços de pesca recreativa ou desportiva
D	Mergulhadores	Mergulhadores profissionais ou amadores e/ou representantes de clubes, associações, ou escolas de mergulho
E	Administração	Entidades com funções administrativas nos sectores: pesqueiro, ambiental, de turismo, e incluindo também os gestores de fundos de apoio à pesca
F	Cientistas e ambientalistas	Cientistas de ciências sociais e biológicas (incluindo mergulhadores científicos), organizações não governamentais (ONGs) e público que tenha intervenção ambiental
G	Outras instituições	Representantes de câmaras municipais, parques naturais, ou outros não referidos anteriormente

[3] **RA #** – Importante: Se o avaliador conhece (i.e. utilizou / desfrutou) mais do que um recife artificial (RA), deverá assinalar todos os RAs conhecidos. Se apenas ouviu falar dos RAs deverá assinalar no espaço respectivo:



[4] O **número ID** do questionário é para ser preenchido **SOMENTE** pelo inquiridor.

Virar S.F.F.

Nas próximas páginas encontrará um questionário sobre os impactes provocados pelo programa de implantação de RECIFES ARTIFICIAIS (RAs) no Algarve. Neste questionário é pedida uma avaliação do impacte causado pela implantação recifal, i.e., para avaliar num todo se esta tem sido benéfica ou prejudicial.

O questionário começa com uma afirmação à qual todos os itens deverão ser endereçados: **'Os RAs implantados têm vindo a contribuir…'** para a ocorrência de várias alterações ou mudanças que produzem efeitos 'desejáveis' ou 'indesejáveis', ou 'nenhum' efeito. As mudanças devem ser consideradas e distinguidas pelo avaliador quanto à sua probabilidade ou improbabilidade de ocorrência e quanto ao seu grau de ocorrência, i.e., se é 'algo' ou 'altamente' (im)provável.

O avaliador deverá usar e interpretar a informação contida na tabela abaixo para pontuar as questões nas páginas seguintes. Contudo, não esqueça que se a resposta a uma dada questão for interpretada como 'não sabe', deverá ser preenchida como tendo efeito neutro de acordo com a escala de 5 pontos da tabela seguinte:

Efeito				
Improvável		**Neutro**	**Provável**	
- -	**-**	**0**	**+**	**++**
Altamente improvável	Algo improvável	Não há alteração ou mudança, ou não sabe	Algo provável	Altamente provável

No questionário são consideradas três dimensões, nomeadamente: Ambiental, Social, e Económica. Devido a razões estruturais, cada dimensão é por sua vez composta por 4 grupos distribuídos de A a L. Cada dimensão contém 18 itens/questões, consistindo no total em 54 itens. **Note que todos os itens deverão ser respondidos.**

Exemplos de como preencher o questionário:

Os RAs implantados têm vindo a contribuir…

x. … para o rendimento dos pescadores de pesca local em Alcoutim……………....………………………. | ⊗ | - | 0 | + | ++ |

Justificação da resposta: Deverá ser interpretada como tendo um efeito improvável porque os pescadores locais em Alcoutim pescam somente no rio Guadiana, i.e., longe dos sistemas recifais (RAs). Devido a esse facto, **é altamente improvável** que o rendimento desses pescadores sofra alterações devido ao contributo dos RAs.

y. … para aparecer pescado de maiores dimensões comparativamente a outros locais…..……...…………. | - - | - | ⊗ | + | ++ |

Justificação da resposta: Deverá ser assinalada a opção de efeito neutro porque não há evidência empírica e científica de que nos recifes aparece pescado maior, i.e., **não há alteração** das dimensões do pescado pelo simples facto de estarem implantados RAs numa dada área.

z. … para dar abrigo a algumas espécies de peixe…………………..…...……………………………… | - - | - | 0 | ⊗ | ++ |

Justificação da resposta: Deverá ser assinalada uma opção de provável ocorrência. Se a percepção do avaliador for de **algo provável** para que aquele RA (blocos de betão) possa ser usado como refúgio para certas espécies, então deve escolher a opção '+'. Contudo, se a percepção ou experiência é a de ser **altamente provável** encontrar muitas espécies de peixe no RA, a resposta deverá então ser um '++'.

Note que a afirmação abaixo deverá ser endereçada a **todos** os 54 itens seguintes:

Os RAs implantados têm vindo a contribuir…

I – Ambiental

A: Uso da área de implantação

	Escala de 5 pontos				
1. … para encontrar mergulhadores nessa área……………………………………………………	--	-	0	+	++
2. … para encontrar pescadores recreativos nessa área………………………………………………	--	-	0	+	++
3. … para encontrar embarcações grandes (e.g. traineiras, arrastões) nessa área…………………………	--	-	0	+	++
4. … para encontrar embarcações de pesca local no RA desde a sua implantação………………………..	--	-	0	+	++

B: Impacte ecológico & bio-diversidade

5. … para promover a bio-diversidade no habitat RA………………………………………………..	--	-	0	+	++
6. … para perder artes de pesca junto e em redor dessa área…………………………………………...	--	-	0	+	++
7. … para ameaçar algumas espécies da vida marinha………………………………………………..	--	-	0	+	++
8. … para a protecção das populações juvenis provenientes de outros locais (e.g. Ria Formosa)…….....	--	-	0	+	++
9. … para competir com recifes naturais ou áreas não-recifais em termos de pescado disponível…..…	--	-	0	+	++

C: Poluição

10. … para a deposição de sedimento contaminado em seu redor……………………………………...	--	-	0	+	++
11. … para descontaminar e/ou despoluir a área ………………………………………………………	--	-	0	+	++
12. … para a presença de fragmentos de betão…………………………………………………………...	--	-	0	+	++

D: Pesca & ordenamento

13. … para impossibilitar o desenvolvimento da aquicultura em mar aberto (*offshore*)…..……………......	--	-	0	+	++
14. … para agregação de fauna marinha na área………………………………………………………....	--	-	0	+	++
15. … ou poderá contribuir para um maior sucesso de acções de repovoamento piscícola…. ……..……	--	-	0	+	++
16. … para aumentar a pressão de pesca à volta dessa área…………………………………………..…….	--	-	0	+	++
17. … para a diminuição de peixes adultos na zona………………………………………………………	--	-	0	+	++
18. … para o ordenamento das pescarias litorais algarvias……………………………………………..	--	-	0	+	++

II – Social

E: Demografia & emprego

	Escala de 5 pontos				
19. … para haver mais emprego nas actividades relacionadas com a pesca nas localidades próximas...…	--	-	0	+	++
20. … para um decréscimo do tamanho da população nas comunidades piscatórias mais próximas…......	--	-	0	+	++
21. … para benefícios sociais (e.g. para mais obras de utilidade pública no local)…...……………………	--	-	0	+	++

F: Fiscalização & comunicação

22. … para não haver necessidade de fazer cumprir regras de uso do mar..……………………………...	--	-	0	+	++
23. … para uma maior necessidade de fiscalização por parte das autoridades locais…………………..…..	--	-	0	+	++
… para o estabelecimento de comunicação entre:					
24. Gestores e pescadores……………………………………………………………………………..	--	-	0	+	++
25. Gestores e outros interessados nos RAs………..…………………………………………………...	--	-	0	+	++

G: Opinião

26. … para a sua não aceitação por parte dos pescadores…………………………………...……………	--	-	0	+	++
27. … para demonstrar aos utilizadores que o programa de RAs é uma mais valia………...…………….	--	-	0	+	++
28. … para atrair utilizadores para as áreas circundantes às suas zonas de implantação………………….	--	-	0	+	++
29. … para uma mudança não desejada…....…………………………………………………………….	--	-	0	+	++
30. … para que a opinião pública discuta o impacte deste tipo de estruturas no mar……………………..	--	-	0	+	++

H: Conflitos

… para gerar conflitos entre:

31. Pescadores da frota local	--	-	**0**	+	++
32. Pescadores das frotas local e costeira	--	-	**0**	+	++
33. Pescadores profissionais e recreativos	--	-	**0**	+	++
34. Pescadores profissionais e mergulhadores	--	-	**0**	+	++
35. Pescadores profissionais e ambientalistas	--	-	**0**	+	++
36. Outros utilizadores ou interessados nos RAs	--	-	**0**	+	++

III – Económica

Escala de 5 pontos

I: Produção & benefícios

37. … para aumentar a quantidade de peixe capturada na área do RA	--	-	**0**	+	++
38. … para encontrar menos espécies de alto valor comercial no mercado local	--	-	**0**	+	++
39. … para que os utilizadores obtenham mais benefícios económicos	--	-	**0**	+	++
40. … para diminuir a certeza de capturas na área de implantação do RA	--	-	**0**	+	++

J: Custos para a sociedade

41. … para pensar que não haviam alternativas mais baratas para construir um RA neste local	--	-	**0**	+	++
42. … para pensar que os materiais afundados foram caros	--	-	**0**	+	++
43. … para perceber que os RAs estão a envelhecer e precisam de um custo extra para a sua reparação	--	-	**0**	+	++
44. … para perceber que não havia melhores locais para implantar os RAs	--	-	**0**	+	++
45. … para a percepção de que estes RAs levaram muito tempo a ser construídos	--	-	**0**	+	++

K: Mudanças na economia local

… para perceber:

46. Um sinal de mudança positiva na economia local	--	-	**0**	+	++
47. Que não há mudanças no sector primário (i.e. pescas, agricultura) na economia local	--	-	**0**	+	++
48. Mudanças positivas no sector secundário (i.e. actividades de transformação) na economia local	--	-	**0**	+	++
49. Mudanças positivas no sector terciário (i.e. serviços) na economia local	--	-	**0**	+	++
50. Que não há canais de venda para o que se pesca no RA (e.g. restaurantes, indústria conserveira)	--	-	**0**	+	++

L: Segurança no mar

51. … para a segurança uma vez que é poupado tempo na busca de pescado	--	-	**0**	+	++
52. … para a necessidade de mudar ou adaptar artes e/ou equipamento para usar a área do RA	--	-	**0**	+	++
53. … para danificar artes por pescar sobre e em redor da área do RA	--	-	**0**	+	++
54. … para a percepção da necessidade de estabelecer um acesso limitado aos utilizadores do RA	--	-	**0**	+	++

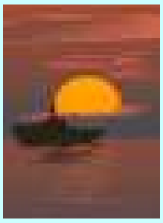
Outros comentários

Se tem outro(s) comentário(s) acerca do(s) RA(s) implantado(s), use as seis linhas abaixo para expôr o ponto de vista da instituição/empresa/pessoa que representa.

A instituição/empresa/pessoa que representa gostaria de colaborar no futuro em avaliações similares?………. Sim ☐ Não ☐

Obrigado pela sua colaboração.

Main fishing gear: ________________ **Fleet segment: ___________**



Maximising benefits from fishing

Survey on the attitudes, carried out by IPIMAR (Pt) / CEMARE (RU)
on the economic efficiency of fishing grounds (Algarve), June 2005

University of Portsmouth

Introduction

Commercial fisheries is certainly an activity that is still very important in the Algarve. It is known that in order to enhance the sector of small-scale fisheries it must be raised the value of the resources, i.e., to attribute added value to the caught fish. We are interested in your opinions about these facts and we would be grateful if you could take part of this survey as a fisherman. Your answers will help us to clear which are the reasons that enter in a choice for a fishing ground and to establish choice priorities. All the information you provide us is only for scientific purposes and is confidential.

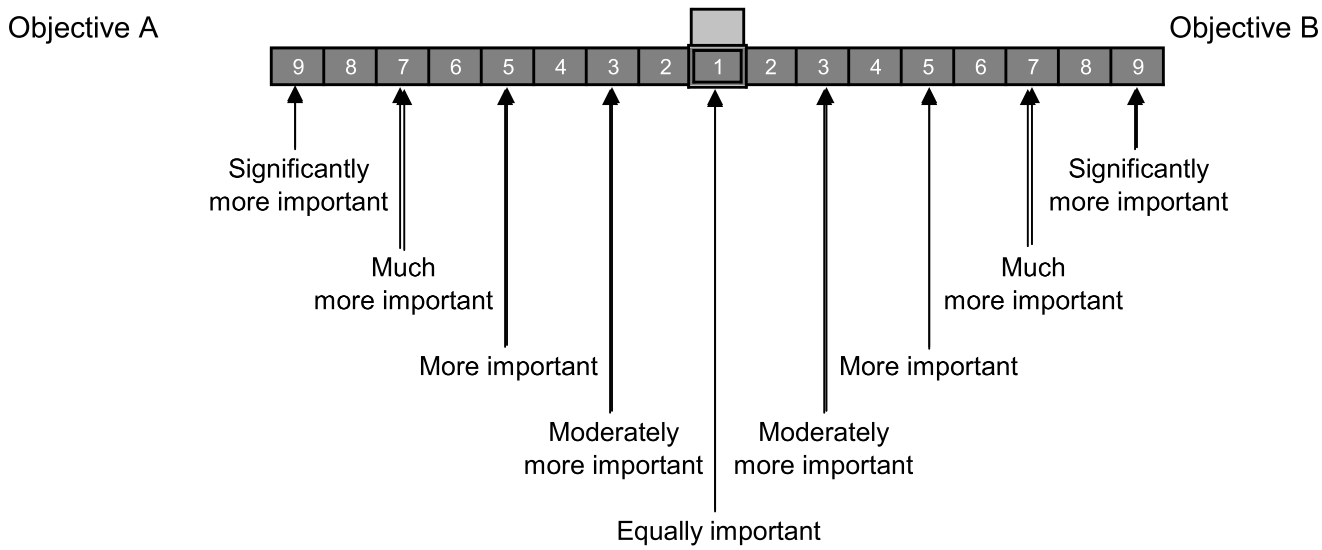
Section A: What criteria are important to decide fishing

This section asks you to compare the various criteria that enter in the decision process of choosing a fishing ground and order their relative importance.

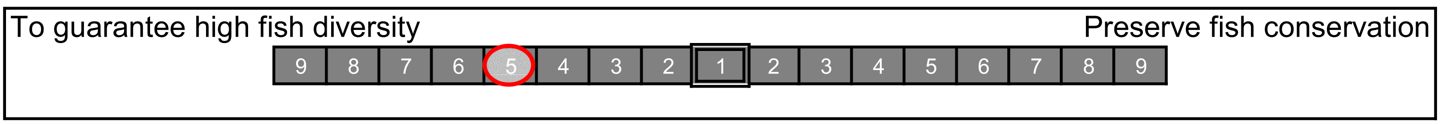
Next you will follow a series of numbered questions. For each one we would like you to indicate us the relative importance of one of the two criteria being represented in the opposite sides of the scale.

To help you use the guide ***How to use the scale*** *and* ***Descriptions*** *contained in the box below.*

How To use the importance scale:



In the example below, if you think that ***to guarantee high fish diversity*** is "more important" than ***preserve fish conservation***, circle the relevant point on the scale as shown:

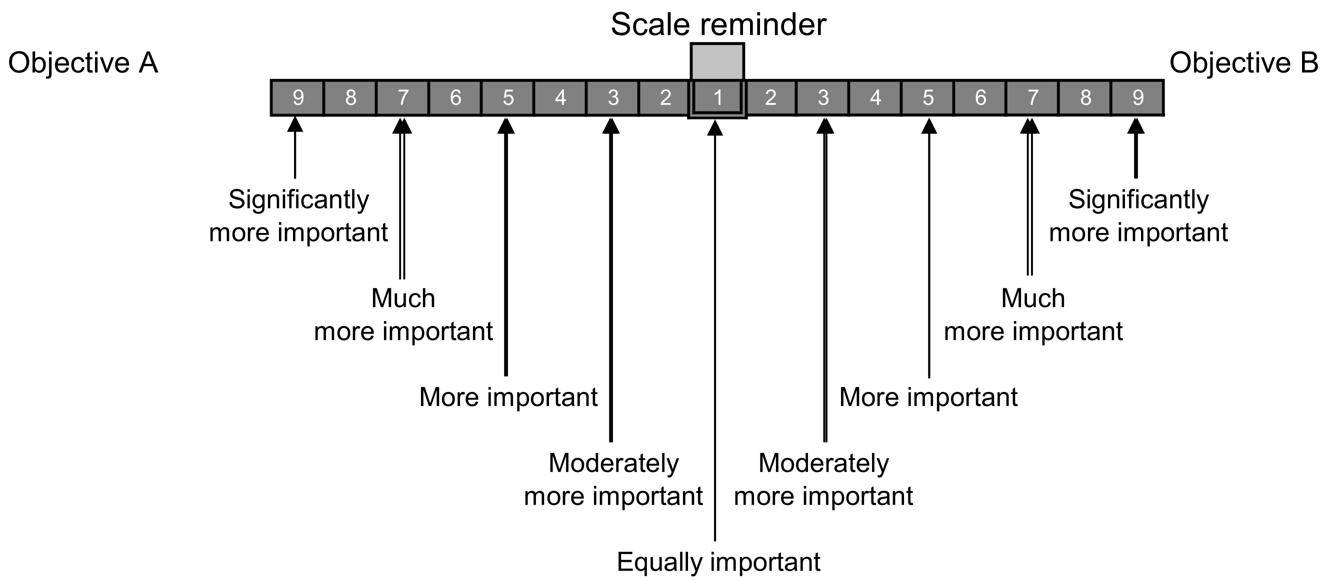


Description of the criteria and the alternatives:

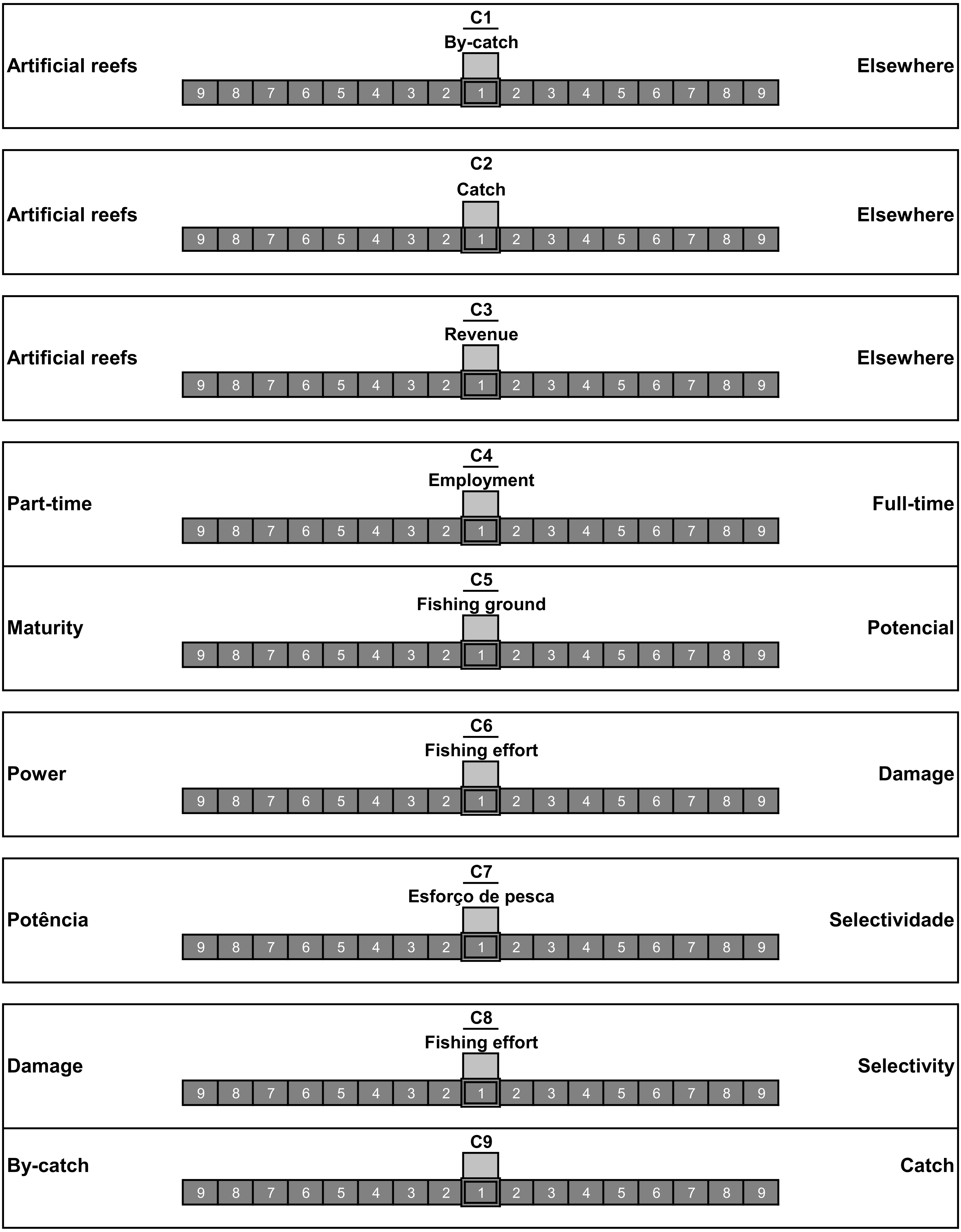
	Criteria	Descriptions
Biological		
	By-catch	It includes commercial species effectively fished that are not targeted by the fishing gear used but are landed. To consider the number of these species…
	In the ARs	By-catched fish caught in the artificial reefs.
	Elsewhere	By-catched fish caught in any site, but not the artificial reefs.
	Catch	Takes into consideration the weight and the quantity of the whole target species.
	In the ARs	Target species caught in the artificial reefs.
	Elsewhere	Target species caught in caught in any site, but not the artificial reefs.
Economical		
	Revenue	Here enters the rate of the most valuable species or conditions that favour a higher revenue from fisheries. It is considered that the daily average monetised revenue of the vessel when fishing…
	In the ARs	Monetised value obtained in fishing in the artificial reefs.
	Elsewhere	Monetised value obtained when fishing in any site, but not the artificial reefs.
	Employment	Number of people that enter in the fishing process and that are related to the vessel in analysis. People who work in the fishing vessel…
	Part-time	When just a part of the fisherman's revenue is from fishing.
	Full-time	When all fisherman's revenue is from fishing.
Technical		
	Ground	Fishing yield capacity that the favourite fishing ground has according to…
	Maturity	Its maturity, i.e., if there are signs that the fishing ground has many marine species and that it is found fish of large sizes.
	Potential	Fish found there is highly valued in the market and there is in large abundancy.

Effort	In what concerns fishing effort the variables to consider are…
Power	The catch rate derived from the engine power and from all the detection equipment onboard.
Damage	Damage that may be inflicted to the available resources.
Selectivity	Species that are targeted with this fishing gear type.

Alternatives	**Description**
Fishing ground location	It is the fishing site location in the southern coastal area of the Algarve. It includes Leeward, Central, and Windward areas.
Fishing ground age	If the fishing site is an AR, it is important to know if this one was recently deployed or not.
Size of the fishing ground	Fishing site comparisons in relation to ARs dimensions. According to size, fishing sites can be small, medium and large.
Distance from the shelter port to the fishing ground	The distance in nautical miles from the shelter port to the chosen fishing ground.



Comparison number



C10	**By-catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Revenue**
C11	**By-catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Employment in fisheries**
C12	**By-catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Fishing ground**
C13	**By-catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Fishing effort**
C14	**Target species catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Revenue from fisheries**
C15	**Target species catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Employment in fisheries**
C16	**Target species catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Fishing ground**
C17	**Target species catch**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Fishing effort**
C18	**Revenue from fisheries**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Emprego na pesca**
C19	**Revenue from fisheries**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Fishing ground**
C20	**Revenue from fisheries**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Fishing effort**

C21

Emprego na pesca | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Fishing ground**

C22

Emprego na pesca | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Fishing effort**

C23

Fishing ground | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Fishing effort**

Section B: Which alternatives there are in a fishing ground choice

Below there is a table characterizing some fishing grounds (Table 1).
Table 2 refers to the distance from the shelter port to the prefered fishing ground.

Table 1.

# - Fishing ground	Site	Age	Size
1 - AR Alvor	Leeward	5 to 10	medium
2 - AR Oura	Central	<5	medium
3 - AR Vilamoura	Central	5 to 10	medium
4 - AR old Faro	Central	>10	small
5 - AR new Faro	Central	<5	large
6 - AR Olhão	Central	>10	small
7 - AR Tavira	Windward	<5	medium
8 - AR Cacela	Windward	<5	variable
9 - Other ground	Leeward	>10	variable
10 - Other ground	Central	>10	variable
11 - Other ground	Windward	>10	variable

Table 2.

Distance to the shelter port	
Nearby	< 6 miles
Medium	6 to 12 miles
Far away	> 12 miles

P24 From Table 1 fishing grounds which one(s) do you prefer?

	#	Size	Distance
1st choice			
2nd choice			
3rd choice			

Now, according to Table 1. above make the comparison, but focusing the importance in the groups:

P25 Fishing ground location	Preference
Sagres to Albufeira (Leeward)	
Albufeira to Olhão (Central)	
Olhão to Vila Real (Windward)	

P27 Fishing ground size	Preference
Small (up to 1 Km2)	
Medium (from 1 to 4 Kms2)	
Large (> 4 Kms2)	

P26 Idade do pesqueiro	Preference
Less than 5 years old	
5 to 10 years old	
More than 10 years old	

P28 Distance to the ground	Preference
Less than 6 miles	
6 to 12 miles	
More than 12 miles	

In this case preferences vary between 1 to 3, where 1 is the 'best' and 3 the 'worst'.

According to the characteristics of the above fishing grounds (Table 1.), answer the following questions (from A32 to A37), as you did in questions C! To C26:

A29

Fishing ground location | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | **Fishing ground age**

A30

Fishing ground location | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | **Fishing ground size**

A31

Fishing ground location | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | **Distance to the shelter port**

A32

Fishing ground age | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | **Fishing ground size**

A33

Fishing ground age | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | **Distance to the shelter port**

A34

Fishing ground size | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | **Distance to the shelter port**

Section C: Possible costs to restrict access to the ARs

There is some evidence that concrete-made modules generate better fishing results, attacting certain fishing gear operators. Thus, the increase in users will sooner or later bring about congesting and overexploitation problems over fishing resources, if adequate measures of restriction or protection are taken. We would like to hear from you if...

Q35. Beyond the present restrictions concerning certain fishing gear (as for example dredges), do you agree that it would be more control over the access to the ARs in the Algarve?

Yes ☐ **No** ☐

Q36. Do you agree with the AR use by...

(a) Only professional fishermen operating eligible fishing gear ☐

(b) Eligible professional fishermen and recreational angling ☐

(c) Eligible professional fishermen and divers ☐

(d) Other users (please indicate them below) ☐

Q37. Do you agree that Ars should be protected and restricting their access?

Yes ☐ (Go to Q41.) **No** ☐ (Go to Q42.)

Q38. If you answered yes, what type of protection?

Access restriction to:

(a) an area (how much?) ☐ **%**

(b) a season (when?) ☐

(c) a given type of users (who?) ☐

(d) any other form (please indicate below) ☐

Q39. Do you think that fishing communities should have priority use rights over their neibouring ARs?

Yes ☐ **No** ☐

Section D: Finally, some questions about yourself

Gender:

Male ☐ Female ☐

Age:

<26 ☐ 26 - 40 ☐ 41 - 60 ☐ >60 ☐

Education:

<6th grade ☐ 6-9 grade ☐ 9-12 grade ☐ UD ☐

UD = University degree

Number of people in the household:

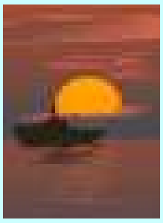
☐ people

Thank you very much for your time.

We appreciated your participation and cooperation.

IPIMAR (Pt) / Cemare (UK)

Arte de pesca principal: ________________ Segmento da frota: ___________



Como maximizar o rendimento da pesca

Pesquisa sobre as atitudes, realizada pelo IPIMAR (Pt) / CEMARE (RU)
no estudo da eficiência económica de pesqueiros (Algarve), Junho 2005

Introdução

A pesca comercial é sem dúvida uma actividade que ainda tem uma grande importância no Algarve. Sabe-se que para melhorar o sector da pesca de pequena escala deve-se valorizar os recursos, isto é, acrescentar valor ao pescado. Estamos interessados nas suas opiniões sobre estes factos, e seria óptimo que pudesse tomar parte desta pesquisa como profissional da pesca. As suas respostas vão-nos ajudar a clarificar quais as razões que entram na escolha dum pesqueiro, e a estabelecer prioridades de escolha. A informação que nos der tem fins puramente científicos e será confidencial.

Secção A: Que critérios entram na decisão de ir à pesca

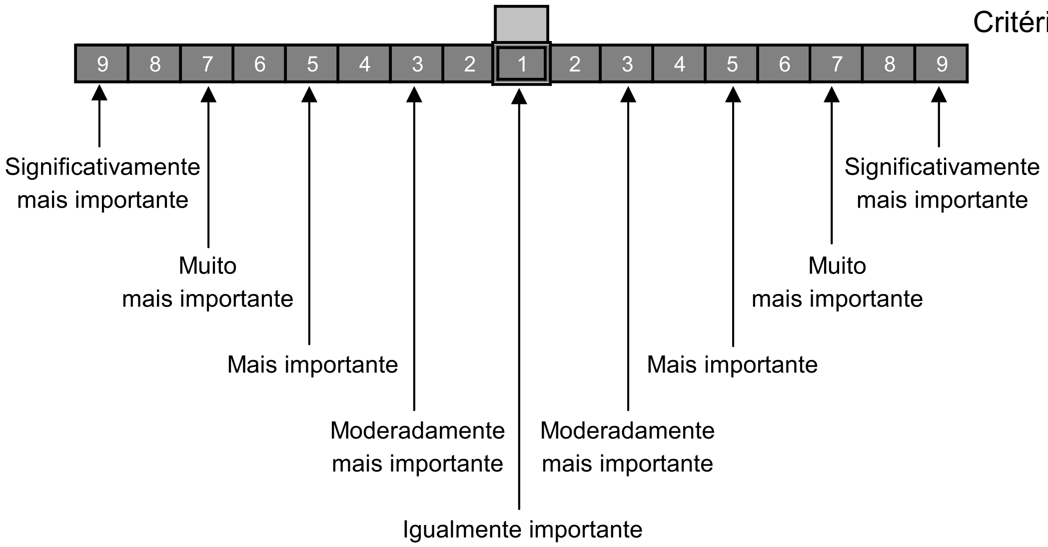
Esta secção pede-vos para comparar os vários critérios que entram no processo de decisão da escolha dum pesqueiro e ordenar a sua importância relativa.

A seguir encontrará uma série de questões numeradas. Para cada uma delas gostaríamos que nos indicasse a importância relativa de cada um de dois critérios representados em cada um dos lados opostos da escala.

Para ajudá-lo use o guia ***Como usar a escala*** *e* ***Descrições*** *contidos na caixa abaixo.*

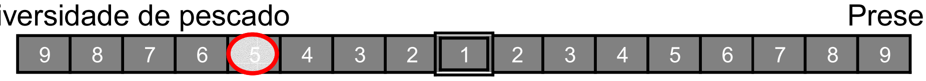
Como usar a escala de importância:

Critério A Critério B



No exemplo abaixo, se acha que ***garantir elevada diversidade de pescado*** é "mais importante" que ***preservar a conservação***, então assinale o valor correspondente na escala conforme é mostrado:

Garantir elevada diversidade de pescado Preservar a conservação



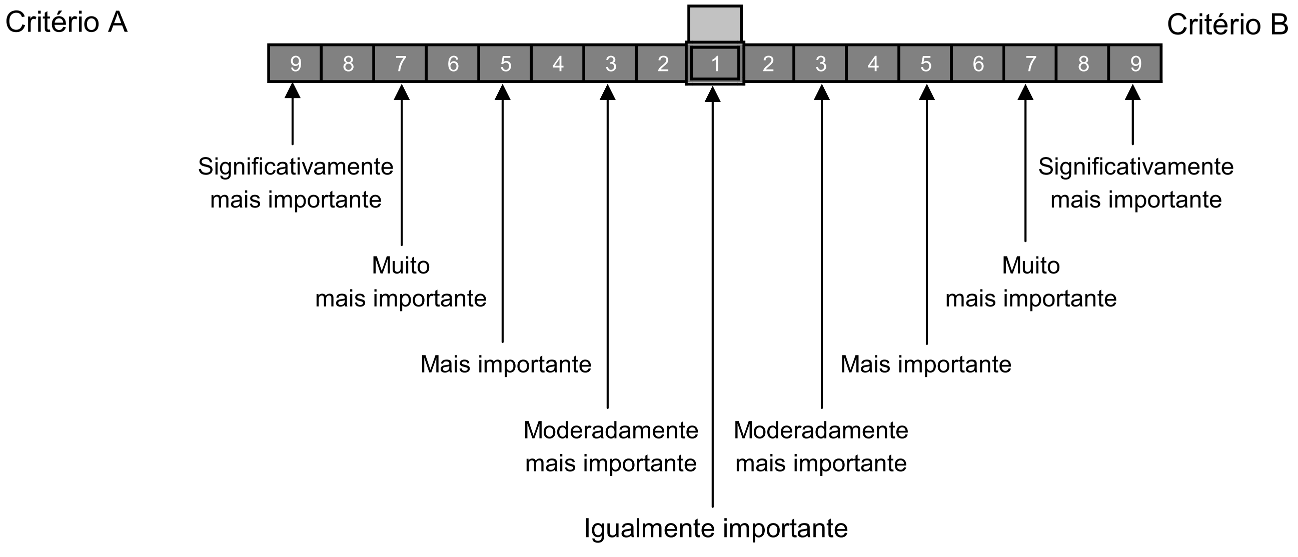
Descrições dos critérios e das alternativas:

Critérios	Descrições
Biológicos	
Pesca acessória	Inclui as espécies comerciais efectivamente pescadas, que não são alvo da arte e que são descarregadas. Considerar o número dessas espécies…
Nos RAs	Pescado acessório capturado nos recifes artificiais.
Noutro pesqueiro	Pescado acessório capturado num sítio qualquer que não os recifes artificiais.
Captura	Toma em atenção o peso e a quantidade total das espécies alvo que são capturadas…
Nos RAs	Pescado alvo capturado nos recifes artificiais.
Noutro pesqueiro	Pescado alvo capturado num sítio qualquer que não os recifes artificiais.
Económicos	
Rendimento	Aqui entra a razão de espécies mais valiosas ou em condições que favoreçam um maior rendimento da pesca. Considera-se o rendimento monetário médio diário do barco quando pesca…
Nos RAs	Valor monetário que se obtém quando se pesca nos recifes artificiais.
Noutro lado	Valor monetário que se obtém quando se pesca num sítio qualquer que não os recifes artificiais.
Emprego	Número de pessoas que entram no processo da pesca e que estão ligadas à embarcação em análise, que trabalham na mesma em…
Tempo parcial	Quando apenas parte do rendimento do pescador provém da pesca.
Tempo inteiro	Quando todo o rendimento do pescador provém da pesca.
Técnicos	
Pesqueiro	Capacidade que o pesqueiro favorito tem para produzir de acordo com…
Maturidade	A sua maturidade, isto é, se há indícios que o pesqueiro tem muitas espécies marinhas e que se encontre pescado de grandes tamanhos.
Potencial	O pescado que lá habita é valorizado no mercado e existe em grande abundância.

Esforço	Quanto ao esforço de pesca as variáveis a considerar são…
Potência	O poder de captura derivado da potência das máquinas e de todo o equipamento de detecção a bordo.
Dano	Os danos que possam ser infligidos nos recursos disponíveis.
Selectividade	As espécies que são alvo da pesca com esta arte.

Alternativas	**Descrições**
Local do pesqueiro	É a localização do pesqueiro na área marítima da costa sul do Algarve. Inclui as zonas Barlavento, Central, e Sotavento.
Idade do pesqueiro	No caso de o pesqueiro ser um RA, convém saber se este foi recentemente implantado ou não.
Dimensão do pesqueiro	Comparações dos pesqueiros relativamente às dimensões dos RAs. Há pesqueiros pequenos, médios, e grandes.
Distância do porto de abrigo ao pesqueiro	A quantas milhas marítimas se encontra o pesqueiro escolhido, em relação ao porto de abrigo ou origem.

Relembrar a escala



Número da comparação

C1

Pesca acessória

Recifes artificiais																		Outro pesqueiro qualquer
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C2

Captura de espécies alvo

Recifes artificiais																		Outro pesqueiro qualquer
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C3

Rendimento da pesca

Recifes artificiais																		Outro pesqueiro qualquer
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C4

Emprego na pesca

Tempo parcial																		Tempo inteiro
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C5

Pesqueiro

Maturidade																		Potencial
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C6

Esforço de pesca

Potência																		Dano
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C7

Esforço de pesca

Potência																		Selectividade
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C8

Esforço de pesca

Dano																		Selectividade
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C9

Pesca acessória																		Captura de espécies alvo
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

C10	**Pesca acessória**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Rendimento da pesca**
C11	**Pesca acessória**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Emprego na pesca**
C12	**Pesca acessória**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Pesqueiro**
C13	**Pesca acessória**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Esforço de pesca**
C14	**Captura de espécies alvo**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Rendimento da pesca**
C15	**Captura de espécies alvo**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Emprego na pesca**
C16	**Captura de espécies alvo**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Pesqueiro**
C17	**Captura de espécies alvo**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Esforço de pesca**
C18	**Rendimento da pesca**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Emprego na pesca**
C19	**Rendimento da pesca**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Pesqueiro**
C20	**Rendimento da pesca**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Esforço de pesca**

C21

Emprego na pesca	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Pesqueiro**

C22

Emprego na pesca	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Esforço de pesca**

C23

Pesqueiro	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Esforço de pesca**

Secção B: Que alternativas existem na escolha dum pesqueiro

Abaixo encontra-se uma tabela que caracteriza alguns pesqueiros (Tabela 1.). A Tabela 2. refere-se à distância do porto de origem ao pesqueiro preferencial.

Tabela 1.

# - Pesqueiro	Local	Idade	Dimensão
1 - RA Alvor	Barlavento	5 a 10	médio
2 - RA Oura	Central	<5	médio
3 - RA Vilamoura	Central	5 a 10	médio
4 - RA Faro antigo	Central	>10	pequeno
5 - RA Faro novo	Central	<5	grande
6 - RA Olhão	Central	>10	pequeno
7 - RA Tavira	Sotavento	<5	médio
8 - RA Cacela	Sotavento	<5	variavel
9 - Outro pesqueiro	Barlavento	>10	variavel
10 - Outro pesqueiro	Central	>10	variavel
11 - Outro pesqueiro	Sotavento	>10	variavel

Tabela 2.

Distância ao porto de origem	
Perto	< 6 milhas
Média	6 a 12 milhas
Longe	> 12 milhas

P24 Dos pesqueiros da Tabela 1., qual(ais) é(são) o(s) seu(s) favorito(s)?

	#	Dimensão	Distância
1a escolha			
2a escolha			
3a escolha			

Agora de acordo com a Tabela 1. acima faça a comparação, mas com a importância centrada nos grupos:

P25 Local do pesqueiro	Preferência
Sagres a Albufeira (Barlavento)	
Albufeira a Olhão (Central)	
Olhão a Vila Real (Sotavento)	

P26 Idade do pesqueiro	Preferência
Inferior a 5 anos	
5 a 10 anos	
Superior a 10 anos	

P27 Dimensão do pesqueiro	Preferência
Pequeno (até 1 Km2)	
Médio (de 1 a 4 Kms2)	
Grande (> 4 Kms2)	

P28 Distância do pesqueiro	Preferência
Inferior a 6 milhas	
6 a 12 milhas	
Superior a 12 milhas	

As preferências variam neste caso de 1 a 3, sendo 1 a "mais" escolhida e 3 a "menos" escolhida.

Dadas as características dos pesqueiros acima (Tabela 1.), responda às questões seguintes (de A32 a A37), tal como fez para as questões C1 a C26:

A29

Local do pesqueiro | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Idade do pesqueiro**

A30

Local do pesqueiro | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Dimensão do pesqueiro**

A31

Local do pesqueiro | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Distância ao porto de abrigo**

A32

Idade do pesqueiro | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Dimensão do pesqueiro**

A33

Idade do pesqueiro | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Distância ao porto de abrigo**

A34

Dimensão do pesqueiro | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Distância ao porto de abrigo**

Secção C: Possíveis custos para restrição de acesso aos RAs

Há evidências de que os blocos de betão proporcionam melhores pescarias, o que atrai certos operadores de determinadas artes elegíveis. Contudo, o aumento de utilizadores irá mais cedo ou mais tarde trazer problemas de congestionamento e sobre-exploração de recursos pesqueiros, se não forem tomadas medidas de restrição ou protecção adequadas. Gostaríamos de saber se…

Q35. Para além das actuais restrições de certas artes (como por exemplo a ganchorra), está de acordo que se deveria controlar mais o acesso aos RAs no Algarve?

Sim ☐ **Não** ☐

Q36. Está de acordo com o uso dos RAs por parte de…

(a) Apenas pescadores profissionais de artes elegíveis ☐

(b) Pescadores profissionais elegíveis e pesca recreativa ☐

(c) Pescadores profissionais elegíveis e mergulhadores ☐

(d) Outros utilizadores (por favor indique-os abaixo) ☐

____

Q37. Acha que os RAs deviam ser parcialmente protegidos restringindo o seu acesso?

Sim ☐ (Passe para a Q41.) **Não** ☐ (Passe para a Q42.)

Q38. Se respondeu sim, que tipo de protecção?

Limitar o acesso:

(a) a uma área de (quanto?) ☐ **%**

(b) a uma altura do ano (quando?) ☐

(c) a um tipo de utilizadores (quem?) ☐

(d) de outra forma (por favor indique-a no espaço abaixo) ☐

____

Q39. Acha que as comunidades piscatórias deveriam ter direitos de uso prioritário sobre os RAs da sua vizinhança?

Sim ☐ **Não** ☐

Secção D: Finalmente, algumas questões acerca de si

Sexo:

Masculino ☐ Feminino ☐

Idade:

<26 ☐ 26 - 40 ☐ 41 - 60 ☐ >60 ☐

Educação:

<6 ano ☐ 6-9 ano ☐ 9-12 ano ☐ CS ☐

CS = Curso superior

Número de pessoas no agregado familiar

☐ pessoas

Muito obrigado pelo seu tempo.

Agradecidos pela sua participação e cooperação.

IPIMAR (Pt) / Cemare (RU)

Choosing the best diving spot

Survey on the attitudes, carried out by IPIMAR (Pt) / CEMARE (RU)

for the International Conference on artificial reefs (CARAH), April 2005

Introduction

Ecotourism has been attracting many people to practice a wide range of leisure activities. Diving is one of them and has increasing number of followers. We are interested in your opinions about these facts and we would be grateful if you could take part of this survey as a diving adept. Your answers will help us to clear which are the reasons that enter in a choice for a diving spot and to establish choice priorities. All the information you provide us is only for scientific purposes and is confidential.

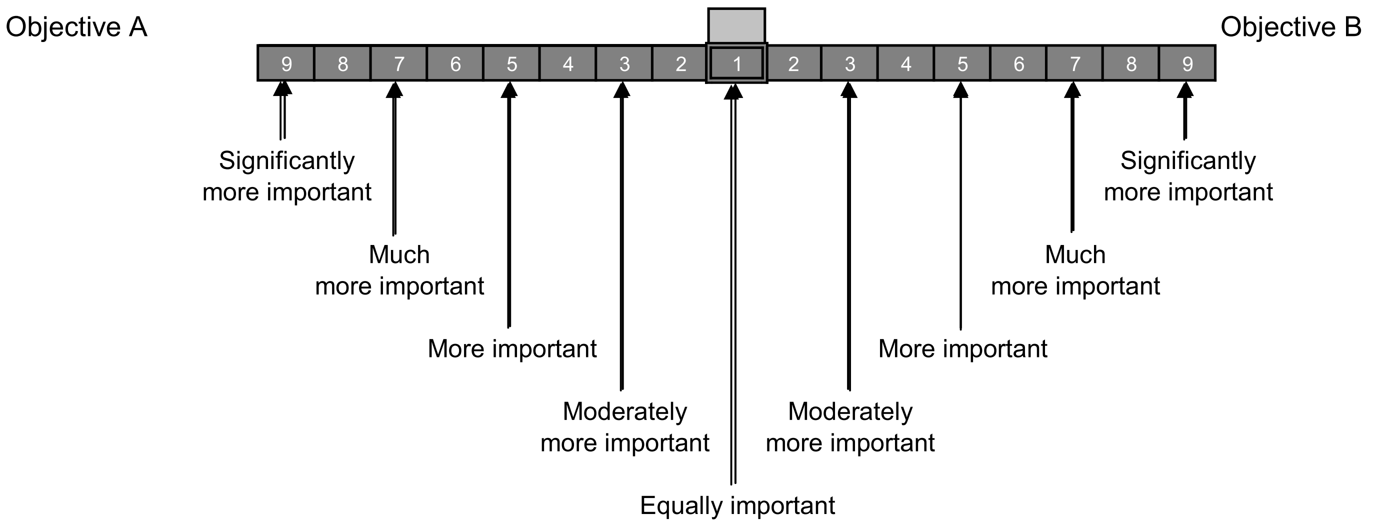
Section A: What criteria are important in the choice of a diving spot

This section asks you to compare the various criteria that enter in the decision process of choosing a fishing ground and order their relative importance.

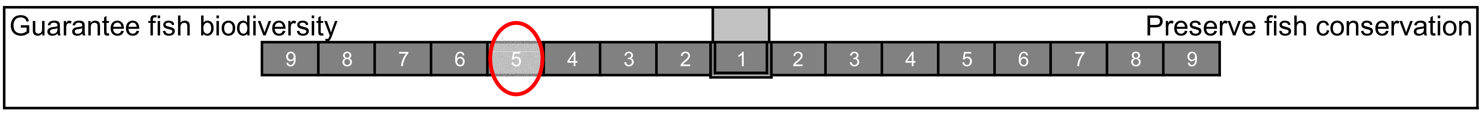
Next you will follow a series of numbered questions. For each one we would like you to indicate us the relative importance of one of the two criteria being represented in the opposite sides of the scale.

*To help you use the guide **How to use the scale** and **Descriptions** contained in the box below.*

How To use the importance scale:



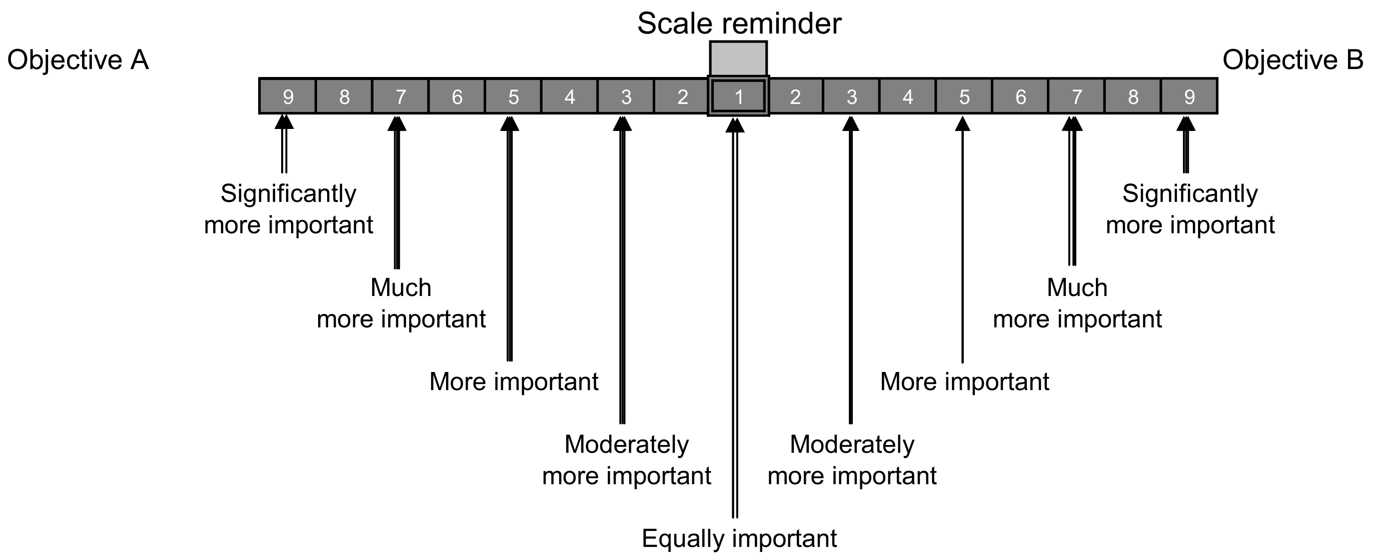
In the example below, if you think that ***to guarantee biodiversity*** is "more important" than ***preserve conservation***, circle the relevant point on the scale as shown:

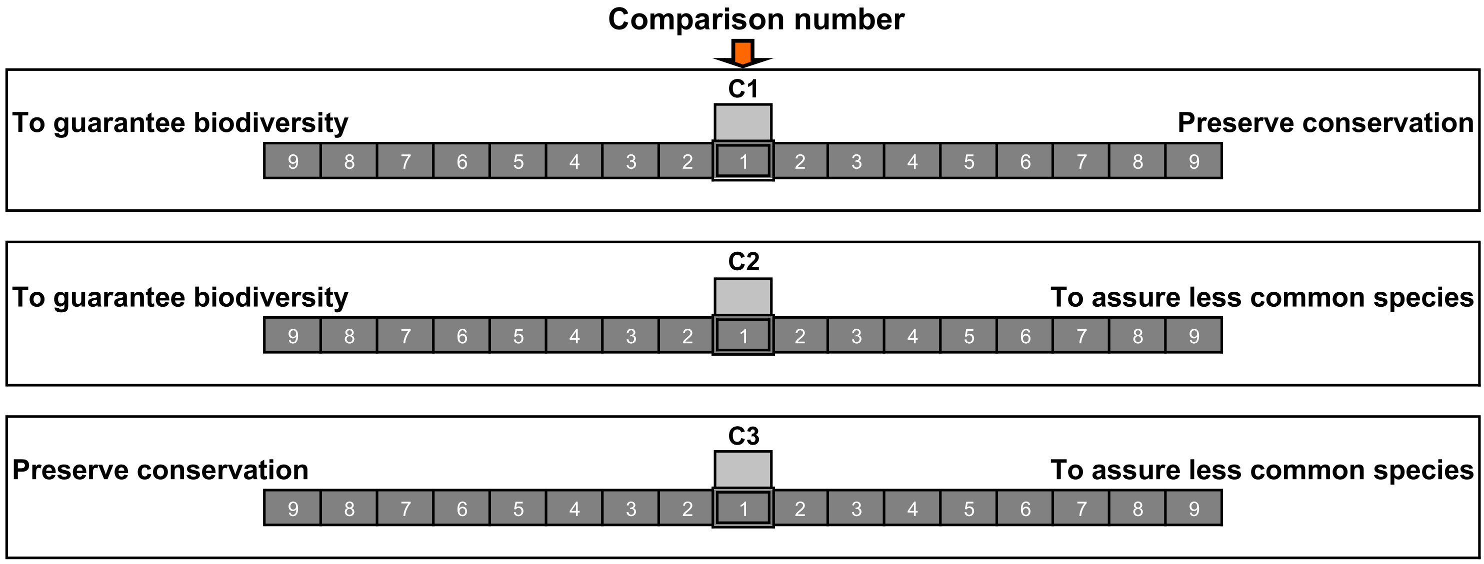


Description of the criteria and the alternatives:

	Criteria	Descriptions
Biological		
	To guarantee biodiversity	To guarantee that is going to be found a high range of different marine species.
	Preserve conservation	To know that the diving site is in good state of conservation. To be able to participate/help actively in the preservation of diving sites of great beauty and/or importance.
	To assure less common species	To assure that is highly possible to find species that are not commonly found/observed, or have a particular behaviour.
Geographical		
	Ease location	Easy access and location, and bing located relatively far from the main disturbed areas (i.e. outside the inlets of inland waters or rivers).
	Topography enrichment	To prefer sites where there are richer topography, or where there are plenty of geographical accidents or rocky intrusions.
	Divable depth	To dive in divable depths means to increase diving time and reduce safety worries.
Atmospheric		
	Reduce sea currents	To reduce the possibility to find any type of currents, whatever they are from the surface, shallow waters, or deep.
	Good visibility	Underwater visibility is considerably improved if there are low precipitation, storms, or other bleaching phenomena. During high planktonic productivity seasons visibillity is reduced considerably.
	Comfortable temperature	Finding a comfortable temperture increases the probability of a successful dive, because the body reacts in accordance to this variable.
Economic		
	Price	The money that each person is able/willing to pay for a given good or service differs amongst people according to each ones' priorities. Therefore, after satisfying the main needs comes the comfort and leisure (e.g. diving).
	Enhance ancillary conditions	The ancillary conditions refer to all the support given by the diving operator, either at quality and functionality of the diving equipment, or by the comfort and safety care before, during, and after diving.
Other incentives		
	To develop diving in other sites	The importance of practising the diving activity in other places as a mean of obtaining higher satisfaction.
	To enhance the knowlege of a known site	The need to improve the knowledge of a given site whatever the purpose, or just by trying to find/study better the spot.
	Uptading skills	The need to improve/update diving skills through the progression in specialized courses. Curiosity enrichment or scientific studies.

Alternatives	Description
Artificial reef	Cubic or octogonal modules made of concrete. Their deployment was deliberated.
Sunken vessel	Vessel that was sunk with the purpose of a reef. Pollutant materials were carefully removed before deployment.
Natural reef	Usually a rocky formation/intrusion that gathers certain particularities that are interesting for divers.
Wreck	Any type of man-made material that was not deliberately sunken (e.g. ships, planes, and their parts).
Archaeological site	Diving site that has historic or archaeologic interest by its value and contribution to the knowledge.





C4

Ease location	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Topography enrichment**

C5

Ease location	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Divable depth**

C6

Topography enrichment	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Divable depth**

C7

Reduce sea currents	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Good visibility**

C8

Reduce sea currents	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Comfortable temperature**

C9

Good visibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Comfortable temperature**

C10

Price	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Enhance ancillary conditions**

C11

Diving in other sites	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Diving in the same site**

C12

Diving in other sites	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Updating skills**

C13

Diving in the same site	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Updating skills**

Now, according to the previous answers make comparisons but focusing in the groups only:

S14

Biological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Geographic**

S15

Biological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Atmospheric**

S16

Biological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Economic**

S17

Biological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Outher incentives**

S18

Geographical	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Atmospheric**

S19

Geographical	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Economic**

S20

Geographical	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Outher incentives**

S21

Atmospheric	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Atmospheric**

S22

Atmospheric	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Economic**

S23

Economic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Outher incentives**

Now, make the comparisons according to your preferred alternatives:

A24

Artificial reef	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Sunken vessel**

A25

Artificial reef	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9]	**Natural reef**

A26

Artificial reef	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Wreck**

A27

Artificial reef	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Archaeological site**

A28

Sunken vessel	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9]	**Natural reef**

A29

Sunken vessel	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Wreck**

A30

Sunken vessel	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Archaeological site**

A31

Natural reef	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Wreck**

A32

Natural reef	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Archaeological site**

A33

Wreck	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Archaeological site**

Section B: Possible costs to restrict access to the ARs

One of the main aims of ARs (concrete-made modules) is to promote biodiversity, which is considered a motivation for the diving practise. However, many divers prefer shallower waters and more irregular topography than the ones that are provided by concrete-made modules.
Other reef types (either natural, or other structures as archaeological sites, sunken vessels, etc.) usually provide highly interesting landscape scenarios at shallower depths.

There is some evidence that concrete-made modules generate better fishing results, attacting certain fishing gear operators. Thus, the increase in users will sooner or later bring about congesting and overexploitation problems over fishing resources, if adequate measures of restriction or protection are taken. We would like to hear from you if you are willing to pay/spend more than now in order to have a restricted concrete-made module area.

Suppose you are interested in diving in the ARs more often…

Q34. Would you pay more to restrict access to the ARs?

Yes ☐ **No** ☐

Q35. If your answer was YES, how much in percentage would you pay to dive in that area when comparing the money you spend in a dive elsewhere in the Algarve region?

☐ **%**

Q36. If your answer was NO, please tick in the appropriate box the answer that best addresses your reason:

(a) Never dives in ARs ☐

(b)Divers shoiuld not pay an extra amount in order to solve resource congestion and over-exploitation problems ☐

(c) Any other reason (please use the lines below) ☐

____

Secção C: Finally, some questions about yourself

Gender:

Male ☐ Female ☐

Age:

<26 ☐ 26 - 40 ☐ 41 - 60 ☐ >60 ☐

Education:

<6th grade ☐ 6-9 grade ☐ 9-12 grade ☐ UD ☐

UD = University degree

Household annual income (€):

<10M ☐ 10-20M ☐ 21-30M ☐ 31-40M ☐ >40M ☐

Number of people in the household:

☐ people

Are you member of any environmental organization?

Yes ☐ No ☐

Do you work in any activity where diving is included?

Yes ☐ No ☐

What type of diver are you:

Professional ☐ Regular ☐ Occasional ☐ Beginner ☐

Thank you very much for your time.

We appreciated your participation and cooperation.

IPIMAR (Pt) / Cemare (UK)

Como se processa a escolha de locais de mergulho

Pesquisa sobre as atitudes, realizada pelo IPIMAR (Pt) / CEMARE (RU) para a Conferência Internacional de recifes artificiais (CARAH), Abril 2005

Introdução

O ecoturismo tem vindo a atrair inúmeras pessoas a praticar diversas actividades de lazer. O mergulho é uma delas e tem cada vez mais adeptos. Estamos interessados nas suas opiniões sobre estes factos, e seria óptimo que pudesse tomar parte da pesquisa como adepto/a do mergulho. As suas respostas vão-nos ajudar a clarificar quais as razões para a escolha de locais de mergulho, e a estabelecer prioridades de escolha. A informação que nos der tem fins puramente científicos e será confidencial.

Secção A: Que critérios entram na escolha dum local para mergulho

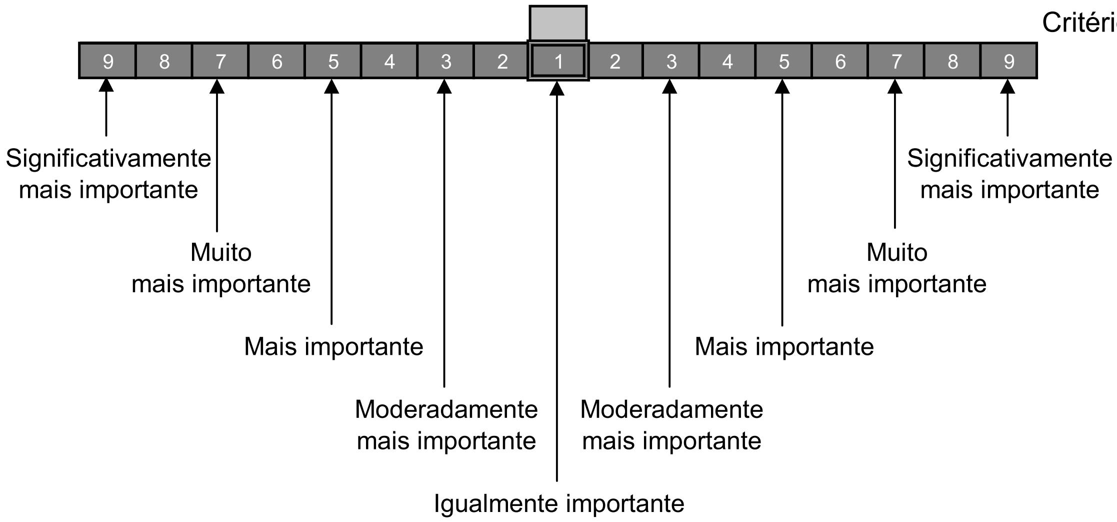
Esta secção pede-vos para comparar os vários critérios que entram no processo de decisão da escolha dum mergulho e ordenar a sua importância relativa.

A seguir encontrará uma série de questões numeradas. Para cada uma delas gostariamos que nos indicasse a importância relativa de cada um de dois critérios representados em cada um dos lados opostos da escala.

Para ajudá-lo/a use o guia ***Como usar a escala*** *e* ***Descrições*** *contidos na caixa abaixo.*

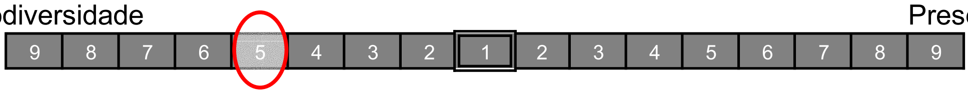
Como usar a escala de importância:

Critério A | Critério B



No exemplo abaixo, se acha que ***garantir elevada biodiversidade*** é "mais importante" que ***preservar a conservação***, então assinale o valor correspondente na escala conforme é mostrado:

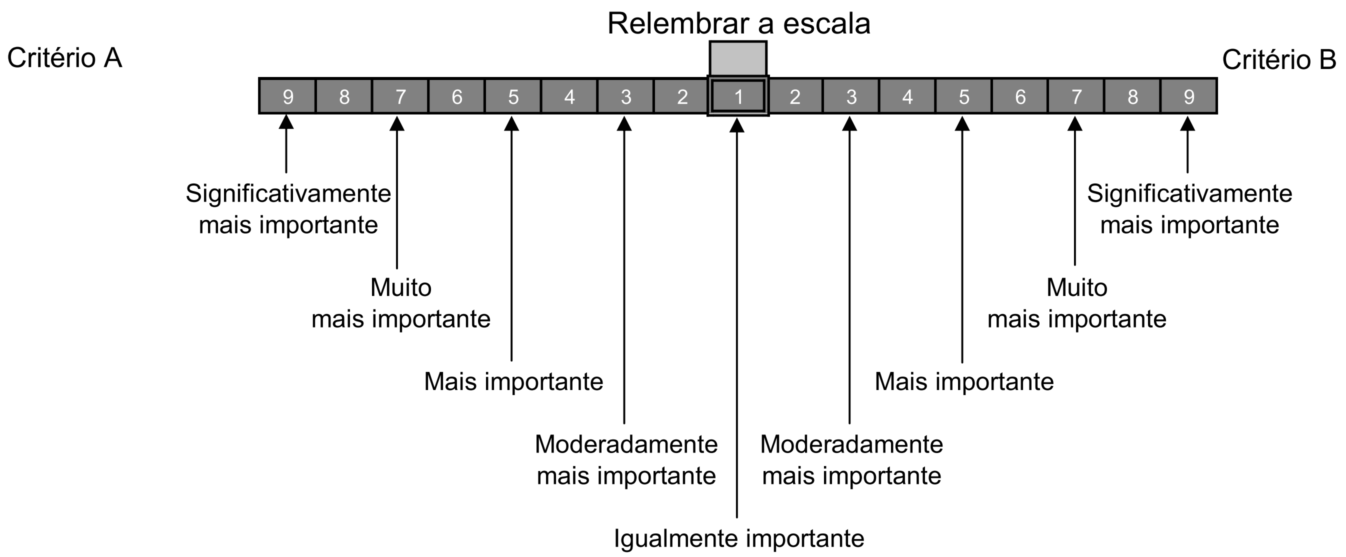
Garantir elevada biodiversidade | Preservar a conservação

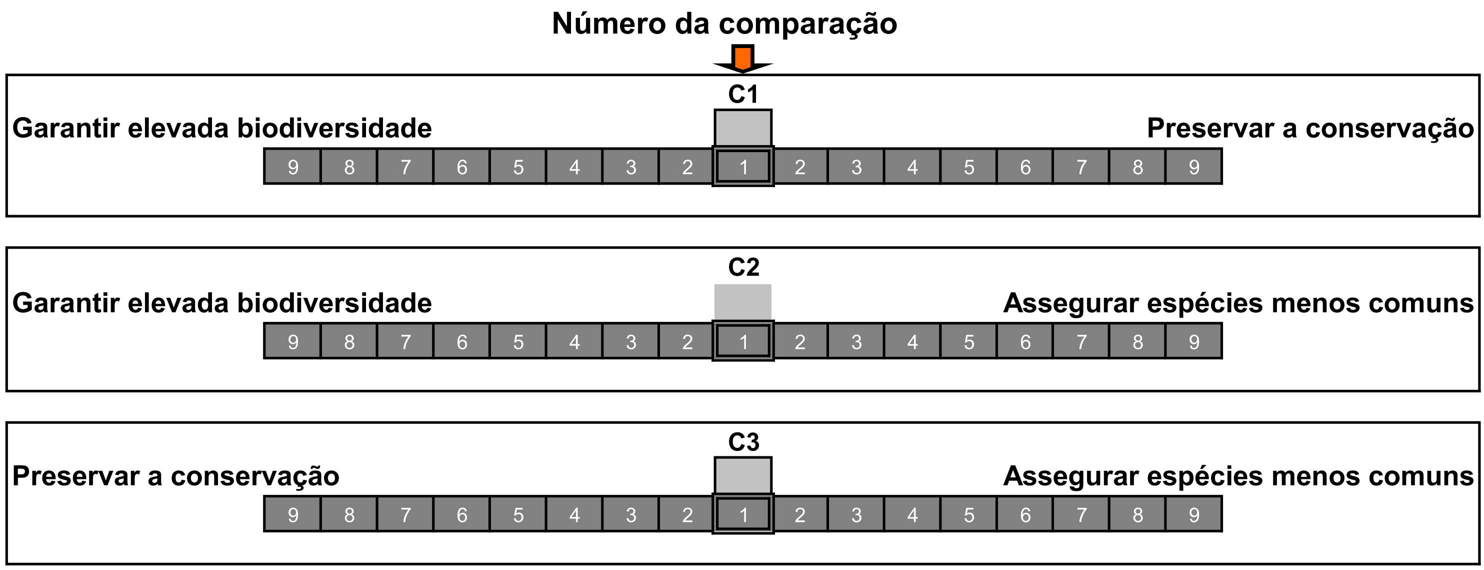


Descrições dos critérios e das alternativas:

	Critérios	Descrições
Biológicos		
	Garantir elevada biodiversidade	Garantir que se vai encontrar uma elevada panóplia de diferentes espécies de seres marinhos.
	Preservar a conservação	Saber que se vai encontrar um determinado local em bom estado de conservação. Poder participar/ajudar activamente na preservação de locais de grande beleza e/ou importância.
	Assegurar espécies menos comuns	Assegurar que se vão encontrar espécies que não são habituais observar, ou que têm um comportamento fora do normal.
Geográficos		
	Facilitar a localização	Acesso e localização fáceis encontrando-se suficientemente longe das principais zonas sujeitas a lixiviação (fora da foz de rio ou ria).
	Enriquecer a topografia	Preferir locais onde há maior riqueza topográfica, ou onde abundam diversos acidentes geográficos ou intrusões geológicas.
	Diminuir a profundidade	Diminuir a profundidade significa aumentar o tempo de mergulho e reduzir as preocupações a nível de segurança.
Atmosféricos		
	Reduzir as correntes	Reduzir a possibilidade de encontrar qualquer tipo de correntes, sejam elas de superfície, meia água, ou fundo.
	Amplificar a visibilidade	A visibilidade subaquática é melhorada consideravelmente se houver fraca precipitação, tempestades, ou fenómenos de lixiviação. Alturas de grande productividade planctónica diminuem-na bastante.
	Permitir uma temperatura confortável	Permitir que a temperatura seja confortável aumenta a probabilidade de o mergulho ser bem sucedido, pois todo o corpo reage em relação a esta variável.
Económicos		
	Preço	O dinheiro que cada um disponibiliza para um determinado bem ou serviço difere de pessoa para pessoa consoante as suas próprias prioridades. Assim, depois de estarem satisfeitas as primeiras necessidades vem o conforto e o lazer (exemplo: mergulho).
	Melhorar condições auxiliares	As condições auxiliares relacionam-se com todo o apoio prestado pela escola ou clube, quer a nível de qualidade e funcionalidade do equipamento alugado/disponibilizado, quer através do conforto e segurança prestados antes, durante e pós mergulho.
Outros incentivos		
	Desenvolver o mergulho noutros locais	Importância de praticar a actividade noutros locais como forma de obter maior satisfação.
	Melhorar local já conhecido	Necessidade de melhorar o conhecimento dum determinado local, quanto mais não seja pela sua enorme riqueza em oferecer algo sempre interessante para se ver a cada vez que lá se mergulha.
	Actualizar aptidões	Necessidade de melhorar/actualizar as aptidões de mergulho através de progressão em cursos. Enriquecimento da curiosidade ou estudos científicos.

Alternativas	Descrições
Recife artificial	Blocos cúbicos ou octogonais feitos de concreto. A sua implantação foi feita deliberadamente.
Navio afundado	Navio afundado com o propósito de servir de recife. Os materiais poluentes foram retirados cuidadosamente antes do afundamento.
Recife natural	Formação geralmente de origem rochosa que tem certas particularidades aliciantes para o mergulho.
Naufrágio	Qualquer tipo de material feito pelo homem e que não tenha sido deliberadamente afundado (ex: navios, aviões, e suas partes).
Sítio arqueológico	Local de mergulho que tenha interesse histórico ou arqueológico pelo seu valor e contribuição para o conhecimento.





C4

Facilitar a localização — **Enriquecer a topografia**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C5

Facilitar a localização — **Diminuir a profundidade**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C6

Enriquecer a topografia — **Diminuir a profundidade**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C7

Reduzir as correntes — **Amplificar a visibilidade**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C8

Reduzir as correntes — **Permitir uma temperatura confortável**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C9

Amplificar a visibilidade — **Permitir uma temperatura confortável**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C10

Preço — **Melhorar condições auxiliares**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C11

Desenvolver o mergulho noutros locais — **Melhorar local já conhecido**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C12

Desenvolver o mergulho noutros locais — **Actualizar aptidões**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C13

Melhorar local já conhecido — **Actualizar aptidões**

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Agora de acordo com o que respondeu acima, faça a comparação mas com a importância centrada nos grupos:

S14

Biológicos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Geográficos**

S15

Biológicos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Atmosféricos**

S16

Biológicos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Económicos**

S17

Biológicos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Outros incentivos**

S18

Geográficos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Atmosféricos**

S19

Geográficos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Económicos**

S20

Geográficos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Outros incentivos**

S21

Atmosféricos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Económicos**

S22

Atmosféricos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Outros incentivos**

S23

Económicos	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Outros incentivos**

Agora faça as comparações em relação às alternativas que mais prefere dum modo geral:

A24

Recife artificial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Navio afundado**

A25

Recife artificial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Recife natural**

A26

Recife artificial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Naufrágio**

A27

Recife artificial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Sítio arqueológico**

A28

Navio afundado	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Recife natural**

A29

Navio afundado	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Naufrágio**

A30

Navio afundado	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Sítio arqueológico**

A31

Recife natural	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Naufrágio**

A32

Recife natural	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Sítio arqueológico**

A33

Naufrágio	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Sítio arqueológico**

Secção B: Possiveis custos para restrição de acesso aos RAs

Um dos propósitos dos RAs (blocos de concreto) é promover a biodiversidade, o que funciona como motivação para a prática do mergulho. Contudo, muitos mergulhadores preferem profundidades inferiores e topografia mais irregular do que aquela que é geralmente proporcionada pelos blocos de concreto. Outro tipo de recifes (naturais, ou estruturas tais como locais arqueológicos, navios afundados, etc.) proporcionam muitas vezes cenários ainda mais interessantes e a mais baixa profundidade.

Há evidências de que os blocos de concreto proporcionam melhores pescarias, o que atrai certos operadores de determinadas artes elegiveis. Contudo, o aumento de utilizadores irá mais cedo ou mais tarde trazer problemas de congestionamento e sobre-exploração de recursos (demersais e bentónicos), se nao forem tomadas medidas de restrição ou protecção adequadas. Gostaríamos de saber se estaria disposto/a a pagar/gastar mais do que já paga/gasta habitualmente num outro sítio qualquer para ter uma área de blocos de concreto, onde o acesso esteja condicionado.

Supondo que estaria interessado/a em mergulhar nos RAs de concreto mais amiúde…

Q34. Estaria disposto/a a pagar mais para haver maior restrição no acesso aos RAs?

Sim ☐ **Não** ☐

Q35. Se respondeu SIM, **quanto mais em percentagem** estaria disposto/a a pagar para mergulhar nessa area em relação ao que já paga/gasta num mergulho noutro sítio qualquer na região?

☐ **%**

Q36. Se respondeu NÃO, por favor assinale no lugar respectivo o que **melhor representa a sua razão**:

(a) Nunca mergulha em RAs ☐

(b) Os mergulhadores não deviam pagar uma quantia extra para resolver os problemas de congestionamento e sobre-exploração de recursos ☐

(c) Outra razão qualquer (por favor indique-a no espaço abaixo) ☐

____

Secção C: Finalmente, algumas questões acerca de si

Sexo:

Masculino ☐ Feminino ☐

Idade:

<26 ☐ 26 - 40 ☐ 41 - 60 ☐ >60 ☐

Educação:

<9 ano ☐ 9-12 ano ☐ CS ☐ PG ☐

CS = Curso superior, PG = Pos-graduação

Rendimento anual bruto do agregado familiar (€):

<10M ☐ 10-20M ☐ 21-30M ☐ 31-40M ☐ >40M ☐

Número de pessoas no agregado familiar

☐ pessoas

É membro de alguma organização ambiental?

Sim ☐ Não ☐

Trabalha nalguma actividade onde o mergulho seja parte integrante do serviço?

Sim ☐ Não ☐

Que tipo de mergulhador/a é:

Profissional ☐ Regular ☐ Ocasional ☐ Iniciante ☐

Muito obrigado pelo seu tempo.

Agradecidos pela sua participação e cooperação.

IPIMAR (Pt) / Cemare (RU)