

SELECTION OF THE PRIORITY AREAS ON THE WEST COASTS OF MERSİN
USING GIS TO ASSESS A MARINE CONSERVATION PLANNING

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ABSTRACT

SELECTION OF THE PRIORITY AREAS ON THE WEST COASTS OF MERSIN USING GIS TO ASSESS A MARINE CONSERVATION PLANNING

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The subject studied by this thesis was the selection of priority areas for marine conservation planning along western coasts of Mersin, by incorporating biological and socioeconomic data through geographical information system (GIS). The geographical borders of the study area were determined by the data availability from previous surveys, which were designed to investigate Mediterranean Monk seal habitats and populations. Also the information derived from the results of monitoring investigations on Kızılliman Marine Protected area was used to divide the area into sub regions.

The fish assemblage of shallow coastal area within depth of 0-10m was assessed by visual census survey, covering the whole area where the stations distributed in near equal longitudinal distance. Assemblage of the demersal species of deeper waters (10-100m) was assessed by trawl sampling. Considering the difficulty of measuring whole biodiversity of the area, surrogates were used to represent biodiversity. Surrogates were coastal habitat types, endangered species habitats and some certain fish species data derived from trawl and visual census data sets. Socioeconomic information was also collected during the surveys which were combined with the information extracted from Google Earth satellite images later on.

All the obtained data was combined under a geo-database and mapped using GIS. After creation of the data layers Marxan was employed for site selection. Marxan is software designed for selection of the areas for creating marine reserves. With Marxan, it is possible to include socioeconomic information and optimize borders of

the reserve system to provide compactness. The strength of the software is the simulated annealing algorithm by which Marxan finds optimal solutions. Several different tests were applied to find suitable values for settings of the software. Afterwards 8 different scenarios were created by changing the representation targets for each conservation feature. Finally a set of different sized but similarly located reserve systems were defined.

Consequently a reserve system composed of three segments were found to be the best selection where the patches were located at west of Anamur (Mellec), surroundings of Kızılliman and Between Akkuyu and Ovacık. Along with the recommendation of priority areas for conservation, the methodology used in this study was recommended for further studies in selection of areas for protection.

Keywords: Marine protected area, geographical information system, Marxan, priority areas, Kızılliman, Mersin, North Eastern Mediterranean

ÖZ

MERSİNİN BATI KIYILARINDA DENİZ KORUMA PLANLAMASI İÇİN COĞRAFI BİLGİ SİSTEMİ YARDIMIYLA ÖNCELİKLİ ALANLARIN BELİRLENMESİ

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Bu yüksek lisans tez çalışmasında araştırılan konu, Mersinin batı kıyılarında, bir coğrafi bilgi sistemi (CBS) tabanı altında birleştirilmiş biyolojik ve sosyo ekonomik verileri göz önünde bulundurarak, deniz koruma planlaması açısından öncelikli alanların seçilmesidir.

Bu çalışmanın coğrafik kapsamı daha önceki Akdeniz foku habitatlarının ve popülasyonunun araştırılması için düzenlenmiş arazi çalışmalarının sonucunda elde edilmiş verilere göre belirlenmiştir. Ayrıca Kızılliman deniz koruma alanı izleme çalışmalarının sonuçlarından türetilmiş bilgiler, çalışma alanının alt bölgelere ayrılmasında kullanılmış, ve yine bu bilgiler, oluşturulan alt bölgelere atanmıştır.

Yaklaşık olarak eşit boylamsal mesafede dağıtılmış istasyonlardan oluşan ve tüm çalışma alanını kaplayan, bir görsel sayım (visual census) araştırması tamamlanmış ve 0-10 m derinlikteki balık tür kompozisyonu belirlenmiştir. Daha derinde (10-100m) bulunan demersal balık türleri ile ilgili veriler trol örnekleme ile elde edilmiştir. Alandaki biyolojik çeşitliliğin temsil edilebilmesi için, tüm biyoçeşitliliğin ölçülmesinin çok zor olduğu düşünülerek, vekil – göstergeler (surrogate) kullanılmıştır. Bu vekiller, kıyısız habitat tipi, tehdit altında olan türlerin habitatları, trol ve görsel sayım verilerinden seçilmiş bazı gösterge özelliğine sahip balıklardan oluşmaktadır. Araştırmalar sırasında sosyoekonomik veriler de toplanmış, ve daha sonra Google Earth uydu görüntülerinden elde edilen verilerle birleştirilmiştir.

Elde edilen tüm veriler CBS yardımıyla bir coğrafik bilgi tabanı altında birleştirilmiş ve haritalanmıştır. Veri katmanlarının elde edilmesinden sonra alan seçimi için Marxan kullanılmıştır. Marxan oluşturulacak deniz koruma alanlarının seçimi için tasarlanmış bir programdır. Marxan koruma alanlarının bütünlüğünü sağlarken sosyoekonomik girdileri de değerlendirerek alanın optimize edilmesine imkan verir. Bu programın güçlü yanı optimal sonuçları bulmak için kullandığı benzetimli tavlama tekniğidir. Program için en uygun olan ayarları belirleyebilmek için bir çok test gerçekleştirilmiş, ve daha sonra her bir koruma özelliğinin temsil edilme değerinin değiştirilmesiyle, 8 farklı senaryo elde edilmiştir. Sonuç olarak bir grup benzer şekilde yerleştirilmiş ancak farklı genişliklere sahip alanlar belirlenmiştir.

Son olarak, batı Anamur (Melleç), Kızıllıman civarı ve Akkuyu ile Ovacık arasında kalan alan olmak üzere 3 parçadan oluşan bir koruma alanı sistemi en iyi olarak değerlendirilmiştir. Bu önerinin yanı sıra, kullanılan yöntem, bu tipte yapılacak daha sonraki çalışmalar için de önerilmiştir.

Anahtar Kelimeler: Deniz koruma alanları, coğrafi bilgi sistemi, Marxan, öncelikli alanlar, biyoçeşitlilik. Kızıllıman, Mersin, Kuzeydoğu Akdeniz

To My Parents

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1 INTRODUCTION

The marine ecosystems are being negatively impacted as a result of anthropogenic activities. One of the most serious consequences of these impacts is the risk of loss of biodiversity. Overexploitation is the most frequent threat to vulnerable marine species, with approximately half of threatened species caught as bycatch in fisheries (Kappel, 2005). Coastal ecosystems have already lost much of their capacity to produce fish because of overfishing, destructive trawling techniques, and destruction of nursery habitats (WRI, 2000). Along with the overexploitation resulting from increasing fishing pressure, coastal development and irregular tourism activities have also adverse effect on the diversity (CBD Guidelines, 2004). The urgent need to improve protection and management of marine areas is becoming more and more apparent as the number and status of many important fish stocks continue to deteriorate (Côté and Finney, 2006).

Marine protected areas (MPAs) are considered to be an important tool for conserving marine species or habitats at risk. By protecting habitats, MPAs shelter the complex, and delicate structure of the sea, including photosynthesis, food chains, nutrient cycle, degradation of pollutants and conservation of biological diversity and productivity (Kelleher, 1999). However MPAs does not have a very long history and covers about 1% of the seas (Sheppard, 2000).

MPAs are defined as ...“any area of the littoral or sub-tidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment”... (Page 7 in Kelleher and Kenchington, 1992). They are designated to enhance conservation of marine resources. The actual level of protection within MPAs varies considerably; most allow some extractive activities such as fishing, while prohibiting others such as drilling for oil or gas (Lubchenco et al. 2003).

According to the World Conservation Union - IUCN (International Union for Conservation of Nature), an MPA:

- includes the marine environment but may also include coastal land areas and islands;
- has some form of protection, usually legal but not necessarily;
- has a degree of protection that is not necessarily the same throughout the area;
- should cover not only the seabed but also at least some of the water column above with its flora and fauna; and
- Protects cultural features such as wrecks, historic lighthouses and jetties.

MPAs are selected and created to protect the areas with high biodiversity or scenic character, like coral reefs (Bohnsack, 1998). Also they are frequently proposed as a tool for managing fisheries (Francour et al, 2001 ; Gucu and Erkan 1999) .

Over 1,388 different terms that are known to be used around the world to designate protected areas each of which is defined within respective national legislation with respect to its objectives and legal protection (Green and Paine, 1997).

The World Conservation Union-IUCN identifies six categories of protected area according to their management objectives and selection criteria (Kelleher, 1999).

Category I - Strict Nature Reserve/Wildlife Area; protection areas (PAs) managed for science, research purposes and wildlife protection.

Category II - National Park; PAs managed mainly for ecosystem protection and recreation.

Category III - Natural Monument; PAs managed for conservation of specific natural features (unique value for aesthetic value or cultural significance).

Category IV - Habitats/Species Management Area; PAs managed for conservation through management intervention.

Category V - Protected Landscape/Seascape; PAs managed for landscape/seascape conservation and recreation.

Category VI - Managed Resources Protected Areas; PAs managed for the sustainable use of natural ecosystems and their resources

1.1 Marine Protected Areas in Fisheries Perspective

It is highly uncertain how marine ecosystems will develop in relation to changes in climate and weather. While these and other environmental factors may certainly affect fish stocks, fishing has in many cases the most important impact.

For a sustainable use of the fisheries resources, the recovery of the most depleted stocks is at the foremost necessity. In order to balance fishing activity against the productive capacity of the stocks, various management tools are implemented (Chopra, 2005). These fisheries management tools are conventionally, classified in two main approach. These are stock based and fleet based approaches. The stock-based management aims keeping the fish stocks to use in most effective and sustainable way. In other words, maintaining the stock size that allows maximum sustainable yield is the major management goal. This is carried out by using some tools such as national quotas, total allowable catch limits or mesh size regulations in order to control the amount of fish landed.

The fleet –based management aims to slow the rate of catch, using tools such as restrictions on type of gear used, restrictions on engine power or maximum length of vessels, seasonal closures to limit total time of fishing, license limitation to keep number of fishers or vessels (fleet) in a tolerable capacity.

However these fishery management tools could not be fully successful because of some constraints. Collapses of the fish stocks within the last 3 decades, one after the other in different seas indicated that the conventional management tools goes failure without additional precautions.

The failure could have several different reasons. Both management tools need a clear stock assessment and knowledge of interactions in the environment. However the uncertainty in biological and ecological information and multi-species structure of the fish communities makes the fisheries stock assessment techniques insufficient. Also in the fleet- based management side the social and economic priorities makes the limitation and size reduction of the fleet, complicated.

Marine Protected Areas provide benefits to both fisheries and conservation (URL 1). For fisheries, protected areas generally can be considered to provide four basic types of fishery benefits:

- Support for stock management, including:
 - protection of specific life stages (larval nursery grounds)
 - critical functions of an exploited population (feeding grounds, spawning grounds)
 - spillover of an exploited species
 - dispersion centre for larval recruitment of an exploited species
- Support for fishery stability
- Ecological offsets—trade-off for ecosystem impacts
- Improved socio-economic outcomes for local communities (Ward and Hegerl, 2003).

The necessity of incorporating the marine reserves into modern fishery management emphasized by Roberts et al. 2005.as they can achieve many things that conventional tools cannot. (Roberts et.al, 2005).

One of the most valuable roles MPAs can play in fisheries management is to reduce the risk of overfishing by providing an ecological buffer against miscalculations in fisheries assessments. MPAs can safeguard against errors in fisheries assessments by providing protection to a portion of the stock so that it can act as a source for population recovery if the unprotected portion of the stock were to collapse (Lauck et.al, 1998).

Together with reduction of the risk of overfishing, MPAs are meant to achieve; management of population structure and maintenance of representative habitat characteristics (Côté and Finney, 2006).

When properly designed, and coupled with other management practices, reserves may provide a better insurance against uncertainties in stock assessment, fishing control and management by protecting a part of the population from exploitation (Gueânnette et.al, 1998).Furthermore they may act as refuges for species diversity and store for genetical characteristics.

1.2 Marine Protected Areas in the World

The terms of “marine reserves” and “marine protected areas” are sometimes used interchangeably. Marine reserves are sometimes called 'ecological reserves,' 'fully-protected marine reserves,' or 'no-take areas.' MRVs are a special category of Marine Protected Areas (MPAs) (Nceas, 2001).

A Scientific Consensus Statement was signed by 161 leading marine scientists and experts on marine reserves of National Center for Ecological Analysis and Synthesis (NCEAS) in USA in 2003.

According to IUCN reports the world urgently needs a comprehensive system of MPAs to conserve biodiversity and to help rebuild the productivity of the oceans (Kelleher, G. 1999).

Several nations, have already legislated the establishment of MPAs as an important component of their fisheries management and conservation strategies. In 2002, parties to the World Summit on Sustainable Development agreed on the objective of establishing national networks of marine protected areas by 2012. In 2003, the World Parks Congress recommended that 20-30% of every habitat in the oceans be given full protection from fishing. In October 2005, the First International Marine Protected Areas Congress convened (Côté and Finney 2006).

The UNEP-World Conservation Monitoring Centre records nearly 6 million km² of protected areas with a marine component, this figure excludes the terrestrial areas of the Greenland National Park which total 972,000 km² (URL2). These statistics indicate that globally less than one per cent of the world's oceans lie within MPAs.

1.3 Marine Protected Areas in European Community

According to the Framework for Community Action in the field of Marine Environmental Policy (Marine Strategy Directive) (URL3) “The marine environment is a precious heritage that must be protected, restored and treated as such with the ultimate aim of providing biologically diverse and dynamic oceans and seas that are safe, clean, healthy and productive” (European Parliament 2006) (URL4).

In European Union legislation for the environment, a biodiversity action plan including the fisheries was authorized. According to the European Parliament

reports, “the plan identified the following priorities to maintain or restore biodiversity threatened by fishing or aquaculture activities:

- promoting the conservation and sustainable use of fish stocks;
- promoting the control of exploitation rates and the establishment of technical conservation measures to support the conservation and sustainable use of fish stocks;
- reducing the impact of fisheries activities on non-target species and on marine and coastal ecosystems;
- avoiding aquaculture practices that may affect habitat conservation.

The members of the community have subscribed to an international political commitment at the World Summit on Sustainable Development at Johannesburg in September 2002 to maintain or restore fish stocks to levels that can produce the maximum sustainable yield, with the aim of achieving these goals for depleted stocks on an urgent basis, and where possible not later than 2015 (World summit on sustainable development, 2002) (URL5).

The regulations, proposals, policies and objectives related to the marine environment of the European Union are composed under Marine Strategy Directive. The thematic strategy on the protection and conservation of the marine environment aims to achieve good environmental status of the EU's marine waters by 2021 and to protect the resource base upon which marine-related economic and social activities depend (URL6).

As declared by the Marine Strategy Directive 2006, in order to promote sustainable use of the seas and to conserve marine ecosystems, priority should be given to achieving good environmental status and to ensuring that subsequent deterioration is prevented (Marine Strategy Directive 2006)(URL3).

In the the same directive, it is stated that, member states should lay down measures for the protection of areas, and designate regions and sub regions as "marine protected areas" (European Parliament, 2006)(URL7).

The need and necessity of establishing marine protected area was also emphasized by marine strategy with the considerations of size, and protection status. Year 2012 was determined to be a target time limit, to achieve the establishment of reserve networks and maintaining and recovering the integrity, structure and functioning of ecosystems (European Parliament, 2006)(URL 7).

According to the regulations it clearly seems that, the marine protection efforts in Europe are going to be accelerated in near future, with more strict regulations. Currently there are 33 Mediterranean MPAs in the European Union covering a total 477453 ha. Five are in France, 11 in Spain, 16 in Italy, one in Greece (figure 1.1).



Figure 1.1 Marine protected areas in the Mediterranean Sea, (URL8).

1.4 Marine Protected Areas in Turkey

Within last 20 years, the efforts for the protection of the marine environment are more noticeable in Turkey. Particularly the process of becoming a candidate to the European Union brought some rapid changes to the policy, legislation and implementation in environmental issues and environment protection (URL9).

Some international environment conventions to which turkey is a party;

- Protocol Concerning Specially Protected Areas in the Mediterranean, Geneva 1982
- Protocol on Biological Diversity, Rio De Janeiro 5.6.1992
- Protocol on protecting the Black Sea against Pollution,
- The Convention on Wetlands of International Importance, especially as waterfowl Habitat

According to The World Database on Protected Areas total number of MPA in the World is 3,459. This number is 14 in Turkey (URL 10). However the status of these

14 protected areas is Specially Environmental Protected Areas which have marine component in its boundaries, but not complete MPAs considering their legal status, zonation and regulation over harvesting.

1.4.1 Legislation

Parallel to the European Union accession process, more intensive scientific researches, environmental projects and increasing social consciousness speeded up the process. Although remarkable changes have been accomplished, there is still an important difficulty in creating the MPAs due to the interference of different institutions in decision making and enforcement of the regulations (Okumus, 2002). Turkish legal protection categories differs then the definitions of IUCN. However there are similar hierarchical levels of limitations (Table 1.1).

Table 1.1 Turkish legal categories with respect to the level of protection (URL 11)

- 1st Degree Natural Sites: These are the areas that call for absolute protection and preservation for public interest due to their scientific values, interesting features and attractions, and rare characteristics. Human activities that may damage the geological characteristics, vegetation cover and general landscape of such sites are prohibited;
- 2nd Degree Natural Sites: These are areas that may accommodate limited public interest use, providing such usage protects and enhances their natural structure. Buildings on such sites, other than those that support the development of tourism are prohibited;
- 3rd Degree Natural Sites: These are areas where residential development may be permitted in the light of the use patterns and the potentials of the region, providing it simultaneously protects and enhances the natural structure

1.4.2 Specially Protected Areas (Özel Çevre Koruma Alanları)

Specially Protected Areas of Mediterranean Interest can be defined as, "sites of importance for conserving the components of biological diversity in the

Mediterranean; contain ecosystems specific to the Mediterranean area or the habitats of endangered species; are of special interest at the scientific, aesthetic, cultural or educational levels". This definition is contained in Article 8(2) of the 1995 Protocol Concerning Mediterranean Specially Protected Areas and Biological Diversity in the Mediterranean

Table 1.2 Specially protected areas and national parks in Turkey (URL9)

MPA Site Name	Designation * international	Date	Total Area (km2)
Foca	Specially Protected Area	1990	27.5
Dilek Yarımadası	National Park	1966	109.9
Patara	Specially Protected Area	1990	190
Göksu Deltası	Specially Protected Area	1990	236
Kekova	Specially Protected Area	1990	260
Gelibolu (Galipoli) Yarımadası	National Park	1973	330
Beydagları coastal	National Park	1972	344.3
Köycegiz-Dalyan	Specially Protected Area	1988	385
Gökova	Specially Protected Area	1989	521
Fethiye-Göcek	Specially Protected Area	1988	613
Datça-Bozburun	Specially Protected Area	1990	1474

This protocol is a base of marine conservation regulations for the Mediterranean Sea. This agreement was authorized as legislation by the decision of the Turkish Council of Ministers and published in the official newspaper of 23 October 1998. In accordance with this protocol some important articles accepted concerning the protection of the Mediterranean Sea. One of the fundamental bases of this protocol is establishment of specially protected areas including marine areas and their environment. After this regulation, 385,000 hectares and 774 kilometers of coastline have been protected (Table 1.2). The management of specially protected areas is

carried out by the Authority for Specially Protected Areas, under the Ministry of Environment.

In Turkey the largest MPA (Kizilliman), located at the west part of Mersin with two different zones, encompassing a number of small core zones was established on the coastal stretch in 1999. Despite being the largest protected area reserved for fishery regulation, Kizilliman MPA is not under the specially protected area directive. According to Gucu and Erkan (2005) one of the main objectives of the protected area was to ensure successful reproduction of monk seals. Therefore, the position and the number of breeding caves used by the seals guided the selection/assignment of location and the number of core zones.

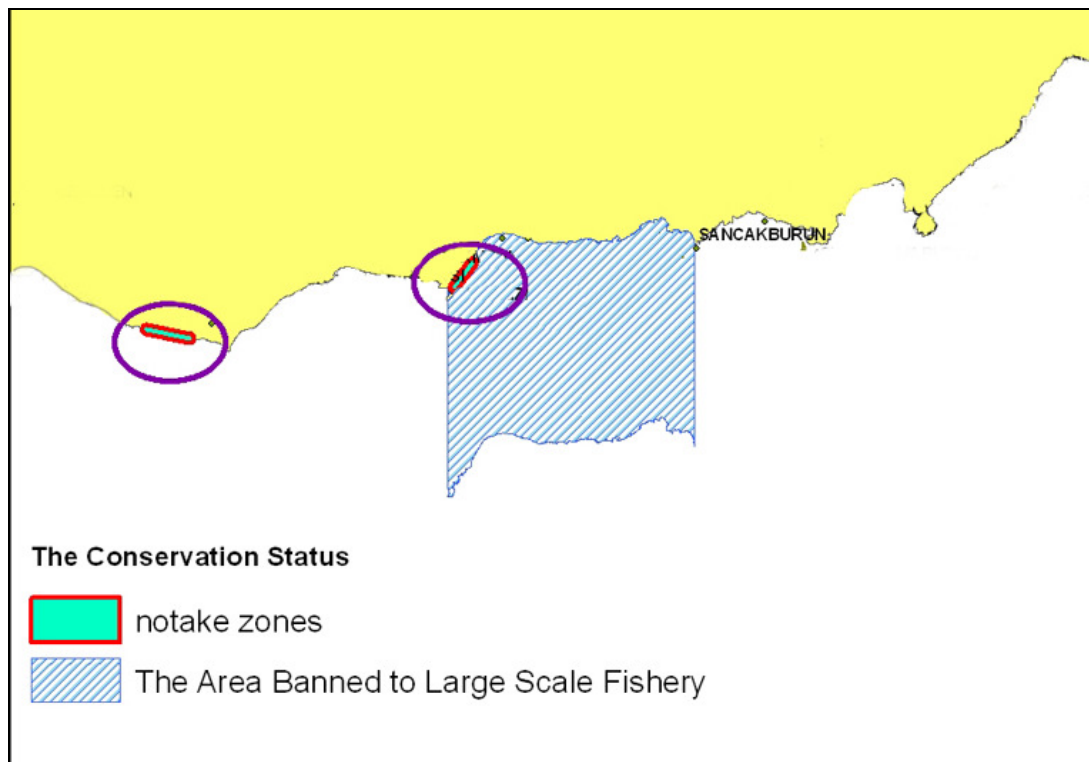


Figure 1.2 Kizilliman MPA; conservation status (circles are no-take zones).

Consequently, using the Mediterranean Monk Seal as the umbrella species, Kizilliman Marine Protected Area, with a 16 nautical miles by 12 miles No-Trawling-Area, two 1 nautical mile by 0.1 mile No-Take-Zone, as well as a 75 km stretch of 1st Degree Natural Asset coast set for land protection, was established (Gucu and Erkan, 1999). Within core zones covering the breeding caves, use of all fishing

types, excluding bottom long line and gill net owned by local small-scale fishermen, has been banned (Figure 1.2) (Gucu and Erkan, 2005).

1.5 Creation of Marine Protected Areas

With zonation, different sub-areas get different degrees of limitations in an hierarchical way. Generally includes a core zone where the restrictions are highest and buffer zones where limitations get gradually flexible. In order to protect the true sites with highest value of biodiversity and less socioeconomic conflict, selection and design is one of the most challenging issues.

1.5.1 Selection and Design

The process of selecting, establishing and managing MPAs requires careful planning and sensitive management. The population range and dispersion of most marine species is unknown, so it is difficult to determine if marine populations in a region are self-sustaining in the long term. Within these constraints, it is clear that one of the most effective and simplest to manage approaches to the conservation of natural resources and biodiversity is to ban certain human activities, such as commercial fishing, in designated areas (Francour, 2001). To achieve conservation objectives, reserves that are valuable for their biodiversity need to be chosen (Roberts et al., 2003).

1.5.2 The Ecological Design Criteria For MPA Networks

With the World Conservation Union (IUCN) report concerning “establishing marine protected area networks”, listed and defined the following 8 ecologic criteria for MPA designation: (WCPA/IUCN., 2007).

Representativeness: MPA networks should represent the range of marine and coastal biological diversity (from genes to ecosystems) and the associated physical environment within the given area.

Replication: All habitats in each region should be replicated within the network and distributed spatially throughout the network.

Viability: MPA networks should incorporate self-sustaining, geographically dispersed component sites of sufficient extent to ensure population persistence through natural cycles of variation. These sites should be independent (as far as possible) of activities in surrounding areas.

Precautionary design: Network designers should base their decisions on the best information currently available, rather than delaying the process to await more and better information. Where information is limited, designers should adopt a precautionary approach.

Permanence. Network design must provide long-term protection to effectively conserve diversity and replenish resources.

Maximum connectivity. MPA network design should seek to maximize and enhance the linkages among individual MPAs, groups of MPAs within a given ecoregion, or networks in the same and/or different regions.

Resilience. MPA networks must be designed to maintain ecosystems' natural states and to absorb shocks, particularly in the face of large-scale and long-term changes (such as climate change).

Size and shape: Individual MPA units within the network must be of sufficient size to minimize adverse impacts from activities outside the protected area (avoiding what is called the "edge effect"). The scale of benefits derived from individual MPAs will depend on their location, design, size, and relationship to other forms of management. MPA networks magnify the benefits of individual sites and protect the large-scale processes that maintain healthy populations, such as connectivity, gene flow and genetic variation.

1.5.3 Zoning

Coastal and marine areas are used for a variety of purposes including fishing, tourism, commerce, aquaculture, preserving natural features, conservation, biodiversity, cultural values, and historical features (Kelleher, 1992). Some of these activities can co-exist, but others are more likely to conflict (Bohnsack, 1996). Zoning is a tool that can be used to separate conflicting uses, usually in space, but also in time, and to protect especially valuable/rare ecosystems within an MPA, while also supporting sustainability, conservation and cultural values (Agardy et al., 2003).

According to Kelleher & Kenchington (1992), the goals of MPA zoning are to:

- Conserve the MPA in perpetuity;
- Provide protection to critical/representative habitats, ecosystems, and ecological processes while allowing reasonable human uses;
- Separate conflicting human activities and to minimize the effects of these uses on the MPA
- Preserve certain areas of the MPA in their natural state, undisturbed by humans, unless for the purpose of research or education.

Salm *et al.*, (2000) summarize these goals into three criteria for zoning: 1) sensitive habitats should be protected; 2) intensive uses should be confined to sites that can sustain them; and 3) incompatible activities should be separated.

There are three general categories of zones typically included in MPA zoning: core zones with a high level of protection; buffer zones that defend other zones from outside influences; and use zones, where human activities are allowed (Salm *et al.*, 2000).

Core zones are strictly protected areas where the objective is to preserve or restore the area to its natural state (Kelleher, 1999). These zones of complete protection are found in almost every multiple-use MPA, and it is generally recognized that they are the most important and should be delineated first (Salm *et al.*, 2000). Buffer zones are transition areas of moderate protection (Francour, 2001, URL 12). They often surround core areas and attempt to minimize conflict between zones. Use zones, which allow a range of human activities, typically offer lower levels of protection and fewer restrictions. Often they are separated into extractive and non extractive uses such as tourism or recreation (Kelleher & Kenchington, 1992; Villa *et al.*, 2002).

There are different methods for developing zoning; generally they are based on scientific analysis or stakeholders' opinion combined by scientific analysis. In all cases a set of criteria is used to determine the value of each area in the MPA, for different kinds of use or protection purposes.

Some of the criteria that have been used include:

- Are there endangered species in the MPA?
- Where are areas of high biodiversity (species and/or habitats)?
- Where are key habitats?
- Are there spawning grounds?
- What is the direction of the prevailing ocean current?
- Where are the most popular fishing/resource?
- What importance does an area hold economically?
- What areas are suitable/popular for tourist and recreation use?

1.5.4 Application of Geographic Information Systems to MPA Zoning

Geographic information systems (GIS) are computer-based tools that aid in the display and analysis of geographically based (spatial) information. GIS has been applied across disciplines and is viewed as a key tool for supporting spatial decision-making in the marine environment (Canessa & Keller, 2003).

Its ability to handle large data sets makes GIS an ideal tool for marine planning. Also its capability of testing, modeling, and comparing the strategies before implementation make planning process more effective.

GIS has been used to aid in the development of MPAs around the world (Airamé *et al.*, 2003; Lieberknecht *et al.*, 2004; Villa *et al.*, 2002). A technique called multiple-criteria analysis, where different data layers are overlaid and weighted, has been used to create marine zones (Villa *et al.*, 2002).

1.5.5 Marxan

MARXAN is a conservation planning optimization tool (software) developed in Australia, which performs decision support for reserve system design (Ball and Possingham, 2000). Marxan is a GIS-based method for siting marine protected areas, which can also assist with zoning. It works in conjunction with GIS, runs a site selection algorithm called simulated annealing. The GIS is used for preparing the planning units that divide the study area, to determine which data fall within each planning unit, and to set targets for the amount of each species to include in the solution. Once the GIS has been used to prepare the data MARXAN runs the simulated annealing algorithm which selects planning units that best meet targets.

Simulated annealing initially generates a random reserve system and then iteratively makes random changes to the selected system by either adding a new site to the system or deleting an already selected site from the system. Each new solution is evaluated against the previous solution and the best solution is kept, potentially avoiding becoming trapped in local optima (Possingham et al., 2000).

1.6 Research Problem

After a series of studies on Monk Seals carried out since 1994, over the western coasts of Mersin, considerable information about the ecosystems and sensitivity of the area has been acquired. Finally in 1998 a protected area has been created primarily considering the important monk seal habitats. Afterwards in 1999 a large area has been closed to large scale fishery, in order to maintain the recovery of the fish stocks which have already been collapsed. This has been followed by researches conducted in and around the MPA in order to monitor the changes and the recovery of the fish stocks and ecosystem.

1.6.1 Research Objectives

The core issue of the research is to generate a methodology on measuring, mapping and analyzing of available marine biodiversity data and surrogates in the study area including the perturbation sources and socioeconomic conflicts, for selection of new priority areas and optimization of the borders of the present protected area. Incorporating all the available information through GIS and prioritization of the sites is the main objectives of this research.

Following four steps needed to complete to achieve the objective

1. Characterize the spatial distribution of marine biodiversity using already available bio-geographical-information such as fishery surveys data, habitat type and the distribution of the habitats of the endangered species.
2. Enhance the on hand bio-geographical-information with supplementary field surveys.

3. Assess a reasonable scoring and representativeness of the available data, for the site zonation along the western coast of the Mersin for a practicable conservation planning process.
4. Optimization of currently existing marine protected area, with the aspect of new reserve design process.

1.6.2 Conceptual Framework

Three main phases can be identified within the research: Data assembling , biodiversity assessment and prioritization (Figure 1.2).

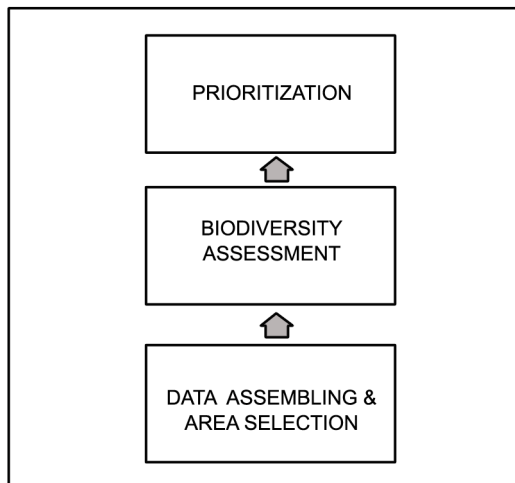


Figure 1.3 Conceptual framework.

In the data assemblage phase firstly the borders of the study area were defined considering the data availability and ecological priority. The data was collected into a database with their geographical references. Additional needs for the biodiversity data was determined and a sampling design was planned and completed. In the biodiversity assessment phase, the appropriate surrogates were determined and a scoring was completed according to the conservation value or impact of the surrogates. Mapping of the information was also performed in this stage. In the prioritization phase, a site selection was made according to the representativeness based on biological and environmental conservation feature goals by aid of Marxan software.

2 MATERIALS AND METHOD

2.1 Study Area

The base data used for this study were derived from field surveys carried out on the coastal area, between Bozyazı and Ovacık. Taking into consideration of the supplementary data, the study was extended the area between Mellec and Bogsak which constitutes a 181km coastline at west of Mersin (Figure 2.1). The offshore extent of the study area was defined by the trawl data availability, which is limited within 2 nautical mile distance from coastline

Except a few small sandy beaches the area mainly consists of rugged cliff coastline in carstic structure. The continental shelf is very narrow. The demersal and the small pelagic fisheries are attached mainly to continental shelf, from the coast to ~200 meters in depth. A protected area (Kızılliman MPA) is situated between cape of Kızılliman and cape of Sancak with a 16 nautical miles by 12 miles no-trawling-area. The study area was divided into equal sized grids in varying dimensions See Table 2.1 for grid sizes). Larger grids were created in accordance with field samples (see the list of field sampling Table 2.4). Reasons and method of creation of the grids is going to be explained in details later (see chapter 2.5.2.).

Table 2.1 Grid sizes of varying dimensions used in the study.

Grid Size (edge length)	Shape of grid	Number of grids
20km	square	6
4.5km	square	27
500m	hexagon	685

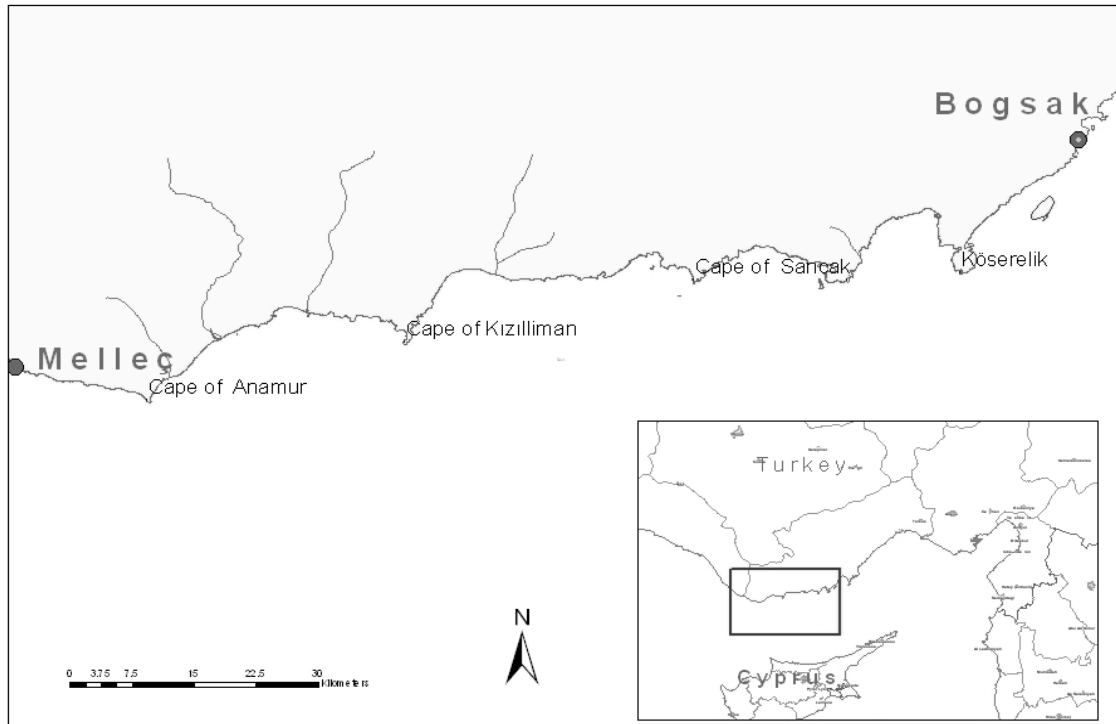


Figure 2.1: Study area.

2.2 Fish Data

Fish data are composed of two different sets. One is the trawl data, associated with the soft bottom species, the other is the visual census data associated with the shallow rocky shore habitat.

2.2.1 Trawl Sampling

Demersal fish data was collected on board the research vessel R/V Lamas from the field survey results conducted between September 2003 and September 2007. The trawling was carried out with R/V Lamas which is 16m long, 105HP wooden hull boat. The trawl net used during the samplings was with 19m head rope and code-end mesh size of 28mm in stretched form. The Sampling was carried out by using a bottom trawl net. The aim of the trawl surveys was studying the demersal fish distribution and composition in and on the adjacent waters of the Kizilliman MPA.

The sampling design was arranged to observe the changes in the Kizilliman Marine Protected area, and monitor the fisheries effect on the stock size and composition

(Gucu and Erkan, 1999). Therefore the sampling locations were scattered to 4 main regions, two were inside the protected area while other two were outside (Figure 2.2). The sampling was carried out twice a year for the monitoring purpose.

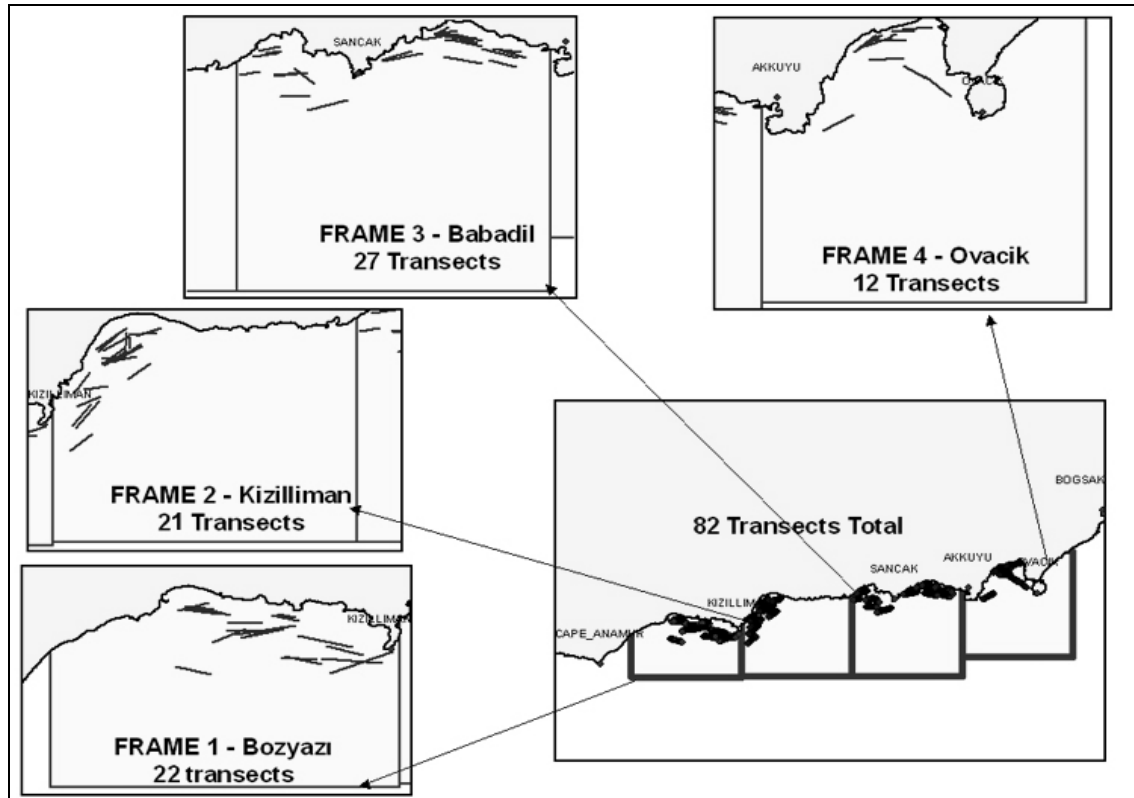


Figure 2.2: Trawl stations in study area

The trawl was towed for 30 minutes at 2, 5 – 3 knots per hour speed using a GPS navigation system. Sampling duration begins at the point of locking the ships trawl winches at the appropriate wire scope. The geographical coordinates, depth wind and wave conditions were, also recorded. The catch had been brought on board, sorted into species and a total weight for each species is then recorded to the nearest 10 gr. Individuals of each species were then measured. The data were available on a logbook where the records have been kept initially onboard. The same data were also available on excel files. The two main tables were the spatial information table and species information table.

The data set was arranged to be made available in GIS and a complete dataset was created with 6323 rows (see Table 2.2 and Table 2.3). The excel data format was changed into geospatial format compatible with GIS software and imported in to the Microsoft Access database. This database includes the station code; transect code, frame number, species length, species Latin name, number of individuals per length, starting coordinates, ending coordinates, depth at start, depth at end and date. Afterwards the length classes of each species were integrated to obtain number of individuals and total weight for each species record was appended.

Table 2.2: Example of trawl station data entries (species information)

ID	Cruise Id	Length	Species	# Indv.	Station	Tow ID
4624	2007_spring	22	<i>Synodus saurus</i>	1	Kızılliman.50_100	Trawl4
4724	2007_spring	22	<i>Saurida undosquamis</i>	2	Turgutlar.0-25	Trawl8
4823	2007_spring	22	<i>Saurida undosquamis</i>	1	Turgutlar.25-50	Trawl9
4841	2007_spring	22	<i>Uranoscopus scaber</i>	1	Turgutlar.25-50	Trawl9
4883	2007_spring	22	<i>Raja miraletus</i>	1	Aydıncık.50-100	Trawl7

Table 2.3: Example of trawl station data entries (spatial Information)

Lat (beg.)	Lon (beg.)	Lat (end)	Lon (end)	Date	Depth	
					(beg.)	(end)
36.0642	33.1172	36.053	33.100	19-Jun-07	78.3	90
36.1533	33.4672	36.151	33.451	20-Jun-07	25.5	13
36.1401	33.5126	36.142	33.492	20-Jun-07	43.4	33.1
36.1401	33.5126	36.142	33.492	20-Jun-07	43.4	33.1
36.1283	33.3578	36.1273	33.3363	20-Jun-07	69.5	68.8

Table 2.4 List of data collected.

Year	# of Stations	Method	Method details	Frequency	Observed variables
2003 - 2007	82	Trawl	Within the depth contours of 0-25, 25 – 50, 50– 75m.	1 or 2 times in a year Σ 7 surveys.	Soft bottom fish assemblage, indo-pacific species, species with conservation value.
2006 - 2007	27	Visual Census	Within the depth of 0-10 meters. Four transects in each point	1 time in October - November 2006	Rocky shore fish assemblage, abundance and size.
2005 - 2007	All along the study area.	Habitat type and human disturbance records.	Direct observations, digital photographing		Coastline topography, bottom type, human settlements and constructions
Year	Number of Stations	Method	Method details	Frequency	Observed variables
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2005 - 2007	All along the study area.	Habitat type and human disturbance records.	Direct observations, digital photographing		Coastline topography, bottom type, human settlements and constructions

2.2.2 Visual Census

Visual census has been carried out in 27 stations (Figure 2.3). The stations were selected to be at similar longitudinal distance (Table 2.5). As the dominant coastal habitat characteristics of the study area is rocky-reef type, all the station were chosen to be represented by the same habitat characteristics. The censuses were conducted at depths ranged from 0 to 10 meters using freediving.

For visual census sampling, the selected transect dimension was 20m length by 5m from each side of the transect line (20 x 10m). The strip transect was a rope rigged with lead weights on every one meters to keep it attached to bottom. Fishes included were only those entering the transect area. Individuals of all recognizable, non cryptic and diurnally active species were recorded on a PVC slate. If the sighted fishes were not in groups larger than 10 individuals, the actual counts were recorded. If they were in schools larger than 10 individuals they were assigned to abundance classes (10 – 20 individuals, 20 – 50 individuals, 50 – 200 individuals, 200 – 500 individuals, 500 – 1000 individuals). The size of individual fish was assigned to one of three classes (small, medium, large) each corresponding to one third of maximum total length of the species according to literature records (Table 2.6). At each station censuses were replicated four times except two stations with two replicates (station 19 and 16). Sampling was conducted in October - November 2006. Total area covered by visual census was 1.08 hectares which constitutes 2 % of the total targeted area.

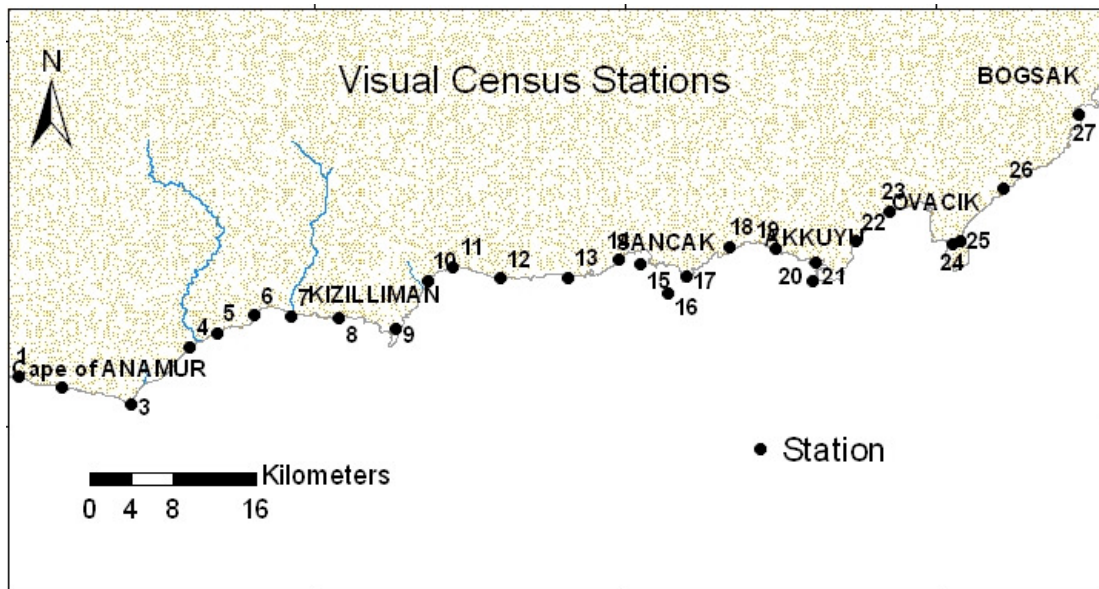


Figure 2.3 Location of the visual census stations.

Table 2.5 Coordinates of the visual census stations

Sta Id	Sta Name	Lat	Lon	#transect
1	Melleç	36.043	32.685	4
2	Piramit	36.033	32.731	4
3	Anamurium	36.019	32.804	4
4	Anamur - iskele	36.068	32.867	4
5	Mamure Kalesi	36.081	32.896	4
6	Bozyazı - liman	36.096	32.936	4
7	Bozyazı - ada	36.094	32.975	4
8	Toslak	36.094	33.026	4
9	Kızılliman	36.084	33.087	4
10	Tekeli - siteler	36.126	33.122	4
11	Tekeli - karakol	36.138	33.148	4
12	Sırtlan	36.128	33.200	4
13	Çarli	36.128	33.270	4
14	Aydıncık - liman	36.144	33.325	4
15	Aydıncık - ada	36.140	33.349	4
16	Yılanlı	36.114	33.377	2
17	Sancak	36.129	33.399	4
18	Babadil	36.155	33.444	4
19	Siteler	36.152	33.493	2
20	Beşparmak	36.125	33.532	4
21	Akkuyu	36.141	33.537	4
22	Hayat	36.158	33.579	4
23	Pinepark	36.185	33.616	4
24	Tisan – batı (west)	36.156	33.683	4
25	Tisan – doğu (east)	36.158	33.691	4
26	Mavikent	36.203	33.737	4
27	Bogsak	36.267	33.819	4

Table 2.6 Size class division (total length).

Fish Species	Max Length	Small	Medium	Large
Greater amberjack (<i>Seriola dumerili</i>)	150cm	0-50cm	50 -100cm	100-150cm
White seabream (<i>Diplodus sargus</i>)	45cm	0-15cm	15-30cm	30-45cm
Ornate wrasse (<i>Thallasoma pavo</i>)	30cm	0-10cm	10-20cm	20-30cm

Data sets were stored into a single Microsoft Access database. The main table includes the fields of family, species, species codes, size classes, station ids, transect ids, depth and geographical coordinates (table 2.7).

Table 2.7 Example of the visual census data entries (N = native, Le = Lessepsian, M = medium, S = small, L= large).

ID	Family	Origin	Species	Size	Count	Sta Name	X(loc)	Y(loc)
1	Sparidae	N	<i>Oblada melanura</i>	M	5	Melleç	36.04	32.68
2	Sparidae	Le	<i>Siganus luridus</i>	S	15	Melleç	36.04	32.68
3	Sparidae	N	<i>Diplodus sargus</i>	L	1	Melleç	36.04	32.68
960	Sparidae	N	<i>Diplodus sargus</i>	S	3	Bogsak	36.60	33.81
961	Pomacentridae	N	<i>Chromis chromis</i>	M	35	Bogsak	36.60	33.81

2.3 Environmental Data

The environmental dataset was consisted of two types of data: conservation features and socio-economic features. The information such as coastal habitat type, habitat and distribution of the endangered species in the study area were determined as conservation features in addition to species data from trawl and visual census datasets. Beside conservation features socio-economic data was necessary for the prioritization and complementarity analyses as being the cost source of the reserve design process. These information were mapped using ArcGIS 9.0 software. The data was stored in shape files in vector format. Each feature was represented by unique layers of same map in GIS. Before any data were added to the geo-database, the spatial extent and the projection of the feature classes were established. Universal Transverse Mercator - Zone 36 projection was selected and used for all maps created in GIS.

GIS allows for the integration of all spatially referenced datasets and is able to display results as maps without the need for any additional software. Particularly considering the data deficiency of this study, the ability of the GIS for the data manipulation and thus enhancement of data, was useful. The opportunity of creating new data layers or excluding existing layers, or refining the boundaries, with the GIS, provided a great flexibility to the study.

Mapping of the coastal structure (habitats, geographical features, human use) was accomplished by using Google Earth images, observation records, local knowledge and personal communication with locals. The images gathered from Google Earth free software were used as a base layer for mapping the environmental data (Figure 2.4) (URL 13). Google Earth constructs pictures of the surface by downloading satellite data from a remote server. After capturing the images in JPEG format they were transferred to TIFF format. Capturing was made according to the available resolution of the satellite images, in scale of 1:3500 or 1:75000 (Figure 2.5 and 2.6). These images were then geo-referenced by geo-referencing tool of ArcGIS where the images were fitted over the coastline layer obtained from NGA Global Shoreline shapefile (URL 14). The necessary part of this file was extracted using the clip tool in analysis tools. A polygon vector mask was used for clipping. The observed information about the coastal structure during the research cruises has been recorded. This information was combined with the Google Earth images. In order to

complete this data set the coastline images were gathered by successive photographs taken by Nikon D70 digital camera with nikkor 80-400mm lens during research cruise on R/V Bilim2 in April 2007 (Figure 2.7). Consequently all the information was used to build digitized vector layers in GIS.

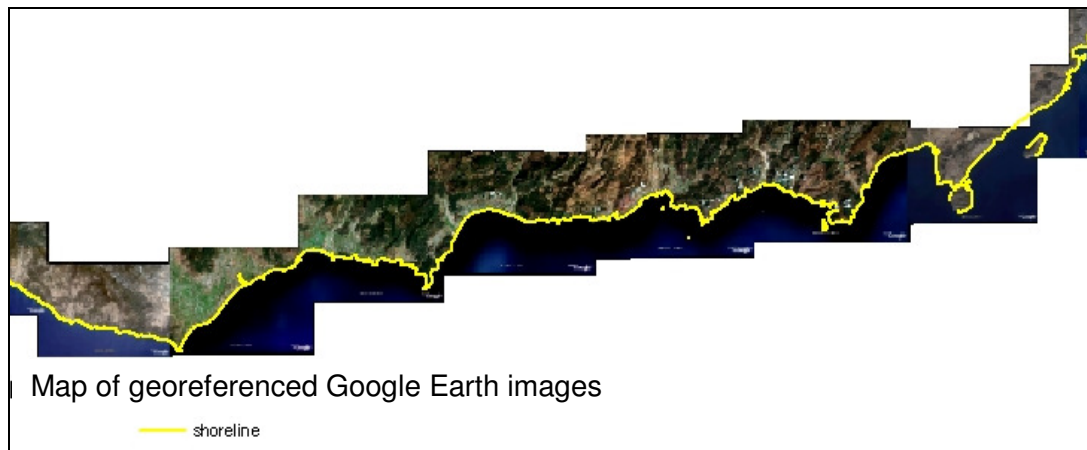


Figure 2.4 Google Earth digitally registered image.

These layers are; high-cliff area, rocky areas(Figure 2.5), sandy beaches (Figure 2.6), areas containing *Posidonia oceanica* beds, islands, Mediterranean monk seal caves, the Audouin's gull (*Larus audouinii*) habitats, marine turtle nesting areas, river mouths, fishing ports, settlements, town centers, intensive agricultural areas close to shore, touristic places, aquacultures and boating/diving areas (Table 2.8).

Table 2.8 Data sources of environmental layers.

Environmental Layers	Type	Source
High-cliff area	Conservation Feature	Geo-referenced Google Earth images, field surveys and local field knowledge. Digital photographs from research vessel.
Sandy beaches	Conservation Feature	
Marine turtle nesting area	Conservation Feature	
<i>Posidonia oceanica</i> beds	Conservation Feature	Google Earth images, Results of the researches on <i>Posidonia oceanica</i> (Celebi, 2007) & questionnaires with fishermen.
Mediterranean monk seal caves	Conservation Feature	Mediterranean Monkseal habitat survey records (Metu – Ims)
The Audouin's gull (<i>Larus audouinii</i>) habitat	Conservation Feature	Eken G. 2006, Monkseal habitat survey records (Metu – Ims)
Intensive agriculture areas	Cost Feature	Geo-referenced Google Earth images, field surveys and local field knowledge, digital photographs from research vessel.
Fishing ports	Cost Feature	
Settlements, town centers and	Cost Feature	
Touristic places	Cost Feature	

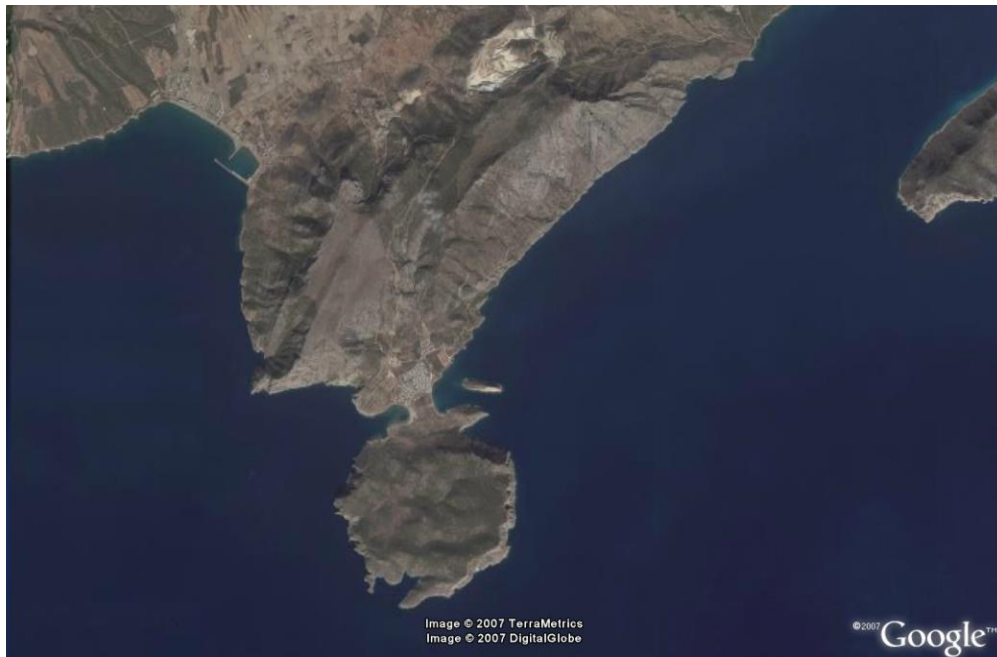


Figure 2.5 Google Earth Image in 1:75000 scale.

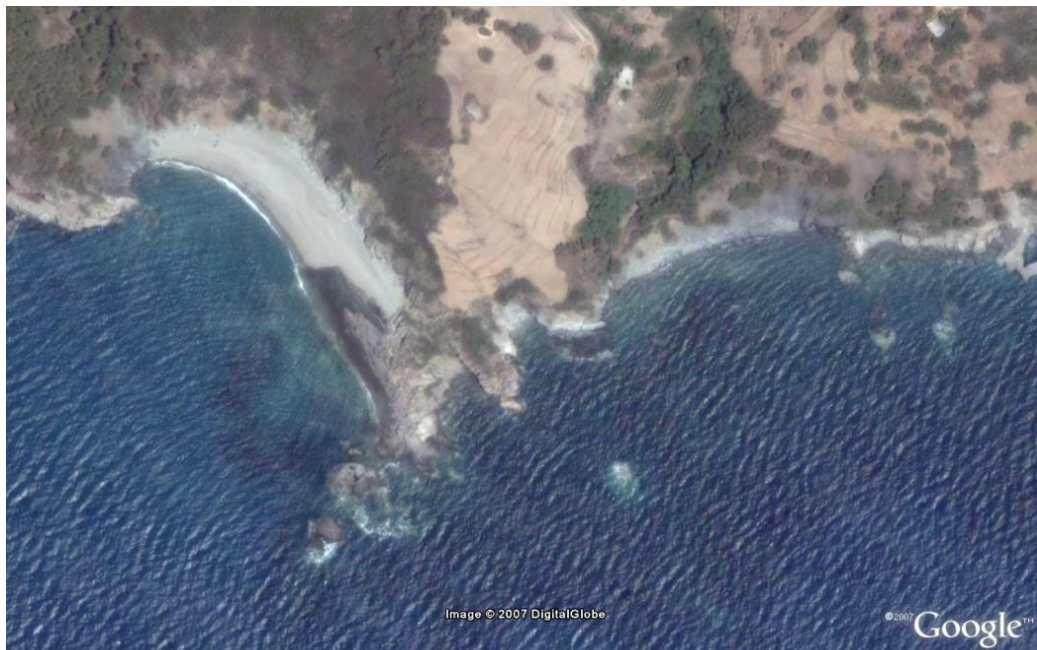


Figure 2.6 Google Earth image in 1:3500 scale.



Figure 2.7 An example image taken by Nikon D70 from R/V Bilim.

2.4 Analysis of data

The analyses were performed in two stages. First phase of the study was assessment of the conservation features, and creating the combination of data layers including socioeconomic, habitat and species information. Second phase was consisted of, setting the conservation scenarios and configuring the data environment to make it available for analysis (Figure 2.8). The ultimate objective was to select optimal sites at optimal size with optimal borders. In order to achieve the objective Marxan software with its optimization algorithm called “simulated annealing” was ideal due to its specifications for marine reserve design. The Marxan software was developed for the specific use as a decision support tool for marine reserve design.

Surrogates (biodiversity indicators) were analyzed and organized to be used for conservation features matrix for Marxan. They were consisted of fish dataset (visual census for shore layer & trawl for middle and offshore layer), critical habitats, and coastal habitat structure. Furthermore socioeconomic impacts used as cost which is used to define undesired areas due to socioeconomic criteria.

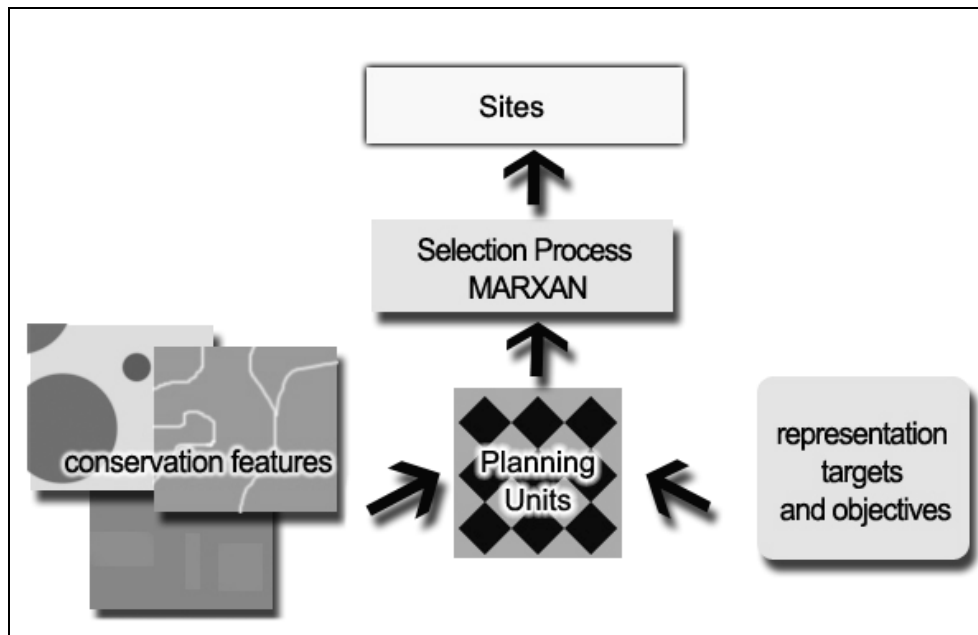


Figure 2.8 Phases of the analysis.

2.4.1 Surrogates (biodiversity indicators) and socio-economic impacts

Socio-economic impacts were consisted of buffer zones created around the source of impacts considering the possible extent of the perturbation and socioeconomic needs using GIS. The radius distance used in creation of buffer zones were selected in arbitrary way but in accordance with their usage procedures in terrestrial environment.

Coastal habitat data and species critical habitats were analyzed in the same manner as socio-economic layer using the buffers around the core areas. Threatened species and critical habitats were one of the most important components of the complementarity analysis, as being a critical surrogate for the biodiversity. This set of layers were comprised by Mediterranean monk seal caves, nesting beaches of marine turtles, beds of *Posidonia oceanica* seagrasses, breeding area of The Audouin's gull (*Larus audouinii*) species. Except *Posidonia oceanica* layer, rests of layers in this category were reconstructed with same buffering method of coastal habitat type.

The map of *Posidonia oceanica* was created according to the results of the previous researches carried out in study area (Celebi, 2007). In this study, the maximum lower depth limit of the region was determined as 31.8 meters. Considering the possible variations of meadow structure and deviation resulted from the bathymetric depth contours, the lower depth limit of the seagrass habitat was accepted to be 50m.

2.4.2 Analyze of the Fish Data

As being the basic element of the site selection process fish data were analyzed in a more inclusive way. As a biodiversity surrogate, fish diversity was studied in two types of dataset. The study area was separated into three layers: shore layer, middle layer and offshore layer. After determining the biodiversity values obtained from fisheries data, scores were assigned to the layers, and finally to the planning units.

2.4.2.1 Visual census data

Shore layer was examined by visual census data, where sampling was carried out on shallow rocky shore habitat. Visual census data was available only for the shore extent. Analyses were made as

- I. Defining the indicator species.
- II. Abundance of large individual in the indicator species.
- III. Shannon index .

$$H = \sum_{i=1}^n - p_i \ln p_i$$

P_i = the proportion of species in the station (# of individuals in a species / # of individuals in the station). H is the calculated Shannon index value. The Shannon index of diversity accounts for both species richness and evenness of a sampling location and is often considered a measure of heterogeneity. Values from the Shannon index are typically between 1.5 and 3.5 (Table 2.9).

- IV. Species richness. (Number of species found within a station)

V. Abundance of the fish species with conservation value

Table 2.9 An example of the Shannon diversity index calculation for a station.

Species	# indiv.	p_i	$\ln p_i$	$P_i(\ln p_i)$
<i>Blennius sp.</i>	5	0.001	-4.75	0.04
<i>Chromis chromis</i>	140	0.24	-1.42	0.34
<i>Coris julis</i>	6	0.01	-4.57	0.04
<i>Diplodus cervinus</i>	3	0.005	-5.26	0.02
<i>Diplodus sargus</i>	22	0.037	-3.27	0.12
<i>Diplodus vulgaris</i>	17	0.029	-3.53	0.10
<i>Liza sp.</i>	16	0.027	-3.59	0.09
<i>Oblada melanura</i>	140	0.240	-1.42	0.34
<i>Sargocentron rubrum</i>	1	0.001	-6.36	0.01
<i>Sarpa salpa</i>	50	0.085	-2.45	0.21
<i>Seriola dumerili</i>	1	0.001	-6.36	0.01
<i>Serranus scriba</i>	1	0.001	-6.36	0.01
<i>Siganus luridus</i>	1	0.001	-6.36	0.01
<i>Siganus rivulatus</i>	30	0.051	-2.96	0.15
<i>Spicara maena</i>	125	0.214	-1.53	0.33
<i>Symphodus rostratus</i>	1	0.001	-6.3	0.01
<i>Symphodus tinca</i>	3	0.005	-5.26	0.02
<i>Thallasoma pavo</i>	19	0.032	-3.42	0.11
<i>Upeneus pori</i>	1	0.001	-6.36	0.01
	Shannon index	$H = \sum_{i=1}^n -p_i \ln p_i$		2.03

2.4.2.2 Trawl Data

Second source of data for fish diversity was trawl dataset, associated with the middle and offshore layers as a surrogate of soft bottom habitat. the total area swept during this study was 300.75 hectares which constitutes 1.5 % of the total targeted area.

Analyses were made in the aspects of:

- I. Proportion of large individuals in the indicator species, which indicates the level of fishing pressure.
- II. Proportion of Lessepsian species in the species community, which reflects ecological intactness.(Gucu et al., 2004)
- III. Average CPUE for each group of trawl stations, which indicates productive areas and the level of fishing.
- IV. Average abundance of species with conservation value.

2.5 Complementarity Analysis.

The GIS does not have the ability to obtain optimal solutions to site selection and zoning when used alone. In this circumstance Marxan was needed to be used in conjunction with the GIS which use specialized optimization algorithms. After building the GIS environment the input files were created for the Marxan analysis from data layers which contain all the information needed.

The Marxan applies a site optimization algorithm that is called ‘simulated annealing’. The software basically tries to lower the objective function value using the optimization algorithm. The simplest form of the objective function is a combination of the economic cost of the reserve and a penalty for not meeting all of the ecological objectives, if any are unmet. (Possingham et.al., 2000) During the run on the algorithm, a collection of planning units is selected at the beginning, and the total cost is calculated. Then, planning units are added and removed to initial selection and the total cost re-evaluated after several iterations to reach a more optimal total cost of the collection. Attempts are made to minimize the total cost by selecting the fewest planning units with the lowest total unit cost needed to meet all biodiversity goals, and by selecting planning units that are clustered together rather than fragmented.

$$\sum_{Sites} Cost + BLM \sum_{Sites} Boundary + \sum_{ConValue} CFPF \times Penalty + Cost Threshold Penalty(t)$$

Equation: Objective Function (Ball and Possingham, 2000).

BLM is the boundary length multiplier which determines the importance given to the boundary length relative to the cost of the reserve system. If a value of 0 is given to *BLM* then the boundary length is not included in the objective function (Figure 2.8).

CFPF (conservation feature penalty factor) also called species penalty factor (SPF) is a weighting factor for the conservation feature (Possingham et. al., 2000) Species penalty factor (SPF) stands for keeping the targeted amount of the value in the reserve portfolio. If the targeted amount could not accomplish, shortfall occurs and SPF increases the objective value by multiplying the shortfall. $SPF \times [(target\ for\ conservation\ feature) - (amount\ held\ in\ the\ portfolio)]$ SPF is most important when model parameters are set so that not all targets can be met (Possingham, 2000 ; Oetting 2004).

The cost threshold penalty is a penalty applied to the objective function if the target cost is exceeded. This specification has not been used in the current study.

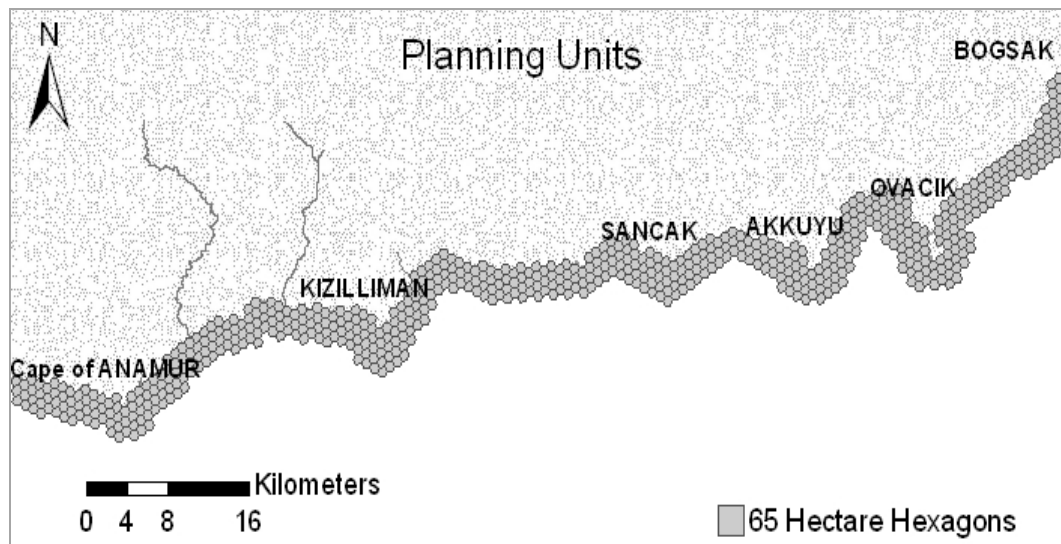


Figure 2.9 Hexagonal planning units.

2.5.1 Marxan Input file preparation

The Marxan input file preparation consists of mainly four stages. 1) Separation of the area into planning units and determining the cost and status of each cell (Figure 2.9). 2) Preparing the conservation feature file, 3) Preparing planning unit versus conservation feature file. 4) Preparing the boundary length file.

2.5.2 Separation of the area into planning units (grid cells).

Three kinds of grid cells were used (Table 2.1). 20 km square grids were set considering the aggregation of trawl stations. 4.5 km square grids were set according to interval distance of sampling points of visual census. Finally 500m hexagons were set to reflect the available data in finer scale. 500m hexagons were fitted perfectly to the using purpose as the study area was examined in three layers from shoreline to offshore and restricted within 2 nautical miles (Figure 2.9) Using ArcGIS and Microsoft Access, hexagons have been assigned with the appropriate values from vector shapefile polygons of GIS layers (cost scores, habitat values etc.), and fish data from 4.5 km and 20km grids.

For creating the planning units an extension to Arcgis “Repeating Shapes Software” (URL 15) was used. Information within each planning unit was compiled from the layers of fish dataset and environmental dataset.

After creation of the grid cells which are the basic elements of the analysis, the information was converted to planning unit file format supported by Marxan. The planning unit file was consisted of three columns: “id”, “cost” and “status” and 685 rows. The cost values varied between 32,5 and 231. (Figure 2.11) “xloc” and “yloc” (geographical coordinates for planning units) columns were not included, since the output files were mapped according to id numbers of the planning unit by ” join” function of Arcgis. With join function it is possible to integrate the results with an existing shapefile which includes all the spatial information, in GIS. Each planning unit has a cost score from intersecting socioeconomic cost layers and a fix cost score from its own surface occupancy. The fix value for each unit is 65 which is equal to the total surface area of any planning unit in hectare. Exceptionally, the planning units located in the former reserve area, was assigned with the fix cost of 32, 5 which is half of the predefined fix cost. The total costs of planning units were

calculated by summing the occupied areas by each negative impact sources intersected within each planning unit.

Example:

The cost of the Planning Unit 1 is formulated as :

$$PU1(cost) = 65 + Tz(pu1) + Urb(pu1) + Agr(pu1) + Hu(pu1) + Fsh(pu1) + Aq(pu1) + Dv(pu1)$$

Where *PU* is Planning Unit, *Tz* is Tourism area occupancy, *Urb* is urban area occupancy, *Agr* is intensive agricultural area occupancy, *Hu* is human settlement area occupancy, *Fsh* is Artisanal fishery area occupancy, *Aq* is aquaculture area occupancy, *Dv* is diving and boating area occupancy. 65 is the total surface area of a planning unit. If there is no intersecting socio-economic layer then the cost is only 65 unless the planning units is not located within the borders of existing protected area where the fix cost becomes 32,5.

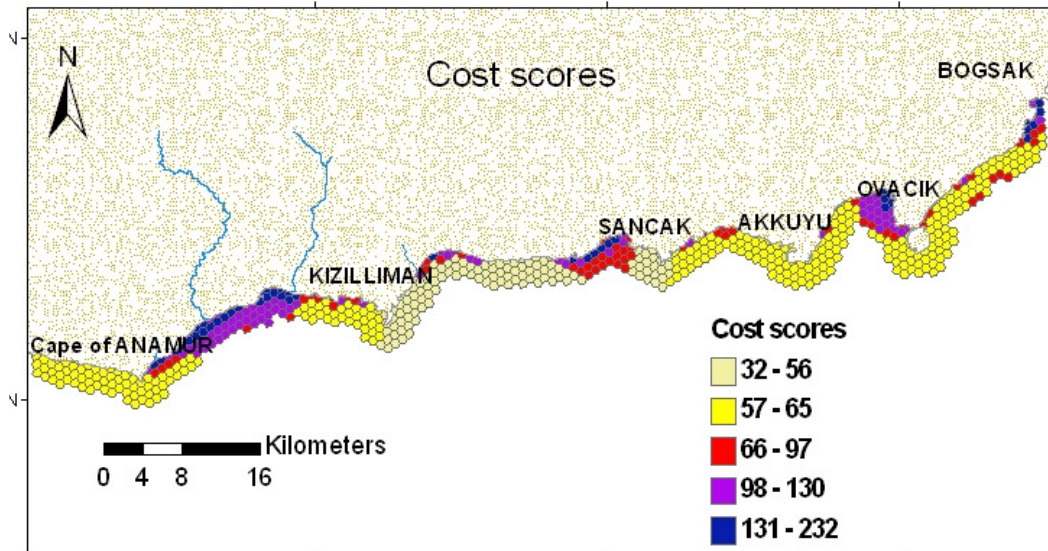


Figure 2.10 Planning units costs map.

Table 2.10 The status of planning units.

Status	Meaning
0	The PU is not guaranteed to be in the initial or 'seed' reserve.
1	The PU will be included in the 'seed' reserve or the initial reserve. It may or may not be in the final reserve. Such as habitats with priorities in conservation.
2	The PU is fixed in the reserve. It starts in the initial reserve and cannot be removed. Such as existing MPA's
3	The PU is fixed outside of the reserve. It is not included in the initial reserve and cannot be added. Such as harbors and military areas.

The status of the planning units is used to lock planning units into or out of the reserve system. The actual reserve areas located around Mellec and Kızılliman were locked using the "2" for status (see table 2.10). Totally 28 planning units were given "2" for the status column which to keep those units locked and placed in reserve system.

2.5.3 Conservation Features

The conservation feature file contains information on each of the biodiversity surrogate under consideration. This file involves the total value of the conservation feature represented the area, and the target amount that is desired to be represented by the reserve system for the each one. Conservation feature file was consisted of four columns (Table 2.11): "id" (id number for each conservation feature), "Target" (the amount that is targeted to be represented in the reserve system), "SPF" (Species penalty factor: Penalty coefficient for the deficit from target amount of that conservation feature unrepresented in the reserve system.)

Table 2.11 Conservation features.

id	Total Value (100%)	30% target	Layer names	Type of Surrogate
1	72.62	21.78	riverin	Habitat
2	1521.18	456.35	cliff	Habitat

Table 2.11 (Continued)

3	121.24	36.37	island	Habitat
4	225.08	67.52	cave	Habitat
5	1893.88	568.16	beach	Habitat
6	20672.51	6201.75	posidonia	Habitat
7	67.33	20.19	mullus_bar	Species
8	70.51	21.15	mullus_sur	Species
9	57.08	17.12	pagellus_e	Species
10	17.50	5.25	lessepsian	Species
11	59.06	17.71	pagrus_pag	Species
12	82.98	24.89	saurida_un	Species
13	7653116.50	2295935	cpue	Species
14	8363.11	2508.93	no_of_spec	Species
15	295.26	88.57	vis_shan	Species
16	46.00	13.80	marginatus	Species
17	1050.00	315	sarg_m_b	Species
18	106.00	31.80	sar_b	Species
19	1761.00	528.30	convalue	Species
20	235.28	70.58	larus_au_1	Habitat
21	124.56	37.36	caretta	Habitat

2.5.4 Conservation Feature versus Planning Unit File

Conservation feature versus planning unit file was another necessary input file for Marxan analysis. This file was consisted of the data entries containing the information about the amount of a conservation feature held by each planning unit. Each row represents the abundances or occurrences of conservation features on a planning unit. The first column contains the planning unit numbers and the other columns are the values for each conservation feature. The entries with 0 value were discarded to avoid confusion. Finally a file with 5580 rows was created, from where

Marxan reads the species information. The data was sorted according to the planning unit column.

2.5.5 Boundary Length File

Boundary Length File shows the length of a shared boundary for any adjacent planning units in the database. The boundary length file has three columns: "id1", "id2" and "boundary". Id1 and id2 are the id numbers of two adjacent planning units. "boundary" is the boundary length between them. This file was necessary to supply boundary information to boundary length modifier feature of Marxan which provides compactness to the reserve system.

2.5.6 Scenarios

Analyses were performed according to different combinations of input parameters. Each different set of parameter combinations were called scenarios. Two types of scenario sets were created for the analyses. First set of the scenarios were constructed to test the effect of parameters to select the optimal combination for input. These parameters were BLM (Boundary Length Modifier), SPF (Species penalty factor) and number of runs. Second set of the scenario was the main scenario set consists of 8 different scenarios, which have been created according to different representation target levels.

2.5.6.1 Testing scenarios

With the testing scenarios a standard value for boundary length modifier, number of runs and species penalty factor was assessed.

2.5.6.2 Main Scenarios

Testing the conservation targets was the final and the decisive phase. A diagnostic approach was applied so as to find a reasonable total surface area . It is assumed that if species and habitats are protected at some specific threshold, biological diversity will be sustained (Richardson et.al, 2006). However the total percentage, to be targeted as threshold is uncertain. Hence the scenarios were constructed by differentiation of the combination of representation targets. The range of

representation target was altered between 10% and %40 which was compatible with the proposed range at the 2003 World Conservation Center (IUCN) World Parks Congress. The extent and coverage of the present Kızılliman MPA was also considered for setting the scenarios. The criterion is to find a value approximate to the size of the existing Kızılliman MPA. The idea behind that criterion is the necessity of convincing official authorities and local people in implementation phase. Different combinations of targets were set and applied due to the ambiguity of the process. The solutions were varied in total boundary length and total surface area. Also variations in irreplaceabilities were observed. The irreplaceability of an area is simply measured by its frequency of being selected within given number of runs of the Marxan.

In this section 8 scenarios were derived and analyzed. SPF was determined to be 10 to keep all conservation feature represented with the targeted amount. Boundary length modifier was also used in optimal value which was determined by previous tests as “10”.

The extent of the conservation targets were the only changing parameters in this set of scenario analysis as the other parameters kept same. Different combinations of target amounts were chosen considering the possible different levels of representativeness expected from reserve system to achieve. The reason for using these proportional biological diversity representation targets is that the biological diversity will be sustained if species and habitats are protected at some specific threshold. (Steward R., 2005). The defined scenarios were “Scen1030”, “Scen102040”, “Scen10”, “Scen2030m”, “Scen2040”, “Scen20”, “Scen30” and “Scen2030”. Scenarios were constructed using different combinations of weightings of conservation features. The scenario names were derived from the representation targets: first two digits stand for habitat representation level, and second two digits is for the species. If second digit group does not exist, then first group is also valid for species. For instance “Scen20” means all conservation features will be protected in 20% level and “Scen2030” means that the habitats will be represented at 20% level while species surrogates will be represented at 30% (Table 2.12). Exceptional “Scen2030m” scenario was constructed to see the effect of the fishery by keeping the level of *Mullus barbatus* representation higher. For each scenario set marxan was run 1000 times using simulated annealing. These 1000 runs were repeated 10 times for each scenario.

Table 2.12 Scenarios.

Scen10	10% of representation for both species and habitats
Scen1030	10% of representation for habitats and 30% for species
Scen102040	10% of representation for habitats and 20% for species 40% for audouins gull
Scen2030m	10% of representation for habitats and species but 30% for <i>mullus barbatus</i>
Scen2040	20% of representation for habitats and 40% for species
Scen20	20% of representation for both species and habitats
Scen30	30% of representation for both species and habitats
Scen2030	20% of representation for habitats and 30% for species

Two types of results were obtained. One is the reserve system with the best score out of 10 replicates of 1000 simulations. That is final selection from the 1000 different reserve system which has the lowest objective value. Second type of results was the irreplaceability. Selection frequency of the planning units within 1000 simulations gives us the irreplaceability score. This means that if a planning unit was selected 1000 times at the end of the runs that planning unit will be 100% irreplaceable or if it was selected 255 times the value will be 25.5%.

3 RESULTS

In this section the results of the study were given in the order of steps applied in complementarity analyses which were performed by Marxan. These steps were (1): defining and quantifying costs of the targeted area, (2) defining biodiversity surrogates, quantifying their conservation values, (3) defining the scenarios to apply, (4) constructing the input files in accordance with the scenarios and (5) evaluating the results of the analysis.

3.1 Costs

Totally 7 different socioeconomic factors having relation with the adjacent coastal marine area were determined; these factors are i) divers boats and boat trips; ii) aquaculture use on the coast; iii) tourist facilities; iv) urban use; v) Intensive agricultural use; vi) human settlements and; vii) artisanal fishery. These factors are mapped using varying values of buffer depending on type of the source (Figure 3.1).

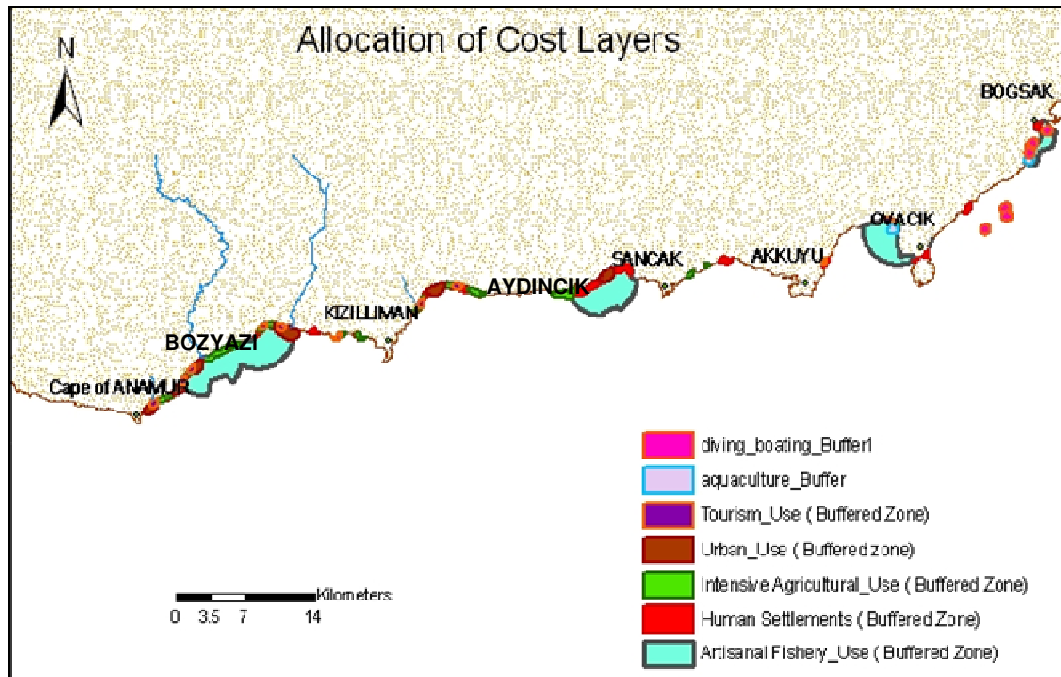


Figure 3.1 Allocation of cost layers.

As may be seen in the figure, the main perturbation sources were concentrated on Anamur and Bozyazı. The perturbations are quantified in cost units/scores. A total of 12617 hectares of cost layers were identified as cost score (Table 3.1). The highest occupation was observed to be accumulated along coasts of Anamur and Bozyazı. The total cost score of Anamur and Bozyazı was 5266 which constitute 41.7% of the total. These two districts accommodate highest human population within the study area. Center of the Aydıncık district is also another significant perturbation source, especially due to sports fishery, greenhouses, and artisanal fishery.

Table 3.1 Cost values derived from the area coverage of socioeconomic layers. Actual value is the area covered by each layer in unit of hectare.

Source of cost	Costs in Units of Hectare
Tourism use	419
Urban use	972
Intensive agricultural use	1335
Human settlements	1878
Artisanal fishery	7297
Aquaculture	157
Diving and boating	560

The highest cost score (7297) was assigned to artisanal fishery. This is 57 % of the total score. Although only 3 fishing ports located in the study area, artisanal fishing boats were aggregated on 5 different centers in Anamur, Bozyazı, Aydıncık, Ovacık and Boğsak (Table 3.2). As indicated by the fishermen of the area the most intense fishery activity was conducted within the 2 nautical miles periphery of the fishing ports.

Table 3.2 The numbers of boats at sheltering areas of artisanal fishing boats

Boat shelters	Number of fishing boat
Boğsak	26
Ovacık Port	19
Aydincık Port	22
Bozyazı Port	23
Anamur	47

Aquaculture, boating and diving activities were observed to be most intense in the north part of the study area between Ovacık and Bogsak. Two diving club and 8 leisure boats have regular daily trips from May to September. They use the islands and bays located at north of Ovacık. Only one touring boat was observed in the area between Anamur and Bozyazı which is active during high tourism season between 1 July and 15 August. The area has not been seriously introduced to aquaculture until now. A new established aquaculture farm with two cages located in a bay close Boğsak constitutes the only aquaculture source of the study area. There are also few cages for temporary use for tuna fish in Ovacık.

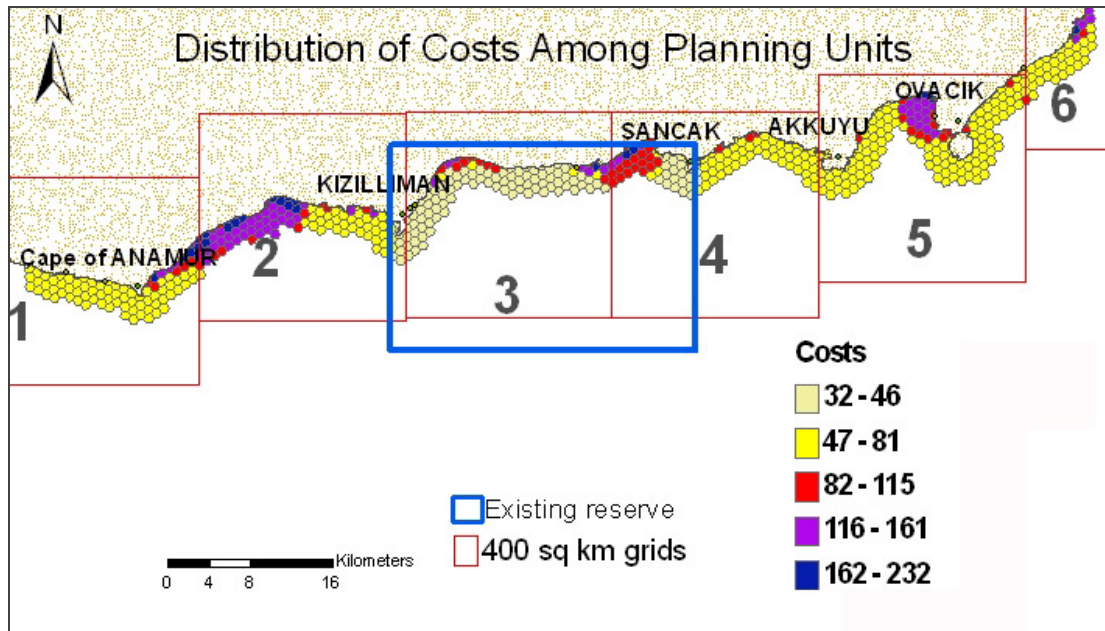


Figure 3.2 Distribution of cost values by planning units.

The map (Figure 3.2) shows the distribution of the cost scores among planning units. Each planning unit has a cost score from intersecting socioeconomic cost layers and a fix cost score from its own surface occupancy. The fix value for each unit is 65 which is the total surface area of a planning unit in hectare. The planning units located in the former reserve area (Figure 3.2), was assigned with the fix cost of 32, 5 which is half of the predefined fix cost. The minimum cost value within the planning units was 32.5 while the maximum value was 231. The total cost score of the study area was 46633 with a mean of 74.7. Sum of the cost values for existing reserve area between Kızilliman and Sancak was 8732 which is 18.7 % of the total cost value. Moreover in Figure 3.3 the mean cost score distribution for the 400sq km grids was shown. The region of grid number 2 has the highest cost score average and it was followed by grid number 6.

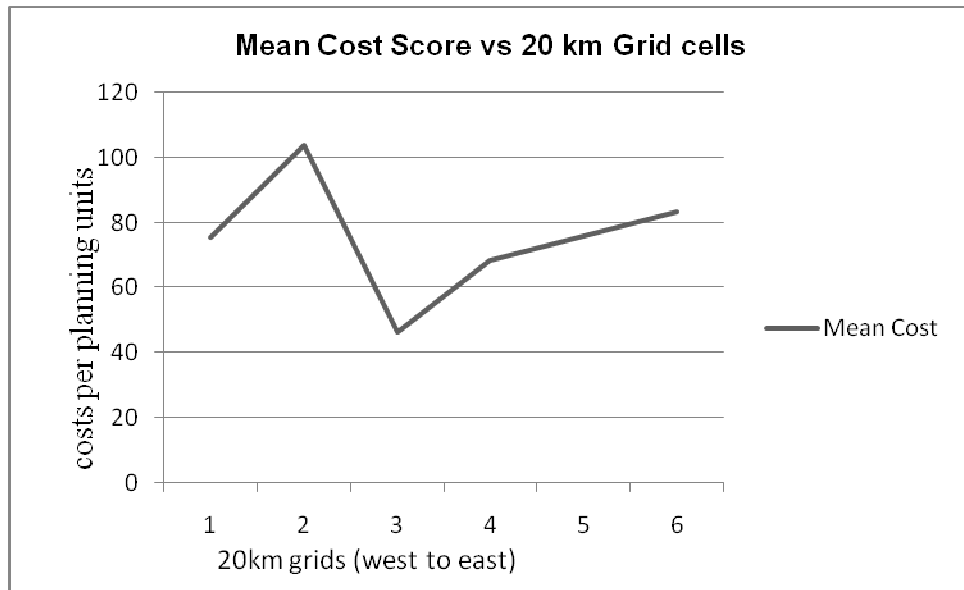


Figure 3.3 Cost distribution from west to east. Averages of planning units in each 20km grid cells.

3.2 Habitats

Within the study area totally 21.3 km of coastline was identified as high cliff area occurring compactly in 5 different points (Figure 3.4). These areas are located at cape Anamur, Kızılliman, Sancak, Akkuyu and Ovacık. All together these areas comprise only 10.6 percent of the total coastline which is approximately 200 km in total length. With the buffer zone, high cliff area covers 1521 hectares. This is about 0.05 percent of the surface which is 35303 hectares in total. Kızılliman, Sancak and Akkuyu regions have the highest value in terms of high-cliff cover. These areas also possess higher intactness value proved to have lower cost score.

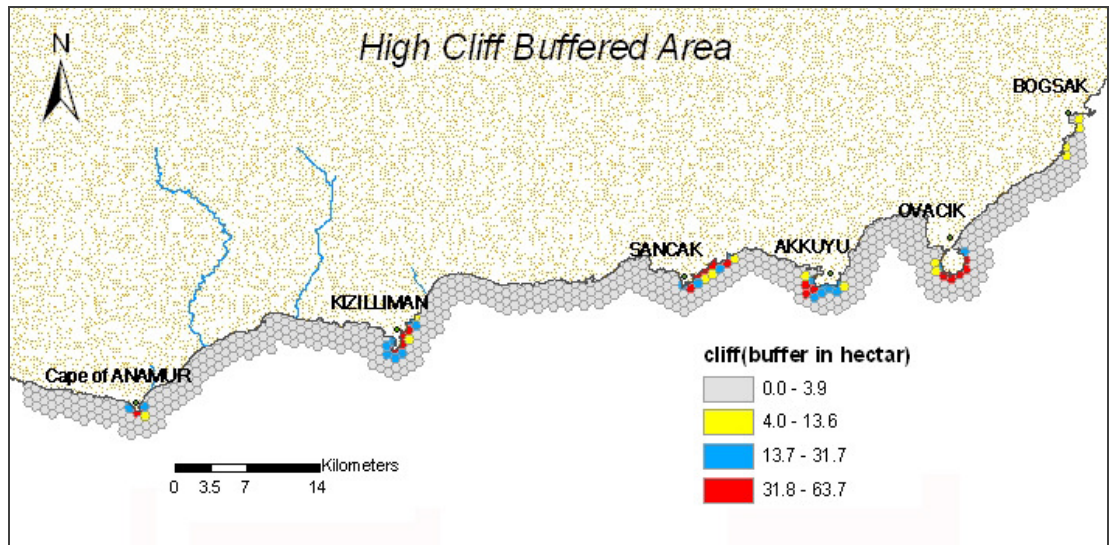


Figure 3.4 Distribution of cliff areas.

Total length of the beaches important for *marine turtle* nesting was 12 km, while total sandy beach area is 24 km. in total. The key nesting beach for the marine turtles (mainly *Caretta caretta*) is situated on the western side of the study area between Anamur and Bozyazı in length of 6km (Figure 3.5). This is the longest unfragmented sandy beach of the area. The rest of the sandy beaches are in fragmented structure and dispersed along the area. With the buffer zone, marine turtle nesting area covers 124 hectares while the total beaches present along the study area was 362 hectares.

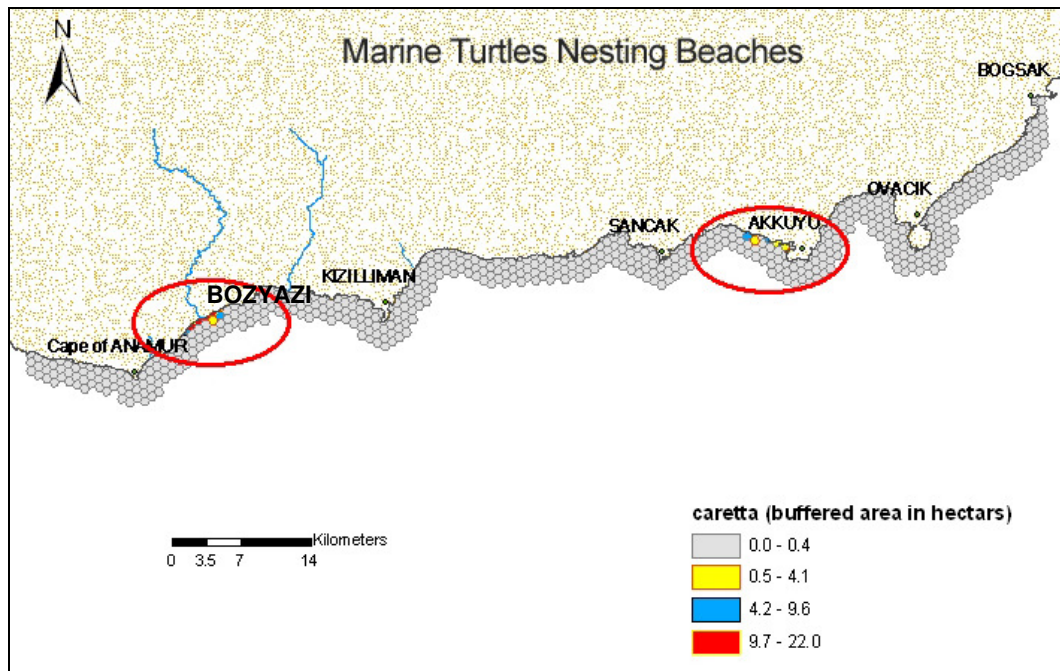


Figure 3.5 Soft sandy beaches used by marine turtles for nesting.

The monk seal whelping site layer was composed of 32 points scattered along the rocky coastline. Although whole area was recognized to have high importance in sheltering an important monk seal colony, the seal caves were observed to be densely aggregated in four points, at west of Anamur, Kizilliman, Sancak and Ovacak. Including the buffer zone fitted on the periphery, the caves occupy 225 hectares of area and 39 planning units. Within these 39 planning units monk seal whelping site occupies 5.7 hectares. With this respect the largest patches were observed to be in Kizilliman and West of Anamur cape, having the buffer area of 35 hectare and 26 hectare, respectively. In this map (Figure 3.6), although the same level of weighting was given to all caves and their usage (such as resting and breeding) were disregarded, the important breeding areas were marked and kept in mind for the final decision of the reserve system. Currently there are two reserve zones for monk seals under strict regulations, in Kizilliman and in west Anamur, occupying 5 kilometers of coastline in total and 10 hectares of surface.

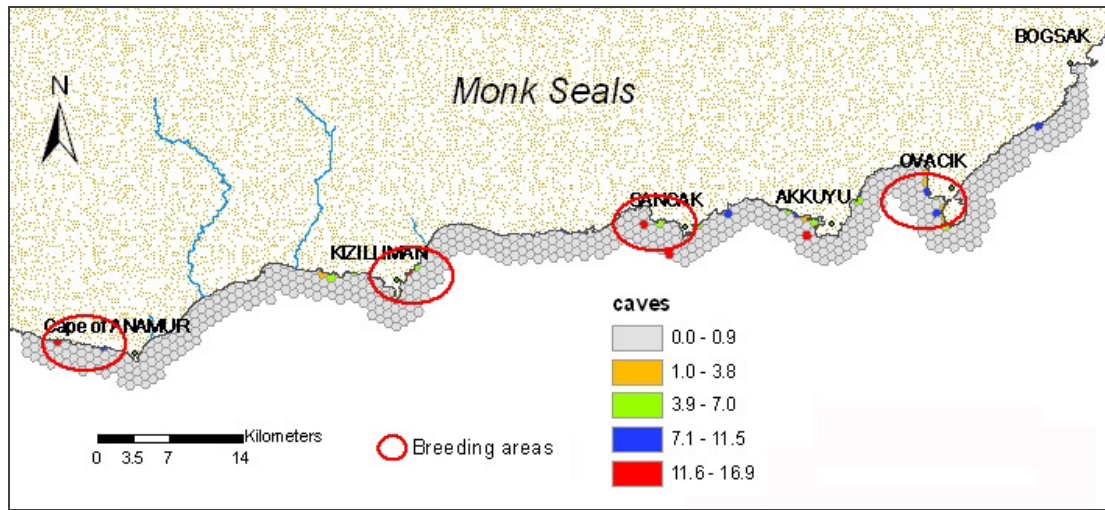


Figure 3.6 Whelping areas and caves used by Mediterranean monk seals.

The Audouin's gull (*Larus audouinii*) was concentrated around a restricted area of small islands and cliffs around Sancak and Akkuyu (Figure 3.7.). The size of the colony is estimated to be 10 – 15 pairs. Similar habitats, around Ovacik, Kizilliman, and Cape of Anamur were observed but no significant sign showing the existence of this species was met. Total buffer zone for this species was 235 hectares, occupying 0.06 % of the total area. The islands and cliffs around Sancak have the highest value for this species having 156 hectares of habitat. The distance between center of Aydıncık and *Larus audouinii* habitat is approximately 3 km. The only interaction with human activities was observed to be artisanal fishery.

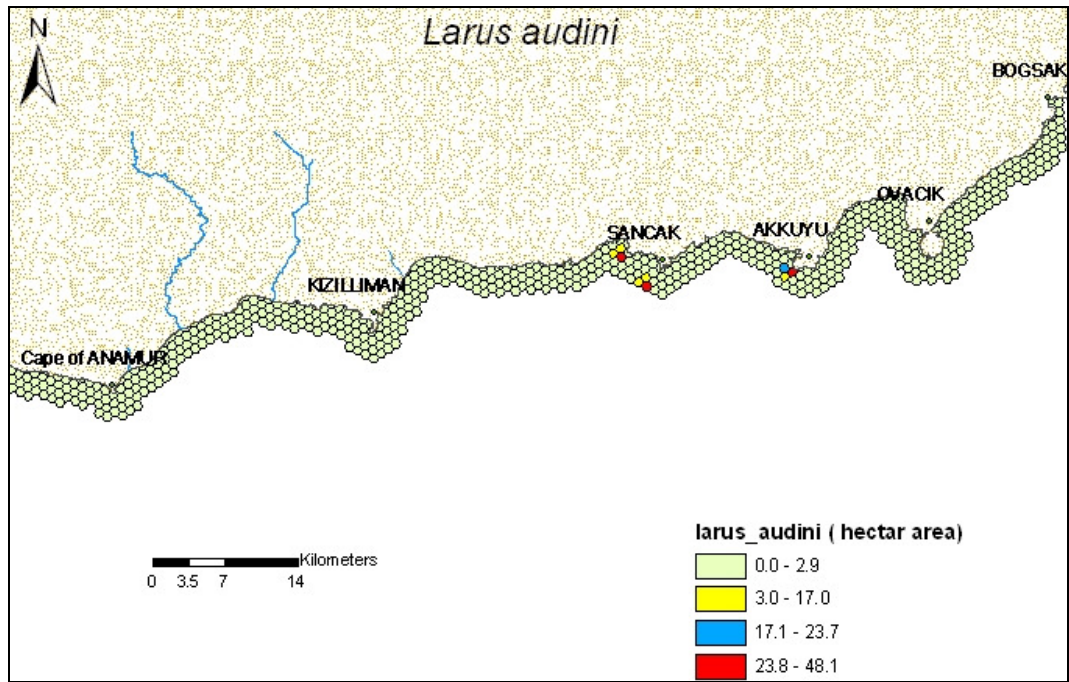


Figure 3.7 Habitat map of the Audouin's gull (*Larus audouinii*)

Totally 12581 hectares of area was defined to be characterized by the *Posidonia oceanica* habitat, disregarding the fragments and small empty patches (Figure 3.8). The west of Akkuyu has been given no value, considering the previously defined easternmost boundary of the seagrass beds. When the area is evaluated in scale of 400 square km grids, the west part exhibits higher value in sea grass coverage (Figure 3.9). Grids number one and number two, constitutes the 67.6% of the *Posidonia oceanica* habitat value of the area. The mean coverage area per planning unit is highest (44.8) in the westernmost grids and declines through the east (Figure 3.10).

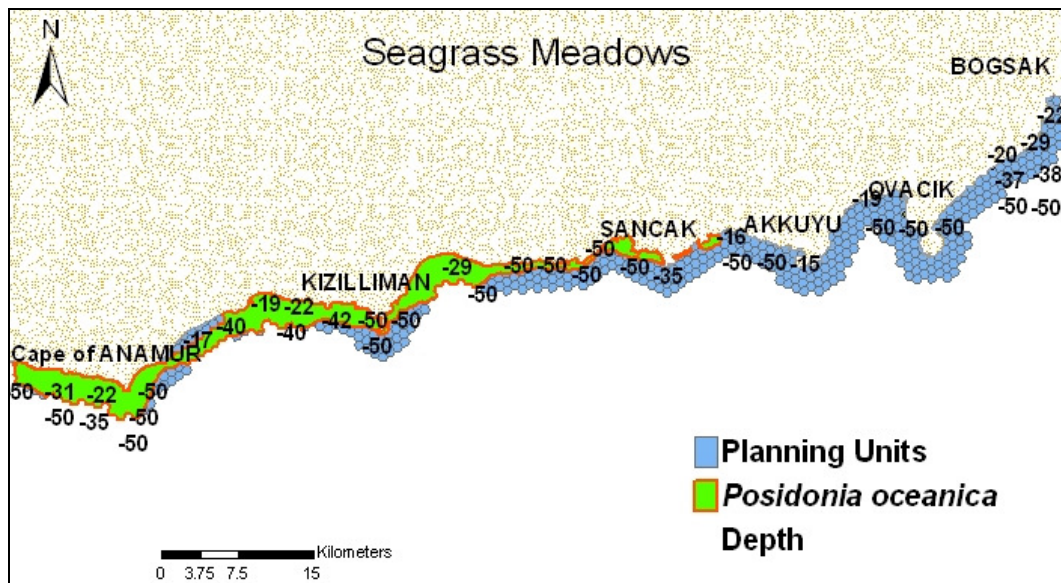


Figure 3.8 Map of *Posidonia oceanica* coverage in the studied area.

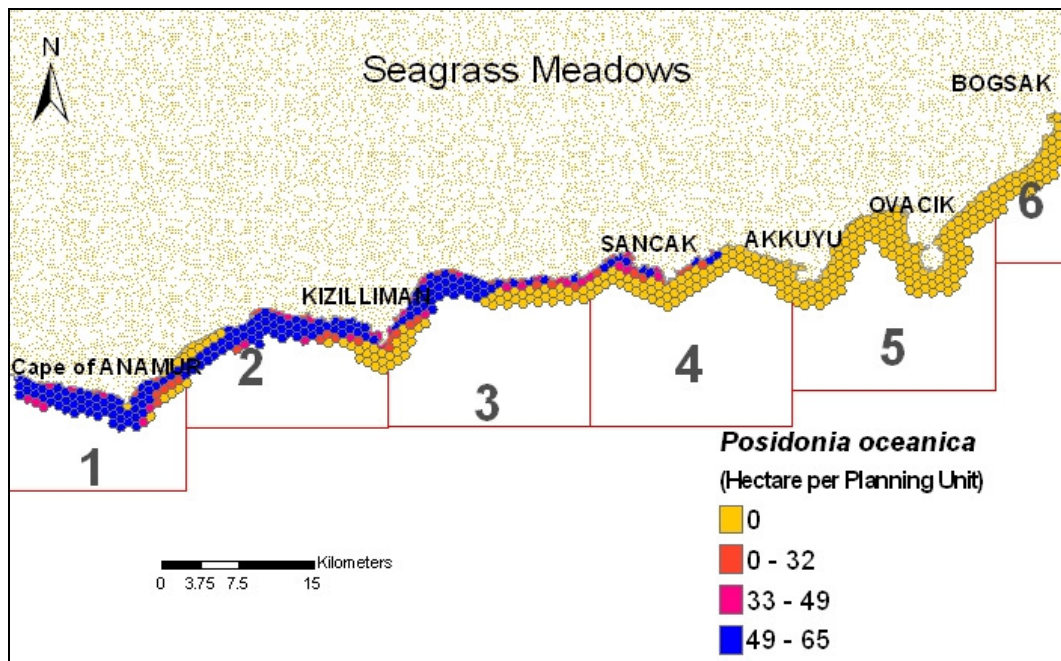


Figure 3.9 Proportion of *Posidonia oceanica* coverage by planning units.

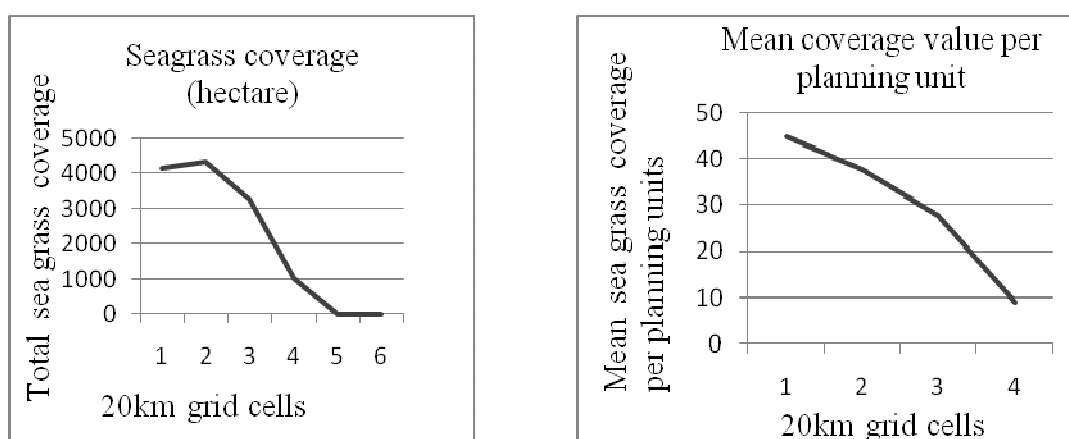


Figure 3.10 Distribution of *Posidonia oceanica* by 20 km grids.

3.3 Fish Component

The fish component is added to the study as one of the main constituent of the ecosystem. Two types of data sets were used in the analysis. These are visual census and trawl survey data.

3.3.1 Visual Census

In total 58 nekton species from 28 families were recorded by visual census sampling. More than 35000 individuals were visually enumerated in which 6 species contributed the 84.5% of the total abundance over the entire sampling (Table 3.3). School forming fishes were the most abundant: *Aterina sp.* (22.9%) *Chromis chromis* (19.4%) *Oblada melanura* (18.4%) *Boops boops* (11.1 %) whereas 98.2 percent of the total observed abundance was constituted by 18 species while 17 species represented by only one or two individuals (Table 3.4). When the species enrolled in respective families, Sparidae appears to be the most frequented (31.1%) followed by Labridae (15.1%) and Siganidae (14.5%). *Diplodus sargus* was the most frequented species within Sparidae, frequented 84 times with 80% occurrence in 104 transects of 27 stations (Table 3.5)

Table 3.3 Observance frequency of fish families in visual census sampling

Family	Frequency	Family	Frequency
Apogonidae	9	Mullidae	20
Apogonidae	1	Muraenidae	8
Atherinidae	16	Myliobatidae	2
Belonidae	2	Octopodidae	1
Blenniidae	3	Pempheridae	5
Carangidae	16	Pomacentridae	59
Centracanthidae	16	Pomatomidae	1
Cheloniidae	2	Scaridae	57
Fistulariidae	12	Scorpaenidae	1
Gobiidae	1	Sepiidae	1
Holocentridae	13	Serranidae	66
Labridae	126	Siganidae	121
Monacanthidae	1	Sparidae	259
Mugilidae	13	Sphyraenidae	1

Table 3.4 Most abundant fish species sighted during visual census

Species	Count	Percent	Species	Count	Percent
<i>Aterina</i> sp.	7826	22.0%	<i>Lithognathus mormyrus</i>	497	1.4%
<i>Chromis chromis</i>	6902	19.4%	<i>Thallasoma pavo</i>	487	1.4%
<i>Oblada melanura</i>	6570	18.4%	<i>Sparisoma cretense</i>	402	1.1%
<i>Boops boops</i>	3962	11.1%	<i>Sarpa salpa</i>	375	1.1%
<i>Siganus rivulatus</i>	2785	7.8%	<i>Sphyræna chrysotaenia</i>	350	1.0%
<i>Spicara maena</i>	2092	5.9%	<i>Siganus luridus</i>	297	0.8%
<i>Diplodus sargus</i>	720	2.0%	<i>Coris julis</i>	240	0.7%
<i>Spicara flexiosa</i>	635	1.8%	<i>Belone belone</i>	140	0.4%
<i>Diplodus vulgaris</i>	611	1.7%	<i>Liza</i> sp.	128	0.4%

Table 3.5 Frequency of species in Sparidae family.

Species (family Sparidae)	Frequency within family
<i>Diplodus sargus</i>	84.00
<i>Diplodus vulgaris</i>	72.00
<i>Oblada melanura</i>	42.00
<i>Sarpa salpa</i>	19.00
<i>Diplodus annularis</i>	17.00
<i>Boops boops</i>	9.00
<i>Lithognathus mormyrus</i>	9.00
<i>Diplodus cervinus</i>	5.00
<i>Diplodus puntazzo</i>	1.00
<i>Sparus aurata</i>	1.00

Diplodus sargus characteristically inhabits the shallow rocky bottoms and possess an important commercial value. Together with other species of the family Sparidae, *D. sargus* was the most frequented fish and dominated the fish assemblages in visual census survey. Considering its ecological reflectance and commercial value, *D. sargus* was used as a surrogate for habitat quality and the lack of intensive fishing of the area. (Lloret and Planes, 2003). Only medium and large sized fishes were used in the analysis. The transects average value of *D. sargus* for each visual census stations were used. Higher values were recorded in the eastern part and decreased through the east (Figure 3.11 and Figure 3.12). The total number of the medium and large species was 151, and 10 % of this abundance was constituted by large individuals.

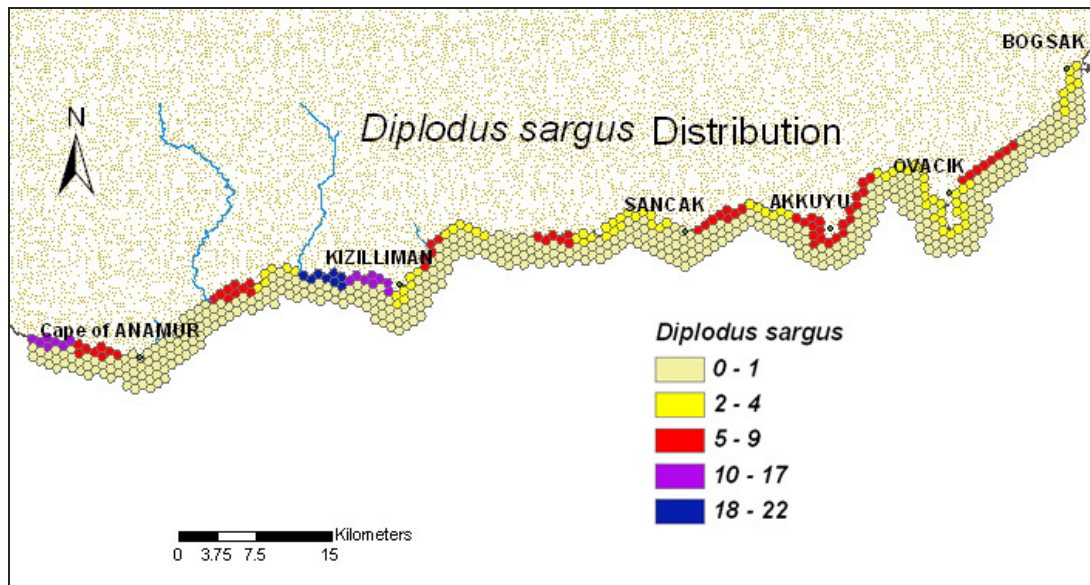


Figure 3.11 .Observation of larger individuals of *Diplodus sargus*.

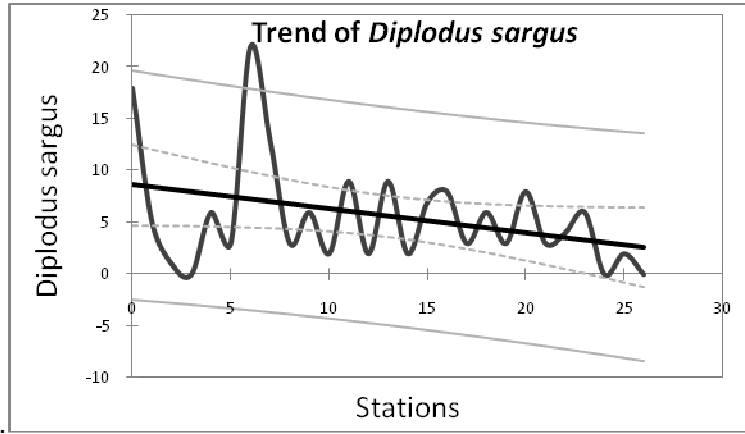


Figure 3.12 Observation of larger individuals of *Diplodus sargus* from west to east.

Epinephelus marginatus is another important surrogate for shallow rocky habitat, as being listed as 'endangered' in IUCN's (World Conservation Union) Red List of Threatened Species (URL 16). *E. marginatus* populations are depleted due to overexploitation mainly by spearing and bottom long-line fishing. In addition it is a good indicator of intactness, as its response to protection was documented (Renones, 2002). *Epinephelus marginatus* was observed in 11 of the stations, and highest numbers were observed in west of Anamur (5), Kızılliman (4), east of Kızılliman (Tekeli siteleri) (4) (Figure 3.13). Considering high sensitivity of the species, this layer was used to indicate the conservation value of the planning units

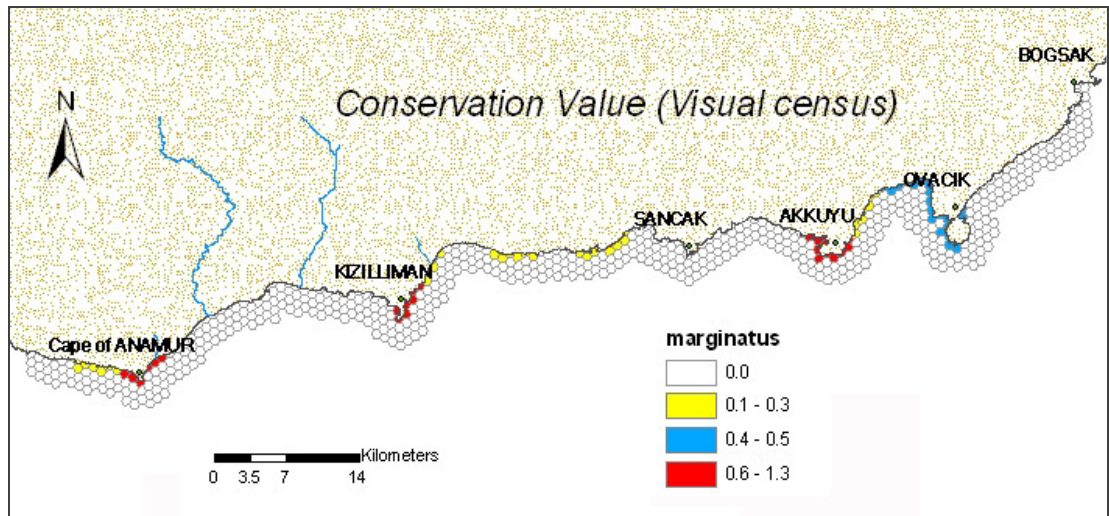


Figure 3.13 Distribution of *Epinephelus marginatus*.

Shannon index and species richness were used as supplementary factors representing the biodiversity in addition to other surrogates. Shannon index varied between 1.03 (minimum) and 2.54 (maximum) (Table 3.6, see also Figure 3.15). In Figure 3.14 the distribution of species richness and Shannon index values were compared by stations. Results showed a slight decrease from west to east in both. Linear trend model of species richness exhibited a steeper decrease in compared to Shannon index (Figure 3.14).

Table 3.6 Shannon index of the fishes enumerated based on visual census survey (see Figure 2.3 for map of locations).

Sta-no	Station	Shannon index	Latitude	Longitude
1	Mellec	2.54	36.043	32.685
2	Piramit	1.42	36.033	32.731
3	Anemurium	1.57	36.019	32.804
4	Anamur - iskele	1.04	36.068	32.867
5	Mamure Kalesi	2.03	36.081	32.896
6	Bozyazı - liman	2.13	36.096	32.936
7	Bozyazı - ada	1.31	36.094	32.975
8	Toslak	1.25	36.094	33.026
9	Kızılliman	1.49	36.084	33.087
10	Tekeli - siteler	1.32	36.126	33.122
11	Tekeli - karakol	2.01	36.138	33.148
12	Sirtlan	1.81	36.128	33.2
13	Carli	1.03	36.128	33.270
14	Aydıncık - liman	2.05	36.144	33.325
15	Aydıncık - ada	1.56	36.14	33.349
16	Yılanlı	1.79	36.114	33.377
17	Sancak	1.79	36.129	33.399

Table 3.6 (continued)

18	Babadil	2.01	36.155	33.444
19	Siteler	1.88	36.152	33.493
20	Beşparmak	1.40	36.125	33.532
21	Akkuyu	1.21	36.141	33.537
22	Hayat	1.53	36.158	33.579
23	Pine-park	1.61	36.185	33.616
24	Tisan - bati	1.19	36.156	33.683
25	Tisan - dogu	1.32	36.158	33.691
26	Mavikent	1.43	36.203	33.737
27	Boğsak	1.54	36.267	33.819

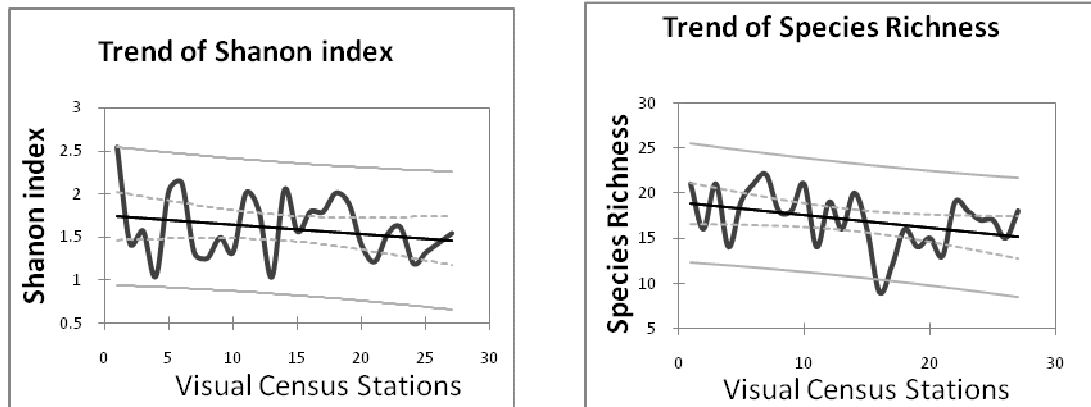


Figure 3.14 Trend of Shannon index and Species richness values from west to east.

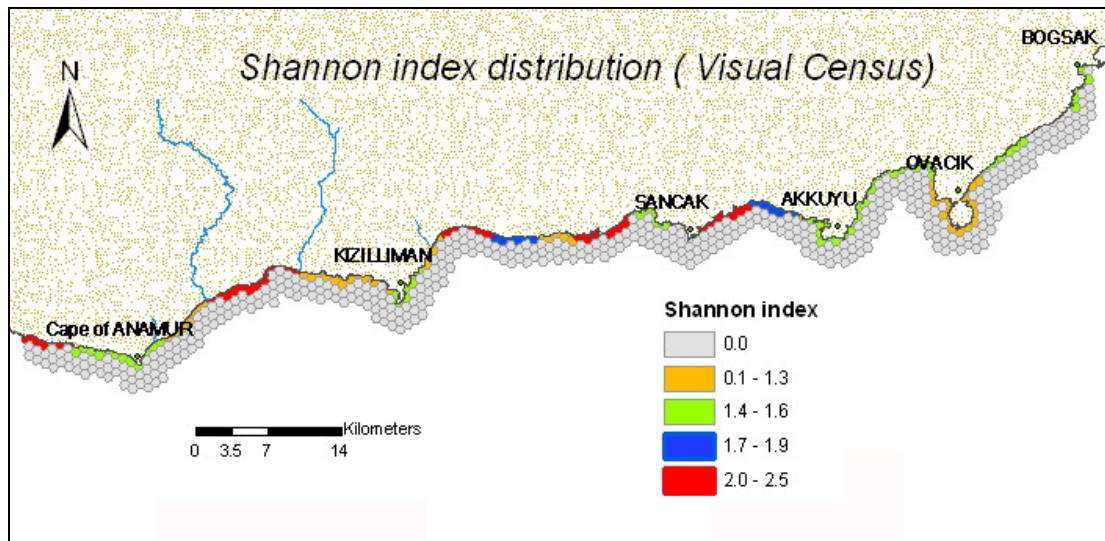


Figure 3.15 Distribution of Shannon index values within visual census sampling locations.

3.3.2 Trawl dataset

Total biomass caught by 82 trawls was 1106 kg where 111 fish species were recorded. 11 of the species were frequented more than 50 % of the trawls are: *Pagellus erythrinus* (70), *Bothus podas podas* (64), *Serranus cabrilla* (61), *Stephanolepis diaspros* (61), *Trigla lyra* (54), *Saurida undosquamis* (53), *Mullus surmuletus* (47), *Diplodus annularis* (43) , *Mullus barbatus* (43), *Spicara flexuosa* (41), *Pagrus pagrus* (40) (see Appendix 1).

Table 3.7 Diet and trophic state of some important fish observed in the bottom trawl catches.

Species	Typical Habitat	Diet	Frequency
<i>Mullus barbatus</i>	gravel, sand and mud bottoms of the continental shelf	small benthic crustaceans, worms and mollusks	52.4%
<i>Mullus surmuletus</i>	broken and rough grounds, sand and soft bottoms	benthic organisms such as shrimps and amphipods, polychaetes, mollusks, and benthic fishes	57.3%

Table 3.7 (continued)

<i>Pagellus erythrinus</i>	rock, gravel, sand and mud	benthic invertebrates and small fishes	85.4%
<i>Pagrus pagrus</i>	rock, rubble, or sand bottoms	crustaceans, fishes, and mollusks	51.2%
<i>Saurida undosquamis</i>	sand or mud bottoms	fishes (anchovy and red mullet <i>Mullus surmuletus</i>)	64.6%

The trawl dataset was analyzed in three aspects: catch per unit effort (CPUE), the percentage of the Lessepsian species over natives, and percentage of the large individuals of indicator species. These indicator species were determined as *Mullus barbatus*, *Mullus surmuletus*, *Pagellus erythrinus*, *Pagrus pagrus*, *Saurida undosquamis* (Figure 3.17). *Indicator species* were selected considering their habitat preference, diet (trophic state), and catch frequency (abundance) (Table 3.7)

As the selected fishes have high commercial value, it was assumed that the proportions of the large individuals in the assemblage may possibly be a good indication value for fishery.

In Table 3.8 the distribution of the catch per unit effort (CPUE) value was given. Whilst the number of trawl stations seems satisfactory for covering the study area, using a fine scale evaluation was unfeasible because of the aggregated distribution of the stations. Therefore the average values were calculated to be used in a coarser scale. The CPUE is the weight of the total biomass of fish species caught by the trawl net in 30 minutes towing time.

Table 3.8 Average CPUE values per locations.

CPUE	Ovacık	Sancak	Kızılman	Anamur
Mean (kg) / 30 min.	32.4 (18.8)	11.9	10.5	11.0
Number of trawl transects	12	27	23	23
Coefficient of variation (%)	1.4	0.9	0.6	0.5

The highest average value (32.4kg) was observed between Akkuyu and Ovacık while lowest average value was in Kızılliman region (10.5kg). The remarkable difference of the average of the Ovacık region is caused by the biomass of an extraordinary sample with large *Chondrichthyes* species, weighted 168.01kg. However, when this value is excluded from the average, the value was still highest (18.8kg per 30 minutes).

The level Lessepsian invasion was used as a factor of the ecosystem stability and intactness. It was assumed that the Lessepsian invaders are more successful in the deteriorated ecosystems and the ecosystem maturity acts as a protective mechanism against invasion. Therefore it was one of the components of reserve selection process as a conservation feature. The level of intactness was derived from the percentage of the number of Lessepsian species to the total number of species. When the percentages were found, the averages were sorted. These values were showing the degree of Lessepsian invasion in negative manner. Positive values were obtained by extracting the values from highest value. Level of protection was appeared to be higher in Ovacık part, followed by Anamur and Kızılliman (Figure 3.16).

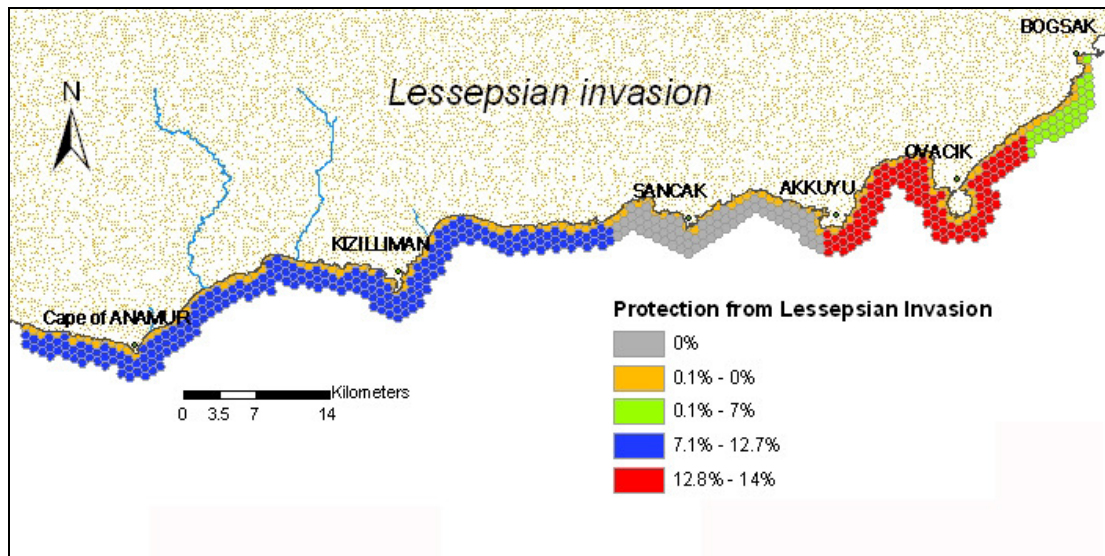


Figure 3.16 Proportional effect of the Lessepsian fish distribution, with respect to trawl data.

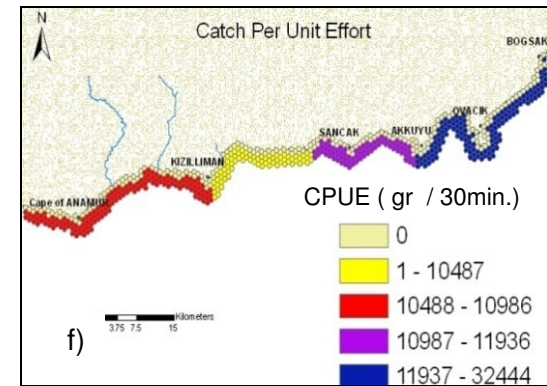
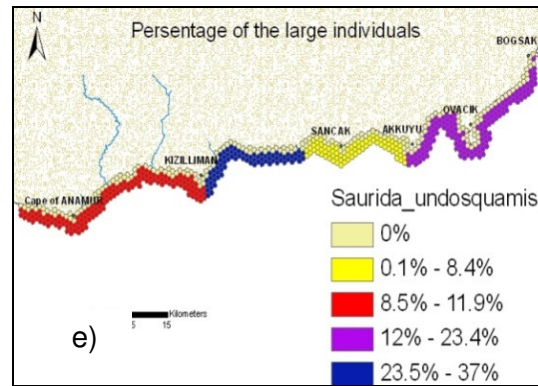
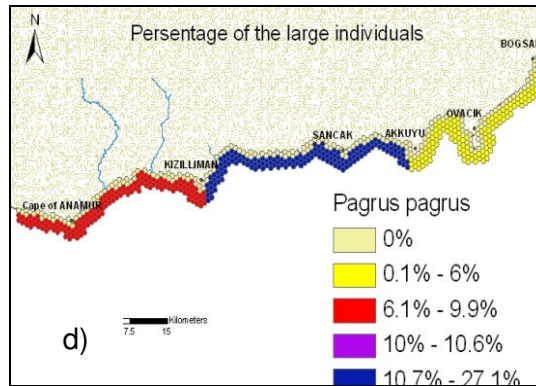
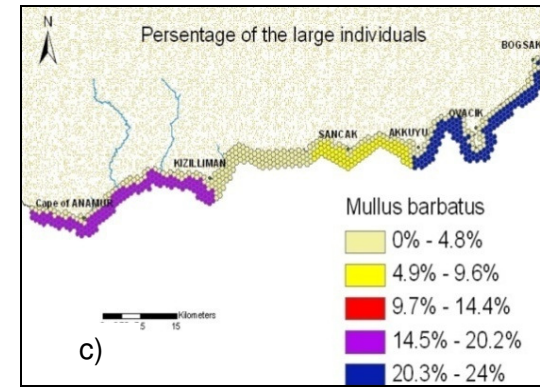
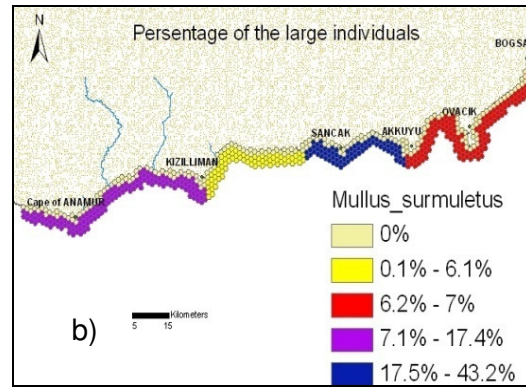
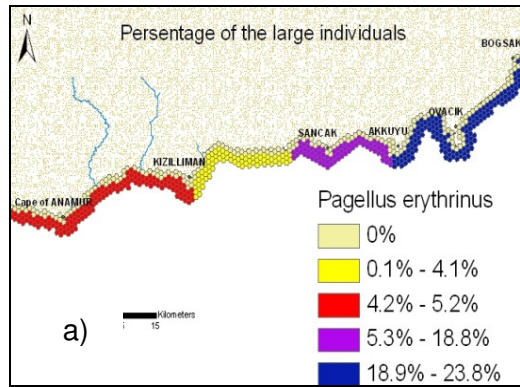


Figure 3.17 Maps of abundance percentage of proportionally large individuals of species and average catch per unit values: a) *Saurida undosquamis*, b) *Mullus surmuletus*, c) *Pagellus erythrinus*, d) *Mullus barbatus* e) *Pagrus pagrus*.) CPUE

The criteria for analyzing the indicator species of trawl data was the ratio of large individuals to the total abundance. Firstly, the largest individuals of each species were queried out of 85 transects. These sizes were; 41cm for *Saurida undosquamis*, 25 cm for *Mullus surmuletus*, 24 cm for *Pagellus erythrinus*, 23 cm for *Mullus barbatus* and 23 cm for *Pagrus pagrus*. Then species categorized as small, medium and large according to the maximum sizes (Table 3.10). Afterwards, for each species, the percentage of the total number of large individuals to total abundance of that species was calculated. Then the average of the percentages was calculated for each coarse scale frames (20 km grids). Value of each species was used as independent surrogates, and the small planning units within the middle and offshore layers were assigned with these values in large grids. Finally each planning unit, excluding those in the shore layer, were assigned with value of *Saurida undosquamis*, *Mullus surmuletus*, *Pagellus erythrinus*, *Mullus barbatus* , *Pagrus pagrus*, CPUE, Lessesian Invasion, and Conservation Value that derived from the trawl dataset.

Table 3.9 Size classes.

	Small	Medium	Large
<i>Saurida undosquamis</i>	0 - 13	13 - 27	27 - 41
<i>Mullus surmuletus</i>	0 - 8	8 - 16	16 - 25
<i>Mullus barbatus</i>	0 - 7	7 - 15	15 - 23
<i>Pagellus erythrinus</i>	0 – 8	8 - 16	16 - 24
<i>Pagrus pagrus</i>	0 – 7	7 - 15	15 - 23

3.4 Complementarity Analysis

In this section the results of the complementarity analyses were given. The results were obtained by application of Marxan by setting inputs according to the predefined

scenarios First group of the scenarios were constructed to determine appropriate values for variables such as boundary length modifier, number of run to perform, and the penalty factor for unrepresented species. Second group was the main scenarios which were built for decision making (Table 2.12). By applying different conservation targets scenarios expected to obtain a set of diverse reserve system designations. These designs were composed of the best of 1000 runs of 10 replications for each scenario. Parallel to reserve designations, a set of irreplaceability maps were obtained which were made up of the selection frequency values of planning units.

3.5 Scenarios

In order to identify potential conservation priority areas across various-sized total area designs, multiple combinations were created as scenarios for Marxan.

3.5.1 Testing Scenarios

In this group of scenarios, variables were tested keeping other parameters constant, but increasing the ranges of parameters that may be influential. Firstly boundary length modifier (BLM) was tested. The boundary length modifier is a tool to overcome fragmentation problem in designation of protected areas. Boundary length modifier acts to minimize the overall edge length of the reserve portfolio. The level of boundary length modifier was increased gradually: by setting the coefficients respectively to 0.1, 0.5, 1, 10, 100 and 1000. With the “0” boundary length modifier the selected reserve area was unacceptably fragmented (Figure 3.18).

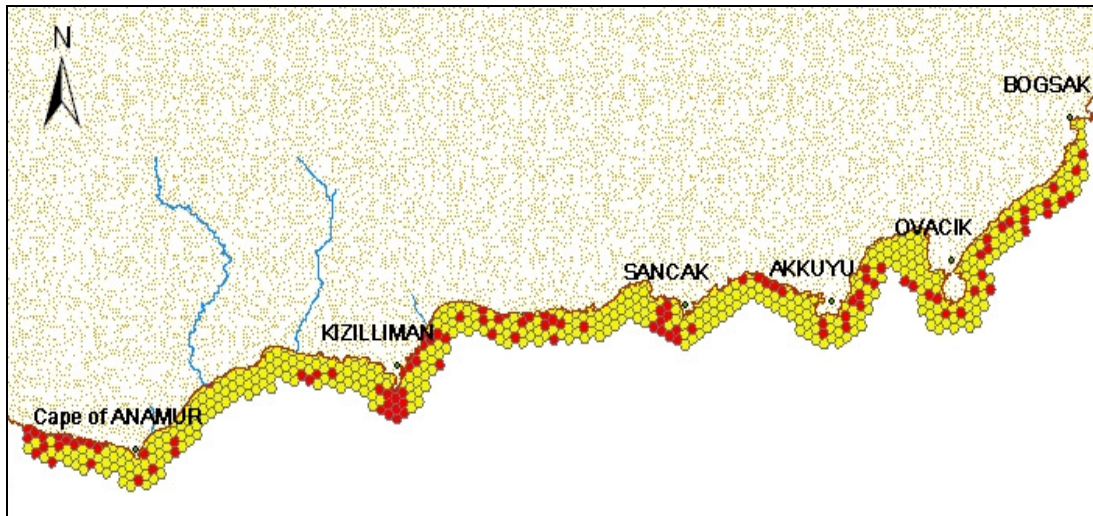


Figure 3.18 Scenario $BLM = 0$ Planning units selected for the best (lowest scoring) reserve network. Boundary length modifier (BLM) set to 0. Red planning units indicating those included in the network.

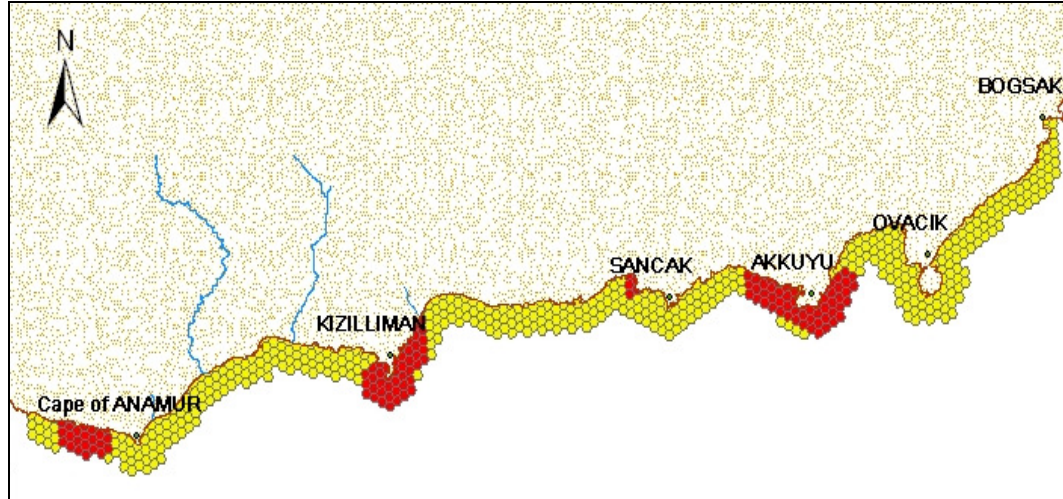


Figure 3.19 Scenario $BLM = 10$ Planning units selected for the best (lowest scoring) reserve network by setting the boundary length modifier to 10. Red planning units indicating those included in the network.

Less boundary length indicates more compactness. Although the values greater than 1 gave very similar results, “10” appeared to be optimal and decided to be used for further scenarios (Figure 3.19 and Figure 3.20).

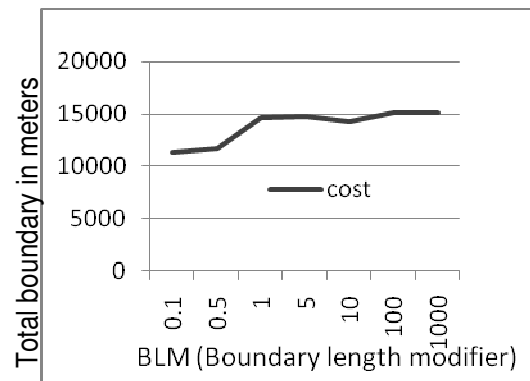


Figure 3.20 BLM test. “10” provides optimal boundary length and reasonable cost score. Less boundary length means less fragmentation.

Number of iterations was important since in each iteration the result are optimized, and the best of them is chosen as final solution. Runs were performed over 10, 100 and 1000 times taking into account the general use of Marxan (Cook, 2005; Grand et al., 2007). With the 1000 runs we got slightly better results (lower objective function scores) comparing to 100 (Figure 3.21).

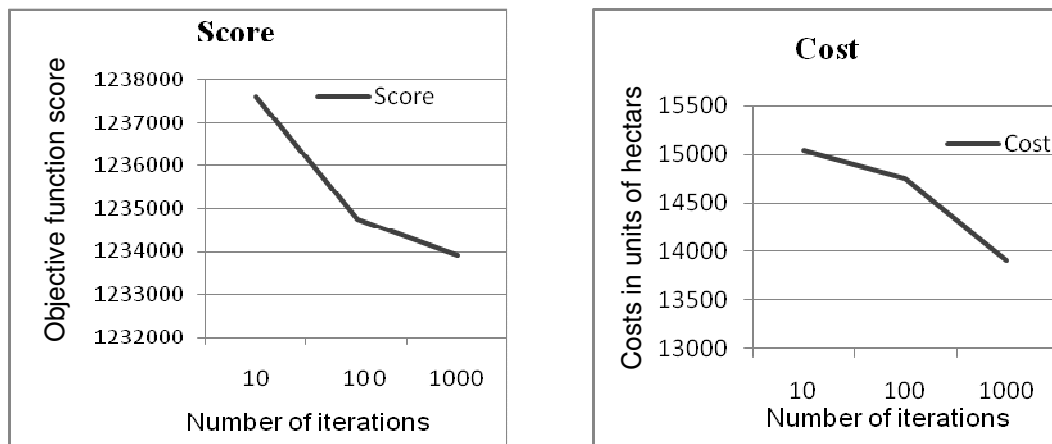


Figure 3.21 Number of runs vs. score (lower is better) and number of runs vs. cost. The change of score and cost of the best solutions with increasing of numbers of runs

Due to the time constrain no value larger than 1000 was tested. While “100” takes 2 – 5 minutes to run, “1000” takes about 32 – 35 minutes. Considering that each

run needs to be iterated 10 times the total computational time for more than 1000 runs would be too long to analyze (Figure 3.22).

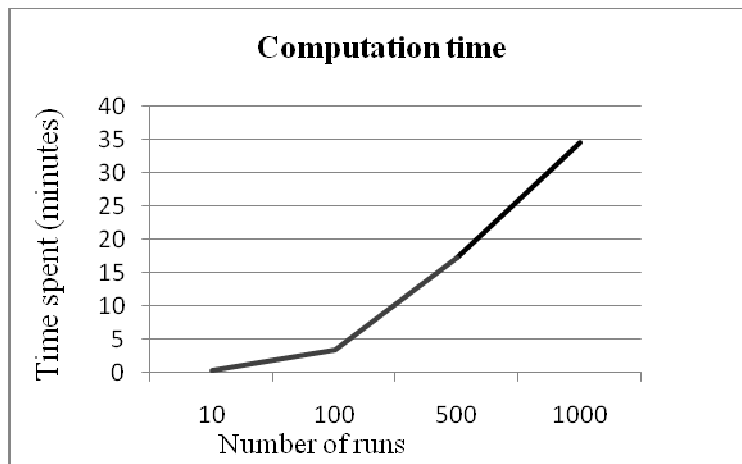


Figure 3.22 Computation time vs. number of runs.

The aim of using the penalty factor was to prevent “species (biodiversity features) shortfall (conservation features which haven’t met their target)”(Ball, 2004) and keep all the targets satisfied. In this study the approach was to meet the entire targets, so species penalty factor (SPF) was needed to set a certain value that no shortfall occurs in solutions. Respectively “1”, “5” and “10” was tested. With “1” 71% of the solutions were containing missing values. This was followed by “5” with 9 % missing values and “10” with 4%. “10” was observed to be enough to ensure all targets to be represented as it finds more than 95% solutions without missing targets (Figure 3.23). A higher value was abstained for not to increase the objective value unnecessarily.

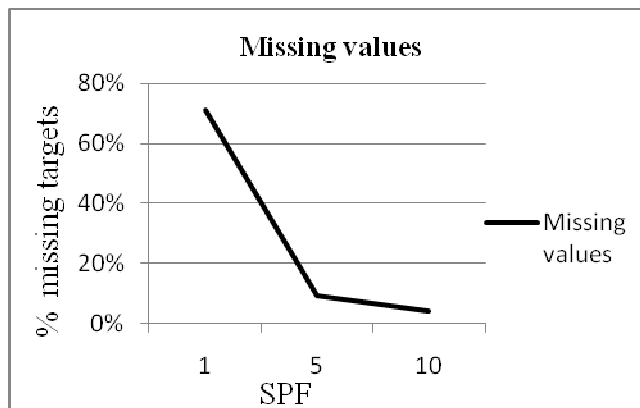


Figure 3.23 Test of the SPF. “10” generates acceptable values.96% of the solutions were without missing values.

3.5.2 Main Scenarios

Scenarios were constructed so as to see how the distribution and size of the total occupied area changes. The challenge here is to decide which combination planning units (areas), to include in the reserve network in order to achieve all the biodiversity goals for minimum cost. Although Marxan finds the optimal solution, the resulting selection should be tuned with the present reserve area, by means of cost and total occupied area.

Tuning was based on measurement of the cost, number of planning units and total occupied area. Although offshore extent of the Kizilliman MPA stretches up to 12 nautical miles distance, only the part intersecting with the study area was counted. The calculated values for Kizilliman MPA are given below in Table 3.2. In evaluation, principle factor is total surface area. If the results exhibit similar surface area meeting the criterion then number of planning units and finally costs were evaluated.

Table 3.10 Portfolio of the Kizilliman MPA.

Number of planning units	166
Cost	8862
Total surface area (hectare)	10782

The strategy was to start with a low representation target (10%) and to see if the results are needed to be further improved or not. Kızilliman region and west of Anamur was locked to keep them in the final reserve network, in any case (Figure 3.24). The results were far below the values of Kızilliman Marine Protected Area. The total surface area was only 4186 hectares which is less than half of the desired total.

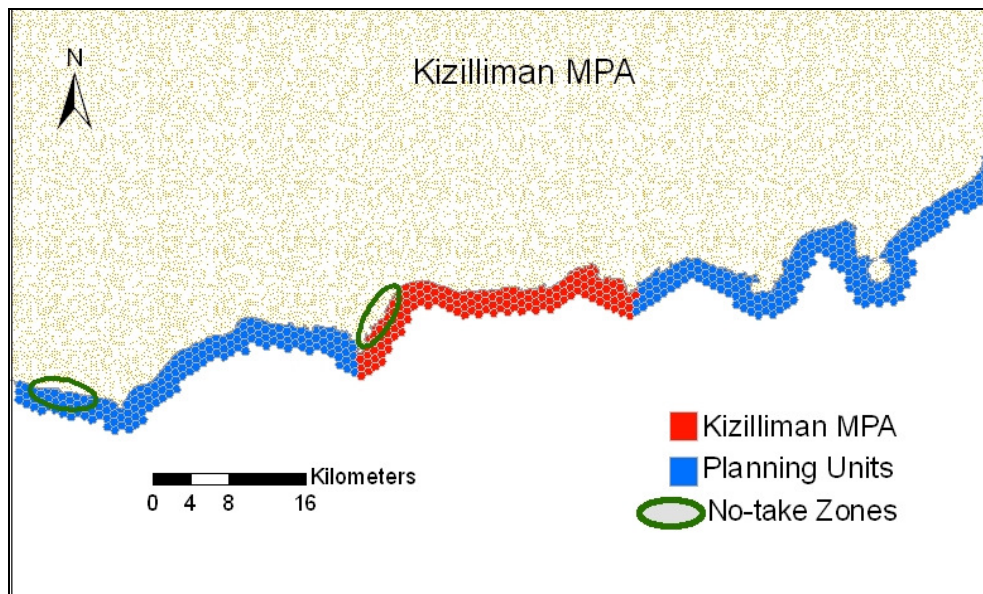


Figure 3.24 Kızilliman Marine Protected Area. Green circles show the existing no-take zones. Red region is the fishery regulation zone where the large-scale fishery (purse-seiner and trawlers) is banned

The irreplaceability results of the scenario “10” have shown a successful distribution of higher values around the desired zones (Figure 3.26). Additionally relatively higher irreplaceability values were assigned to the region of Akkuyu which clarifies the accumulation of the planning units around this area in the best solution (Figure 3.25).

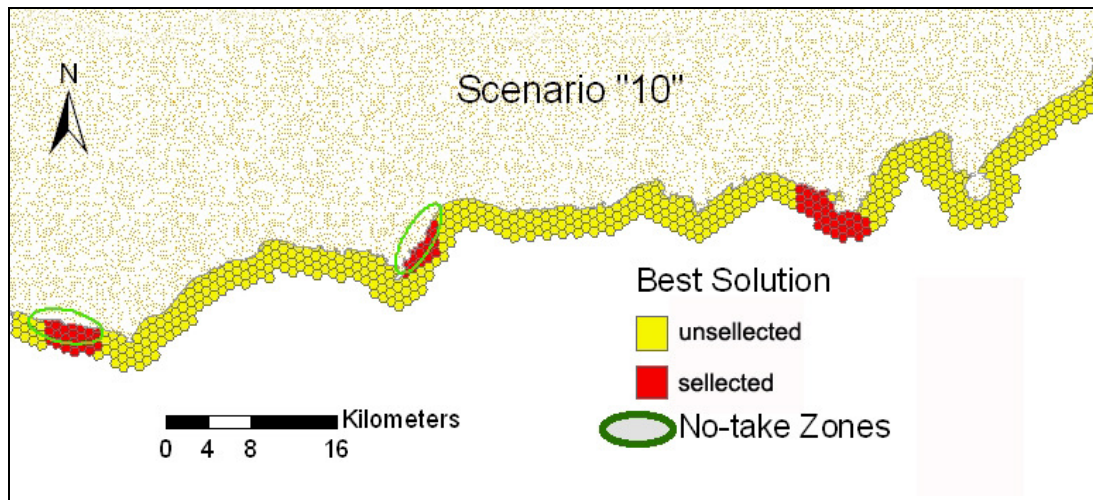


Figure 3.25 Scenario "10" (lowest scoring), red planning units indicating those included in the network.

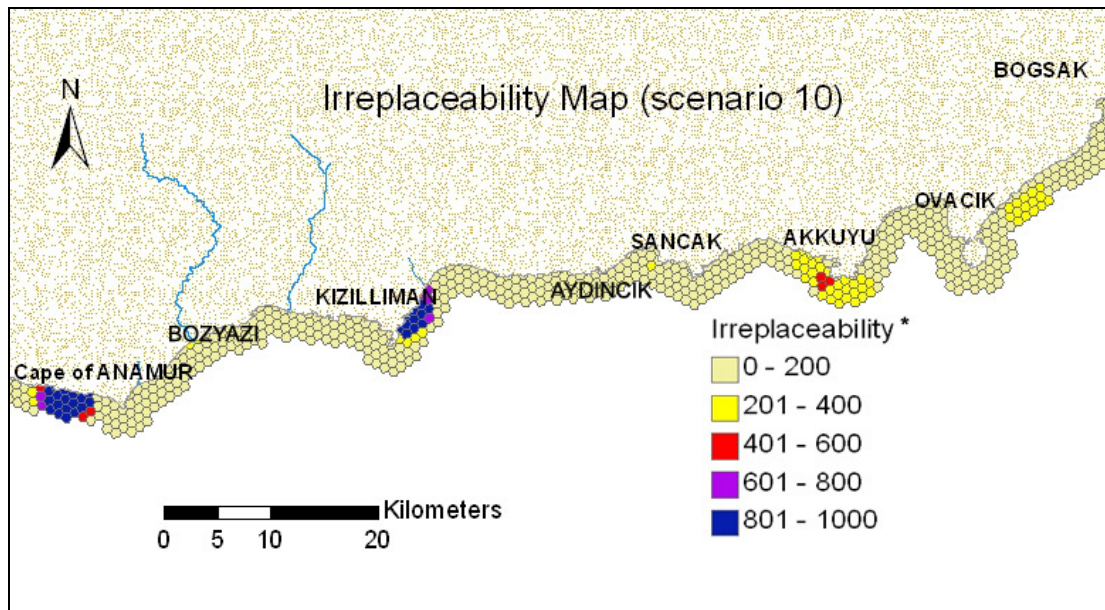


Figure 3.26 Irreplaceability map of the Scenario "10" * irreplaceability: number of time that a cell is selected by 1000 runs.

As these results did not satisfied the objectives, a new scenario was designed by increasing the representation level of the species within the targets. Second scenario was named "102040". The digits in the name come from 10: % of habitats,

20:%species and 40: % *Larus audouinii* (see table 2.14). With increasing level of representation in species an increase over the size of the area was expected. Audouin's gull, *Larus audouinii* was assigned with this special increased target, so as to see the difference resulted from emphasizing single species. With its narrow habitat located around Aydıncık and Akkuyu, Audouin's gull was an appropriate factor for testing the single species increase.

However a very insignificant increase was occurred (Figure 3.27). The area was increases to 4266 hectares and only one extra planning unit was added. The increase in the total surface was only 2%. Moreover the decrease of the reserve size around the core zones made this scenario unsuccessful. Nevertheless the shape of the reserve was changed; a small patch around Aydıncık was introduced in the new design.

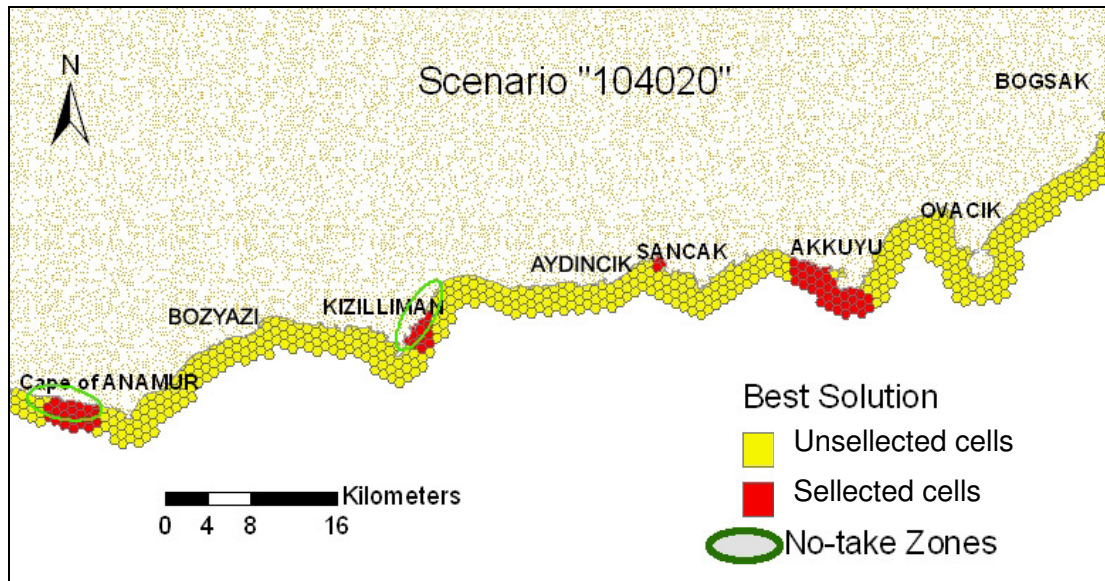


Figure 3.27 Scenario "102040", red planning units indicating those included in the network.

When the irreplaceability of this scenario is checked Akkuyu region seemed to be emphasized with higher values again (Figure 3.28). This is probably as a result of the increased target level of Audouin's gull. Also the highlighted planning units around Sancak are probably as a result of this increase in Audouin's target level.

However no significance has shown by the increased species level (20 %). This is probably due to the reason that the threshold for representing new species target level has not been exceeded. In other words, the planning units selected in first scenario ("10") have already involved the 20% representation target level.

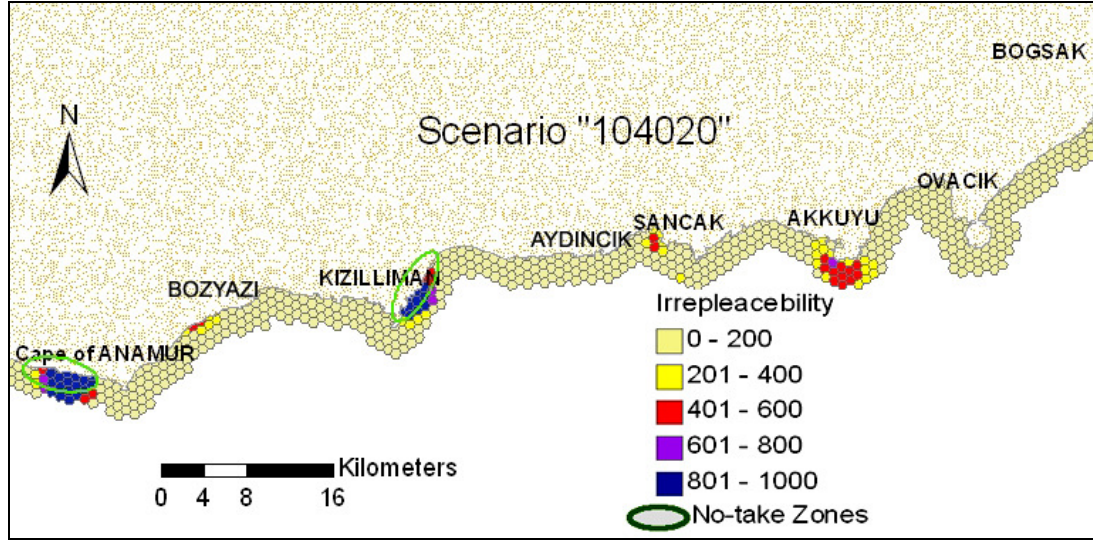


Figure 3.28 Irreplaceability map of the Scenario "102040"

These results indicated that the targets should be further increased with a new scenario. Therefore the scenario "20" was constructed, where the term "20" means that the model is asked to select the best option that preserves 20% of the species in question and 20% of the defined habitat types. This scenario exhibited a significant increase (78%) in surface area comparing with previous one and the new total area was 7623 hectares with 133 planning units.

The new reserve system was consisted of three large segments (Cape of Anamur, Kızilliman and Akkuyu) and one relatively small segment (Aydıncık) (Figure 3.29). The largest segment was the Akkuyu with 3237 hectares of surfaces and 56 planning units. It was followed by Kızilliman 2794 hectares and 47 planning units. The last large segment was located at west of Anamur with 1358 hectares area and 25 planning units. A small segment was selected around Aydıncık coasts consisting of 5 planning units and 233 hectares of surface area.

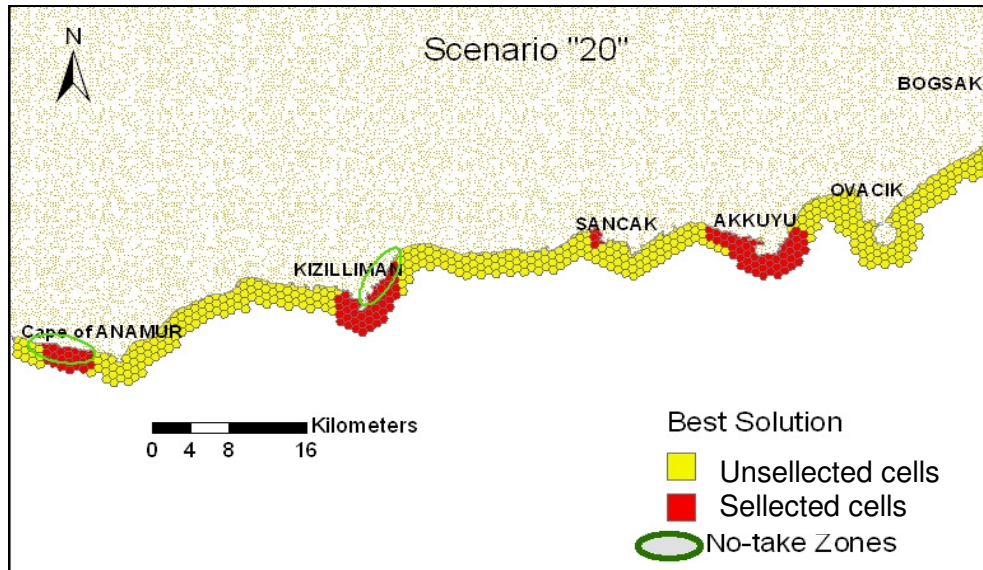


Figure 3.29 Scenario 20 “best score”. Red planning units indicating those included in the network.

The scenario “20” with increased surface area was corresponding 21% of the total surface of the study area. However it was still below the desired amount. The increase was occurred mainly in Kızilliman and Akkuyu. Result implies that the increased targets were best met by the region of Akkuyu and Kızilliman

However when the “best solution” results evaluated in view of irreplaceability, the impact of the boundary length modifier can clearly be seen with regards to the planning units with considerable irreplaceability values around Ovacık, Anamur and Sancak(Figure 3.30).

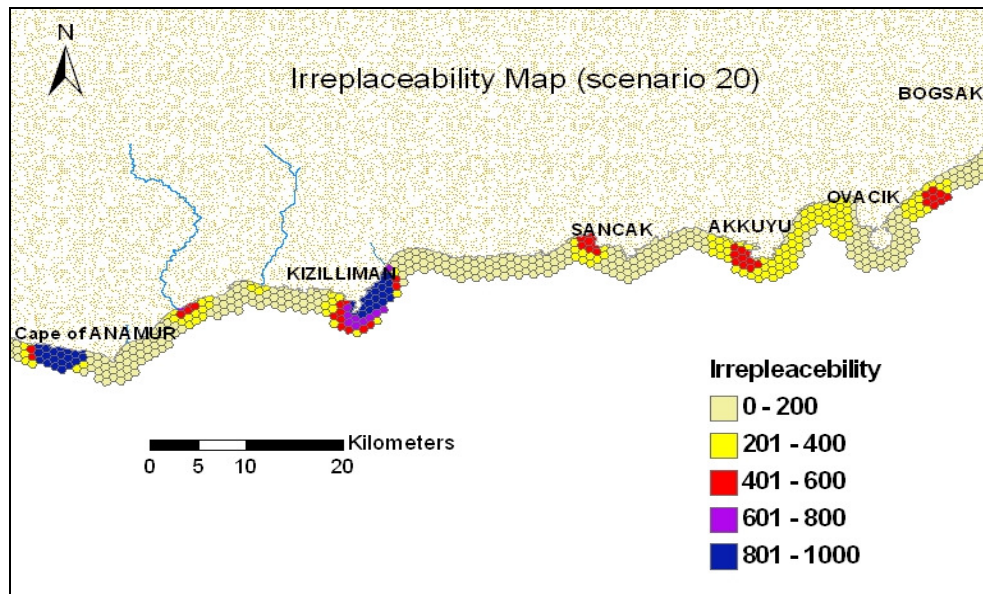


Figure 3.30 Irreplaceability map of the Scenario “20”

Even though a significant increase has been obtained by scenario “20” the aimed score still could not be achieved. Consequently another scenario was derived by increasing the target of red mullet *Mullus barbatus* by 20%. Red mullet is the most important commercial species of the area, thus targeted by both trawling and artisanal fishery. With increasing the target representation level of red mullet, an increase in the coverage area was assumed while focusing on the protection over soft bottom fish communities.

Result was completely different comparing with the previous scenarios (Figure 3.31). The protection border was shifted through Anamur, and the weighting over the Akkuyu region was completely removed. A new patch was appeared east of Ovacık. The result was undesirable, due to its extent over Bozyazı of where the human use is denser. However a fisheries aspect was obtained with this scenario. Irreplaceability was denser in western regions. Addition to surroundings of no-take zones, irreplaceability was higher around the river mouths. Surrounding area of Ovacık was also appeared with relatively high irreplaceability (Figure 3.32. Selection of east Ovacık was probably a contribution of the Dana Island which is the largest island in the study area.

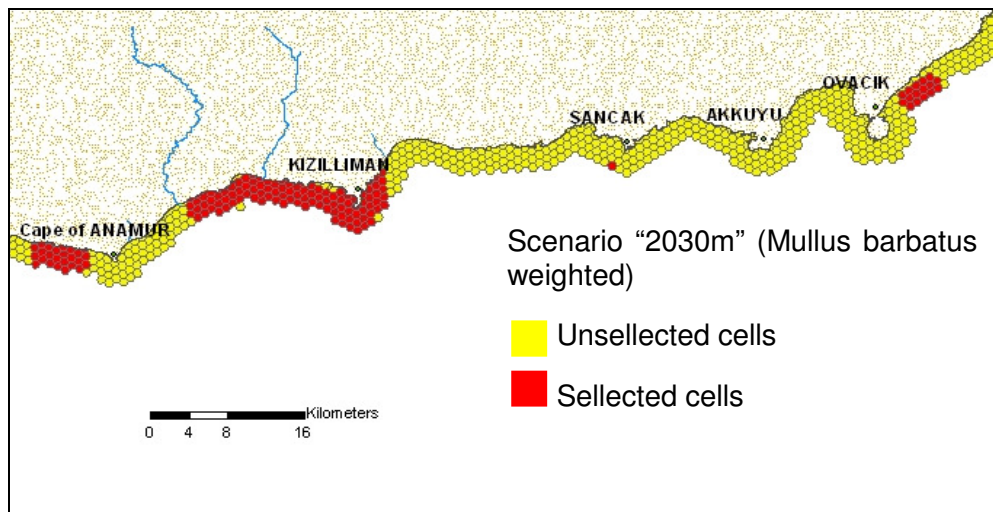


Figure 3.31 Scenario "2030m" (*Mullus barbatus* weighted) the best (lowest scoring), red planning units indicating those included in the network.

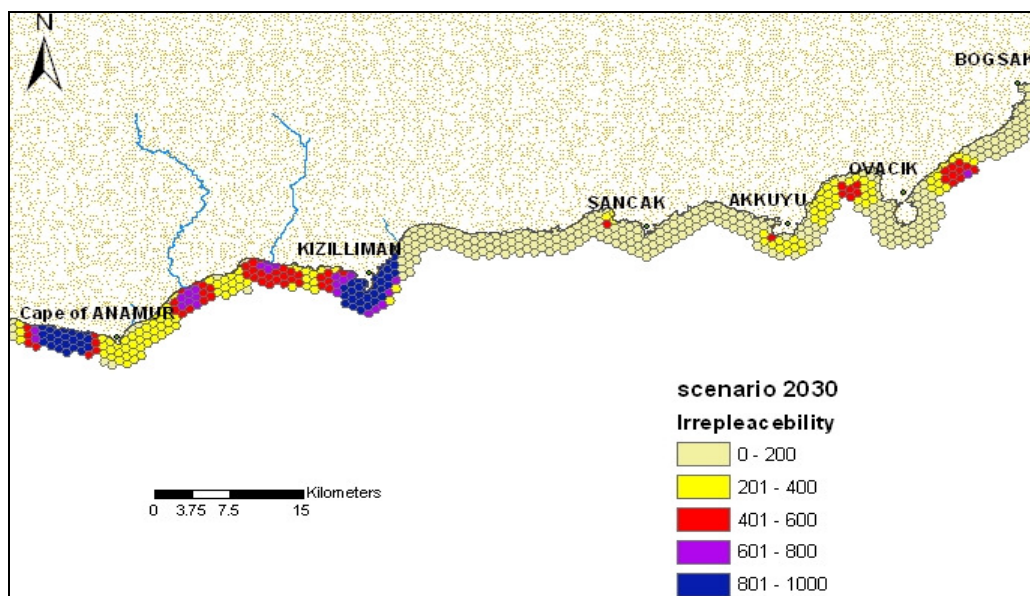


Figure 3.32 Irreplaceability map of the Scenario "2030m" (*Mullus barbatus* weighted)

Beside the undesirable expansion through the most populated areas, the total coverage was 8920 hectares which is 17 % below the objective (This implied that an increased target is needed with new scenarios).

A new scenario was created by dramatically increasing the target level of the species from 20% to 40 % .The new scenario was named as “2040”. Enormous surface area was covered around Ovacık and Akkuyu. This reserve system was enclosed all desirable areas with targeted species and habitats. The proposed network system with this scenario was covering (14490 hectares) the 41% of the total surface of the study area (Figure 3.33).

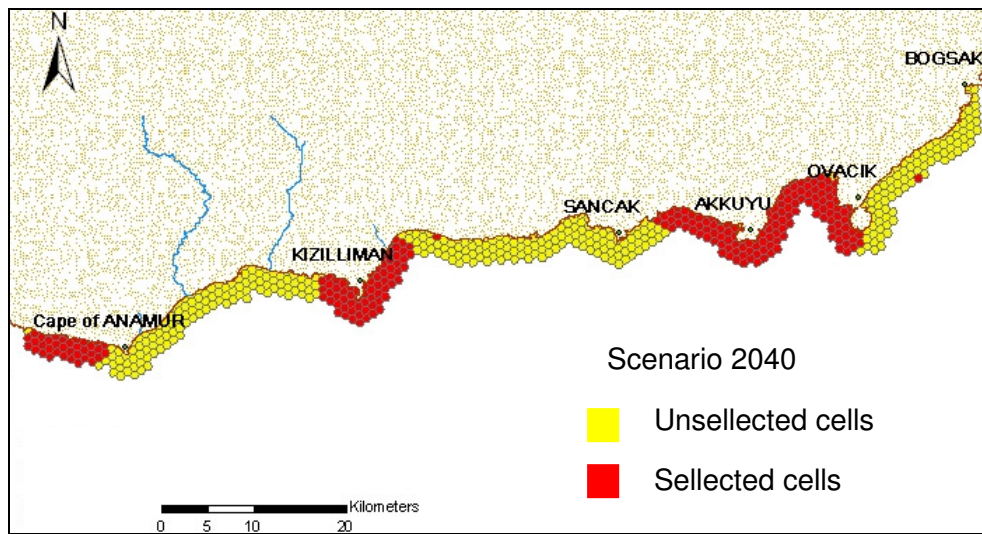


Figure 3.33 Scenario “2040” (best score), red planning units indicating those included in the network

The result was 34% larger than the objective, which makes this selection discarded, due to the difficulty of implementation. However the irreplaceability map of the same scenario exhibits a better picture by means of site prioritization. In figure 3.34 the three core zones are distinguishable with reasonable dimensions. A gradient of irreplaceability values were visible around the core zones. Although the scenario is rejected due to the “best solution” result (Figure 3.33) the results are meaningful in the context of irreplaceability.

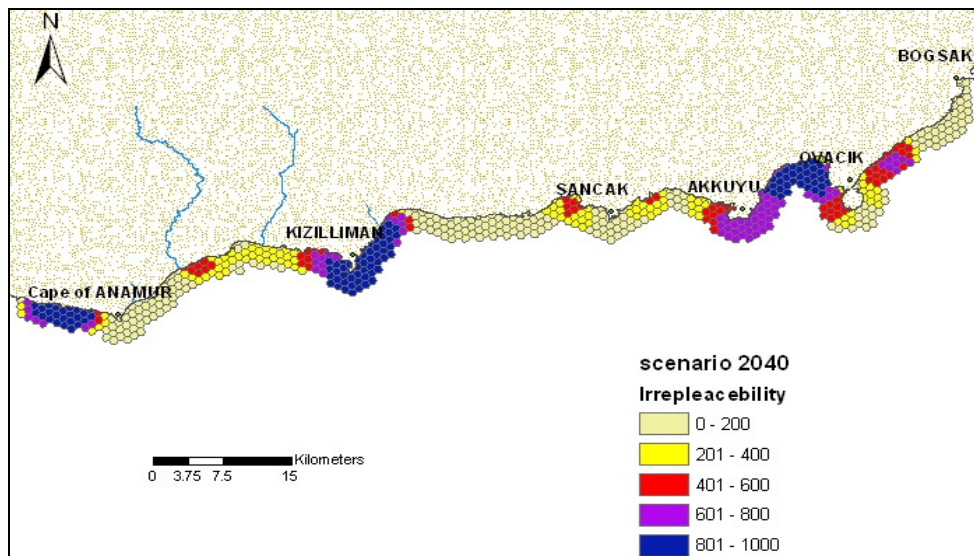


Figure 3.34 Irreplaceability map of the Scenario “2040”

Another trial aimed to reach the objective was performed by “Scenario 30 “where all the representation targets were set to 30%. The total surface area was decreased 22% compared to previous scenario. This design seems more reasonable as it is only 3% larger than the objective (Figure 3.35). But there was still an expansion through Bozyazı which is not preferred due to possible conflicts resulting from the dense human activity.

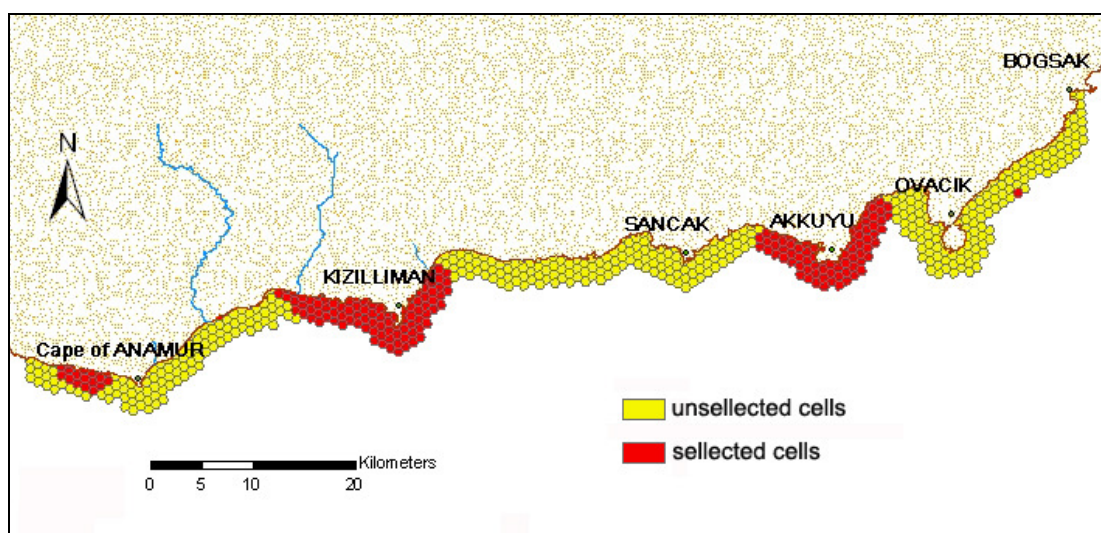


Figure 3.35 Scenario 30 “best score”, red planning units indicating those included in the network.

The expansion of the reserve patch through Bozyazı was not observed with the scenario “2040” even though the total area coverage was much higher than scenario “30”. The only possible reason for that stretching seemed the increase at percentage of the habitat targets. However when irreplaceability map is considered, west of Kızılliman exhibits low values comparing with the patches, at east Ovacık, Sancak and Anamur (Figure 3.36). This was probably resulted from a trade off due to the impact of boundary length modifier. This ambiguity was needed to be resolved with a new scenario.

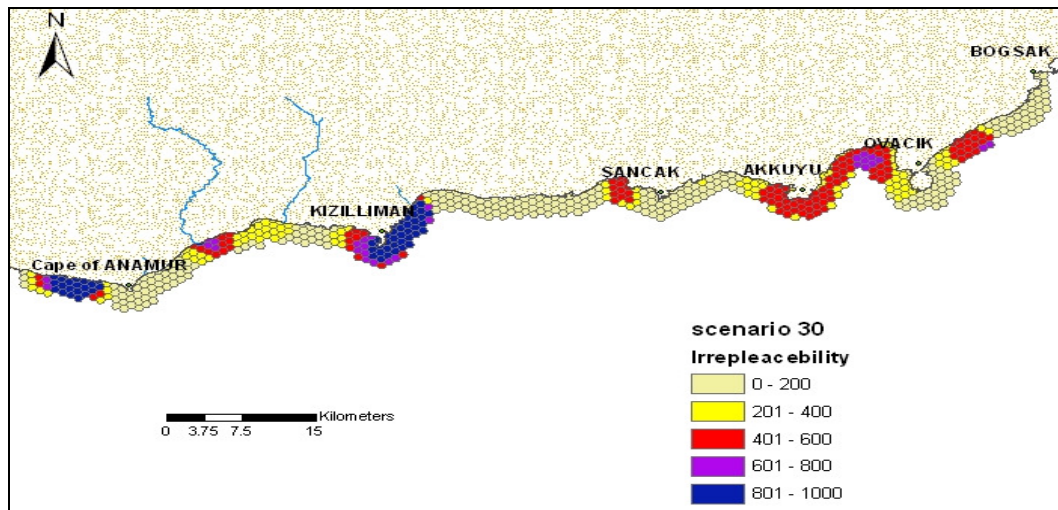


Figure 3.36 Irreplaceability of each planning unit in “scenario 30”. Darker colors indicate higher selection frequencies (greater irreplaceability). The irreplaceability was high around the closed areas.

Finally two new scenarios were produced by lowering the percentage of the habitat value: “scenario 2030” and “scenario 1030” (Figure 3.37). These two scenarios gave very similar results and nearly equal surface area to the objective (Table 3.11). The differences between two results were only one planning unit and 46 hectares which can be disregarded unhesitatingly.

This high similarity between two scenarios was probably caused by the threshold of the selected planning units for habitat values which are capable of satisfy both the 10% level and 20%. This result also implies that the selected area is very near to the optimal, as it is possible to protect 20% of the habitat value by targeting only 10%.

In the aspect of zonation the irreplaceability map of the scenario "1030" exhibits a better picture, as it is more focused on the one region (West Ovacık) compared to the scenario "2030"

Table 3.11 Final solutions vs. existing reserve

Scenario	Area (hectar)	Number of planning unit	Boundary (km)
Objective	10782	166	97
Scen1030	10843	189	120
Scen2030	10889	190	124

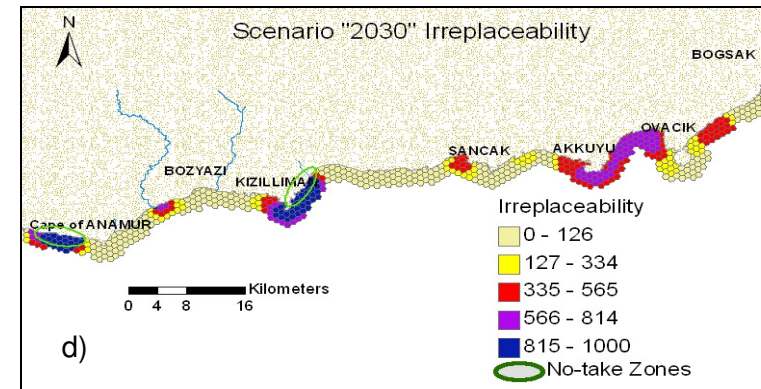
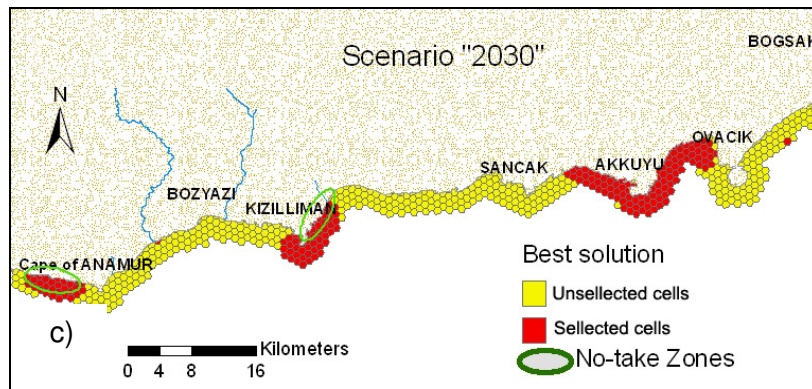
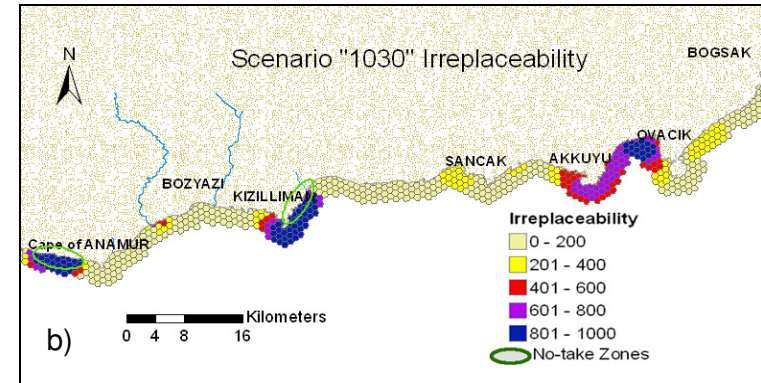
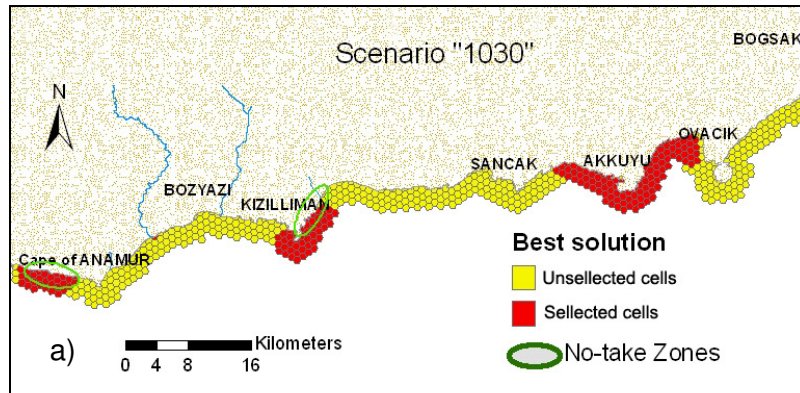


Figure 3.37 Final Solutions. a) Scenario "1030"(best score) b) Irreplaceability map of the Scenario"1030" c) Scenario "2030"(best score) d) Irreplaceability map of the Scenario"2030" In "best score" maps red planning units indicate those included in the network In "irreplaceability" maps, darker colors indicate higher selection frequencies (greater irreplaceability).

In table 3.12, the results of the scenarios were given in detail. 1. Column shows the names of the scenarios, 2.column: total surface area of the best design, 3.column: the percentage of the surface area to the total surface area of the study, 4.column: Total cost score of the reserve design, 5. column: total number of planning units forming the reserve and 6. Column is the total boundary length of the reserve.

Table 3.12 Main scenarios. (see table 2.12 for scenario details).

Scenario	Area (hectares)	%(of total surface)	Cost	Number of planning units	Boundary length (km)
Scen10	4187	12%	4396	74	60
Scen1030	10843	31%	12242	189	120
Scen102040	4267	12%	4596	75	63
Scen2030m	8920	25%	11797	150	116
Scen2040	14490	41%	16850	254	156
Scen20	7623	21%	7797	133	94
Scen30	11160	32%	11577	187	148
Scen2030	10889	31%	12419	190	124

As the Marxan uses an optimization algorithm for selecting the areas with given definitions, and even finds near optimal values, there is no exactly absolute solution. In order to validate the solutions, replications for each scenario were done.

The scenarios were then compared based on each replication. The comparison was performed by multi dimensional scaling using the multivariate analysis of XLSTAT2007

software . All replicate solutions ($n = 80$) were compared with the presence/absence of planning units in the reserve network as the sample data (Figure 3.38).

The similarity of spatial configurations of the scenarios were grouped in there region, where the scenario"30" and "2040" were very similar as the scenario "1030" and "2030".This comparison shows that different combinations of targeted amounts of habitats and species can give different result. Furthermore the replications of the same scenarios gave similar results, which prove the accuracy of the selections.

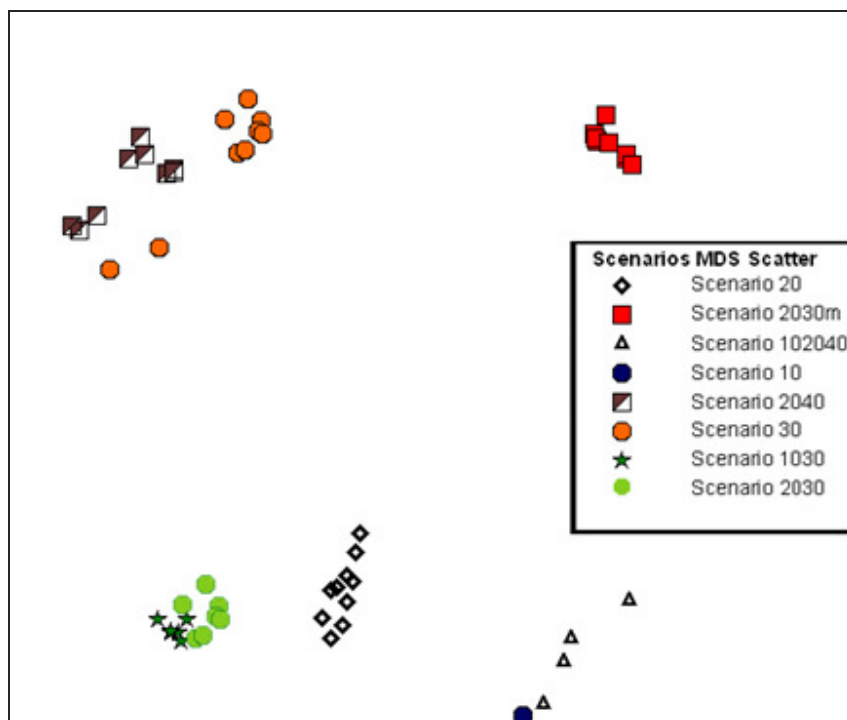


Figure 3.38 Ordination of planning unit presence absence in the replicate marine reserve designs. ($n = 10$ for each 8 reserve design scenarios). Symbols denote specific scenario.

4 DISCUSSION

Designing a marine reserve with optimal size at optimal locations is a very complex issue. An initial attempt to resolve this problem might be to set aside the locations with high species diversity (Woodhouse et.al., 2000). Consideration of multiple factors including cost, socioeconomic environment of the area is required along with the ecological factors. The biggest problem is to find an optimal solution that provides the best balance of biodiversity and socioeconomic concerns. The Kızılıman Marine Protected Area is designated to restore the marine ecosystem deteriorated by excess fishing pressure. Since the ultimate goal of this work is to optimize the conservation measures in the MPA analysis have basically focused on the fish communities and use it as a tool for supporting conservation site prioritization. Moreover considering the insufficiency of fish data for site prioritization, supplementary information such as critical habitats and coastline structure were used. As being one of the basic components of the decision making process the socioeconomic structure of the area was also assessed and incorporated in the analysis.

One of the basic data sources of this research was the results of the trawl surveys which were conducted to monitor the changes in the nektonic communities in the Kızılıman protected area after the designation of protective measures. The design of the trawl sampling was made to keep destructive effect of the trawling at minimum by choosing lesser amount of stations that are just enough for the comparison of in and out of the protected area. Therefore the stations were amassed only at four sub regions. Two sub regions were located inside the protected area and two were out (Figure 2.2). Western sub regions were positioned to include the sea-grass beds in sampling area. Although the total number of trawl hauls was 82, they were all situated in 4 points with nearby positions. Therefore data were averaged and fitted to four equal sized grid cells. Even though such a coarse-scale data was not preferable, it was important as a being indicative for whole area. More numerous sampling locations was elaborated by visual census technique, nevertheless it was restricted to 0 – 10 meters depth, which

represents only a narrow part of the coastline along the study area. The results of this study would be more representative if the research would have been conducted through a finer scale sampling design. Despite the limitations of fish dataset, a fine-scale spatial data with better quality was available for endangered species and habitat types as biodiversity surrogates.

Good recognition of the area was one of the main strength of this study. The interest of METU – IMS to the area begun at 1980's with fishery surveys and more intense attention was given after 1994 with the Monk seal researches. The coastline was completely covered during the Monk seal habitat surveys, which allowed seeing the basic picture of the biodiversity of the area. Results of the 8 researches and conservation projects with numerous surveys allowed determining the borders of the study area and appropriate type of the data for site prioritization. Although most of the data could not be used due to their low resolution, they act as inventory to compare the results of this study.

The study was configured to identify the best areas where the reserves can be fitted optimally, with higher biodiversity and better ecological condition, while keeping the conflicts with socioeconomic factors minimum. So the framework consisted of fundamentally three legs: Socioeconomic factors, habitats and species.

The socioeconomic factors were crucial to determine the undesirable areas, to keep perturbation sources away from the protected area, while sustaining an implementable planning not too much interfering with human use. The socioeconomic data was restricted to coastline and principally composed of the observations from the sea. Considering that the assessment can be criticized for not being sufficient due to its data collection constraint, we used Google Earth together with GIS, to access and extract satellite imagery to view and map the details of the area.

4.1 Socioeconomic factors

Socioeconomic factors were selected based on their possible impacts and exploitation purposes over adjacent waters. Fishery, tourism and aquaculture were based on direct

use of the marine area while human settlements, urban areas and intensive agriculture were secondary factors. However they were treated as they had same level of impact since there is no actual assessment, classification or definition for the costs of closing a marine area for protection.

In site prioritization for conservation different methods are used to determine a cost value for the area (Possingham et.al., 2000) General method uses the complementary factors (generally surface area) as an indicator of cost value. In this study surface area was used as a base for scoring the cost. In addition, for assigning a negative weighting to the zones with higher user interaction, surface area values from each layers were added together. This approach worked well, as the results kept the areas outside of the reserve system where human use interference is high. However this is an arbitrary approach and need to be modified with different combinations, such as weighting the fishery areas used by artisanal fishery.

4.2 Surrogates

Lack of information on the bottom types of the area was another drawback of this research. At least a seabed map of the area with sediment information would be a representative surrogate for assessing the biodiversity structure of the area. This deficiency has been mitigated involving the geological structure of the coastline by creating buffer zones around them as an estimation of their sphere of influence. Additionally a high-quality data for the endangered species (*Monachus monachus*, *Larus Audounii* and Marine Turtles) habitat was available. Although there is a need for special care due to their high sensitivity and critical status, they were also involved in the planning process as biodiversity surrogate. This is for the reason that, each of these species needs a unique habitat for a viable population (Coastal caves located at rocky areas for monk seals, islands and cliffs for Audouin's Gull, soft sandy beaches for marine turtles). Additionally sea grasses within the study area were studied recently in the area in question (Gücü and Gücü, 2002). Although the coverage of the seagrass beds has not been exclusively mapped, the lower depth limit was measured and eastern boundary of the seagrass beds was determined. (Celebi, 2007) In this study considering the lower depth limit and eastern border of the seagrass, mapping was

accomplished with the aid of GIS. The area was clipped using the bathymetric contour of 50m as mask, and also the part beyond the boundary was extracted. According to a questionnaire with local fishermen, the sea-grass map was modified. Although the lower depth limit was set as 31.8m for this endangered plant, this value was expanded to 50m for safety reasons.

4.3 Interpreting the fish data

In evaluation of the fish data, not all the species were used in same manner. The indicator species were selected among the fish assemblages and they were processed in detail. This subset of species was used as surrogates for all other taxa in study area. This approach is highly used in reserve design processes as the distribution and abundance of all species in all places cannot be determined.

From the bottom trawl data, species indicators were chosen within commercially targeted species which were sampled frequently, considering their habitat preference and diet. Only two species were chosen as surrogate from the visual census sampling according to their special ecological reflectance.

4.4 Complementarity analyze

Kızilliman Marine Protected Area is located in a critical area that shelters delicate habitats such as Mediterranean Monk Seals and Audouin's Gull and considerable size of surface which is essential for recovery of the fish stocks and being sanctuary for cetaceans, marine turtles and many other species. Zonation within present MPA comprised by two different regulations: a large fishery regulation area where large-scale fishery is banned, and a small no-take zone where all kinds of extractive activities are banned.

Additionally another no-take zone exist in west of Anamur, over a delicate area specially designed for Mediterranean Monk Seals. However, the protected area here is quite small, which makes the protection of this area vulnerable. A new zonation with expanding the current protection zone and creating a buffer-zone was needed to

achieve. This was one of the main subject to deal with. Also the study area contains a wide range of biodiversity, that the Kizilliman Marine Protected Area is incapable to embrace all. So the problem summarized as to allocate the protected areas in an optimal way in the context of socioeconomic factors and biodiversity surrogates, including all predetermined biodiversity targets while involving the delicate areas that are currently “small no-take zones”.

The approach to achieve adequate representation of the biodiversity was to set conservation goals for each kind of biodiversity feature in the study area while assigning area divisions (planning units) with cost values resulted from the human use. Then select a set of areas within the region that contribute most efficiently to meeting the conservation goals.

The foremost issue was deciding which combination of areas (planning units), to include in the reserve network in order to achieve all the biodiversity goals for minimum cost.

In order to meet this complex challenge use of Marxan was vital in conjunction with GIS. Exploratory scenarios can make valuable contribution to the reserve design process through definition of the solution spaces (i.e best and worst case), which then serves to better define the reserve design problem (Steward et.al., 2003).

The set of scenario created in this study was aimed to reach the size of existing protected area, with a new design. Therefore scenarios were created by modifying the conservation targets, and different combinations for habitats and species objectives. Finally a set of different solutions were found according to the scenarios. The area coverage appeared to increase in linear fashion with increasing representation target. Also boundary length was increased linearly depending on the area coverage (Figure 4.1).

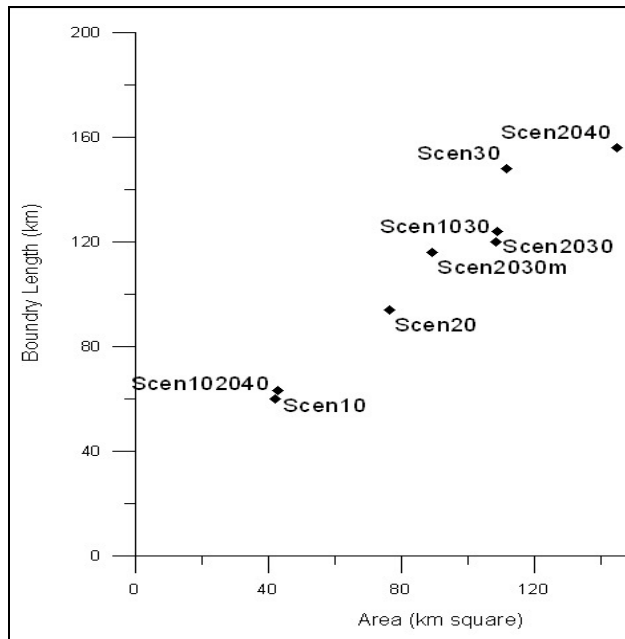


Figure 4.1 Scenarios vs. area and boundary length.

The size and shape of the Marine Protected Areas are conceptually subject to debates. The question is to protect a single large area or several small areas (Francour et.al, 2001). The debate is mainly arises from the criteria used to design the MPA, whether it depends on ecological needs or human factor. In the case of current study the final reserve design solution was consisted of three segments, which can be considered as a reserve network. The reserve design problem was attempted to solve by considering both biodiversity and socioeconomic factors. The optimal solution, depending on the data, objectives and optimization algorithm implemented by Marxan software can also be considered as an answer to the size-shape questions.

4.5 Irreplaceability

Two types of solutions were generated: best solution (lowest objective function score) and Irreplaceability (selection frequency of the planning units). The importance of the irreplaceability is its capability of reflecting priority classification of the area. According to Carwardine "Sites with rarer biodiversity features have higher irreplaceability values

than sites with more common features, for which there are many conservation options in the landscape". (Carwardine et.al., 2006). Additionally if the establishment of the reserve is subject to negotiation, most irreplaceable sites can form the core of the system, and the remainder of targets can be adjusted accordingly. (Pressey and Logan, 1998; Ferrier et al. 2000, ; Carwardine, 2006).

4.6 Zonation

As considering the one of the major issue in designation of the marine protected areas is zonation, the irreplaceability results were evaluated in the context of zonation. The predefined no-take zones were situated as the core areas within the reserve system. As they were locked (not allowed to exclude from the final reserve design) during the analysis their irreplaceability was always highest. Also their surroundings were resulted with high irreplaceability.

The irreplaceability was separated to 5 classes from 0 to 1000. The areas can be defined as core zones or no-take zones where the irreplaceability values higher than 800. Classification can be completed by identifying the zones where the irreplaceability is lower than 800. The protection regulation and size can be negotiated but most strict regulations should be given to the areas with highest irreplaceability.

The ideal solution recommended by this study was shown in figure 3.37(a & b). The results propose a reserve network composed of three segments. Two segments are located at Kızılliman and west Anamur where the highest strict regulations needed to be placed. The other segment is located between Akkuyu and Ovacık (figure 3.37) which is more flexible for consideration of different zonation plans. Although the area close to Ovacık seems to have higher irreplaceability, the core zone should preferably created around Akkuyu Peninsula where the human activities are more negligible.

CONCLUSION

Main issue of this study was to select priority areas for the marine conservation planning on western coasts of Mersin while optimizing the borders of existing marine protected area (Kızılliman MPA). The challenge was to employ a systematic methodology which includes socioeconomic criteria together with the biological information. As it was quite difficult to assess all the biodiversity components of the area, surrogates were used for a general coverage of the biodiversity which is in relation with selected factors. In this study the surrogates, were coastal habitat types, certain fish species and certain endangered species habitats which were assumed to be representative for the general biodiversity.

The framework was constructed to place two predefined critical zones at core of reserve system, which are most effective whelping sites of the Mediterranean monk seals in Turkish seas. With the aid of GIS and Marxan this aim was achieved by including the rest of the available biologic and socioeconomic information where the size and borders were optimized. Additionally a new zone located at neighborhoods of Akkuyu and Ovacık was identified as priority area. Finally two kinds of results were generated: best solution and irreplaceability. While decision of locating the protected areas was accomplished by best solutions, the irreplaceability values were essential for classifying the importance of the zonation and identifying the hotspots.

Consequently a reserve system was selected consisting of three regions. The regions were located at Anamur, Bozyazı and Ovacık. Moreover Akkuyu region where the nuclear power plant construction is on focus , found to be located in one of the core area of the reserve system assessed by this study. This result shows that a need for reassessment for the location of power plant need to be done, considering the possible negative effects of the nuclear power plants, over ecosystems.

The benefits of using the geographical information systems in marine applications including marine conservation planning have already been proved. With this study the

available data was converted to spatially usable geographic data and group of maps consisting of layers. The final geo-database was one of the most important outcomes of the study. Marxan which is recently developed software for reserve designation was used in conjunction with GIS. The efficiency of the software was tested using several different scenarios. However there are debates for the use of these kinds of software in site selection, the results of this study was proved that this methodological concept provided by Marxan was crucial for selecting the optimal areas by incorporating socioeconomic, habitats and species data.

This study could be improved by additional information such as benthic habitat types, a more detailed map of the sea grass, and fine-scale species information including fish and invertebrates, cetacean colonies and wintering areas of marine turtles. Also the boundaries of the study area could be enlarged for a more adequate conservation planning along the Turkish coasts.

Although the quality of the data used in this study may be subject to criticism in general, the provided methodological framework is the strength of the study considering the urgent need of systematic conservation planning in Turkish coasts. Consequently this study was an initial attempt for systematic site selection for conservation planning by incorporating all available information. It is hoped that results of this study will guide further studies for selecting priority areas along Turkish coasts.

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APPENDICES

Appendix 1: Fishes species and their frequencies in the trawl surveys.

Species	# of fish	Species	# of fish
<i>Pagellus erythrinus</i>	70	<i>Diplodus sargus</i>	21
<i>Bothus podas podas</i>	64	<i>Dasyatis pastinaca</i>	19
<i>Serranus cabrilla</i>	61	<i>Lagocephalus spadiceus</i>	19
<i>Stephanolepis diaspros</i>	61	<i>Scorpaena scrofa</i>	19
<i>Trigla lyra</i>	54	<i>Sparisoma cretense</i>	17
<i>Saurida undosquamis</i>	53	<i>Microchirus ocellatus</i>	16
<i>Mullus surmuletus</i>	47	<i>Pagellus acarne</i>	16
<i>Diplodus annularis</i>	43	<i>Arnoglossus imperialis</i>	15
<i>Mullus barbatus</i>	43	<i>Serranus scriba</i>	15
<i>Spicara flexuosa</i>	41	<i>Trachinus draco</i>	15
<i>Pagrus pagrus</i>	40	<i>Upeneus pori</i>	15
<i>Citharus linguatula</i>	37	<i>Caranx rhonchus</i>	14
<i>Zeus faber</i>	36	<i>Fistularia commersonii</i>	14
<i>Arnoglossus laterna</i>	33	<i>Callionymus filamentosus</i>	13
<i>Siganus rivulatus</i>	33	<i>Gymnura altevela</i>	12
<i>Upeneus moluccensis</i>	31	<i>Lithognathus mormyrus</i>	12
<i>Uranoscopus scaber</i>	31	<i>Siganus luridus</i>	12
<i>Raja radula</i>	30	<i>Blennius ocellaris</i>	11
<i>Spicara smaris</i>	29	<i>Monochirus hispidus</i>	11
<i>Boops boops</i>	27	<i>Pagrus ehrenbergi</i>	11
<i>Synodus saurus</i>	27	<i>Pteragogus pelycus</i>	11
<i>Trigla lucerna</i>	27	<i>Serranus hepatus</i>	11
<i>Diplodus vulgaris</i>	26	<i>Symphodus tinca</i>	11
<i>Lagocephalus suezensis</i>	25	<i>Coris julis</i>	10
<i>Upeneus assymmetricus</i>	23	<i>Epinephelus aeneus</i>	10

<i>Fistularia tabacaria</i>	10	<i>Dactylopterus volitans</i>	8
<i>Leiognathus klunzingeri</i>	10	<i>Sparus aurata</i>	8
<i>Scorpaena notata</i>	9	<i>Spicara maena</i>	8
<i>Scorpaena porcus</i>	9	<i>Syngnathus sp.</i>	8
<i>Symphodus mediterraneus</i>	9	<i>Cynoglossus sinusarabici</i>	7
<i>Gobius niger jozo</i>	7	<i>Merluccius merluccius</i>	2
<i>Blennius gattorugine</i>	6	<i>Mustelus mustelus</i>	2
<i>Conger conger</i>	6	<i>Myliobatis aquila</i>	2
<i>Dentex dentex</i>	6	<i>Oblada melanura</i>	2
<i>Pomadasys incisus</i>	6	<i>Pagrus auriga</i>	2
<i>Raja miraletus</i>	6	<i>Sardinella aurita</i>	2
<i>Trachinus araneus</i>	6	<i>Symphodus cinereus</i>	2
<i>Balistes carolinensis</i>	4	<i>Symphodus ocellatus</i>	2
<i>Engraulis encrasicolus</i>	4	<i>Cepola macrophthalma</i>	1
<i>Lagocephalus sceleratus</i>	4	<i>Echelus myrus</i>	1
<i>Lepidotrigla cavillone</i>	4	<i>Macrohamphosus scol.</i>	1
<i>Muraena helena</i>	4	<i>Microchirus varigatus</i>	1
<i>Symphodus rostratus</i>	4	<i>Oxyurichthys papuensis</i>	1
<i>Trachurus trachurus</i>	4	<i>Oxyurichthys petersi</i>	1
<i>Apogon nigripinnis</i>	3	<i>Pagellus bogavera</i>	1
<i>Aterina sp.</i>	3	<i>Penaeus semisulcatus</i>	1
<i>Epinephelus alexandrinus</i>	3	<i>Remora remora</i>	1
<i>Rhinobatus rhinobatus</i>	3	<i>Sardina pilchardus</i>	1
<i>Solea vulgaris</i>	3	<i>Sardinella aurita</i>	1
<i>Spondyiosoma cantharus</i>	3	<i>Sardinella madarensis</i>	1
<i>Apogon imberbis</i>	2	<i>Scomber japonicus</i>	1
<i>Ariosoma balearicus</i>	2	<i>Seriola dumerili</i>	1
<i>Chromis chromis</i>	2	<i>Solea lascaris</i>	1
<i>Clupeid</i>	2	<i>Torpedo marmorata</i>	1
<i>Gobius sp.</i>	2	<i>Triglaporus lastoviza</i>	1