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ABSTRACT

PAST, PRESENT STATUS AND FUTURE OF THE
MEDITERRANEAN MONK SEAL (*Monachus monachus*, Hermann 1779)
IN THE NORTHEASTERN MEDITERRANEAN

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Status and distribution of the Mediterranean monk seal in the northeastern Mediterranean were studied between October 2003 and December 2005. In total, 7 research cruises and 8 research visits were carried out to the region in the study period. The study was generally focused on two regions. First region was mainly around the Cilicia basin in the northeastern Mediterranean where a known Mediterranean monk seal colony (the Cilician colony) inhabits. Second region was around the Gulf of İskenderun where the population status of the monk seals was unknown.

In the northeastern Mediterranean, all monk seal caves especially those used for breeding have been checked for whelping and monitored during the study period. In total, 7 pups were found including one death pup in the study period. Observations of the breeding behavior of the species indicated that, whelping also takes place in 2 new caves in addition to the 39 caves already reported for the study area in the earlier studies. Increase in the number of breeding caves showed that the breeding sites of the species has been expanded within the last 5 years. The Cilician colony size was estimated as 30 individuals in 2005. Identification catalog for each individual in the Cilician colony was prepared. Finally, population viability analysis (PVA) for the Cilician monk seal colony was carried out by evaluating the vital parameters of the species, which have been collected since 1994. This analysis was carried out for both pre-conservation phase and the post-conservation phase. In post conservation phase, the survival and fecundity rate of the Cilician colony was found as 0.976 and 0.169 respectively whereas these values were estimated as 0.902 and 0.200 respectively in pre-conservation phase. It was found that there is a 26.9% risk that the monk seal colony abundance will fall below the existing level (30 individuals) at least once during the next 20 years and there is also 0.2% risk that the monk seal colony abundance will fall below 12 at least once during the next 20 years. The risk was found as 21.7% by evaluating the status of the colony in pre-conservation phase. It was the first PVA study for this species, in which all the parameters used in the analysis were based on the study population, instead of the congeneric Hawaiian Monk Seal.

Prior to this study, although monk seals have been frequently sighted by local people in the region, status of the Mediterranean monk seals and presence of the suitable habitats for the species in the Gulf of İskenderun was unknown. Therefore, population status of the Mediterranean monk seal in the Gulf of İskenderun and suitable habitats were investigated. In total, 30 caves were discovered and 7 of them were classified suitable for the Mediterranean monk seal. In addition, a monk seal information network was established in the region in order to gain information about the species especially when the individuals are sighted (alive, injured or death). In total, 51 sighting reports were obtained from local people via the Mediterranean monk seal information network during the study period.

Since there are sampling difficulties due to critical status of the Mediterranean monk seal, alternative sampling techniques were investigated in order to find answers to questions related to the monk seal colony inhabiting in the northeastern Mediterranean. For identification of the individuals, comparison of the individuals and monitoring the individuals, 3D model construction technique from photographs was tested as an alternative photoidentification technique for the Mediterranean monk seal. It was found that at least 100 reference points were needed to construct the 3D model of the monk seal.

Keywords: the Mediterranean Monk Seal, the Northeastern Mediterranean, Photo-identification, Population Viability Analysis (PVA).

ÖZ

AKDENİZ FOKU’NUN (*Monachus monachus*, Hermann 1779)

KUZEYDOĞU AKDENİZ’DEKİ GEÇMİŞİ, BUGÜNKÜ DURUMU VE GELECEĞİ

OK, Meltem
Yüksek Lisans Tezi, Deniz Biyolojisi ve Balıkçılık Bölümü
Tez yöneticisi: Doç. Dr. Ali Cemal GÜCÜ
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Bu çalışmada Kuzeydoğu Akdeniz’de yaşayan Akdeniz foklarının günümüz statüsü ve dağılımı Ekim 2003 ile Aralık 2005 tarihleri arasında araştırılmıştır. Çalışma süresince bölgede toplam 2 araştırma seferi ve 8 araştırma gezisi gerçekleştirilmiştir. Çalışma genel olarak bölgede bilinen tek Akdeniz foku kolonisini barındıran Kilikya baseni ile Akdeniz foku’nun bölgede statüsünün bilinmediği İskenderun körfezi olmak üzere iki ana bölgede yoğunlaşmıştır.

Çalışma süresince Kilikya baseninde bulunan tüm Akdeniz foku mağaraları, özellikle üreme amacıyla kullanılanlar, kontrol ve takip edilmiştir. Çalışma süresi boyunca biri ölü bulunan toplam 7 yavru dünyaya gelmiştir. Üreme davranışı üzerine yapılan gözlemler, doğumun ayrıca geçmiş çalışmalarda Kilikya kıyıları için rapor edilen 39 mağaraya ek olarak 2 yeni mağarada daha gerçekleştiğini göstermiştir. Üreme mağaralarının sayısındaki artış türün üreme alanlarının 5 yıl içerisinde genişlediğini göstermektedir. Kiliya kolonisinin 2005 yılı itibariyle 30 bireyden oluştuğu tahmin edilmektedir. Çalışmada Kilikya kolonisinde bulunan her bir birey için tanımlama kataloğu hazırlanmıştır. Ayrıca, 1994 yılından beri toplanan yaşam parametreleri değerlendirilerek Kilikya baseninde yaşayan Akdeniz fokları için populasyon yaşam analizi (PVA) yapılmıştır. Bu analiz koruma öncesi ve koruma sonrası olarak 2 dönem için ayrı ayrı yapılmıştır. Koruma sonrası dönem içinde Kilikya kolonisinin yaşam payı 0.976, doğurganlığı ise 0.169 olarak, koruma öncesi dönem için ise 0.902 ve 0.200 olarak hesaplanmıştır. Kilikya kolonisindeki

birey sayısının gelecek 20 yıl içinde en az bir kere mevcut sayının (30 birey) altına düşme riski %26.9, 12 bireyin altına düşme riski %0.2 olarak bulunmuştur. Bu risk koloninin koruma öncesi durumu değerlendirilerek ele alındığında %21.7 olarak bulunmuştur. Bu PVA çalışmasında, tür üzerine yapılan benzer PVA çalışmalarından farklı olarak, türün Havai keşiş foku gibi hemcinslerinin yaşamsal parametreleri kullanılmamıştır. Sadece Akdeniz foku Kilikya kolonisi üzerinde yapılan çalışmalar sonucunda elde edilen verilerden hesaplanan yaşamsal parametreler kullanılmıştır.

İskenderun körfezinde yöre insanı tarafından sıklıkla gözlemlenmesine rağmen Akdeniz foku'nun statüsü ve uygun habitatlarının var olup olmadığı bilinmemekteydi. Bu nedenle çalışmada, türün populasyon statüsü ve tür için uygun habitatların var olup olmadığı araştırılmıştır. 7'si Akdeniz foku için uygun olmak üzere toplam 30 mağara bulunmuştur. Ayrıca bölgede tür hakkında bilgi elde etmek ve özellikle birey gözlemlendiği zaman (canlı, yaralı veya ölü) bu bilginin en kısa zamanda ilgili yerlere ulaşmasını sağlamak amacıyla Akdeniz foku bilgi ağı kurulmuştur. Çalışma süresince toplam 51 Akdeniz foku gözlemi bu bilgi ağı sayesinde bölgede yaşayan insanlar tarafından rapor edilmiştir.

Sahip olduğu kritik statü gereği Akdeniz fokları üzerinde sınırlı sayıda örnekleme metodu kullanılabildiği için alternatif örnekleme teknikleri Kuzeydoğu Akdeniz'de yaşayan Akdeniz fokları ile ilgili sorulara cevap bulmak için araştırılmıştır. Bireylerin tanımlanması, karşılaştırılması ve izlenmesi için fotoğraflardan 3 boyutlu model oluşturma tekniği Akdeniz fokları icin alternatif foto-tanımlama tekniği olarak test edilmiştir. 3 boyutlu Akdeniz foku modeli oluşturmak için en az 100 referans noktasına ihtiyaç olduğu bulunmuştur.

Anahtar kelimeler: Akdeniz foku, Kuzeydoğu Akdeniz, Foto-tanımlama, Populasyon yaşam analizi (PVA).

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1. INTRODUCTION

1.1 The Mediterranean Monk Seal

The Mediterranean monk seal, *Monachus monachus* (Hermann, 1779) is one of the rarest and most threatened species in the world. It is also Europe's most endangered marine mammal (Johnson and Lavigne 1998). The Species Survival Commission of the World Conservation Union (IUCN, 1996) has assessed the species as ‘‘Critically Endangered’’ since 1996. Today, Mediterranean monk seal is protected by Bonn (Appendix I and II), Bern (Appendix II), CITES (Appendix I), Barcelona (Fourth protocol species), and Biodiversity (Eligible species) Conventions.

Monk seals are the only phocid seals living in sub-tropical waters (Reijnders et al., 1997) and they are the most primitives of the seals alive today. Of the three species that have survived into the recent era, the Caribbean monk seal, *Monachus tropicalis* (Gray, 1850) is believed to be extinct although Boyd and Stanfield (1998) carried out the study based on interviews with fishermen and they concluded that it is possible that the species is not extinct in the West Indies, and the other two, *Monachus schauinslandi* Matschie, 1905 and *Monachus monachus* (Hermann, 1779) have very small populations (Dosi, 2000).

Adult Mediterranean monk seal males and females are at maximum 260 cm long, and at least 300 kg weight. Females are slightly lighter than males. At birth pups are 80-110 cm long and 15-20 kg weight. They have a black woolly coat with a white or yellow patch on the belly. Adult monk seal can be any colour from dark-brown to light-grey. Pelage is usually dorsally dark and ventrally light (Marchessaux 1989; Rejinders et al., 1993). Females reach sexual maturity probably at around 5-6 years of age, though age of an ovulating female was estimated as 4 years old. Gestation lasts approximately 11 months (Pastor and Aguilar, 2003). Duration of the breeding season extends over a long period at least from April to December and the duration of lactation is in between 6 and 8 weeks. Although formerly the Mediterranean monk seals used to be observed to haul out on beaches, because of persecution of the species and the destruction and disturbance of its habitat, the haul out usually occurs in caves in recent decades (Rejinders et al., 1997; Johnson and Lavigne, 1999a). They use the caves also for resting or sheltering.

The original distribution range of *M. monachus* extended through the whole Mediterranean basin including the Black Sea up to Odessa, the Atlantic coast, the Canaries and Madeira (Panou et al., 1993). During the 20th century population has declined dramatically, in part due to exploitation for pelts, skins, and oil. At the turn of this century, the Mediterranean monk seal was already a rare species (Panou et al., 1993). Today, the species has disappeared from most of its original range and can be found only in small isolated subpopulations in the Turkish and Greek coast, the Mediterranean coast of Morocco and western Algeria, the Desertas Islands in the Madeira archipelago and the Sahara coast (Israëls, 1992). Although there are no reliable figures available for the total number that survive today, it is commonly accepted that their worldwide population is not greater than 500 individuals (González, 2004).

1.2 General Distribution of the Mediterranean Monk Seal in the World

Considering the overall distribution of the species around the world, the remaining individuals are found in remote and undisturbed areas around the Mediterranean Sea and northwest African coast. In other words, there are two isolated monk seal population today; Atlantic and Mediterranean populations. The most important populations are located in Greece, Mauritania / Western Sahara, Turkey, the Portuguese Desertas Islands (Madeira), while small numbers are also present in Algeria, Morocco, Libya, Cyprus and Croatia (Figure 1).

Monk seal population in Greece is the largest population located in the Eastern Mediterranean with an estimated size of 200-250 individuals. According to MOM (Hellenic Society for the Study and Protection of The Monk Seal), 16 monk seal births have been recorded during the 2003-2004 breeding season in the three main study areas (González, 2004).

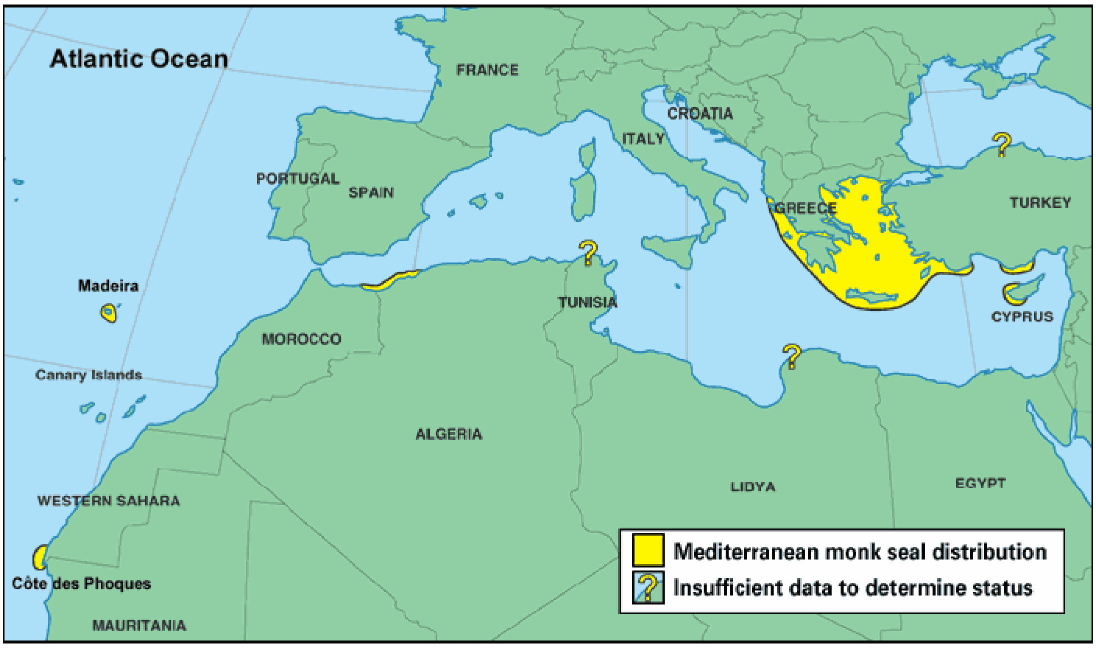

Figure 1. General distribution of the Mediterranean monk seals in the world (By Lavigne and Johnson, 2001).

The Mauritania-Western Sahara colony experienced a dramatic mass mortality caused by a virus epidemic or biotoxin (Costas and Lopez-Rodas, 1998; Harwood, 1998) that struck the world's largest surviving monk seal colony in 1997. One hundred and three individuals were estimated to survive (mean estimate: 95% CI: 77 – 148, Forcada, Hammond and Aguilar 1999), down from 300. Recent estimate of monk seal colony size in the area is suggest not more than 150 individuals (González, 2004).

In Turkey, former distribution of the species extends from the Black Sea including the Marmara Sea and the Aegean Sea to the Mediterranean coast (Berkes et al., 1978; Sergeant et al., 1978; Mursaloğlu, 1984; Marchessaux, 1987, Reijnders et al., 1997; Kıraç and Savaş 1996). Today, the distributions is limited to the Aegean and the northeastern Mediterranean Coast; and the Mediterranean monk seal is assumed to be extinct in Black Sea (Kıraç, 2001; González, 2004), although Güçlüsoy et al. (2004) indicated the existence of the last few individuals on the central Black Sea coast, and southern Sea of Marmara coast. Although recent estimate of total population of monk seal along Turkish coast has been given as 50 individual (Johnson, 2003; González, 2004), latest studies (Gücü et al., 2004) show signs of increase of population at certain sites. Reasons of this promising increasing tendency in the population size will be mentioned in the following chapters.

By the mid-20th century, in the Portuguese Desertas Islands (Madeira), mainly due to fishing pressures and human disturbance, seals were facing extinction. Nevertheless their decline was eventually reversed following implementation of the recovery plan in 1988, which established of the Desertas Islands Nature Reserve. From a population of just 6-8 seals, the numbers at the Desertas have since increased to 23 individuals (Pires and Neves 2000).

Though the population estimate of the species in Algeria is about 10-20 individual, 5-10 individuals in Morocco and 5-10 individuals in Libya (González, 2004), there is a significant information gap on the conservation status of the species along these countries (Aguilar 1998).

In Cyprus, despite habitat suitability for monk seals, there are very few and irregular sightings and no evidence of whelping of monk seals (Gücü et al., 1995). Haigh (2004) showed that there was an evidence of monk seal existence (this was by scent), found 14 caves and inspected 4 of them for suitability. In addition, data on the species have been inadequate in past reports of animal sightings, which have diminished in recent years leading to the hypothesis that the species may have become extinct (Dendrinos, P. and Demetropoulos, A., 2000). Today, approximately 5 Mediterranean monk seal individuals are believed to inhabit in Cyprus (González, 2004).

Although there have been several sightings recently reported from the Adriatic coasts and islands of Croatia (Antolovic, 1998), the species is thought to have become extinct in these areas (Johnson and Lavigne, 1999b; Lavigne and Johnson 2001).

1.2.1 General Distribution of the Monk Seal in the Northeastern Mediterranean

The species is extinct entirely in Egypt, Israel, Lebanon (Panou et al., 1993) and Serbia and Montenegro, Slovenia, Albania (González, 2004). In Syria, the Mediterranean monk seal presence has never been verified along Syrian shores and there is a large information gap both as to the species' historical and more recent occurrence. However, preliminary information has shown that some monk seal observations are reported by local communities along the country's northern shores down to Lattakia and Banyas (Mo et al., 2003). In Cyprus Island, the data on the species have been largely limited to past reports of animal sightings. On the other hand, the research results carried out on the southern (Dendrinos and Demetropoulos 2000) and the northeastern Cyprus (Gücü et al., 1995) represented very similar results that despite the habitat suitability, there has been very few and irregular sightings and no evidence of whelping. The Mediterranean monk seal still exist in the northeastern Mediterranean coast of Turkey.

1.3 The Northeastern Mediterranean Colony Size

Determination of the population or colony size of the Mediterranean monk seals is certainly the main step for understanding the biology and behavior of the monk seal, monitoring the current status and finally regulation of conservation measures of the species. However, considering the total number of monk seals throughout the world that continue stable around 500 individuals (González, 2004), studies targeting the determination of the colony size of the monk seals in the area is not an easy one.

As was underlined above, the monk seal colony in the northeastern Mediterranean is confined to Turkish coast and, to a minor extent, down to Cyprus and Syria. There is no evidence of a resident monk seal colony on the Cyprus coast. In Syria, although some scientists mention the existence of seals in their territorial waters (Mo et al., 2003; Amir Ibrahim, pers. comm.), their belief has never been proofed and published.

On the Turkish coast, after the first published record and taxonomic identification made by Mursaloğlu (1964) and questionnaire studies carried out by Ronald and Healey (1974), the Mediterranean monk seal population census was made by Berkes in 1976-1978 and the size of the colony was estimated between 150-300. Around the same years, Boulva estimated the colony size as 50-60 (Boulva 1975). Berkes (1982) also carried out the study on southwest coast of Turkey and estimated 50-100 seals within the area. From 1987 to 1991, Özturk was carried out a country wide study identifying 20-50 seals and reported a dramatic decline in the number of seals inhabiting the Turkish coast (Öztürk, 1992; Öztürk, 2001). Right after, Güçlüsoy and Savaş carried out the research project in 1993 targeting the Aegean population of the Mediterranean monk seal and they indicated that there was a small population consisting of 9 individuals (Güçlüsoy and Savaş, 1997).

During various studies carried out by Middle East Technical University, Institute of Marine Sciences, in total, 25 individuals were identified throughout the coastline from Antalya-Gazipasa to Mersin-Erdemli (Gücü et al., 2004). The group of individuals identified in this area is named as Cilicia colony by the authors.

1.4 Threats

Populations of the Mediterranean monk seal have declined dramatically and survive in subpopulations scattered throughout their original distribution (Karamanlidis et al., 2004a). Threats to its survival were clearly identified at the First International Conference on the species held in Rhodes, Greece in 1978 (Ronald and Duguy, 1979; Texel, 1990; Johnson and Lavigne, 1998). These are increased mortality of the species due to deliberate killing (generally by fishers), incidental entanglement in fishing gear, human disturbance (activities such as tourism, fisheries, and shipping), increased pup mortality caused by pupping in inappropriate locations due to loss of preferred habitat, poor conditions due to lack of food due to overfishing, reduced fecundity and pup survival probably caused by inbreeding depression.

The major threats for the Mediterranean monk seal in the eastern Mediterranean were also listed by Yediler and Gücü, (1997) as:

- Habitat loss,
- Impact of tourism,
- Overfishing,
- Incidental catches,
- Industrial, agricultural, and domestic wastes,
- Plastics,
- Heavy sea traffic,
- Diseases.

The authors underlined further that the destruction of the seal habitats (including caves) due to for example to fast development and intensive urbanization of the coastal strip. Further within the study area, in the coastal strip between Erdemli and Tasucu, nearly all caves have been abandoned due to increased human activities which were used before.

Impact of mass tourism is another threat facing the seals of the region. Over the years, tourism has severely developed throughout the Mediterranean coast. Many factors related to tourism imposed harmful effects on monk seal population. The most dramatic examples are the altered breeding habitat of the species. Today breeding takes place in caves, whereas as suggested by Sergeant et al. (1978), original breeding habitat was not caves, but was the beaches. Moreover, due to the great sensitivity of pregnant monk seals, abortion may be caused or mother-pup bond may be weakened by human disturbance (Mursaloğlu, 1986).

Depletion of the fish stocks due to overfishing is another threat for monk seal existence. According to Gücü and Bingel (1994), the fish stock only food source of the monk seal, started to decline because of the increasing fishing power. Moreover, illegal fishing, such as usage of explosives, and trawling within the banned 3 miles zone, is another factor undermining fish stocks. Consequently, as the food structure, carrying capacity of the Cilician fisheries ecosystem and the amount of fish removed by the fishing fleet are taken into account, existence of a large apex predator population, such as monk seal, in the region is getting improbable (Gücü, 1995).

As a side effect of the increased fishing pressure in the region, the monk seals, other marine mammals and other marine animals such as marine turtles become entangled in nets so incidental catches is certainly another threat for the monk seals. Considering heavy fishing activities in the area, however, incidental capture is particularly dangerous for the pups because of weakness and lack of swimming experience (Gücü et al., 2004).

Industrial, agricultural, and domestic wastes may be given as the last, but not the least threat. In marine environment the persistent substances such as heavy metals passed from one organism to another in cumulative steps. Although few investigations have been made into the accumulation behavior of such compounds in the Mediterranean monk seal (Yediler et al., 1993), the area is highly industrialized.

Therefore; that substance may be a crucial factor influencing reproductive success of the monk seal population.

Besides, according the previous studies carried out in the area (Bingel et al., 1987), solid pollutants such as plastics were observed basin-wide, moreover they are accumulated due to the permanent anticyclonic eddy formed in the northeastern Levant Sea, a huge amount of debris was washed up along the coast and filled the caves where nearly all phases of monks seal production take place. In addition, synthetic fishing nets discarded by fishermen, plastic bottles, bags etc., which were frequently observed in the study area, can entangle or be ingested by monk seals.

No evidence has been found indicating disease outbreak in the study area. On the other hand, in the early 1990's an enormous number of the marine mammals, mainly dolphins died in the western Mediterranean because of morbillivirus infection (Scoullos et al., 1994). With the five dead monk seals found in the western Mediterranean at the same period, even tough actual cause of death could not be pointed out, the morbillivirus disease came up as a potential threat for the Mediterranean monk seal population. Moreover, the mass die-off occurred among the Mediterranean monk seal on the north coast of the Cap Blanc peninsula during May 1997. This mortality phenomenon was effected 47% of the total population. Cause of mortality was based on two hypotheses as follows: the biotoxin hypothesis and the epidemic hypothesis caused by a viral infection (Jiddou et al., 1997).

1.5 Current Conservation attempts

The Mediterranean monk seal has been protected in Turkey by national and international laws since 1977. In addition to these laws, National Mediterranean Monk Seal Committee (UFK) was founded in 1991 with the coordination of Turkish Ministry of Environment in order to harmonize and ensure the implementation of the laws related with the species. After the decision taken by the National Mediterranean Monk Seal committee, two local monk seal committees were established in Foca (1992) and in Yalikavak (1993). Lately, the sub committee composed of Ministry of Environment, Ministry of Agriculture, SAD-AFAG (Underwater Research Society-Monk Seal Research Group), Istanbul University Faculty of Fisheries and Middle

East Technical University Institute of Marine Sciences was constituted by the National Mediterranean Monk Seal committee.

Conservation targeting monk seals and their habitat protection has been actively applied in the northeastern Mediterranean. In the northeastern Mediterranean, according to scientific research carried out by Middle East Technical University, Institute of Marine Sciences the most significant threat, which is mentioned above for monk seals survival, was proved to be over-exploitation, and thus, reduction of the fish stocks (Gücü et al., 2004). Therefore, a large area (16x12 nautical miles) was prohibited to large-scale fishery by Turkish Ministry of Agriculture and Rural Affairs since 1999. Moreover, a network of small no-fish-zones was set in front of the breeding caves. The Turkish Ministry of Culture has also set aside a coastal stretch exceeding 75 km, which practically covers all important seal habitats, for the protection of the species.

Because the most crowded population in the northeastern Mediterranean is sheltered in, the Kızılliman Marine Protected Area has a crucial importance for the monk seals in the region. Therefore, establishment of the Kızılliman Marine Protected Area played a key role for the conservation attempts of the species. It was not only important for the Mediterranean monk seal, but also for the entire ecosystem that has assumed to be recover since its establishment.

1.6 Photo-identification and 3D Modeling

Rarity, vulnerability and critical status of the monk seal, has always been the main factors limiting the number of scientific studies on the Mediterranean monk seal. The standard sampling methods that are commonly applied to other animals are not practical for the Mediterranean monk seals. For example, simply to measure the body length or weight of a specimen, one can not catch such a precious and large sample due to the risk of injury or even death risk during handling. Likewise, estimating the size of a colony is of great difficulties due to again the rarity of the species. Therefore various alternative techniques must have been developed. One of the widely used methods is to observe them from far but sometimes this is not effective to obtain required data, especially when dealing with extremely small colonies. Another method is to use photo-identification of monk seals. It was effectively used on monk seals by Hiby and Jeffery (1987), Scoullos et al. (1994), Forcada and Aguilar (2000) and Gücü et al. (2004). It was also used in sea lions by Waite and Horning (2000). According to Waite and Horning (2000), the use of photogrammetry allows researchers to measure sea lion without having capture, anesthetize, or handle them. This eliminates many of the hazards and difficulties associated with handling animals.

Generally, photo identification is a method to identify the objects from photographs. One technique of the photo identification is to extract precise measurements and accurate 3D models from 2D images. This technique follows several steps. Firstly, the pictures taken by using digital camera are loaded into the modeling program. Shooting two or more overlapping photos simultaneously from different angles is necessary for accuracy. Secondly, some reference features on the pictures are marked to overlap the different pictures to each other. Then the modeling program forms an accurate model of a desired object (the Mediterranean monk seal in this study) from these pictures. This model can be exported as XYZ data or as a graphic file to use in CAD (Computer Aided Design) a program, which is a method of creating designs and blueprints using a computer, animation.

As it mentioned above, as a photo identification technique, PhotoModeler was used in one of the studies carried out in Texas A&M University at Galveston for assessing morphometrics and estimating body mass of Steller sea lions (*Eumetopias jubatus* Schreber, 1776). Researchers generated three-dimensional computer models of twenty Steller sea lions of various age classes from multiple time-synchronous digital photos. According to them, preliminary results from this technique are very promising. For instance, the photogrammetrically measured standard lengths are on average within ±1.7% of physically measured standard lengths. Using three-dimensional photogrammetry to remotely measure morphometrics on Steller sea lions is an accurate and relatively simple technique. This technique can be used to monitor large numbers of animals on a regular basis to analyze growth trends and body condition without the need for dangerous, multiple recaptures or excessive stress-causing disturbances (Waite and Horning 2000).

In photo identification technique, one of the methods to identify, catalogue, compare the individuals is to use automatic cameras to take high resolution photographs of seals as they enter and leave the caves used as refuge or for pupping.

Cameras suitable for this kind of monitoring were developed in the mid-1980 and used in a few monk seal caves in the Ionian Sea (Hiby and Jeffery, 1987, Scoullos et al., 1994), in Foça (the Aegean Sea) (Mo et al., 2001) and in the northeastern Mediterranean (Gücü et al., 2004).

1.7 Population Viability Analysis (PVA)

Population viability analysis is a method or collection of methods for evaluating the threats faced by population of species, their extinction or decline, and their expected chances for recovery, based on species-specific data and models (Akçakaya and Sjogren-Gulve 2000). Generally, demographic and habitat data are used by PVA models to predict such measures. Compared to other alternatives for making conservation decisions, PVAs provides a rigorous methodology that can incorporate different types of data, uncertainties and natural variation, and provide outputs or predictions that are relevant to conservation goals (Akçakaya and Sjogren-Gulve 2000).

Population viability analysis (PVA) is used in conservation biology to predict extinction probabilities for threatened species. The process of assessing viability usually involves the use of mathematical models that are explored using computer simulation. There are several general software available for assessing the viability of population or collection of population; for example ALEX (Possingham and Davies 1995), GAPPS (Harris et al., 1986; Downer 1993), INMAT (Mills and Smouse 1994), RAMAS (Akçakaya and Ferson 1992; Ferson 1994, Akçakaya 1997), ULM (Ferrière, et al., 1996) or VORTEX (Lacy et al., 1995).

PVA seeks to improve chance of survival of the species and it is a probabilistic rather than a predictive tool. In PVA, factors that are most likely to limit the persistence of a species over time are focused (Noon et al., 2000).

Various studies have shown that small populations are more likely to go extinct than large ones (Sutherland, 2004). Small populations may also suffer from the Allee effect that refers a positive relation between population density and the per capita growth rate, the decline in survival rate or mean reproductive output at small populations due to a range of process such as increased predation, reduced ability to find mates, reduced hunting ability or reduced breeding success in small groups

(Courchamp et al., 1999, Stephens and Sutherland 1999; Stephens et al., 1999; Gücü and Erkan, 2005).

Population viability models can be also functional in determining conservation actions (Sutherland, W. J., 2004). Such models can be useful in convincing policy makers that extinction is real possibility (Lindenmayer et al., 1993).

1.7.1 Previous Population Viability Analysis Studies targeting the Mediterranean Monk Seal Populations

Up to now, population viability analyses targeting the Mediterranean monk seal are very scarce and carried out for eastern Atlantic population and Greek population of the species. For the eastern Atlantic populations, Population and Habitat Viability Assessment (PHVA) workshop was conducted in 2001 in Spain to develop more effective conservation strategies for populations of the Mediterranean monk seal in the eastern Atlantic. In this population viability analyses, VORTEX (Lacy 1993), a simulation software package written for population viability analysis was used to study the interaction of a number of Mediterranean monk seal life history and population parameters treated stochastically, to explore, which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected island-specific management scenarios in monk seals in the Eastern Atlantic (González et al., 2002a).

For Greek population of the Mediterranean monk seal, the Population and Habitat Viability Assessment (PHVA) Workshop held in Athens, Greece in 1994 to apply recently developed procedures to the Greek population of the Mediterranean monk seals. In the workshop, stochastic population simulation models were initialized with ranges of values for the key variables to estimate the viability of the wild population of monk seals using VORTEX software modeling package. Although the analysis provided very useful information for the colony in Greece including a set of recommendations for reducing of human-caused mortality, needed research and management of wild populations as well as sections on population history, population biology and simulation modeling was prepared, the main drawback of the study was the lack of field data reflecting the population characteristics of the colony in question. VORTEX requires estimation of a number of population parameters and current population size. Direct estimates of the values of these variables were not available for the Mediterranean monk seal in Greece (Scoullos and Seal, 1994). The Working Group therefore chose the values, which were valid for other regions i.e. eastern Atlantic and/or other relative species i.e. Hawaiian monk seal for illustrative purpose.

It was underlined that in the both Population Viability Analyses carried out in Greece and in the Eastern Atlantic Studies, that the researchers used some vital parameters of different species instead of the Mediterranean monk seal due to unavailability of the continuous data of monk seals.

1.8 Objectives of the study

Although the species inhabits and reproduces in the area, there are information gaps on monk seals in the region. Therefore, following tasks were determined as the objectives of this study to be fulfilled.

The objectives of this study are to:

i. Examine trends and current status of the Cilician monk seal colony as well as the positive and negative implications of conservation measures applied in the area on the colony's demography.

ii. Determine possible geographical extensions of the Cilician colony towards the suitable habitats in the Gulf of İskenderun, where the monk seal existence and status were unknown.

iii. Assess the current demography and the risk of decline of the colony and predict the possible demographic structure of the Cilician colony in the future by using Population Viability Analysis.

iv. Examine probability of movements or migration of the species in the region.

v. Determine the impact of human disturbance and some other threats of monk seal on conservation basis.

2. MATERIALS AND METHODS

Material and methods of this study are discussed in the following sections on 1) Study area, 2) Data collection 3) The Mediterranean Monk Seals in the Northeastern Mediterranean 4) Population Viability Analysis carried out for the Cilician Monk Seal Colony. Each of these sections (except "Study area") includes description of the data processing procedures applied in this study.

2.1 Study Area

The study area extends from Antalya-Gazipasa to Turkey-Syria border (Figure 2).

Figure 2. The study area extends from Antalya-Gazipasa to Turkey-Syria Border.

Topography of the Turkish Mediterranean coast is generally mountainous while it is flat and sandy from Mersin to İskenderun. Similarly, the region between Samandağ-Meydan village and the Turkey-Syria border, the topography is rugged with steep mountains plunging into the Mediterranean, with a cliff bound coastline and a rapid deepening in the offshore direction (Yediler and Gücü 1997).

In the Turkish Mediterranean, industrial activities and construction of secondary houses have been concentrated mainly around Mersin and the Gulf of İskenderun coast since the topography of the region allows settling on the coast. On the other hand, due to its difficult accessibility, the area from Gazipaşa to Tasucu has been considerably less populated than Mersin and the Gulf of İskenderun coast (Gücü 2005).

2.2 Data Collection

Methods were used for data collection included direct observation, field surveys, camera traps, and evaluation and quantification of human disturbance on the monk seal habitat.

2.2.1 Direct Observation

Direct observations of the Mediterranean monk seal have been carried out in two ways. These are active and passive observations, which will be explained in the following section. Monk seal observations directly obtained from field surveys recorded on the observation protocol and pup identification protocol (Appendices I), it was also made from the camera trap and via seal information network established among the local people in the region. Certain features of each sighted individual and pup were recorded on the seal observation protocol (Annex 3) and pup identification protocol (Annex 4).

2.2.2 Field Surveys

The field surveys of this study started in October 2003 and ended in December 2005 (Table 1). Throughout these surveys, coastline from Antalya-Gazipasa to Turkey-Syrian border was covered (Figure 3). The observations on the monk seal were made in three ways:

1) Active survey/observation: carried out both using the research vessel of the Institute while it was cruising and with an inflatable sea boat. In active survey, the related protocols (see Annex I, II, III, IV, V, VI and

VI) were filled and continuous observation by researcher was made in order to obtain monk seal observation while cruising.

2) Passive observation: conducted at a high point on land where presence of the monk seal is confirmed or previously reported. The related protocols were filled and continuous observation by researcher was made.

3) Cave survey: made by entering the cave provided that necessary precautions are taken not to disturb the seal or their habitat. Coastline from Antalya-Gazipasa to Turkey Syrian border was covered in order to determine suitable caves for use of the monk seal. When a cave is investigated, as much characteristic of the cave as possible were listed according to its number of entrances, number of platforms, direction of the entrances etc. The coordinates of the cave were recorded with GPS. Caves were classified into four categories according to Gücü et al. (2004); Active—caves in which one or more seals were sighted or there was evidence of seal use (e.g., tracks, body depressions, faeces), breeding—caves in which whelping occurred, abandoned—caves in which seals were historically observed, but were no longer in use, and potential—caves, which met the requirements and descriptions of a monk seal cave (IUCN/UNEP 1988), but lacked any sign of use.

Table 1. Details of the cruises carried out throughout the study.

Date of the Survey	**Covered Survey Area**	**Type of the survey**
16-24 October 2003	Adana-Karataş to Syria Border	Active
14-27 January 2004	Samandağ to Syria Border	Active
3-4 April 2004	Samandağ to Syria Border	Active/Passive
17-18 April 2004	Samandağ to Syria Border	Active/Passive
27-28 June 2004	Samandağ to Syria Border	Active/Passive
30-31 July 2004	Samandağ to Syria Border	Active/Passive
20 Sep-10 Oct 2004	Gazipaşa to Syria Border	Active
23 Nov-13 Dec 2004	Melleç to Syria Border	Active
05-11 May 2005	Erdemli-Anamur	Active
28-29 May 2005	Erdemli-Anamur	Passive
20-24 June 2005	Erdemli-Anamur	Passive
23-26 July 2005	Erdemli-Anamur	Passive
14-16 October 2005	Erdemli-Anamur	Passive
9-14 November 2005	Erdemli-Melleç	Active/Passive
21-24 December 2005	Erdemli-Anamur	Active/Passive

While making observation, 7 different protocols were used to record and process various aspects of the monk seal colony (see Annex I, II, III, IV, V, VI and VI).

1. Fishermen survey protocol: In order to determine number of fishermen and number of boats that use the fishing port, origin and age of the fishermen and their attitude towards the monk seal in the port, the fishermen survey protocol was prepared.
2. Field survey protocol: This protocol was prepared to record the usable data of each survey day such as weather and sea condition, number of discovered caves during the survey day with their latitude, longitude and distinctive remarks and finally starting and ending time of the survey.
3. Seal observation protocol: In order to record the features of observed individuals (adult, juvenile, youngster), seal observation protocol was prepared.
4. Pup identification protocol: In order to record the features of observed pup, pup observation protocol was prepared.
5. Human disturbance protocol: This protocol was prepared to quantify and compare the level of human disturbance at different sites and at different seasons.
6. Cave inventory protocol: This protocol was prepared to record information of newly discovered cave.
7. Seal sighting protocol: In order to record the sighting information coming from the fishermen, local people and various people, the seal sighting protocol was prepared (see Annex I, II, III, IV, V, VI and VI).

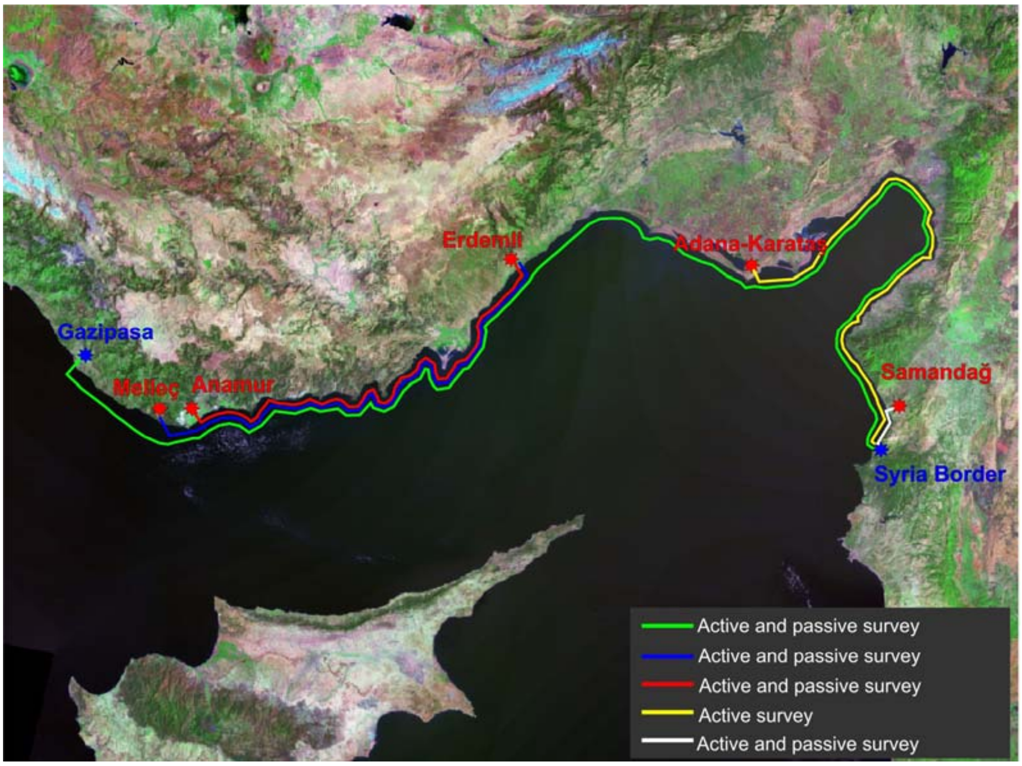

Figure 3. Coastline from Antalya-Gazipasa to Turkey-Syria border was covered during the study period.

2.2.3 Camera Traps

Within the framework of the monk seal research project in the Gulf of İskenderun, some of the caves in the northeastern Mediterranean, that are suitable for seal use was equipped with infrared monitors from January 2003 to December 2005. Vigil P-Box infrared monitoring system was used to observe the activities of the monk seals with in the caves. They were also installed to acquire suitable monk seal photographs for photomodeling of the species in this study.

These monitors detect up to 18 meter with a passive infrared motion detector that sense heat-in-motion with its conical beam. The system records seal movements inside a cave by date and time. Furthermore, a 35-mm digital camera (Olympus Camedia D-390) with a built-in flash is attached to the recording system. The receiver automatically activates the camera when an event occurs. This is essentially the same approach that had been successfully applied before by Gücü et al. (2004) to understand cave use pattern and for photo-identification of the seals in the Cilician colony. The only difference is the method used in the detection. Trailmaster is twopiece active infrared monitoring system which uses an invisible infrared beam across the trail between the transmitter and receiver. Each time the seal passes through the infrared beam, the event is recorded by date and time to the minute.

Installation of the camera traps, in other words in-cave monitors, was important step for the process of monk seal photo identification in this study. After determining the suitable monk seal cave for installation of the monitor, the right location where the animals spent most of the time in cave must be determined. It can be a wide resting platform, a sandy beach or even a cave entrance. Monitor should cover one of these locations to get appropriate photos. Besides, the place where the monitor installed should not be effected from the waves or bad weather conditions.

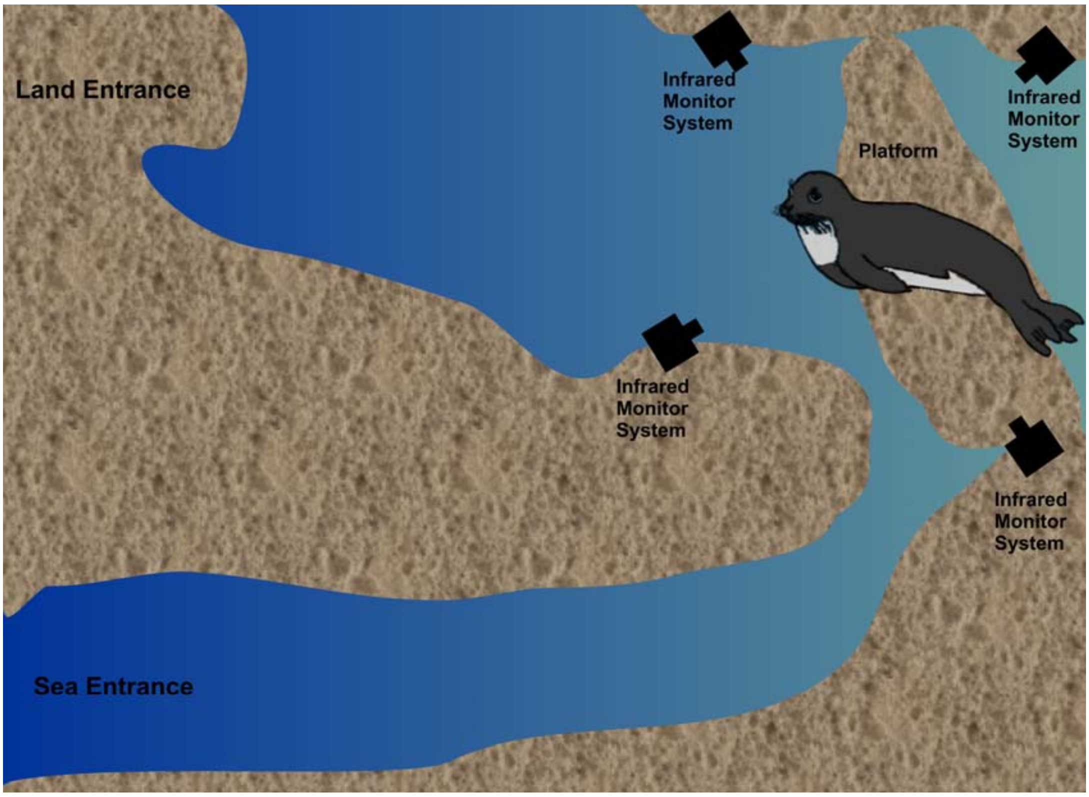

Figure 4. Schematic map of the cave and suitable location for the infrared camera system to obtain suitable photographs for photoidentification while the monks seal resting.

Schematic map of the suitable location and installation of the infrared monitor systems to a typical monk seal cave are shown in Figure 4. Because of the

3D model construction software requirements, four different camera systems were installed into the cave and were set to take photographs from four different angles.

In total, infrared monitoring systems and camera traps were successfully installed 7 times in to the 3 different caves located in the habitat of the Cilician colony; 5 times to the resting cave and 2 times to the breeding caves. Additionally, the system was also installed 2 times to one of the formerly abandoned but recently re-populated cave, which is located just between the Cilician colony in the northeastern Mediterranean and the group in the Gulf of İskenderun. The monitoring systems were also successfully installed 4 times into 2 suitable monk seal resting caves and 2 times to the breeding cave in the Gulf of İskenderun.

2.2.4 Evaluation and Quantification of Human Disturbance on the Monk Seal Habitat

All possible types of human activities were listed and classified in order to assess and quantify human disturbance on the monk seal habitat. These human activities are mainly classified as sport fishing (liners with and without boat), detrimental fishing (fishing by using dynamite, explosive or poison, spear fishing, trawl, purse seine, trap), artisanal fishing (fishing by using long line or gill net or other small scale fishing methods), leisure boats (carrying bathers, skin divers, hikers), diving/scuba (for training, regular diving or adventure diving), boat tours (yachting, daily tours, overnight charters, speed boats, sailboat or others), others (agriculture, sea traffic, life stock breeding).The origin of the disturbers and the age distribution of the people took part in the activity were also evaluated.

Moreover, the monk seal information network has been established in the study area. Thus, monk seal sightings reported from local people via this information network has allowed determining the most important habitats for monk seals and verified previously determined habitats. Furthermore, it was useful for monitoring the status of seals in the area.

2.3 Data Evaluation

In this chapter, 3D model construction method was tested as an alternative photoidentification technique on monk seals. Moreover, available data allowing investigation the demographic structure of the Cilician monk seal colony inhabiting in the northeastern Mediterranean in order to evaluate current status and future of the colony.

2.3.1 Photo-identification

2.3.1.1 Identification Catalogue of the Cilician Monk Seal Colony

All the individuals identified up until now (including those found before the study period) were re-evaluated in order to update the knowledge on the Cilician colony in the northeastern Mediterranean. The photographs, descriptions, video footages, drawings were complied out for each individual and identification sheet was prepared. The sheets were compiled in an identification catalogue. It included the basic characteristic of the individual such as name, age, sex, date of first sighting, category at first sight and present category, habitat information of the animal (for appendices II identification catalogue of photographed colony members).

2.3.1.2 3D Construction Programme

3D model construction technique is based on matching the points on a set of photographs of the same object taken from different angles.

A 3D model is a set of connected 3D points, which represent an object. Three dimensional points have coordinate values for each of the Cartesian axes (X, Y, and Z). The points in a 3D model can be connected by lines or by triangular patches, called surfaces. These connections help to visualize the three dimensions when the model is projected onto a flat surface such as a computer monitor or a printed page.

Following steps were carried out in process of the 3D model construction. These are:

1) Setting the approximate project size and data unit,

2) Defining the parameters of the camera used,

3) Importing the photographs,

4) Marking and referencing points,

5) Processing the project.

The most important step in the photo-modeling study is to choose sufficient and appropriate reference points that precisely describe the shape of an object. This is rather simple in the geometrically uniform objects, i.e. a minimum of 5 reference points are required to reconstruct a pyramid, and 8 points are needed for a cone shape. However this is particularly difficult when dealing with irregular objects. Therefore 10 cm long seal statue having true proportions of a monk seal was used to estimate the minimum number of reference points that is needed to reconstruct an object in a "seal form" with a reasonable accuracy. Vertical and lateral lines were drawn on the statue to ease determination of reference points (Figure 5).

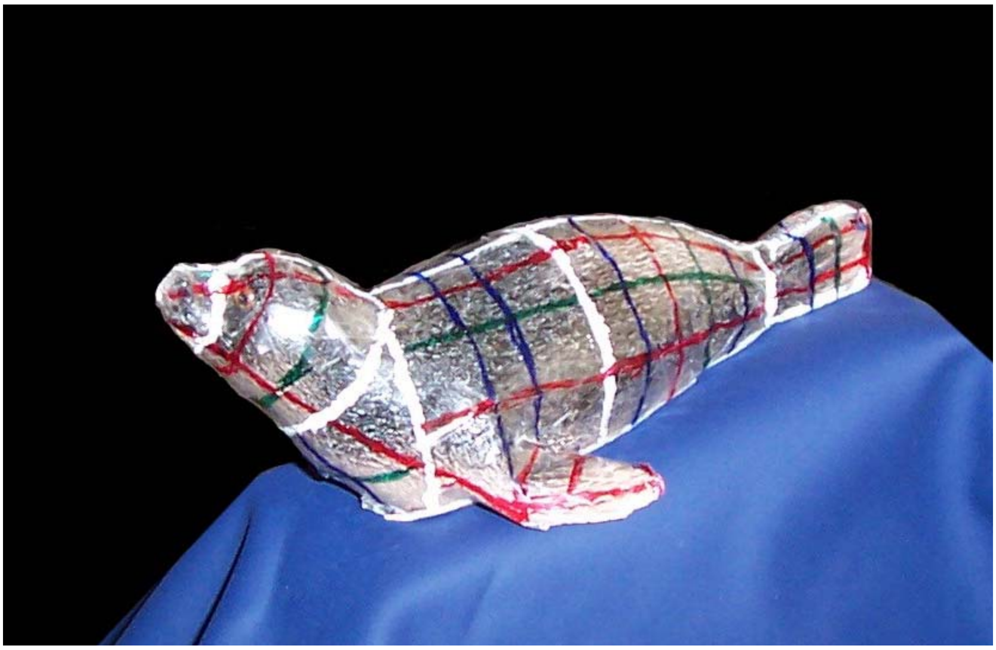

Figure 5. A 10 cm long monk seal statue was used in the model trial.

After taking the photographs of the monk seal statue from four different angles (from right-front and right-back, left-front and left-back), approximate project size (it is 10 cm long in this study) and the measurement units have been determined.

The photographs used in the statue analysis have been taken by Olympus Camedia D-390 digital camera, which was also attached in incave infrared monitor traps, was used. In order to make the photographs compatible camera parameters were entered in to the modeler.

Suitable monk seal photographs taken by digital cameras were transferred directly in to the computer. For the first study (on monk seal statue), four images taken from four different angles were imported into the computer for the referencing process of the model (Figure 6).

Figure 6. Photographs of Monk seal statute taken from four different angles.

After finishing these first three steps, the marking procedure was done for creating and positioning the monk seal statue on photographs. Points and lines were marked on each photograph. Once points were created, lines and surface elements were added between these points via the feature of program. These points and lines were base of 3D model construction (Figure 7).

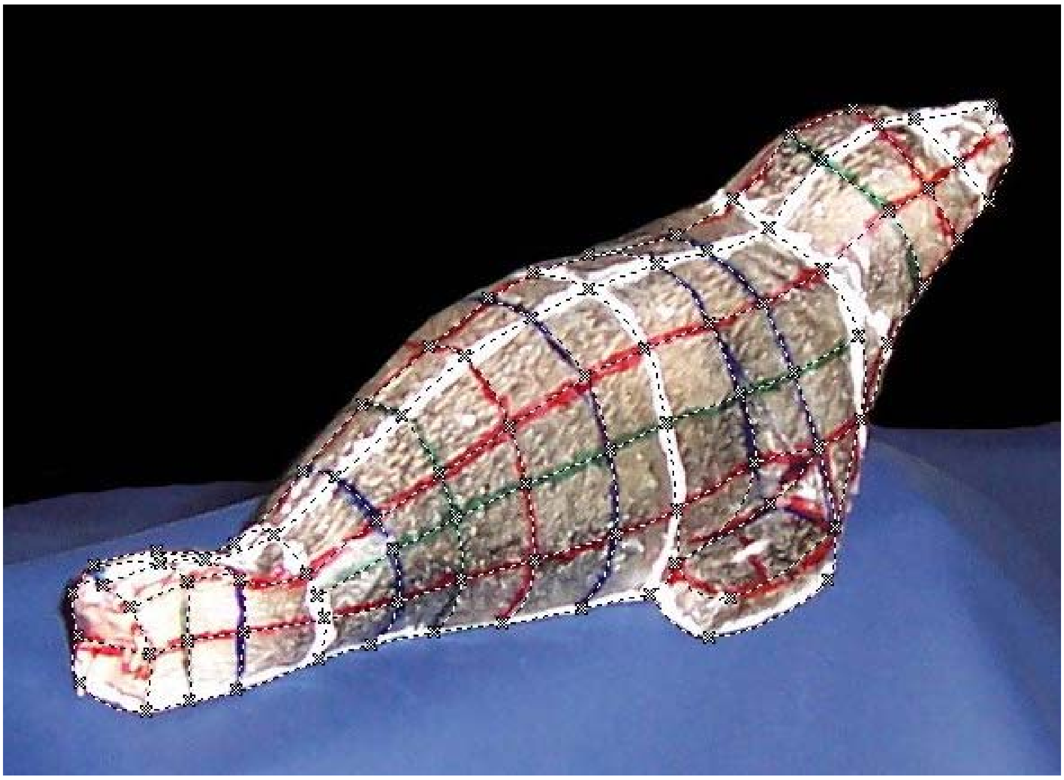

Figure 7. Monk seal statue with marks and lines.

Following step was referencing process and in these process two points, marked on two different photographs, represents the same physical point in space so these two points marked as matching points. Therefore, each point was referenced in every photograph it was marked on, to every other instance of the same point, in all of the photographs it appeared on. Points were referenced on at least two photographs, but generally can be referenced on as many photographs as there are in the project. When two marked points were referenced they represented two different views of the same 3D point in space. Lines and surfaces were connected to 3D points and they were created by connecting two or three marked points, but the program treated them as connected 3D points (Figure 8).

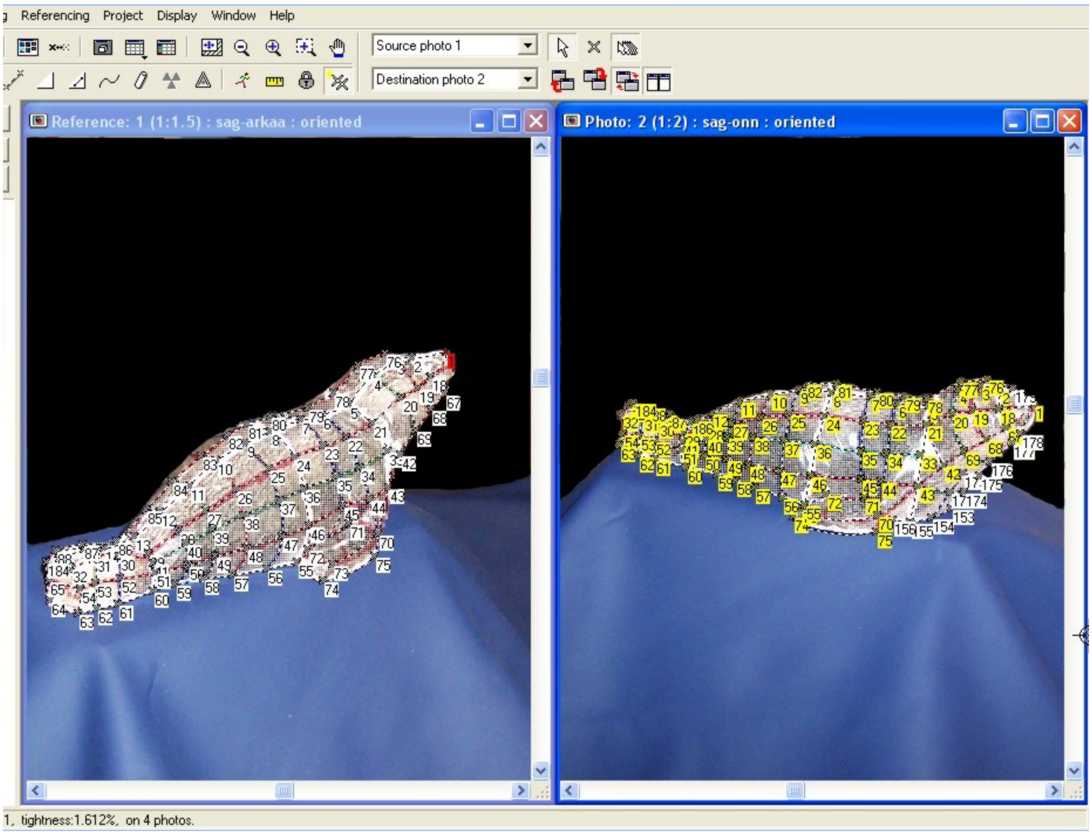

Figure 8. Referencing process of the statue.

After all these steps, lastly, scaling and rotation of the project were done in order to find out any length between two points and the volume of the project. For scaling, length between two selected points was first actually measured on the statue and then this value was used as 3D scale and rotation input in the program. For rotation, the XYZ coordinates of the project on the photograph were determined by choosing the right points as the XYZ coordinates (Figure 9).

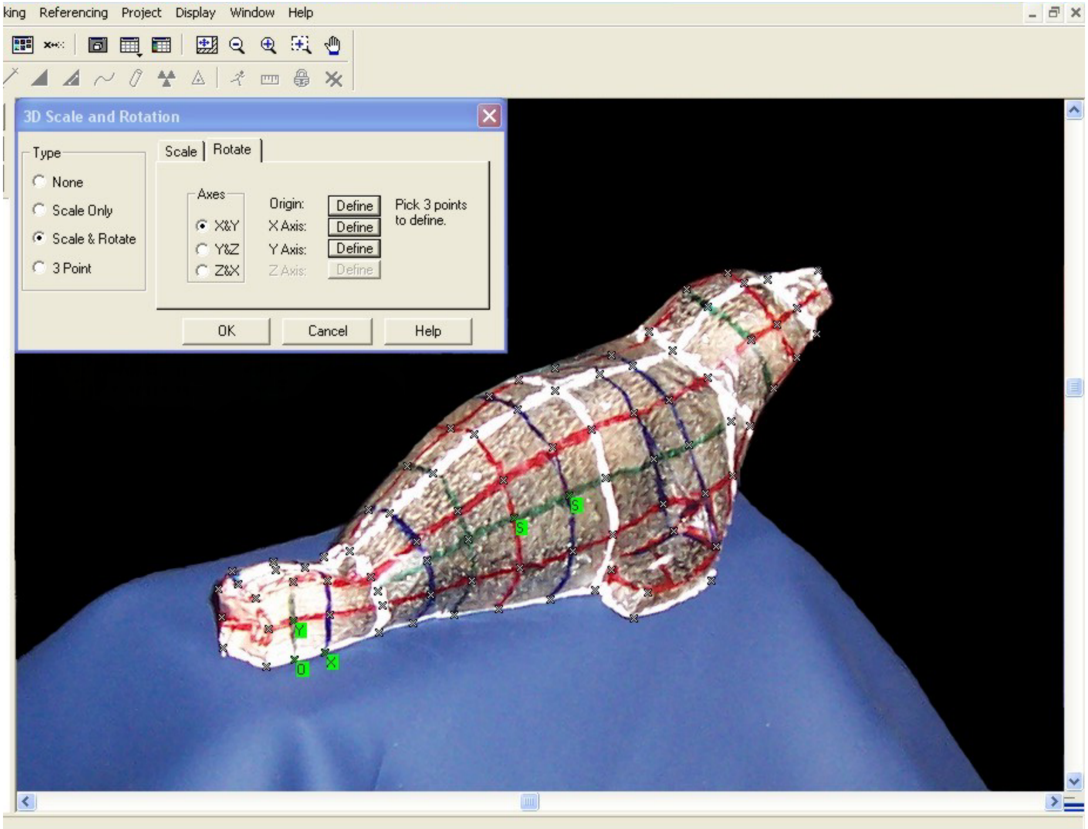

Figure 9. Scaling and rotation process of the project. S signs show the length between two selected points that was physically measured on the statue. The origin (Q), X axis and Y axis were defined. Two specified axes were adequate for the construction.

To create a 3D model from the camera and photograph marking information, the program uses a special numerical algorithm. This algorithm uses advanced mathematical techniques to adjust the input data, to create the 3D point data and to minimize errors in order to maximize accuracy. Processing is an iterative process so it repeats a sequence of steps as many times as necessary to determine the location of each point in three dimensions and to minimize the total error. A 3D model is a set of connected 3D points, which represent an object. Three-dimensional points have coordinate values for each of the Cartesian axes (X, Y, and Z). The points in a 3D model can be connected by lines or by triangular patches, called surfaces. These connections help to visualize the three dimensions when the model is projected onto a flat surface such as a computer monitor or a printed page.

Figure 10 shows a final view of the statue project. After all this process, volume of the object (monk seal shaped) or desired distance between two points can be measured easily.

In order to make comparison between the actual volume of the object and model predicted volume of the object, the actual volume of the object was needed. The actual volume of the object was calculated physically the method based on Archimedes's principle: the buoyant force is equal to the weight of the displaced fluid. Therefore, the statue was put into the tube, which containing water, and the volume was calculated from the water level difference between before and after the statue presence.

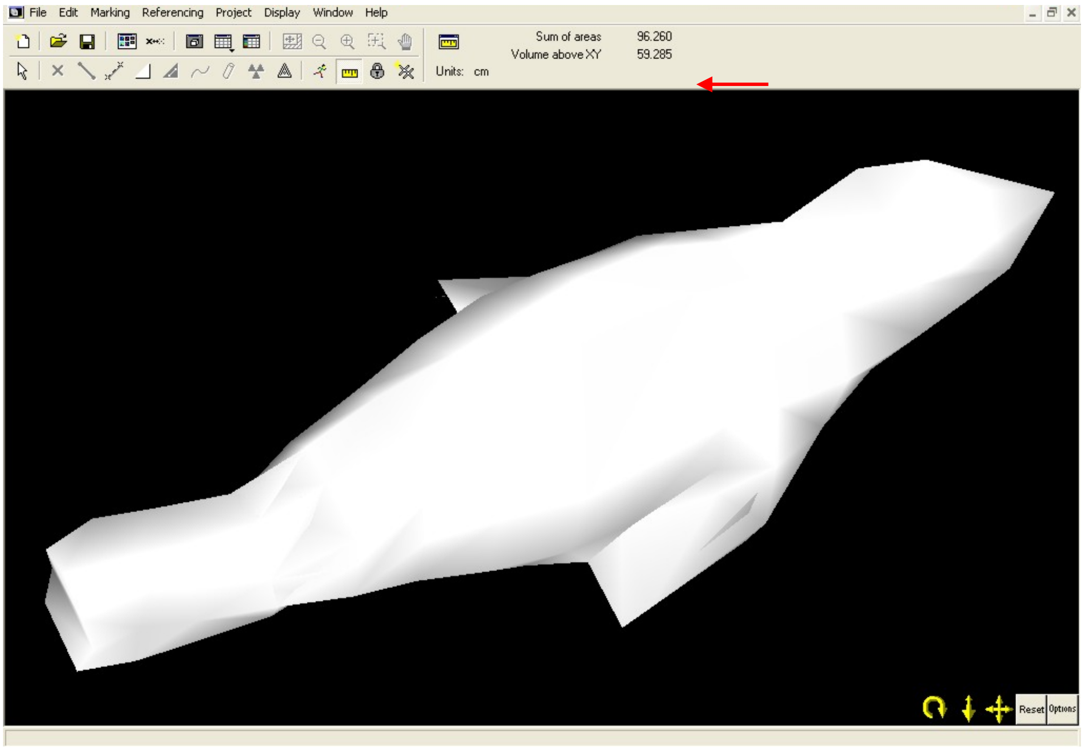

Figure 10. Final 3D view of the monk seal statue and measured total volume.

The main data needed to reconstruct a seal via 3D construction program is a set of photographs taken at different angles. In the first trial, the best scenes in a video footage of a seal displaying all aspects of the body were captured in still images. These images were transferred to computer and processed following the steps described at the beginning of this chapter. The number of reference points marked on the images (Step 4) was determined based on minimum number of reference point estimation given above (Figure 11).

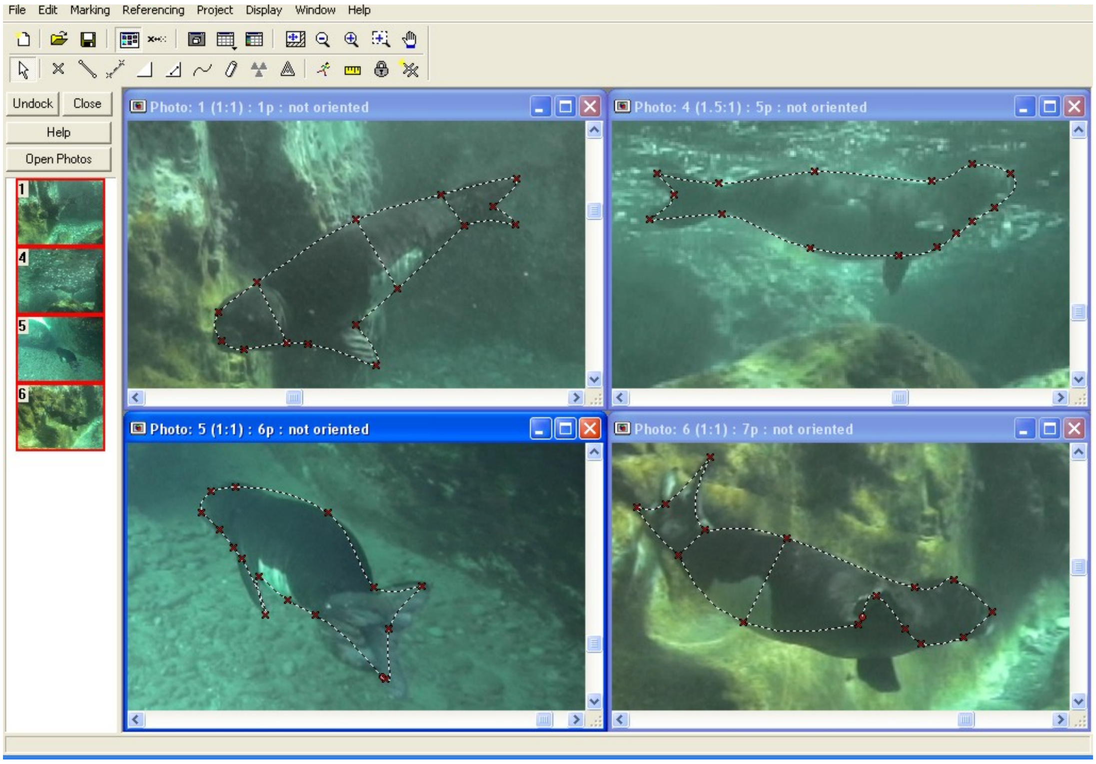

Figure 11. First trial of 3D modeling of monk seal.

In the next step, still photographs of a seal taken at the same time from varying angles were required due to the limitation emerged in the use of photo captures from a video footage. To achieve this task, four digital cameras automatically triggered by infrared sensors were attached to the corners of a hauling platform in an actively used cave. The system was kept active for 33 hours and a total of 30 images were obtained from a seal. These images were processes in the same manner as described at the beginning of this section.

2.3.2 Demographic structure of the Cilician colony

In order to understand present demographic structure of the Mediterranean monk seal colony of the Turkish coast, age determination and morphological classification of the identified individuals have been evaluated based on Samaranch and González (2000) (monk seal classification), Dendrinos et al. (1999) (pup classification) by using reprocessed data collected previously by Gücü et al. (2004). The minimum ages of the specimens were estimated according to the method given by Gücü (2004).

Estimated minimum age in years; Aest= (P-D)/365+X

D: Julian date of first sight.

P: Julian date for present estimation is assumed to be 31 December 2005.

X: the age of the individuals at first sighting.

X is formulated as follows: most females reach sexual maturity at 5 years of age and have their first pup at 6 years of age. The first successful mating of male takes place when he is 7 years old (Scoullos et al., 1994). Therefore in order to estimate minimum age of an individual in years, X is assumed to be 20 for senescent female, 9 for adult male (elder), 8 for adult male (elder), 7 for adult female (young), 6 for adult female (young), 2.50 for sub adult individuals, 0.33 for youngster individuals who are weaned, 0.14 for pups who have not been weaned yet, 0.08 for pups who are molting, 0.03 for pups who look fat and has not been molted yet, and finally 0.00 for pups who look skinny and again he/she has not been molted (Table 2).

The formula (Estimated minimum age in years) was used in this study to find out the minimum age of each identified individuals living in Cilician colony.

Table 2. Modified morphological categories of the Mediterranean monk seal (after Samaranch and González, 2000 and Dendrinos et al., 1999).

Stage	Characteristics	Period (years)
1	skinny (pup-premolted; pms)	0.00-0.03
2	fat (pup-premolted; pmf)	0.03-0.08
3	pwm moulting (pup-preweaned; pwm)	0.08-0.14
4	pup-preweaned (pw)	0.14-0.33
5	youngster- weaned (y)	0.33-2.50
6	subadult (sa)	2.50-6.00
7	adult female – young (afy)	6.00-7.00
8	adult male young (amy)	7.00-8.00
9	adult female elder (afe)	8.00-9.00
10	adult male elder (ame)	9.00-20.00
11	senesce female (sf)	20.00- -

2.3.2.1 Fecundity of the Cilician Colony

Overall fecundity of the colony was calculated using:

$F_t = P_t + 1 / A_t$ (Akçakaya et al., 1999)

F_t: Fecundity at time t.

P_{t+1}: Number of pups born at time t+1.

A_t: Number of parents at time t.

Average value of the fecundity rates calculated in 2000 through 2005 was used as present fecundity rate of the colony.

2.3.2.2 Annual Birth Rate of the Colony

Applying Gazo et al., (1999) approach, the annual birth rate of the colony was calculated for each year as the ratio of the number of pups.

$ABR_t = P_t / AF_t$ (Gazo et al., 1999)

ABR_t: Annual birth rate at time t.

P_t: Number of pups born at time t.

AF_t: Number of sexually mature females at time t.

Average birth rate of the colony calculated from 1994 to 2005 was used as the annual birth rate of the colony.

2.3.2.3 Survival and Mortality rates of the Cilician Colony

Number of individuals and deaths recorded from 2000 to 2005 were used to calculate the annual mortality rate and subtract from one to obtain overall survival rate to the next year. Following formula summarizes the calculation:

$S_t = 1 - (D_{t+1} / N_t)$ (Akçakaya et al., 1999)

S_t: Survival of the individuals at time t.

N_t: Number of individuals at time t.

D_{t+1}: Number of deaths at time t+1.

It was used as current survival rate of the colony.

Moreover, one way ANOVA (Analysis of variance) was used to evaluate if there were any significant differences in survival rates of the Cilician colony and number of pups born in the colony between two time period: before and after the conservation.

2.4 Population Viability Analysis for the Mediterranean Monk Seal Colony in the Northeastern Mediterranean

In this study, population viability analyses (PVA) was used to analyze current and future status of the Mediterranean monk seal colony inhabiting the northeastern Mediterranean and evaluate the effect of Kızılliman Marine Protected Area on the colony.

2.4.1 Population Viability Model Overview

Ramas Ecolab 2.0. (Akçakaya et al., 1999) was used to conduct PVA using a stage-structured stochastic population model. This kind of model, which is sometimes referred to as a frequency-based model, groups individuals in a population according to their age or morphological characteristics, allowing vital rates (survival and fecundity) by age or stage-class to be integrated in the model (Akçakaya 2000). Available data allowed estimation of only 2 or 3 demographic parameters, making an age-structured model the most feasible approach. The population was considered as a single population and currently comprised of 20 adults, 7 subadults and 3 pups.

Model results were summarized in terms of population trajectories and risks of decline within different time durations and different parameters.

2.4.2 Demographic Model

The census carried out in 1994 was used as the starting point (Gücü et al., 2004). The demographic structure estimated in 1994 was updated with the number of dead seals and pups found in each subsequent year. Secondly, the data were averaged over the period from onset of the study to the time (1999) when the MPA was designated, and used as pre-conservation phase. The rest of the study period is processed as the post-conservation phase. Thirdly, Ramas Ecolab 2.0 (Akçakaya et al., 1999) was used to conduct age structured Population Viability Analysis of the Mediterranean monk seal colony.

2.4.2.1 Survival

Average annual survival rate was derived from the mortality rate of the colony that was calculated as number of recorded deaths divided by a weighted average based on a cumulative total of number of adults observed throughout the years. Because of the small sample size, the pooled (overall) survival rate was used for all age classes in the model simulations. Uncertainty range of the survival rate was based on assumption of as many unreported deaths as reported ones and was used as low survival rate in the model simulations while evaluating the effect of Kızılliman Marine Protected Area.

2.4.2.2 Fecundity

For future of the colony, average annual fecundity was calculated as a weighted average based on a cumulative total of number of parents observed in 2000 through 2004, divided by a cumulative total of number pups recorded in 2001 through 2005. For the pre-conservation period, fecundity rate was calculated as a cumulative total of number of parents observed from 1994 to 1998, divided by a cumulative total of number pups recorded in 1995 through 1999.

2.4.2.3 Growth rate

Growth rate was calculated as follows:

$R_{(t)} = N_{(t+1)} / N_{(t)}$ (Akçakaya et al., 1999)

$R_{(t)}$: Growth rate at time t

$N_{(t)}$: the number of individuals at time t.

$N_{(t+1)}$: the number of individuals at time t+1.

2.4.2.4 Model Structure

The model was age structured including 7 age classes. Age class 0 referred to the individuals at 0 year age. It continued similarly till age 6+ which referred as individuals at 6 year of age and also older. The age of first reproduction was assumed to be 6. It was also assumed that there was no senesce. Thus, the Leslie matrix was;

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & F_{6+} \\ S_o & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & S_o & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & S_o & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & S_o & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & S_o & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & S_o & S_o \end{pmatrix}$$

where F6+ was adult fecundity of 6 years old or older and So were overall survival of all age classes.

2.4.2.5 Environmental and Demographic Stochasticity

Both demographic stochasticity (the intrinsic variability especially caused by small population sizes) and environmental stochasticity (the extrinsic variability in the biotic and abiotic factors influencing a population) were incorporated into the model. After calculating the total variance of survival and fecundity demographic stochasticity was calculated as based on Akçakaya 2002 and extracted from the total variance so as to estimate environmental stochasticity. It was assumed that all of observed variances were environmental for both survival and fecundity in the model.

RAMAS Ecolab software (Akçakaya et. al, 1999) incorporates demographic stochasticity to each time step of each model replication by sampling the number of survivors from a binomial distribution and the number of pups from a Poisson distribution (Akçakaya 1991).

2.4.2.6 Sensitivity Analysis

Each variable was varied as ± %10 of its actual value while holding others constant to identify sensitive variables in the model.

2.4.3 Model Use

If there is a lack of information on the endangered species, like the monk seals, density independence provides a conservative assessment (Ginzburg et al., 1990). Thus, the monk seal colony was modeled using the exponential growth option in Ramas Ecolab. However, this may be an optimistic assumption for the monk seal, if the number of caves in the protected area (where protection and hence seal productivity is expected to be higher) is limited or becomes limiting in the future as the population grows. In this case, productivity (fecundity) may decline as some seals use (e.g., give birth in) less protected areas. In contrast, the density-independent model assumes that fecundity and survival will have the same average value regardless of population size.

The model scenarios were as follows:

- No change: current conditions continue to foresee the next 20 and 50 years of the colony.
- Increased mortality of individuals due to presence of as many unrecorded deaths as recorded deaths.
- Decreased survival and fecundity of individuals in case of protection is removed (pre-conservation).

2.4.3.1 Simulations

A number of simulations were run to address different questions. To evaluate the effect of conservation, models with parameters estimated from the pre-conservation period (1994-1999) and post-conservation period (2000-2005) were compared. To evaluate the future of the colony, a model with parameters estimated from the post-conservation period (2000-2005) was used.

The simulations are summarized below.

Simulation I

Firstly, to evaluate the future of the colony under existing environmental and demographic stochasticity, model projection was run for the next 20 years with the parameters estimated for post-conservation period. Colony abundance in 2005 was used as the initial abundance in the model. Additionally, the model was re-run using estimated low survival rate of the colony within this period. Low survival rate calculation used in model simulations was derived from the model scenarios.

Simulation II

Secondly, model parameters (survival and fecundity) were calculated for pre-conservation period (1994-1999), seeded the model with these inputs and run for 6 years. The output of the model was a prediction reflecting what would be the demographic structure of the colony at year 2005 if no conservation was applied. This model was also re-simulated with the estimated low survival rate of the colony. Moreover, model predicted demography was compared with the actual numbers obtained in 2005 to see the impact of conservation measures.

Simulation III

Thirdly, the output of the model, which was run using the parameters estimated for the post-conservation phase was compared with the actual demography of the colony by using chi-squire test for verification of this model.

The viability of the Cilician monk seal colony in the Turkish Mediterranean was assessed by using two criteria: population trajectory and risk of decline to 12 individuals. When population size becomes very small, changes in sex ratio and age structure, as well as other changes may cause a decline in survival and fecundity, leading to Allee effects. Such effects are unknown in this population, because the population has never been observed at very low abundances. Thus, this may not reliably to predict the risk of extinction. One way to overcome this difficulty is to predict the risk of decline instead of risk of extinction. Because the population has never been observed at 12 or fewer total individual, the risk of decline to 12 individuals was used as one of the results of the model. To validate the model simulations, obtained results were compared to actual population trends.

3. RESULTS

Results were given under the following headings: the Cilician monk seal colony and the group in the Gulf of İskenderun, and Population Viability Analyses of the Cilicia colony inhabiting the Turkish Mediterranean.

3.1 The Mediterranean Monk Seal Cilician Colony

For comparison and assessment of the colony a 3D construction technique was applied (2.3.1.2.). Hence the results obtained from this exercice will be given in the following.

3.1.1 3D Construction

To test the accuracy of the modeling results, real volume of the statue was compared to those estimated by the model. Total number of reference points used in the estimation was plotted against the error term (the error term: the real volume / the estimated volume by the model (Figure 12). The error term has decreased as the number of reference points increased. The 90 % accuracy was obtained above 100 reference points including 25 reference points in the head, 66 reference points in the abdomen and 9 reference points in the tail. The maximum accuracy was reached at 150 reference points similarly including 30 reference points in the head, 100 reference points in abdomen and finally 20 reference points in the tail (Figure 13).

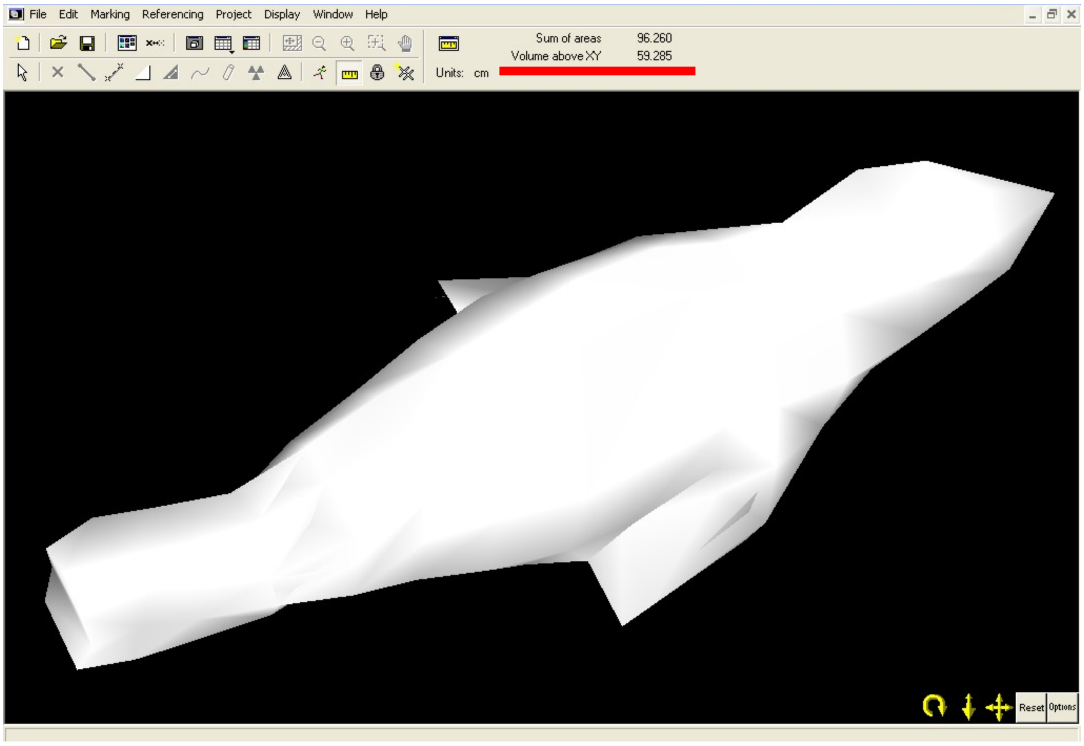

Figure 12. 3D view and calculated volume of the object.

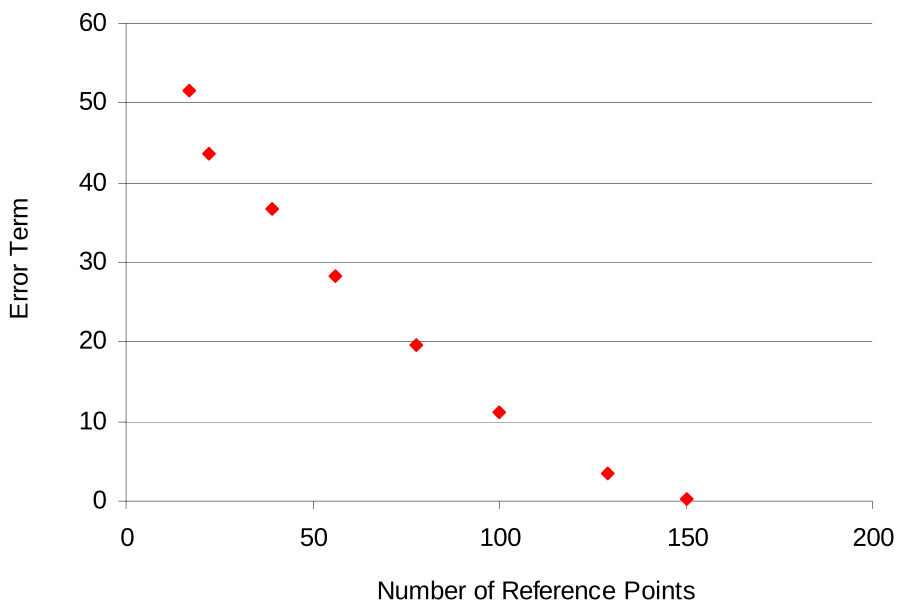

Figure 13. Different 3D monk seal model volume results with different number of reference points. The error term: the real volume/ the estimated volume by the model.

The seal modeling trials using the photographs captured from video footage were failed to give accurate results. Increasing the number of the reference points, even higher than 150 (Figure 14) did not improve the accuracy.

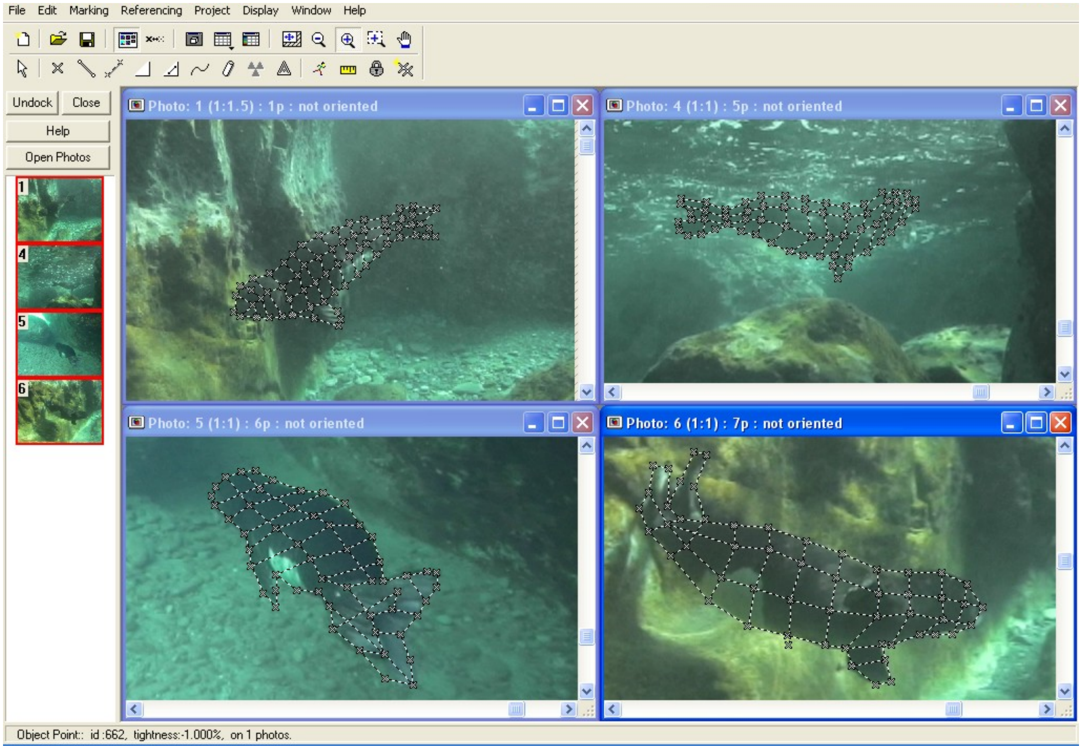

Figure 14. 3D model of the monk seal with higher reference points.

In an attempt to photograph four main aspect of a seal, photographs were deployed at 2 caves, one was in Mersin-Bozyazı, and another was in Mersin-Akkum. Finally, 4 seals were photographed at their haul out platforms in the resting caves. A total of 98 pictures were taken. The ceiling of the cave in Mersin-Bozyazı was too low to mouth the cameras in the proper position. Therefore, none of the photographs were good enough to display entire body of the seal. In the other cave, the photographs were able to frame the whole body of the seal. Due to dimmed light in the cave, only 25 reference points could be choosen on the photographs (Figure 15).

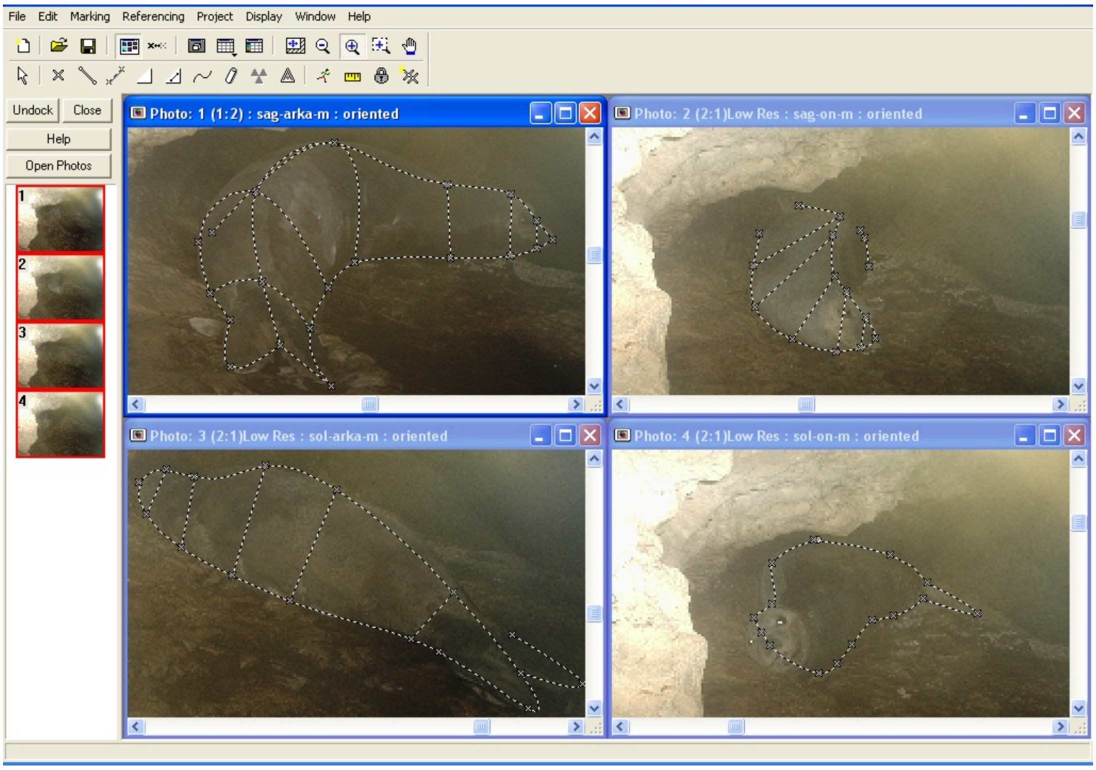

Figure 15. Photographs that used in last 3D monk seal model construction trial.

3.1.2 Observation on Cilician Colony

In the northeastern Mediterranean, between 2003 and 2005, in total, 45 monk seals and 7 newborn pups sighting information were collected by direct observation.

Up to now, 10 different seals including 1 new-born pup were photo captured by means of the system while they were resting. 2 were from the cave located between the Cilician colony in the northeastern Mediterranean and the group inhabiting the Gulf of İskenderun. Remaining 8 were from the existing colony in the northeastern Mediterranean.

3.1.3 Observation on the Gulf of İskenderun Group

Apart from the existent Cilician monk seal colony in the northeastern Mediterranean, this study exhibited that a small group of 2-3 individuals also inhabited the Gulf of İskenderun. The information was collected from the sightings reported via the seal information network and the evidences of monk seal existence founded in the cave, which were track and odor of the individuals. However, up to now, there were no direct monk seal or newborn pup observations from this area. Similarly, although the infrared monitoring systems were successfully installed 4 times into 2 suitable monk seal resting caves and 2 times to the breeding cave in the Gulf of İskenderun, no photos were captured.

3.1.4 Current Demographic Status of the Monk Seal Cilician Colony in the northeastern Mediterranean.

It was assumed that the last of the adult identifications, apart from the new born pups, in the Cilician colony was made and registered in 1998. Therefore, by the end of 1998, with the completion of all the reproductive adult members' identifications, it is assumed that the numbers of the Cilician colony was finalized and all were listed. The total number of the listed members of the colony was 18 at the end of 1998.

With the addition of these new members to the colony, the 1998 list (Gücü et al., 2004) was updated, by adding newborn pups and subtracting dead animals, which were either found or reported. By the end of 2005, in total, 30 individuals were believed to inhabit the Cilician colony. Summary of the information of all identified member of the colony were depicted in the Table 3. For each identification card of the individuals see the appendices II.

List of all identified members of the colony with their estimated minimum ages were summarized in the Table 4 and it was also completed backward through back projection to evaluate demographic changes in the colony (Table 4).

Table 3. Identified individuals with their characteristics.

Categories; BAM: Black adult male, LGS: Large grey seal, MGS: Medium grey seal, J: Juvenile, Y: Youngster, P: Pup, †: Dead individual.

Name	Est. Year of Birth	Min. Est. Age	Category	Family ties	Photo	Sex	ID Card #
Tekin	1977	28.39	LGS	No	Yes	F	1
Kokona	1986	19.39	LGS	Yes	No	F	2
Meryem	1987	18.39	LGS	Yes	Yes	F	3
Kamash	1987	18.39	BAM	Yes	Yes	M	4
Bombacı	1987	18.39	BAM	Yes	Yes	M	5
Yasli	1988	17.39	LGS	Yes	Yes	F	6
Yagiz	1989	16.39	BAM	Yes	Yes	M	7
Anac	1990	15.39	LGS	Yes	Yes	F	8
Yakisikli	1991	14.39	BAM	Yes	Yes	M	9
Melek1	1991	14.39	LGS	Yes	No	F	10
Meltem	1992	13.39	LGS	No	No	F	11
Ceren	1995	10.45	LGS	Yes	Yes	F	12
Arap	1996	9.15	BAM	Yes	Yes	M	13
Ferit Jr.	1996	9.09	BAM	Yes	No	M	14
Charlie	1997	8.25	LGS	Yes	No	F	15
Askim	1997	8.16	BAM	Yes	Yes	M	16
Ney	1998	7.39	LGS	Yes	Yes	F	17
Saklikuzu	1998	7.23	LGS	No	Yes	M	18
Sedef	1999	6.21	MGS	Yes	Yes	F	19
Sanda	1999	6.19	MGS	Yes	Yes	F	20
Yalcin	2000	5.15	MGS	Yes	Yes	M	21
Uykucu	2001	4.34	MGS	Yes	Yes	M	22
Gelincik	2001	4.34	MGS	Yes	No	F	23
Tarcin	2002	3.24	MGS	Yes	Yes	M	24
Kay	2004	1.26	J	Yes	Yes	F	25
Luigi	2004	1.09	J	Yes	No	M	26
Rane	2004	1.08	J	No	Yes	F	27
Levant	2005	0.19	Y	No	No	M	28
Tahta	2005	0.13	P	No	No	M	29
Lamas	2005	0.02	P	No	No	F	30
Yula †	1985	†	†	No	No	M	-
Kır †	1986	†	†	No	No	F	-
Dede †	1986	†	†	No	No	F	-
Japon †	1987	†	†	No	No	M	-
Cecan †	1987	†	†	No	No	M	-
Bozzy †	1989	†	†	Yes	Yes	F	-
Charlie †	1994	†	†	No	No	F	-
Umit †	1996	†	†	Yes	Yes	F	-
Zeynep †	2003	†	†	Yes	Yes	F	-
Lal †	2003	†	†	Yes	Yes	F	-
Afag †	2004	†	†	Yes	Yes	M	-

Table 4. Identified Cilician colony members with their estimated minimum ages. †: the monk seal that found or reported as death from 1994 to 2005. *: Back projected individuals.

Sex	Name/Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
F	Tekin	17.38*	18.38*	19.38*	20.38*	21.38	22.38	23.38	24.38	25.38	26.38	27.39	28.39
M	Yula †	9.38	†										
F	Kokona	8.38*	9.38	10.38	11.38	12.38	13.38	14.38	15.38	16.38	17.38	18.39	19.39
F	Kır †	8.38	†										
F	Dede †	8.38	†										
F	Meryem	7.38*	8.38*	9.38	10.38	11.38	12.38	13.38	14.38	15.38	16.38	17.39	18.39
M	Kamash	7.38*	8.38*	9.38*	10.38	11.38	12.38	13.38	14.38	15.38	16.38	17.39	18.39
M	Bombacı	7.38*	8.38	9.38	10.38	11.38	12.38	13.38	14.38	15.38	16.38	17.39	18.39
M	Japon †	7.38	†										
M	Cecan †	7.38	†										
F	Yasli	6.38*	7.38*	8.38	9.38	10.38	11.38	12.38	13.38	14.38	15.38	16.39	17.39
M	Yagiz	5.38*	6.38*	7.38	8.38	9.38	10.38	11.38	12.38	13.38	14.38	15.39	16.39
F	Bozzy †	5.38*	6.38*	7.38	8.38	†							
F	Anac	4.38*	5.38*	6.38*	7.38*	8.38	9.38	10.38	11.38	12.38	13.38	14.39	15.39
M	Yakisikli	3.38*	4.38*	5.38*	6.38*	7.38	8.38	9.38	10.38	11.38	12.38	13.39	14.39
F	Melek1	3.38*	4.38*	5.38*	6.38	7.38	8.38	9.38	10.38	11.38	12.38	13.39	14.39
F	Meltem	2.38*	3.38*	4.38*	5.38*	6.38*	7.38	8.38	9.38	10.38	11.38	12.39	13.39
F	Charlie †	0.66	†										
F	Ceren		0.44	1.45	2.45	3.45	4.45	5.45	6.45	7.45	8.45	9.45	10.45
F	Ümit †			0.38	†								
M	Arap			0.15	1.15	2.15	3.15	4.15	5.15	6.15	7.15	8.15	9.15
M	Ferit Jr.			0.08	1.08	2.08	3.08	4.08	5.08	6.08	7.08	8.09	9.09
F	Charlie				0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25
M	Askim				0.16	1.16	2.16	3.16	4.16	5.16	6.16	7.16	8.16
F	Ney					0.38	1.38	2.39	3.39	4.39	5.39	6.39	7.39
M	Saklikuzu					0.22	1.22	2.23	3.23	4.23	5.23	6.23	7.23
F	Sedef						0.21	1.21	2.21	3.21	4.21	5.21	6.21
F	Sanda						0.19	1.19	2.19	3.19	4.19	5.19	6.19
M	Yalcin							0.14	1.14	2.14	3.14	4.14	5.14
M	Uykucu								0.34	1.34	2.34	3.34	4.34
F	Gelincik								0.34	1.34	2.34	3.34	4.34
M	Tarcin									0.24	1.24	2.24	3.24
F	Zeynep †										0.46	†	
F	Lal †										0.24	1.24	†
M	Afag †											0.26	†
F	Kay											0.26	1.26
M	Luigi											0.09	1.09
F	Rane											0.08	1.08
M	Levant												0.19
M	Tahta												0.13
F	Lamas												0.02
# of Adults		11	8	9	11	11	11	11	12	14	16	18	20
# of Pups		1	1	3	2	2	2	1	2	1	2	4	3
# of Immatures		6	4	4	4	5	7	9	9	9	8	7	7
Total # of Individuals		18	13	16	17	18	20	21	23	24	26	29	30

Increase of numbers of individuals in the colony throughout the years were depicted in the Figure 16. As clearly seen, the colony has suffered a decline.

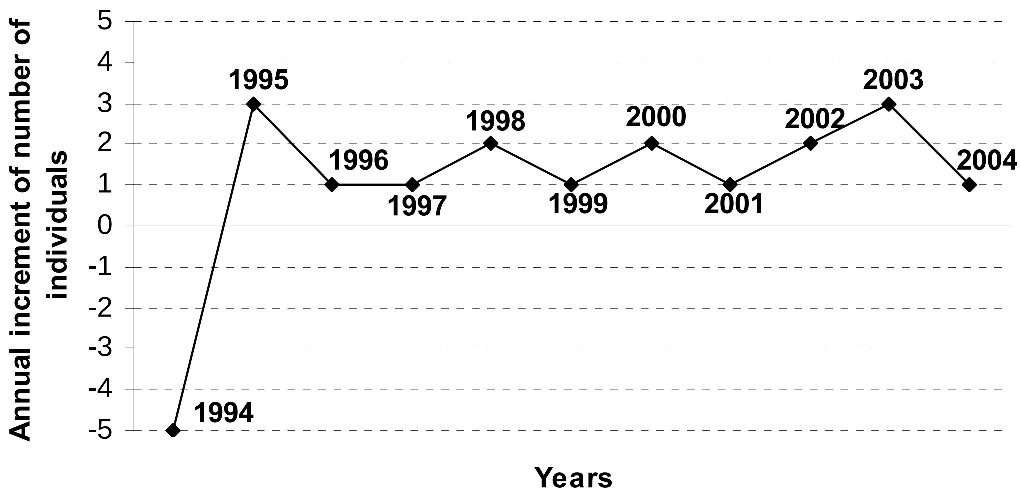

Figure 16. Annual increment of number of individuals.

The age distributions of the colony in 2005 according to their ages were summarized in Figure 17.

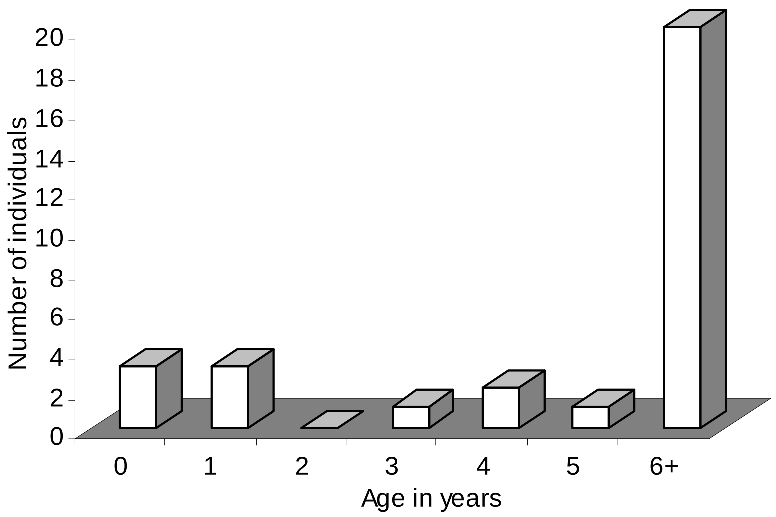

Figure 17. Estimated demographic structure of the monk seal colony in 2005.

Moreover, the population pyramid showing the distribution of the individuals according to their sex and numbers represented in the colony in 2005 were produced (Figure 18).

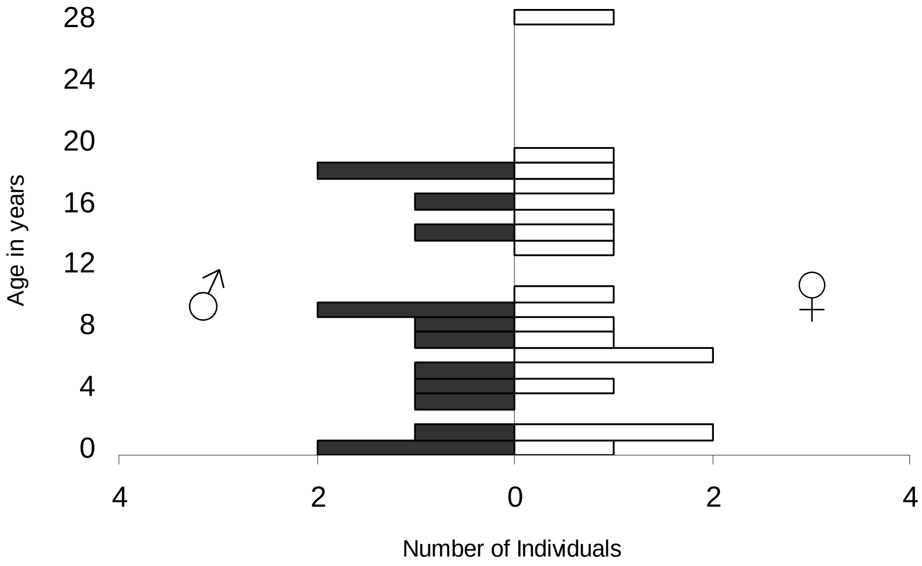

Figure 18. The population pyramid of the colony in 2005.

The overall survival rate of the colony was calculated as 0.976 for the period between 2000-2005. A total of 3 individuals died in the same period. 2 of them were juvenile and 1 was a pup.

The variations in annual survival rates from 1994 to 2005 were summarized in Figure 19. Apart from the low survival rate in 1994 which was a result of 6 individuals deliberately killed, the general survival rates were following a relatively constant trend along the progressive years.

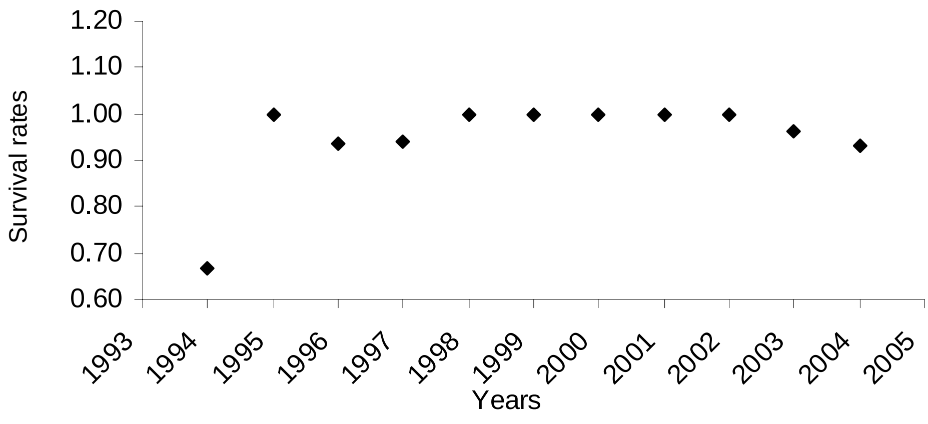

Figure 19. Estimated annual survival rates of the colony from 1994 to 2004.

Average fecundity rate of the colony was calculated as 0.169 from 2000 to 2005. This value was used in population viability analysis of the colony (Figure 20).

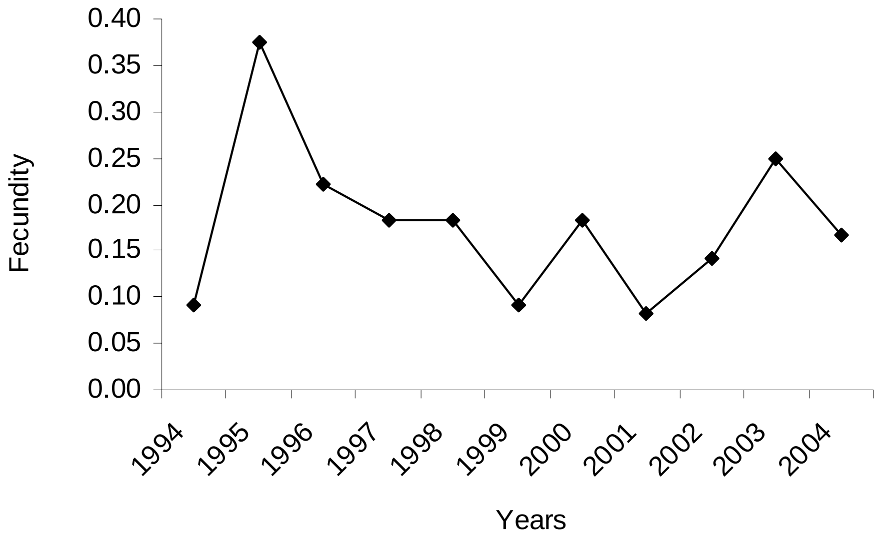

Figure 20. Estimated fecundity rate of the colony along years.

The estimated annual birth rate (ABR) ranged from 0.12 to 0.5, with an average of 0.26 pups per female from 1994 to 2005. The variations in annual birth rates from 1994 to 2005 were summarized in Figure 21.

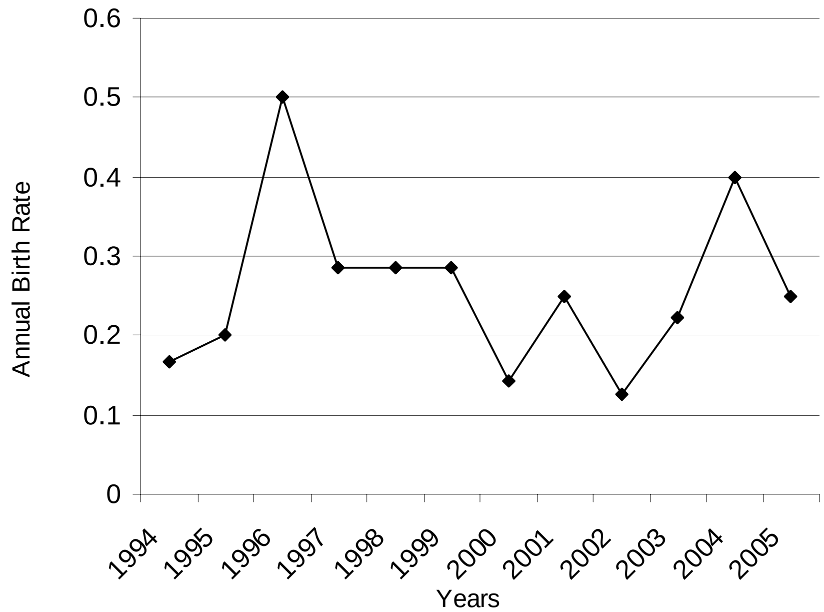

Figure 21. Annual birth rate of the Cilicia colony in the northeastern Mediterranean from 1994 to 2005.

It was found that there is a statistically significant difference between basic population parameter, namely survival ($F_{1,38}$=5.65, $P<0.05$) estimated for two time periods; before and after conservation. The significant difference was also found in number of pups born in the Cilicia colony between pre-conservation and post-conservation periods.

3.1.5 Current Status of the Mediterranean Monk Seal in the Gulf of İskenderun

Although there was not direct observation of Mediterranean monk seal in the Gulf of İskenderun, tracks and odor of the seals, which were found during the cave checking proved the existence of the seals in the area. Moreover, 51 seal sightings were reported in total by local people via seal information network, which was established at the beginning of the research project of the Mediterranean monk seal in the Gulf of İskenderun. 1-3 individuals sighted at the same time. Furthermore, one adult male was monitored throughout the Gulf of İskenderun by means of the information network (Figure 22).

Approximately 59% of the sightings were reported by the local fishermen fishing in the region. All of the observed individuals were reported as alive. The reported sightings were evaluated and schematic map was produced according to the latitude and longitude of the reported locations (Figure 22).

The sightings were mainly accumulated inner part of the Gulf where there were some areas that limited for entrance and less disturbance and around the mountain Kel where the suitable monk seal habitat exist and again less disturbance due to moderately difficulty accessibility.

Figure 22. Monk seal sighting locations reported by local people and the route of the male monk seals tracked from sighting reports.

3.1.6 Human Disturbance in the Gulf of İskenderun

During the field surveys, different disturbance types were recorded. Number of times a disturber was observed was used to assess relative importance of the disturber. As seen from the Figure 23, the most frequently observed disturbance type was fishery related.

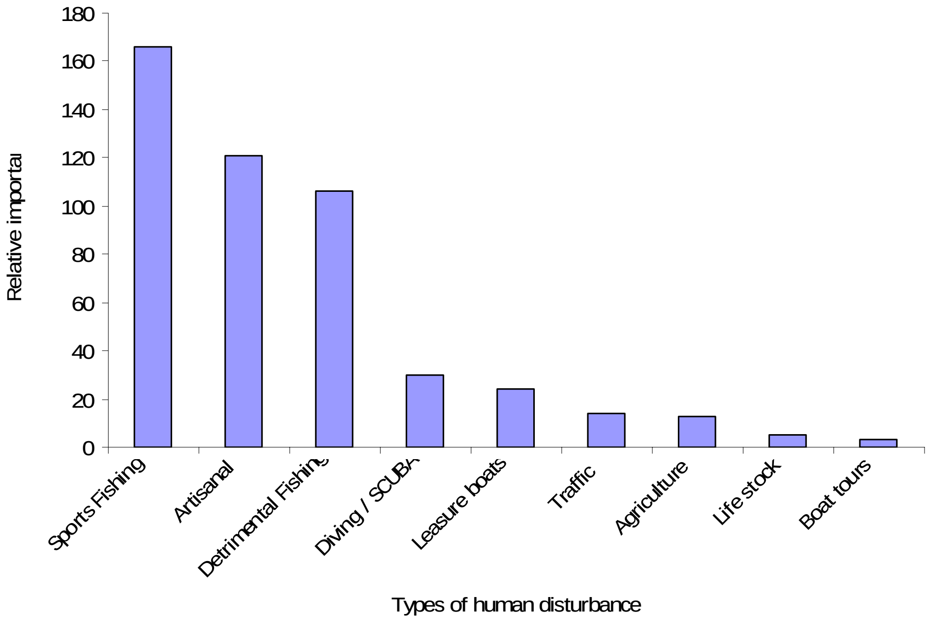

Figure 23. Types and relative importance of human disturbance.

The disturbers showed seasonality (Figure 24). In general, fisheries related activities were more common during autumn and early winter while tourist activity were concentrated in summers.

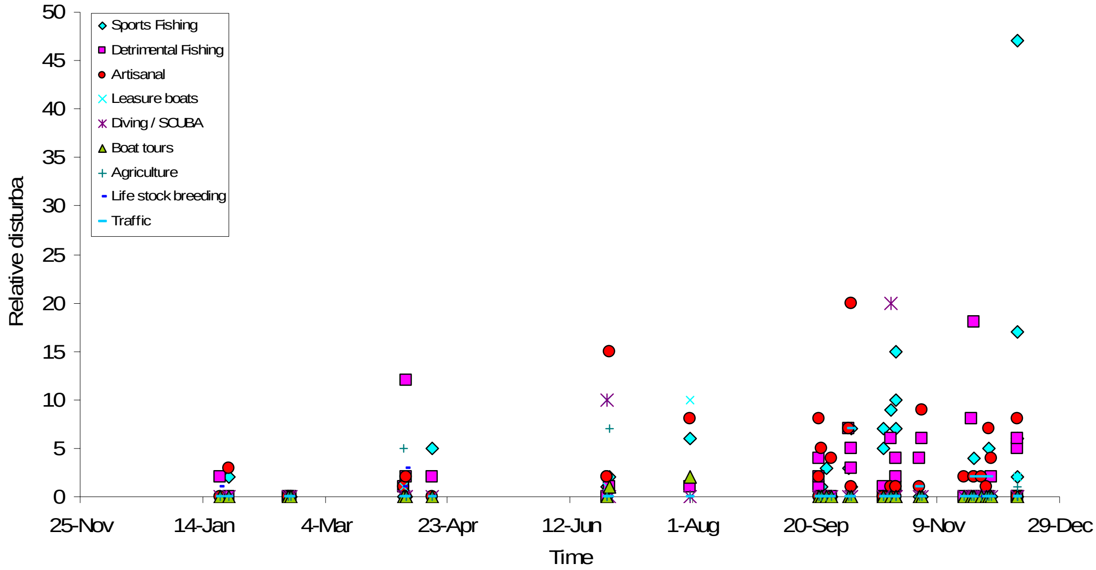

Figure 24. Annual variation in the type and relative importance of human disturbance.

The area use and coastal structure of the coast of the Gulf of İskenderun were classified as shown in the Figure 25. As it mentioned in the introduction chapter, industry is well developed inner part of the Gulf. The habitats determined as suitable for monk seals (some part of the rocky coast on the map) were considerable less industrialized than the other part of the Gulf.

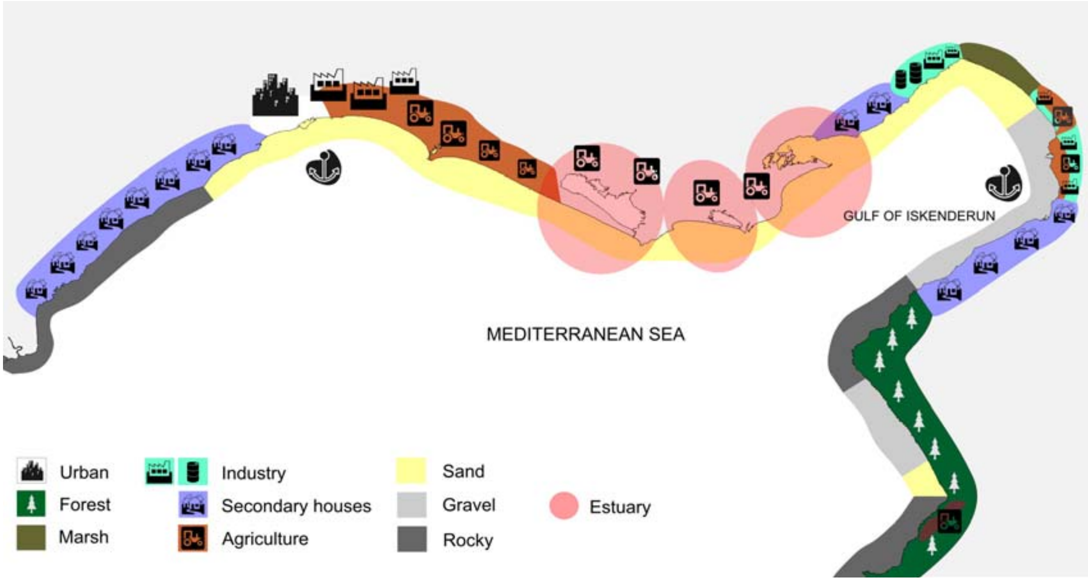

Figure 25. Schematic map of the area use and coastal structure on the coasts of the Gulf of İskenderun.

3.2 Population Viability of Mediterranean Monk Seal Colony in the Northeastern Mediterranean

The model parameters S (survival) and F (fecundity), their variability (temporal standard deviations for modeling environmental stochasticity), and their uncertainty (upper and lower bounds on average values) were based on the data summarized in Table 5.

Table 5. Summary of the monk seal colony data from 1994 to 2005.† Growth rate is calculated as R (t) = N (t+1) / N (t). ‡ Fecundity is calculated as the number of pups in year t+1, divided by the number of parents in year t). na: not available (cannot be calculated for 2005).

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of adults (>6 years old)	11	8	9	11	11	11	11	12	14	16	18	20
Number of pups (<1 year old)	1	1	3	2	2	2	1	2	1	2	4	3
Number of immature individuals (incl. pups)	7	5	7	6	7	9	10	11	10	10	11	10
Total number of individuals (N)	18	13	16	17	18	20	21	23	24	26	29	30
Growth rate from year t to t+1 (R) †	0.722	1.231	1.063	1.059	1.111	1.050	1.095	1.043	1.083	1.115	1.034	na
Fecundity (pups per parents) (F) ‡	0.091	0.375	0.222	0.182	0.182	0.091	0.182	0.083	0.143	0.250	0.167	na
Number of recorded deaths	0	6	0	1	1	0	0	0	0	0	1	2
Overall survival rate from year t to t+1 (S)	0.667	1.000	0.938	0.941	1.000	1.000	1.000	1.000	1.000	0.962	0.931	na

3.2.1 Fecundity

Average annual fecundity of the colony was calculated as 0.169 pups per adults (aged 6 years and older). This was a weighted average based on a cumulative total of 71 adults observed in 2000 through 2004, divided by a cumulative total of 12 pups recorded in 2001 through 2005 (the unweighted average of the fecundity values given in Table 5 is 0.165). Demographic stochasticity of fecundity was modeled by sampling the number of offspring from Poisson distributions.

The temporal variance of calculated fecundity value was 0.0037. The observed variance includes variability due to both environmental fluctuations and demographic stochasticity. Since demographic stochasticity was already incorporated into the model, the variance to model environmental stochasticity must exclude expected variance due to demographic stochasticity (based on Akçakaya 2002). However, for precautionary assessment, it was assumed that all of observed variance was due to environmental stochasticity.

3.2.2 Survival

In total, there were 3 recorded deaths between 2000 and 2005 (Table 5). Average annual survival rate of the colony was calculated as 0.976, as a weighted average based on a cumulative total of 123 adults observed in 2000 through 2004, and the 3 recorded deaths (the unweighted average of the survival values given in Table 5 is 0.979). Repeating this calculation separately for immature and adults gave 0.951 and 0.963, respectively. Overall survival rate of 0.976 was used for all age classes because of the small sample size.

To account for the possibility of unrecorded deaths, a lower bound on average survival rate was estimated as 0.951, which assumes 3 more deaths (i.e. as many unrecorded deaths as recorded deaths). The temporal variance of the overall survival rate was 0.0010. Expected variance due to demographic stochasticity was calculated as 0.0008 and environmental stochasticity was calculated as 0.0003 (based on Akçakaya 2002). However, for precautionary assessment, all of observed variance was assumed to be due to environmental stochasticity (as for fecundity; see above).

3.2.3 Model Trajectories and Results

The first model trajectory, which was run for evaluating the future status of the colony, demonstrated that there is not significant risk of decline that the colony abundance will fall below 12 individuals for next 20 and 50 years. However, it was found that there was a 26.9% risk that the monk seal colony abundance will fall below the existing level at least once during the next 20 years. This risk tended to increase considerable to 48.7% with the increasing mortality for next 20 years (Figure 26).

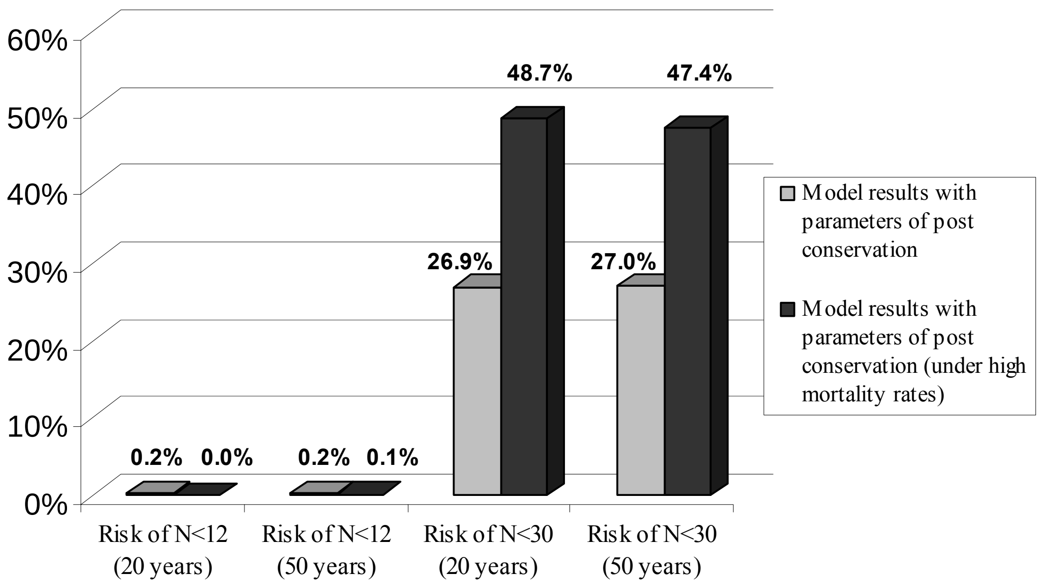

Figure 26. Risk of decline to 12 individuals and risk of colony abundance that falling below the current level.

The second model trajectory that aimed to evaluate the effect of the conservation pointed out that if there were no conservation application, the risk of decline of the colony to 12 individuals would be 22.7% at the year 2005. Besides, it was found that if the conditions remained the same as was in pre-conservation period, probability of the risk of colony abundance falling below the existent level at the year 2005 would be inevitable 99.9%. These risks (risk of N<12 within next 20 years) unsurprisingly increased to 69.0% when low survival rate was used. The model predicted demography and the observed demography at the year 2005 were compared in order to evaluate the impact of conservation (Table 6). Highly significant difference (chi-square: $P<0.01$) between observed and estimated values were found.

In the third model trajectory that aimed to validate the model, there was no statistically significant difference between expected frequency of the age classes of the monk seal, $X^2_6=4.53$ ($P<0.05$), which produced by the model simulated for the post-conservation phase and the actual i.e. observed demography of the colony in 2005. This result was found by using chi-squire test and verified the model (Table 7).

Table 6. The model predicted demography and the observed demography including all age classes.

Stage/# of individuals	Observed 1999	Observed 2005	Predicted (pre-conservation)	Predicted (post-conservation)	Predicted (pre-conservation) with low survival	Predicted (post-conservation) with low survival
0	2	3	2	2	1	2
1	2	3	1	2	1	2
2	2	0	1	2	0	1
3	2	1	1	1	0	1
4	1	2	1	1	0	1
5	0	1	1	1	0	1
6+	11	20	11	17	5	14
Total	20	30	18	26	7	22

Table 7. Observed and expected frequencies of monk seal age classes in 2005 and their calculated chi-squire values.

Age Classes	**Observed # of individuals**	**Expected # of individuals**	**X^2**
0	3	2	0.5
1	3	2	0.5
2	0	2	2
3	1	1	0
4	2	1	1
5	1	1	0
6+	20	17	0.5
Total	30	26	4.53

3.2.4 Sensitivity Analysis

In order to evaluate contribution and impact of each parameter to the model results, significance test was applied. It is clear from the Figure 27 that the survival rate of the colony has utmost importance in the analysis. The model is by far less sensitive to fecundity. Standard deviation of the parameters has little effect on the results, which indicates that environmental and demographic variability has little consequence on the colony.

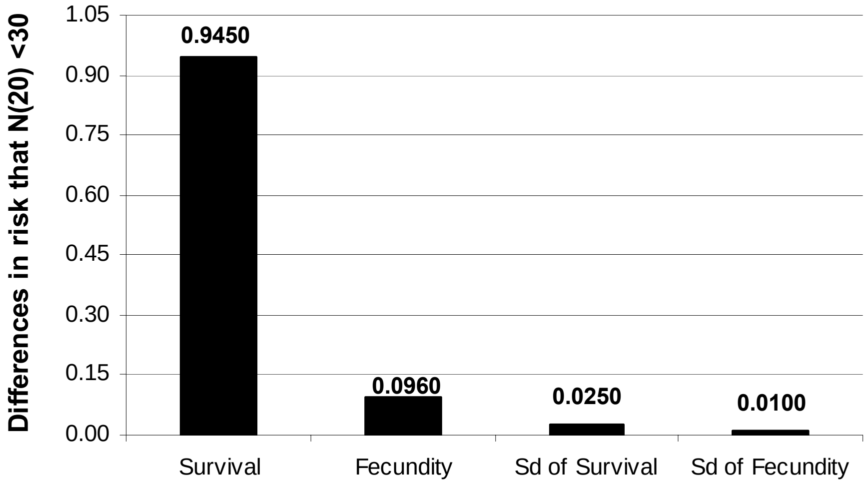

Figure 27. The sensitivity of 4 parameters used in population viability analysis of the Cilicia colony.

4. DISCUSSION

The Mediterranean monk seal is one of the last two remaining phocid species that still exist and inhabit warm and tropical waters (Pastor and Aguilar, 2003). The species has been assessed as critically endangered (CR) since 1996 by the IUCN Red List Criteria CR C2a, meaning that it is facing an extremely high risk of extinction in the wild in the immediate future; (C) Population estimated to number less than 250 mature individuals and: (2) a continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of (a) severely fragmented (i.e. no subpopulation estimated to contain more than 50 mature individuals).

Since the world population has been currently limited to only two regions; one is in the north-east Atlantic, off the coast of north-west Africa, the other is in the eastern Mediterranean (Tudela, 2004), small fragmented groups attract significant attention (Gücü et al., 2004). Amongst the Mediterranean coastal areas, Turkish coast provide one of the last refuge areas where the monk seal still exists and can successfully reproduce. One such area is in the northeastern Mediterranean, engulfing the Cilicia coast, Levant basin, and the Gulf of İskenderun.

In this study past, present, and future status of the critically endangered Mediterranean monk seal in the northeastern Mediterranean was investigated. The study of the colony in the Cilicia coast and the small group in the Gulf of İskenderun have provided results that were used in firstly; evaluating the current and the future status of the species; secondly, assessing the implications of conservation measures that were applied for the survival of the Cilician colony, specifically in the northeastern Mediterranean since 1999, and lastly, evaluating the impacts of the current threats that the species faces. Moreover, population viability analysis (PVA) was performed on the Cilician colony and it provided the first PVA study specifically carried out on the monk seals inhabiting the Turkish coast. Similar analysis was used previously in Greece (Scoullos and Seal, 1994) and the Eastern Atlantic (González et al., 2002a) by other researchers for evaluating the status of the Mediterranean monk seal population inhabiting these areas.

4.1 The Mediterranean Monk Seals in the Northeastern Mediterranean

Considering that the total number of the species throughout its distribution range is estimated as stable around 500 individuals (González, 2004), The Mediterranean monk seal Cilician colony in the northeastern Mediterranean with a colony size of 30 animals in total in 2005, has a critical importance for the species' global survival. Furthermore, its importance is amplified by the fact that the colony is following an increasing trend in size since the last 5 years.

Because of the rarity and solitary roaming of the species, the probability to observe the individual by direct observation during the field survey was low. Besides, the weather conditions at the field, long distance to the main field station or to the institute, fewer chances of frequent direct monitoring of the caves and therefore, longer apart intervals of cave checks have been factors that limit the data obtaining. On the other hand, infrared monitor system results indicated that one of the most effective methods to gain data about such a rare species is to use automatic infrared monitor system, which was also previously indicated by Scoullos et al. (1994) and Gücü et al. (2004). Such methods give the researcher an idea about the usage of the cave, the usage frequency of the cave by individuals, number of individuals that use the same cave, individual identification and comparison of different individuals that are photographed. On the other hand, structure of the cave, the cave and sea condition and the period of the year have direct effect on the success of both installation and operation of the infrared systems hence obtaining the monk seal photographs.

In general, the Cilician colony in the northeastern Mediterranean is increasing in size from 1996 onwards, and the recovery rate has amplified as a consequence of 7 years of conservation, targeting mainly the protection of the breeding sites\caves, regulation of the fish stocks within a confined area by banning large scale industrial fishing, creating a no-fish-zone and better patrolling the area for the effectiveness of the management decisions. There is highly significant difference between survival rates of pre-conservation and post-conservation phase as well as between the numbers of pups again estimated for these two periods also showed this effect. The PVA analysis carried out in this study also proved that the colony's survival chances remarkably increased after the conservation actions. It is believed that the regulations targeting utilization of the fish stocks, ensures higher fecundity levels through increased food availability.

The lowest survival rate of the colony was calculated as 0.67 for the year 1994 due to the 6 deliberately killing of monk seals in the same year. Dealing with a species whose overall population size not more than 500 individuals, even single individual may have a vital importance for the colony’s future. For instance, Gücü et al. (2004) found that there are four subgroups in the Cilician colony that each social group inhabiting the respective sub-region is ruled out by Black adult males (BAM). The death of a single BAM within the subgroup could lead to unbalance the demography of entire demography.

In general, one of the causes of monk seal mortality was deliberate killing and it is reported as the major threat to adult monk seals in the Mediterranean Sea (Vlachoutsikou and Lazarides, 1990; Panou et al., 1993; Yediler and Gücü 1997; Johnson and Lavigne, 1998; Androukaki et al., 1999; Tudela, 2004). The analysis of necropsy results from 2000 carried out by Hellenic Society for the Study and Protection of the Monk Seal revealed that deliberate killing still represented the single greatest cause of mortality in monk seals in Greece (Androukaki, 2001). In the seal colonies (Cilicia and İskenderun) monitored in this work only 5 dead monk seal were found or recorded after the mass deliberately killing episode occurred in 1994 in the area. The average survival rate of the colony calculated as 0.95 that was considerably high.

Gazo et al. (1999) found that the annual birth rate of the Capo Blanco colony has ranged from 0.30 to 0.43 and authors indicated that it was extremely low compared to the other Pinniped populations. Similarly, Gücü et al. (2004) estimated the annual birth rate of the Cilician colony as 0.23 and noted that this value was remarkably lower than the range given for the Capo Blanco colony. Some authors (Riedman, 1990) list the Hawaiian monk seal, which is genetically closest relatives of the Mediterranean monk sea, among the phocids having lowest annual birth rate ranging 0.54 and 0.67 (Johanos et al., 1994; Johnson and Johnson,1984), which is range slightly higher than the annual birth rate estimated for the Mediterranean monk seal in this study.

The estimated annual birth rate of the colony ranged between 0.12 to 0.5, with an overall average of 0.26 pups per female from 1994 to 2005. Although the value is still too low compared to other monk seal populations inhabiting different areas and other Pinniped species, it may be said that there is a small improvement on it, especially in the last years. Number of pups found per breeding season increased almost two times during last two breeding season, as presented in the previous chapter. During the study period, 1 monk seal pup was found dead. Although there has been no systematic study carried out specifically on pup mortality of monk seal in the Mediterranean Sea, main causes of pup mortality were given as entanglement to the fishing net (Gücü et al., 2004), unfavorable seasonal conditions (storm etc.) and unsuitability of the breeding cave (Mursaloğlu, 1984). The dead pup found during the study period was probably died due to a different reason rather than listed above: together with the dead pup, another one was also sighted at the same cave at the same time, indicating that they were most probably siblings from the same mother. The dead pup was bearing indications of abortion. Reason of abortion could be insufficient food source for the twins or biologically young and inexperienced mother since Riedman (1990) and González et al. (2002b) have indicated that in many Pinniped species, young mothers have a lower reproductive success than older ones.

Although the colony showed a trend of steady increase in size (Figure 16), the population pyramid of the colony produced for 2005 and shown in Figure 18 is rather different than from the ideal form described by Odum (1971), which is shown below (Figure 28). Furthermore, it is clear that there were missing age class at earlier life stages (Figure 17). It could be due to low survival rates in early life stages. There were at least two possible causes of low survival rate at early life stages: harsh weather and sea conditions around breeding locations. For instance, in Desertas Island breeding season coincides with the season in which ocean storms are the most frequently occurred (Pires, 1997 cf. Neves and Pires, 2001). Pups are still so vulnerable in this stage that they can be under various risks (Neves and Pires, 2001). Similarly at Capo Blanco, the pup mortality is as high as 40% and this rate is exclusively due to harsh sea conditions (Gazo et al., 2000). Entanglement in fishing net is the second possible cause of low survival at earlier phase. Since the pups are generally inexperienced at the sea in this phase and not able to escape by clawing the net, entanglement in the fishing net can be fatal in most cases. Gücü et al. (2004) revealed that the main causes of pup mortality was incidental catch due to entanglement in fishing gear since the region has been under heavy fishing pressure and they found that four of the six pups born in the colony died due to that reason.

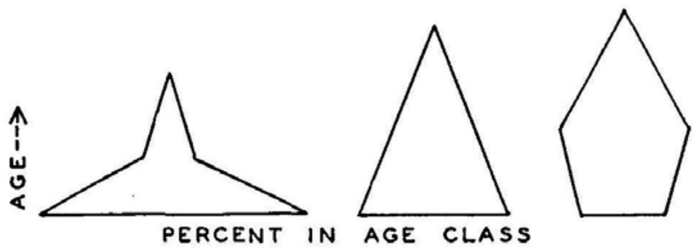

Figure 28. Types of age pyramids: a pyramid with broad base (left), indicating a high percentage of young individuals; a-bell-shaped figure (middle), indicating a moderate proportion of young to old and finally an urn-shaped figure (right) would be generally be characteristic of a senile or declining populations (Odum, 1971).

4.2 The Mediterranean Monk Seals in the Gulf of İskenderun

Although data from direct observations could not be obtained, information on seal presence was mainly collected from cave checks and from the seal information network, which investigated the local knowledge on the species' possible distribution. The data collection continued over a 2 year period, and proved that 1-3 animals (sightings reports) were observed throughout each year, using the same habitat (for e.g.: near the Syrian border). Reported sighting also indicated that some of them are permanent within the area but some of them may be mobile in the region. The highest number of monk seal sighting were reported by local fishermen after the activation of the monk seal information network.

The possible reasons that the direct observations and infrared monitoring systems did not show clear results in the Gulf of İskenderun were listed as follows;

- In contrast to the Cilician colony, the Mediterranean monk seals in the Gulf of İskenderun were assumed to form a small group including only 1-3 individuals. Therefore, data collections targeting the biology and existence of the species in the area more difficult since the probability of coming across with this endangered and rare species were less possible.

- Unsuitable weather conditions that was frequently experienced by the research team during the study period also did not allow the use of each sampling day effectively. Under high wave conditions, when the caves are washed out completely, the monitoring system failed to operate since infra-red light blinds in the sea-water.
- Due to limited number of field surveys and unsuitable weather conditions, there was a fewer chances of frequent monitoring of the suitable caves in the area. Moreover, time intervals between the cave checks could be long to obtain sighting data.
- Sometimes the infrared monitoring systems did not work properly. Hiby and Jeffery (1987) indicated that there could be insufficient temperature difference between the seal and its surroundings to trigger the infrared monitoring systems. This could be true in some cases of installation of the infrared monitoring systems during the study period. These limitations decreased the probability of obtaining direct observation data.

This study was the first comprehensive study carried out to determine the status and suitable habitats of monk seals in the Gulf of İskenderun. Although the parameters related to demography of the individuals in the Gulf could not be acquired during the study period, existence of the monk seals in the region was proved and the possible group size and their suitable habitats were determined.

4.3 What are the Important Threats the Species is Facing Today in the Northeastern Mediterranean?

The main threats for the survival of the Mediterranean monk seal are listed by many authors (Marchessaux and Duguy, 1977; Panou et al., 1993; Reijnders, et al., 1997; Yediler and Gücü 1997; Johnson and Lavigne 1998, 1999b; Güçlüsoy et al., 2004; Karamanlidis et al., 2004b). Deliberate killing, accidental killing/capture, disturbance and habitat destruction, pollution, overfishing, infectious diseases, or other catastrophes are assumed as the main threats. They are all currently potential threats for individuals that in both the northeastern Mediterranean coast and the Gulf of İskenderun. However their importance according to these regions was different from each other. Human disturbance was found significantly high in the Gulf of İskenderun because of intensive industrial activity carried out in the area and aggregation of the settlement on the coastal areas.

When compared with the Gulf of İskenderun, seal abundance was higher in the area where the Cilician colony inhabits. Possible reasons for higher seal abundance in the northeastern Mediterranean coast could be the higher availability of suitable habitat for the species (for breeding, mating, feeding, resting, etc), and lesser human disturbance, since in the area human activities are regulated in last years, and conservation measures for the species' survival and habitat exists. Other reasons could be due to the geographic limitations. The region, where most part of the coast is uninhabitable, with steep and harsh cliffs, which intrinsically limit any form of intensive human use (agriculture, settlement, etc).

Whereas, significantly low number of suitable breeding and resting caves exist in the Gulf of İskenderun. In other words there is limited area of suitable seal habitat for breeding, mating, feeding, and resting. Moreover, the area is highly industrialized and the coast is inhabitable because there are not any geographic limitations for human settlement.

As discussed above, from the information gathered from the seal info network, and from cave checks, showed that the seals are present in the Gulf of İskenderun. Since suitable seal habitat is limited in the Gulf, the presence of seals there could be explained by possible migration or long distance movement from the Cilician colony. This movement could be driven by search of food out of the previous suggested home ranges or search for new breeding areas for newly recruited territorial male adults into the colony. It was known that the Mediterranean monk seal is capable of doing considerable movement. The different records suggesting monk seals movement along shore about 50-600 km (Sergeant et al., 1978). Berkes (1978) indicated that the home range of the species on the Turkish Aegean was about 40 km. Besides, Mursaloğlu (1991) monitored one specific individual and indicated that it could swim about 80 km around its cave to find food during only one day.

It was observed during the study that an animal undergone a long distance move from inner part of the Gulf İskenderun to Turkey-Syria border in a 2 months period. There is no scientific evidence to predict home range of this individual, however, the sighting records were encouraged to speculate that this individual is a member of the Cilician colony. Furthermore, infrared monitoring system placed in a formerly abandoned cave in Akkum proved that at least 2 animals re-populated the cave for resting. These findings proposed the possibility of migration or long distance movements between the two habitats.

4.4 Photoidentification

To further investigate the possibility of migration, the study needed to prove that the seal identifications were accurate and that there was a circulation of movement between different areas used by the same seals belonging to the Cilician colony. Therefore, application of alternative photometry techniques were tested in the study area, which would allow highly accurate non-intrusive ways of seal identification, and enable better investigation of the possibility of migration, or long distance movement of identified individuals from the Cilician colony to the available seal habitats in the Gulf of İskenderun. First, the level of accuracy necessary for the photometry technique was tested by creating a 3D model from monk seal shaped object. This resulted that in order to reach the necessary accuracy level for correct identification of monk seal, which has a specific body shape, at least 100 numbers of points including 25 reference points on the head, 66 reference points on the abdomen and 9 reference points on the tail and at least 4 phonographs taken simultaneously from 4 different angles were needed. The most difficult body part in the monk seal 3D model construction was the head part since it is very much detailed in shape compared to the abdomen and the tail part.

With the existent infrared systems, this research could not reach the necessary levels due to improper operation of the systems, which of the results mentioned previously in this chapter. 3D modeling from video capture failed because of the plasticity of the body of the seal while swimming or crawling on the land. 3D modeling from photographs was also failed because the space of the cave was limited so the probability of capturing whole body of the seal was quite low.

Besides, wider angle lens may be preferred, source of the light may be improved and infrared film may be used. However this method seems to be a promising method and need to be improved for further studies.

4.5 Conservation and Survival Success of the Cilician Colony

Population viability analysis carried out for the Cilician colony proved that the conservation measures applied in the Kızılliman Marine Protected area in the northeastern Mediterranean improved the status of the colony. The Kızılliman Marine Protected area is one of the important marine protected areas dedicated to protection of monk seals in the northeastern Mediterranean.

The model trajectories run to evaluate the future status of the colony demonstrated that the risk of decline of the colony to 12 individuals for the next 50 years is very low with as far as current population status is concern. However, there is still a risk that the monk seal population abundance may fall below the existing level at least once during the next 20 years. Various studies have showed similar result about the fate of the species in different regions. Durant and Harwood (1992) indicated that a number of local populations (particularly in Greece and in the Western Mediterranean) have shown signs of a high risk of extinction (40-80%) within the next 60 years. Moreover, the population viability analysis carried out on the monk seal population in Greece has pointed out that unless the potential rate of increase of the population is greater than 3% per year, extinction of the species within the next 200 years will be inevitable with current level of deliberately killing (Scoullos and Seal 1994). Population viability analysis demonstrated that the survival success of the Cilician colony was the most important demographic parameter influence the risk of decline of the colony. The survival success of the colony depends on several factors. Most possible factor that may influence the survival success of the colony in the regions is the food availability. It may effect both adult and pup survival since the fish stocks of the region were depleted as a consequence on heavy fishing pressure in the region (Gücü and Erkan, 1999). Following the regulations applied in the region, there are positive signs of recovery of the fish stock within the Kızılliman MPA (Gücü and Erkan, 2005). There are some studies showing that the seals become more opportunistic and feed on trapped fish on the gill nets when food resource declined (Cebrian et al., 1990; Salman et al., 2001; Gücü et al., 2004). Therefore, the probability of getting entangled in a fish net and the hostility between seals and the owners of the fish net may remarkably increase (Gücü et al., 2004).

Without doubt, the main target of every conservation programme for a threatened species must be to reduce its extinction risk (Ballou 1993). So, the question is if the risk of decline was reduced for the Cilician colony by the establishment of the Kızılliman MPA and by the implementation of the conservation measures in the area. Results of the PVA showed that the risk of decline for the monk seal in the area was certainly reduced and thus, the conservation decisions and their implementation seemed appropriate for the species as well as for its habitat. Moreover, the current colony size would be definitely less than today's actual colony size if the conservation did not implemented. However, considering that the PVA analysis has limitations, it was not possible to consider all the factors affecting this free ranging species' survival and as a consequence, the real extinction risk could be underestimated (RAC/SPA, 2005). Hence, either the general situation or the colony size could be worse than the PVA estimation presented in this study, especially if conservation efforts and Kızılliman MPA were not in operation.

5. CONCLUSION

The results of direct observations on whelping success and mortality of the Cilician colony indicated that there is a statistically significant difference between basic population parameter, namely survival estimated for two time periods; before and after conservation and also number of pup born in the colony in these two time periods. This difference, increased survival and number of pups, is in favor of the colony.

The same trend has been verified by the Population Viability Analysis. The population trajectories seeded by the population parameter estimated for the period before any conservation measures applied in the area, has resulted in very high probability of extinction in the very near future. Whereas the demographic structure that the colony has attained after the conservation is more hopeful; very high level of risk of decline (21.70 %) estimated for pre-conservation period has decreased to 0.2 % with the increased fecundity and reduced mortality rate of the last 6 years. To improve the accuracy of the PVA and to enhance its effectiveness as a management tool, continuous monitoring activities for the Cilician colony and for the monk seal group in the Gulf of İskenderun need to be performed in the area.

The data at hand may suggest that the positive changes in the population structure and demography of the Cilician colony is direct consequences of the conservation activities carried out in the region.

In the Gulf of İskenderun, 2-3 monk seals live in the Gulf but the area is highly industrialized and human disturbance is quite high. If the colony is isolated, there may not be a hope for these individuals with such a small colony size. Besides, expanding the study area to the neighboring sites such as Cyprus would give a better idea about the status of the colony seals in the northeastern Mediterranean. The photoidentification technique tried to be modified in this study were not yielded successful, however it was proven that the technique is able to provide valuable data on seals without giving any disturbance to the animals. At least 4 cameras should be placed horizontally in a way to capture lateral, anterior and posterior aspects of the animal. The 3D modeling attempt indicated the in order to secure 90% error margin, at least 100 reference points should be determined on the body. Among those, 25 reference points should be selected on the head; 66 points on the abdomen and 9 points on the tail may be preferable to reconstruct the posture of the individual. The light, in many of the seal caves, are nearly always too dimmed to take pictures suitable for photo-identification. Therefore to ensure sufficient illumination and full framing wide-angle lenses are recommended.

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APPENDICES

Appendix 1: Fishermen Survey Protocol

Protocol #: 1

Date :
Time :
Surveyor :
Fishing Port :
Number of fishermen using the port :
Number of fishing boats in the port
    Trawlers :
    Purse seiners :
    Artisanal (1) with engine :
    Artisanal (2) without engine :

Number of fishermen interviewed :

	Origin of the fishermen			Age of fishermen			
	village	Near towns	Far cities	0-15	16-25	26-50	50<
Trawler							
Purse seiners							
Artisanal1							
Artisanal2							

General attitude towards seal (Positive/Neutral/Negative) __________

General attitude towards project (Positive/Neutral/Negative) __________

Remarks:

Appendix 2: Field Survey Protocol

Protocol #: 2

Date:		Time started at:		Ended at:
Team:		Survey Type:		
Weather Conditions				
Wind speed	Calm	Medium		Strong
Cloudiness	Bright	Partly Cloudy	Cloudy	Rainy

Sea Condition								
Wave direction	N	NE	E	SE	S	SW	W	NW
Wave strength:	Calm	Moderate	Rough	Storm	Swell			
Turbidity:	Clear/bottom visible	Bluish Green	Green	Brown				
Tide:	Up tide	Normal	Low tide					
The Coastal Stretch covered	**From:** **Lat :** **Lon :**	**To :** **Lat :** **Lon :**	**GPS file:**					

Caves Discovered			
ID	**Lat**	**Lon**	**Remark**

Remarks			
Event	**Time**	**Lat**	**Lon**

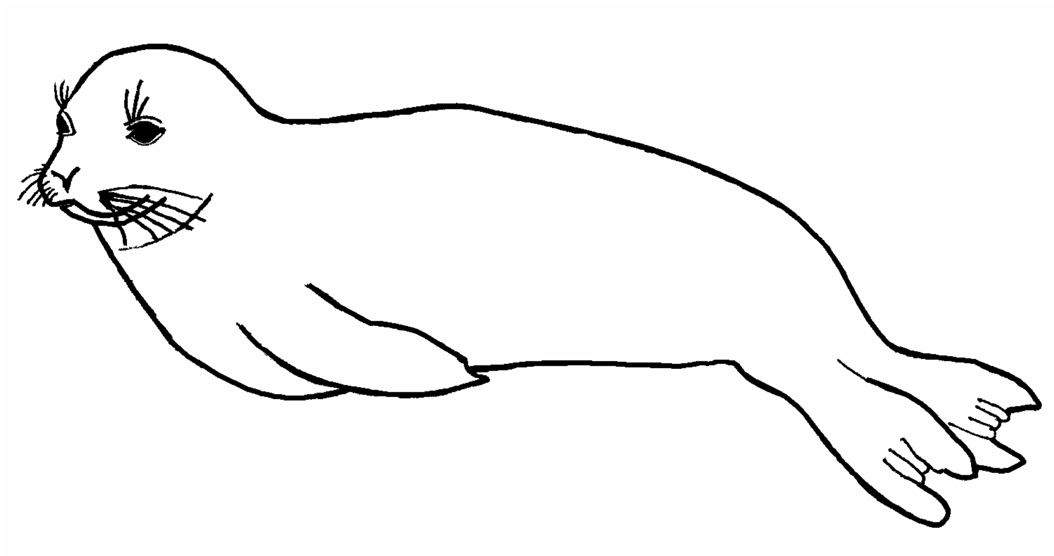
Appendix 3: Seal Observation Protocol

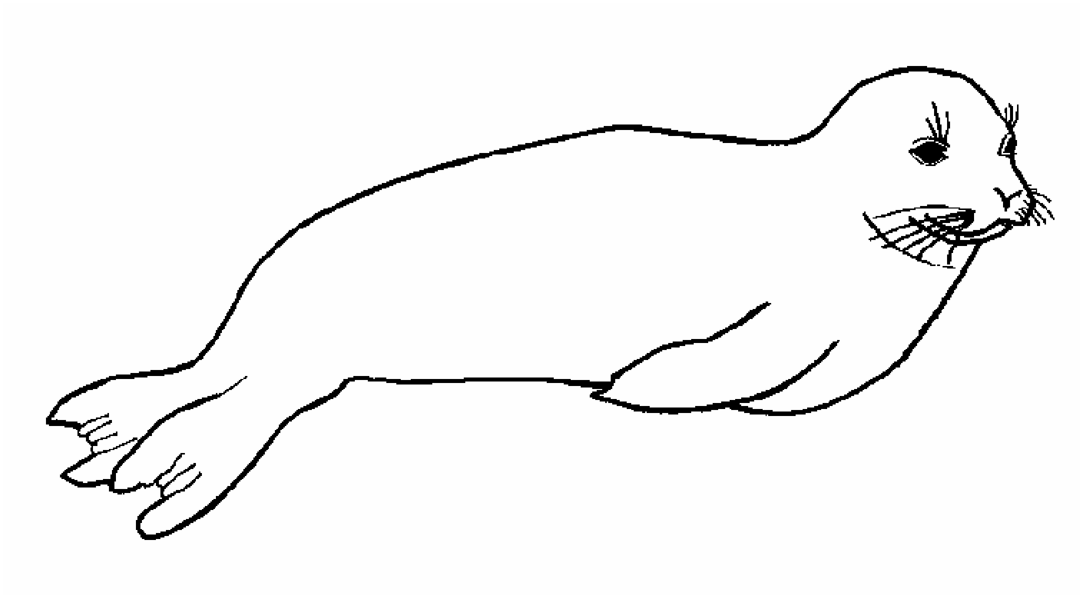
Protocol #: 3

Code	Date	Time	Seal Id	Location	#	Color	Closeness(m)	Observer

	**BAM** Black Adult Male	Black pelage; belly with a white patch. Back and neck with white scars.	
	**LGS** Large Grey Seal	Pelage is usually dorsally dark grey a light below. Back interrupted by white scars with a dorsal patch	
	**MGS** Medium Grey Seal	Pelage is usually dorsally dark grey and light below. Back interrupted by white scars with no patch	
	**J** Juvenile	Pelage is usually dorsally brown grey and light below. Body with few scars or without them	
	**Y** Youngster	Pelage is usually dorsally light grey and lighter below. Body with no scars. Fatty appearance	
	**P** Pup	Black pelage, belly with a white patch. Body with no scars. Body fur forming pleats in the first 10 days.	

Name of the individual:





Appendix 4: Pup Identification Protocol

Protocol #: 4

Date	Time	Location	Name	Pup Id	Observer

Inside a cave	Outside a cave	On the land	In the sea	Alone	With mother	Asleep	Awake

Thin-newly born (0-10 days old) ____

The fur is black and the texture of the hair is in clumps and has a wet appearance. The patch in the belly area in the animals of this age appears yellowish-orange in coloration. In terms of the animal's body shape, it appears skinny in such a way that the skeletal features are visible .The umbilical cord was still attached to the abdomen or the umbilicus was still not healed completely having a fresh pink coloration.

Spindle-wooly coat (10-30 days old) ____

With respect to their fur, they also had the dark gray to black lanugo, but its appearance and texture was wooly, even and fluffy when dry. Even when the fur was wet it still had an even and uniform appearance. The patch in the belly area was yellowish-white. The body became clearly spindle, and well rounded, while the skeletal features are no longer evident. The umbilical cord had dropped and the umbilicus was healed.

Spindle-patchy coat (30-50 days old) ____

The animals were undergoing their fur molt. The appearance of their fur was very irregular and patchy, since parts of their body were covered by lanugo, while others were covered by new fur. Relative to their body shape, all the animals exhibited again the spindle shape and well rounded and their umbilicus was completely healed.

Fat-short coat (50+ days old) ____

They had completed their molt and were covered by a new short fur, of grayish coloration, dark dorsally and distinctly lighter ventrally. Their bodies were more developed and fat, giving the impression of being bloated. The characteristic of abdominal patch is less distinct and is clearly identifiable only at the lateral borders where it meets dark coloration. In certain cases it appears that the patch has completely faded away.

Appendix 5: Human Disturbance Protocol

Protocol #: 5

Date:	**Place from**:		**to:**	
Time from:	**to:**	**Survey Type:**	**Observer:**	
		Group of people		**Age of people**

Type of activity	villager	near towns	far cities	0-16	16-25	25-50	50<
Sports Fishing							
Liners with boat							
Liners without boat							
Detrimental Fishing							
Dynamite							
Spear fishing							
Trawl							
Purse seine							
Trap							
Poission							
Other							
Artisanal							
Long line							
Gill net							
Others							
Leasure							
Bathers							
Skin divers							
Hiking							
Diving / SCUBA							
Training							
Regular Diver							
Adventure divers							
Boat tours							
Yatching							
Daily tours							
Overnight charters							
Speed boats							
Sailboat							
Others							
Agriculture							
Smuggling							
Gathering							
Life stock breeding							
Others							
Remarks							

Appendix 6: Cave Inventory Protocol

Protocol #: 6

Cave Code / Name / Discovered by			

Cave Info								
Latitude / Longitude / Photo frame								
Total length in meters (opening to far end)								
Seal (s) :		Sight Code :				Odor :		
Number of chambers		With air :				Without air :		
Entrance	Surface	Underwater	Land	Depth	Height	Width	Direction	
Platform	Position	Length	Width	Texture	Suitability	Feces	Fur	Track

Seal Evidence					
Platform	Depression	Track	Fur	Feces	Other

Sketch of the cave

Appendix 7: Seal Observation Protocol

Protocol #: 7

Number of Observation	**1**	**2**	**3**	**4**	**5**
Code					
Date					
Time					
Name					
Location/Cave					
#					
Behavior					
Length					
Color					
Sex					
Closeness					
Observer					

Protocol #:

Remarks:

Appendix 8: Identification Card 1

ID CARD-1

Seal Name: Tekin
Sex: Female
Morphology: Light grey
Age (Estimated Minimum in 2005): 28.39
Home Range: Satellite around Bozyazı
Date of First sighth: 10.03.1998
Category at first sight: LGS
Present Category: LGS

Picture is not available

Family tree is not available

Appendix 9: Identification Card 2

ID CARD-2

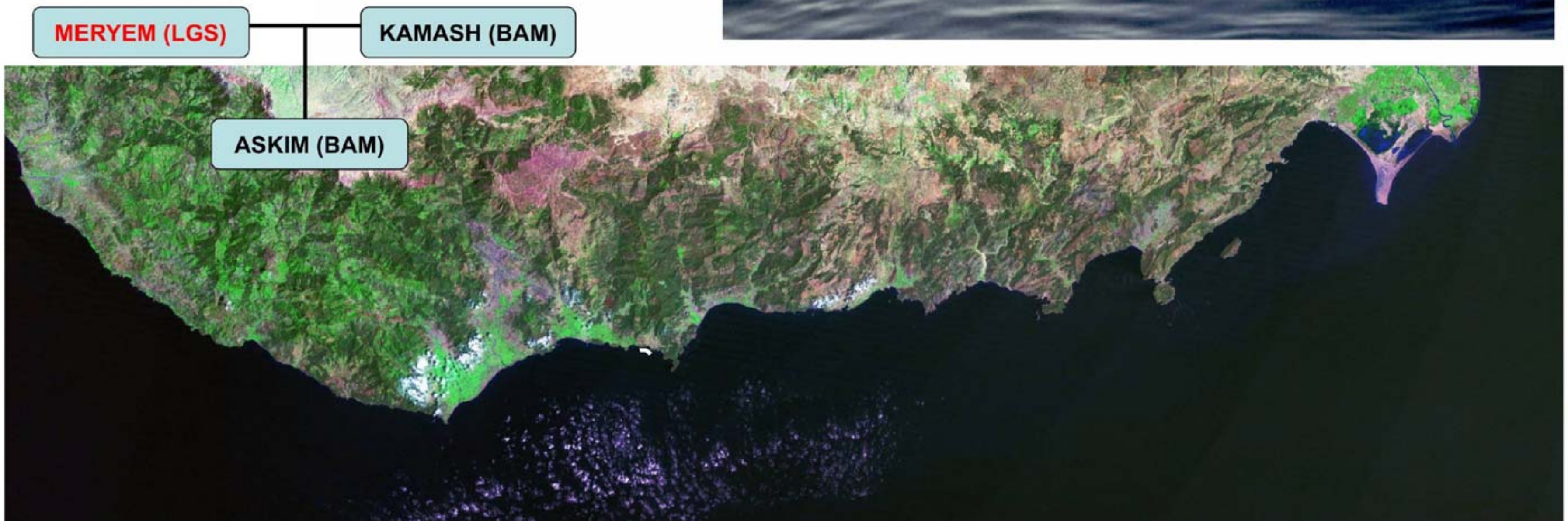
Seal Name: Kokona
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 19.39
Home Range: Gulf of Ovacık
Date of First sight: 23.07.1995
Category at first sight: LGS
Present Category: LGS

Picture is not available

Appendix 10: Identification Card 3

ID CARD-3

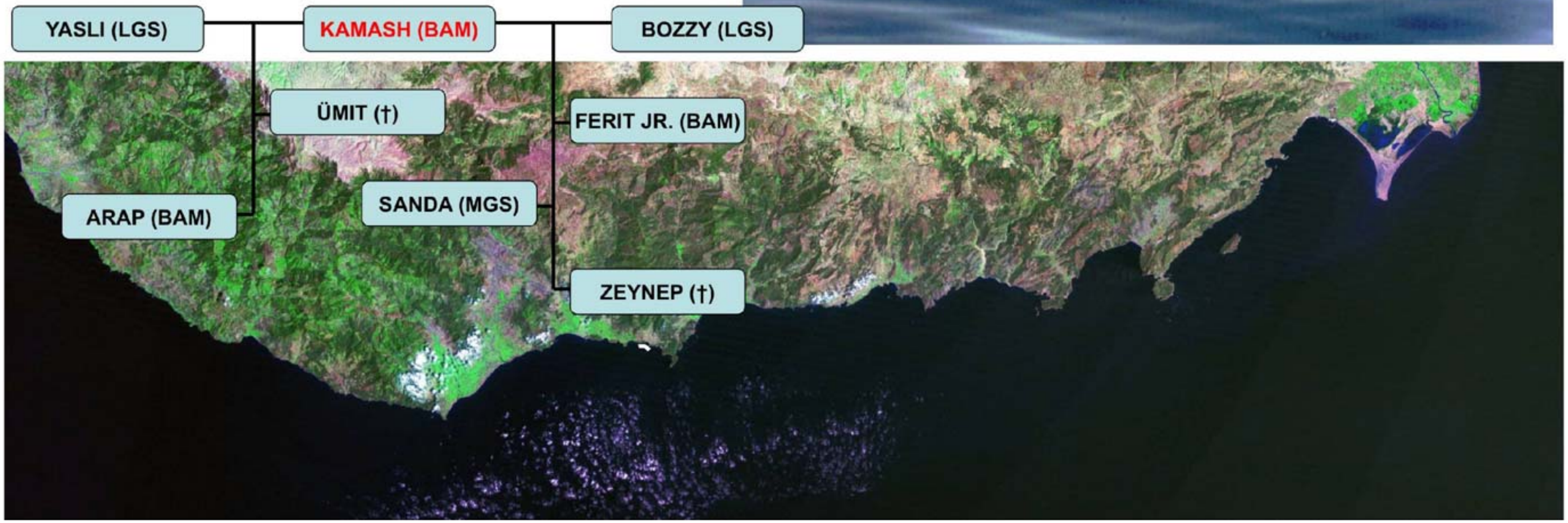
Seal Name: Meryem
Sex: Female
Morphology:Baldness on head, scars on back
Age (Estimated Minimum in 2005): 18.39
Home Range: Around Bozyazı
Date of First sighth: 10.03.1998
Category at first sight: LGS
Present Category: LGS



Appendix 11: Identification Card 4

ID CARD-4

Seal Name: Kamash
Sex: Male
Morphology: Distinct family mark
Age (Estimated Minimum in 2005): 18.39
Home Range: Around Bozyazı
Date of First sighth: 10.05.1997
Category at first sight: BAM
Present Category: BAM



Appendix 12: Identification Card 5

ID CARD-5

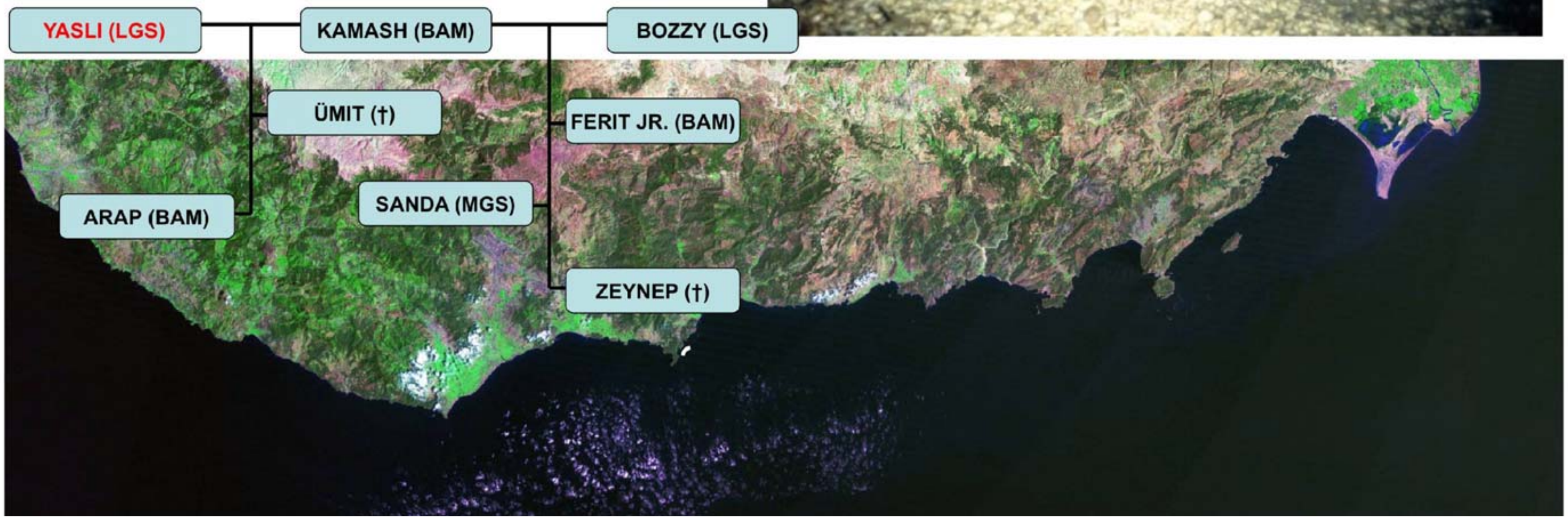
Seal Name: Bombacı
Sex: Male
Morphology: Distinct family mark
Age (Estimated Minimum in 2005): 18.39
Home Range: Around Bozyazı
Date of First sighth: 16.04.1995
Category at first sight: BAM
Present Category: BAM

Picture is not available

Appendix 13: Identification Card 6

ID CARD-6

Seal Name: Yaslı
Sex: Female
Morphology:Mating scars on the back, a circle above right fore flipper
Age (Estimated Minimum in 2005): 17.39
Home Range: Around Kızılliman
Date of First sighth: 21.08.1996
Category at first sight: LGS
Present Category: LGS



Appendix 14: Identification Card 7

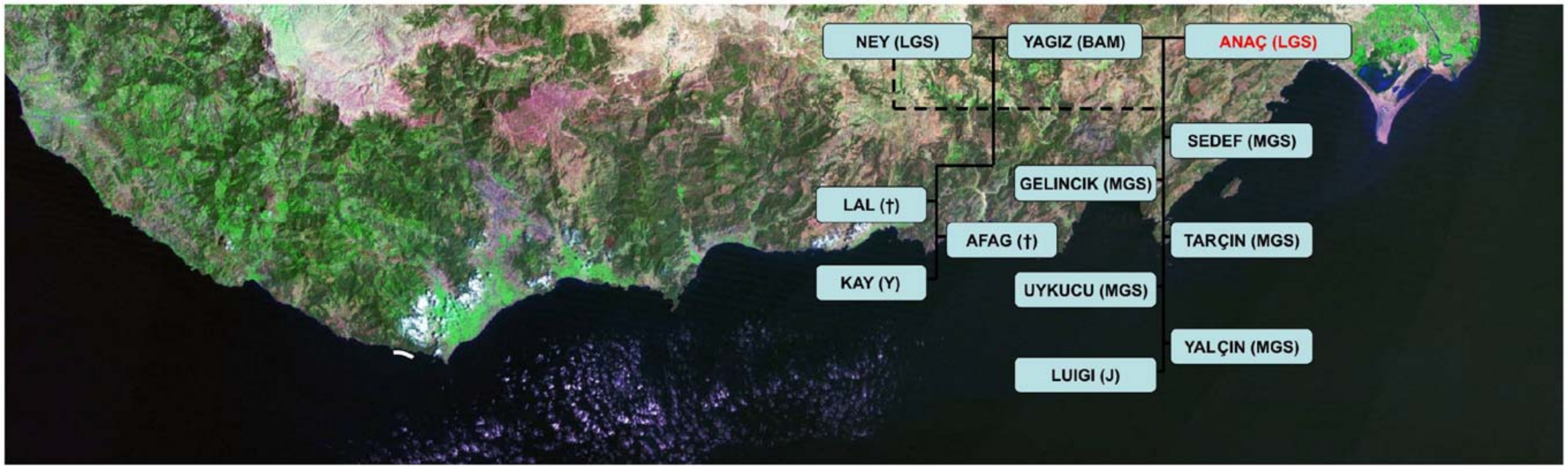
ID CARD-7

Seal Name: Yağız
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 16.39
Home Range: Around Aydıncık
Date of First sighth: 24.08.1996
Category at first sight: BAM
Present Category: BAM

Appendix 15: Identification Card 8

ID CARD-8

Seal Name: Anaç
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 15.39
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 20.08.1998
Category at first sight: LGS
Present Category: LGS



Appendix 16: Identification Card 9

ID CARD-9

Seal Name: Yakışıklı
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 14.39
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 19.08.1998
Category at first sight: BAM
Present Category: BAM

Picture is not available

Appendix 17: Identification Card 10

ID CARD-10

Seal Name: Melek1
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 14.39
Home Range: Around Aydıncık
Date of First sighth: 11.10.1997
Category at first sight: LGS
Present Category: LGS

Picture is not available

Appendix 18: Identification Card 11

ID CARD-11

Seal Name: Meltem
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 13.39
Home Range: From Gazipaşa to Kaledran
Date of First sighth: 13.03.1999
Category at first sight: MGS
Present Category: LGS

Picture is not available

Family Tree is not available

Appendix 19: Identification Card 12

ID CARD-12

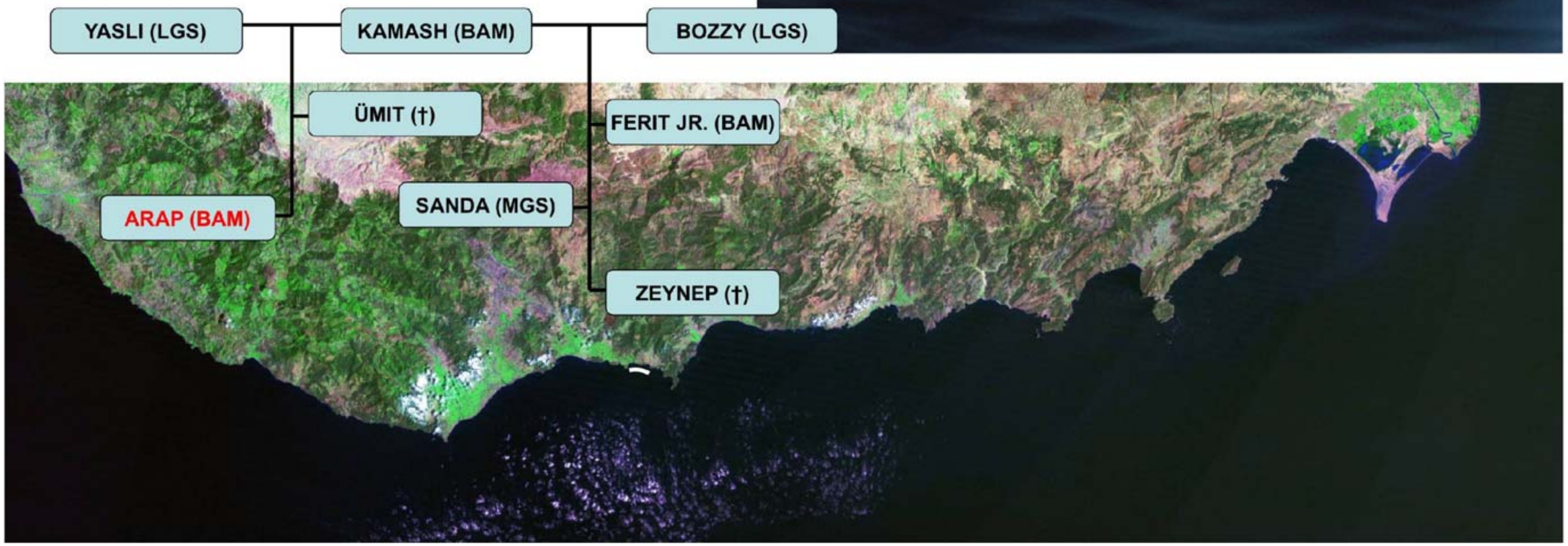
Seal Name: Ceren
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 10.45
Home Range: From Ovacık to Akkum
Date of First sighth: 30.07.1995
Category at first sight: Y
Present Category: LGS

Picture is not available

Appendix 20: Identification Card 13

ID CARD-13

Seal Name: Arap
Sex: Male
Morphology:White patch
Age (Estimated Minimum in 2005): 9.15
Home Range: Around Bozyazı
Date of First sighth: 15.11.1996
Category at first sight: J
Present Category: BAM

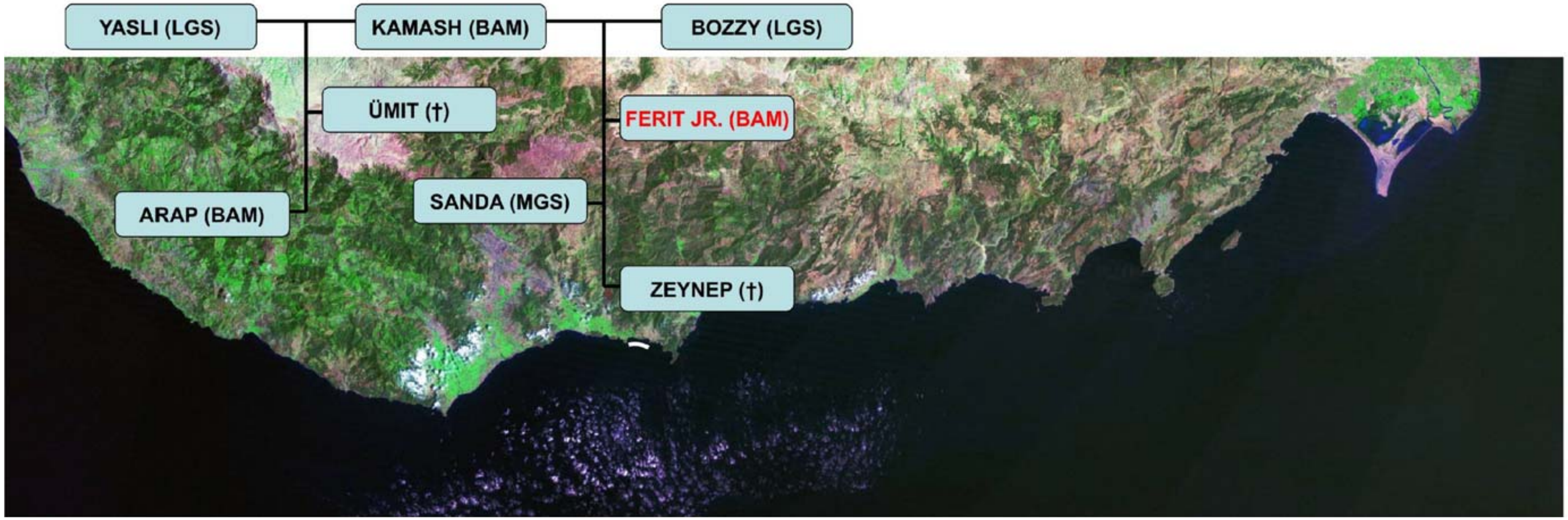


Appendix 21: Identification Card 14

ID CARD-14

Seal Name: Ferit Jr.
Sex: Male
Morphology: Triangular white patch on right side
Age (Estimated Minimum in 2005): 9.09
Home Range: Around Bozyazı
Date of First sighth: 02.12.1996
Category at first sight: Y
Present Category: BAM

Picture is not available



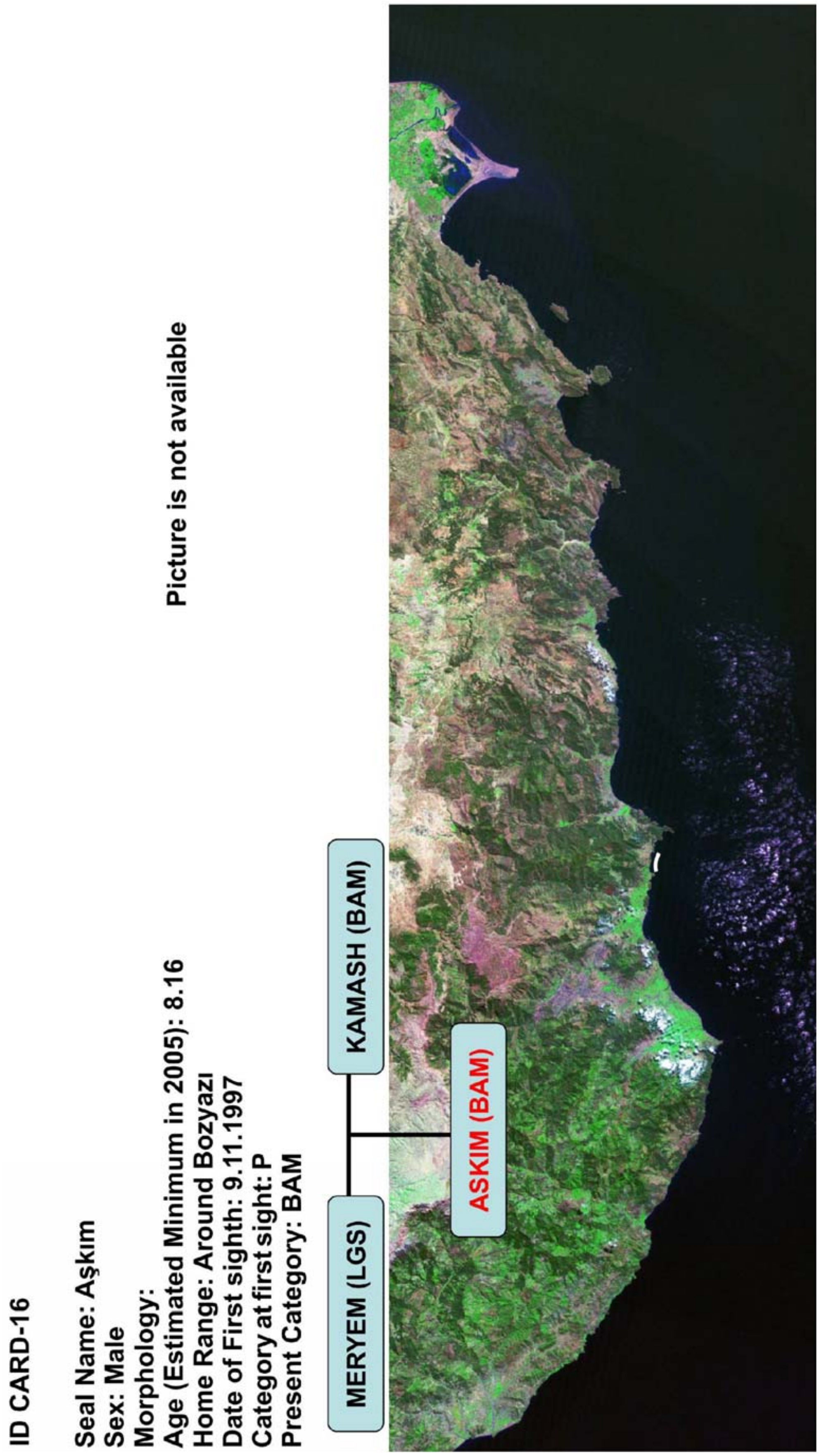
Appendix 22: Identification Card 15

ID CARD-15

Seal Name: Charlie
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 8.25
Home Range: Around Aydıncık
Date of First sighth: 11.10.1997
Category at first sight: J
Present Category: LGS

Picture is not available

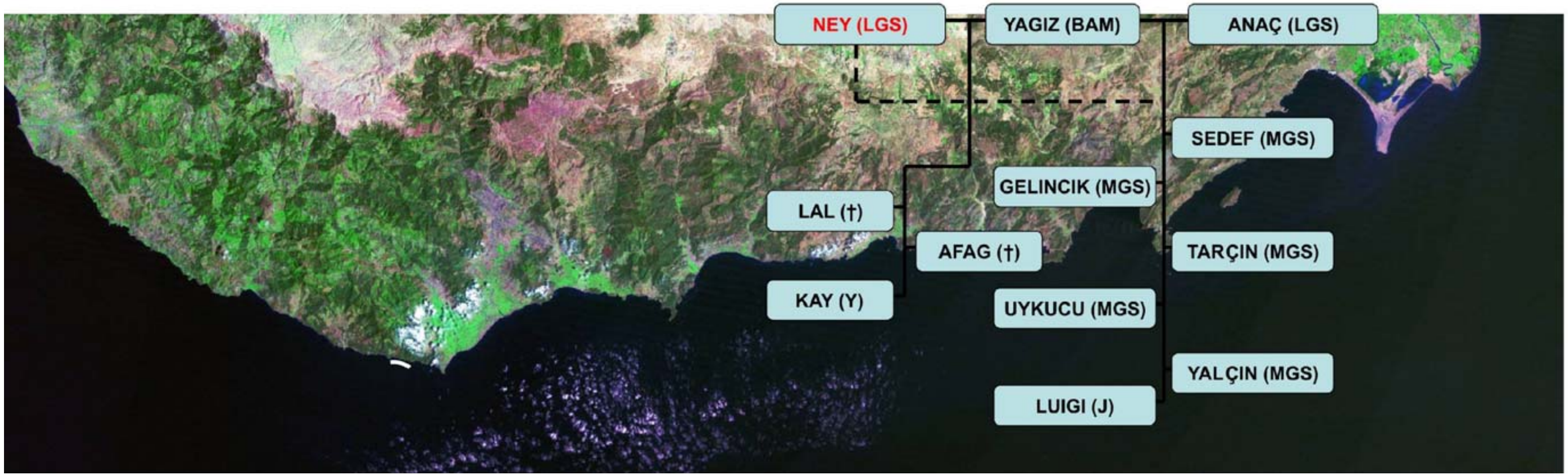
Appendix 23: Identification Card 16



Appendix 24: Identification Card 17

ID CARD-17

Seal Name: Ney
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 7.39
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 20.08.1998
Category at first sight: P
Present Category: BAM



Appendix 25: Identification Card 18

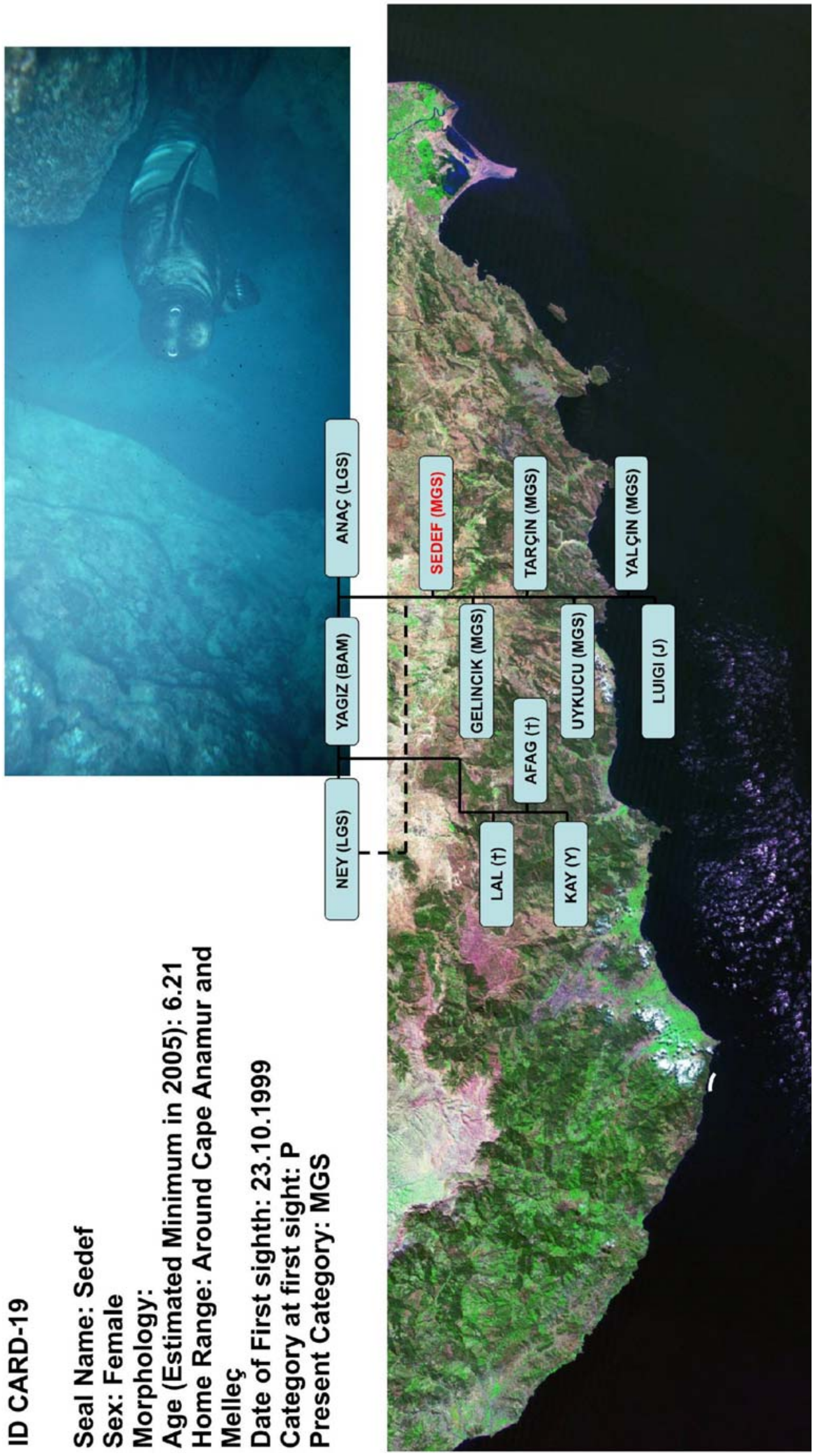
ID CARD-18

Seal Name: Saklıkuzu
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 7.23
Home Range: From Gazipaşa to Kaledran
Date of First sighth: 18.10.1998
Category at first sight: J
Present Category: LGS

Picture is not available

Family Tree is not available

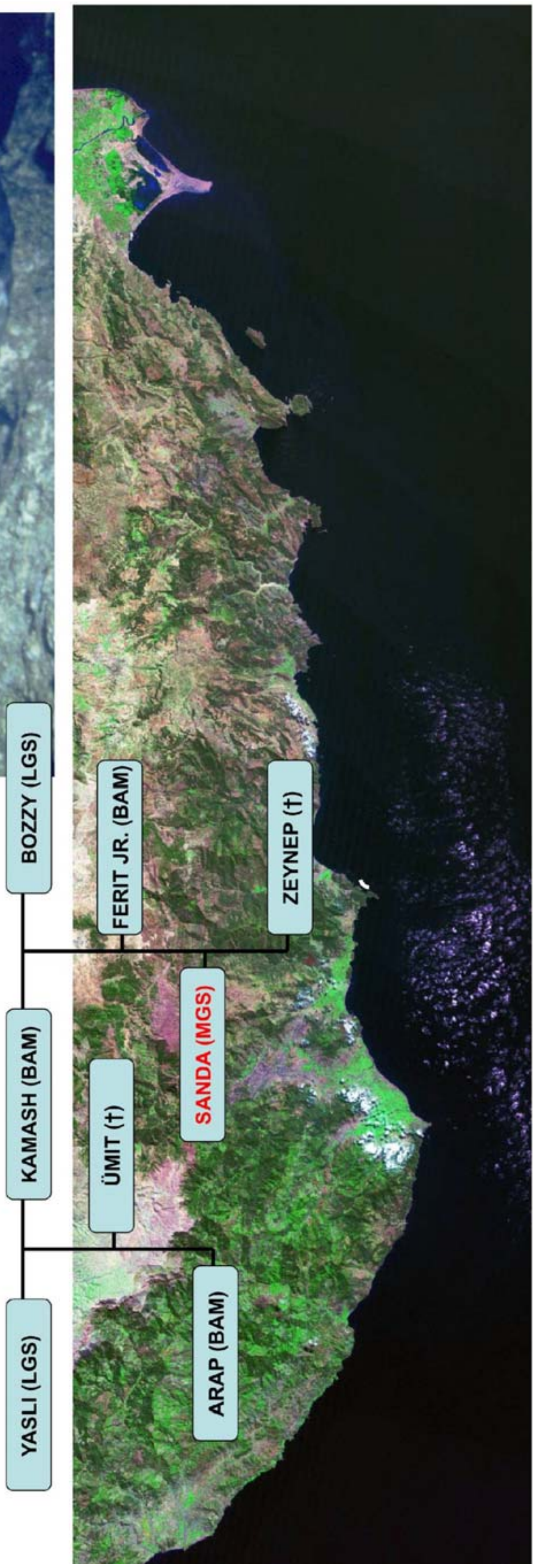
Appendix 26: Identification Card 19



Appendix 27: Identification Card 20

ID CARD-20

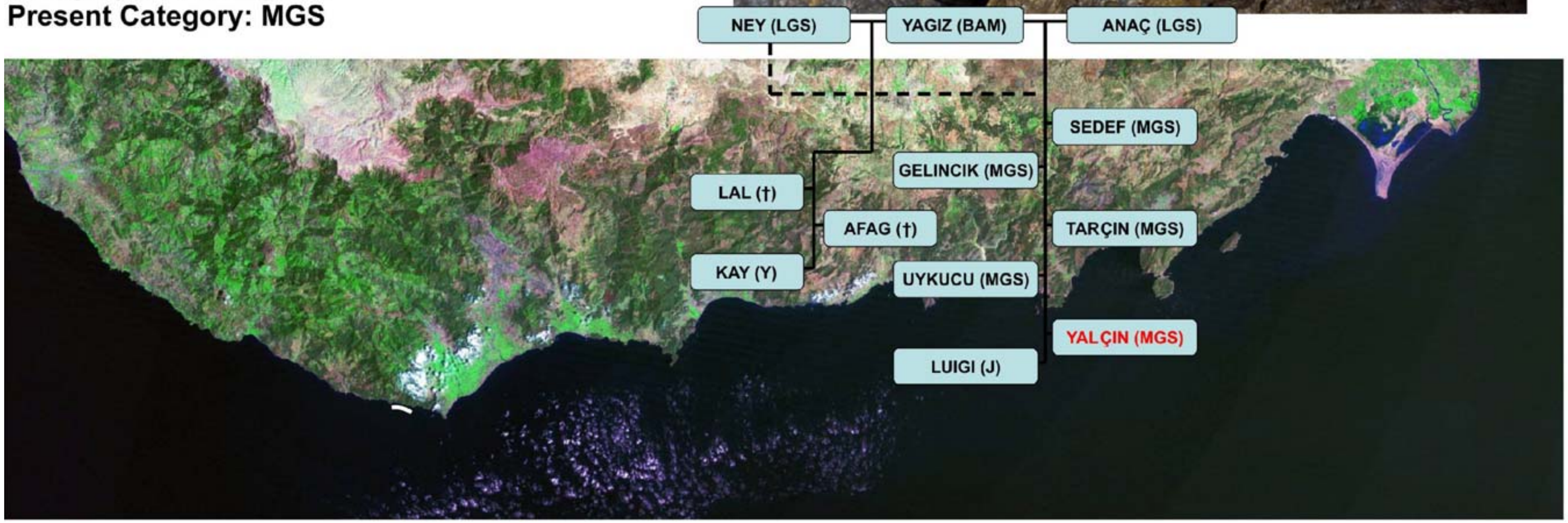
Seal Name: Şanda
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 6.19
Home Range: Around Kızılliman
Date of First sighth: 24.10.1999
Category at first sight: P
Present Category: MGS



Appendix 28: Identification Card 21

ID CARD-21

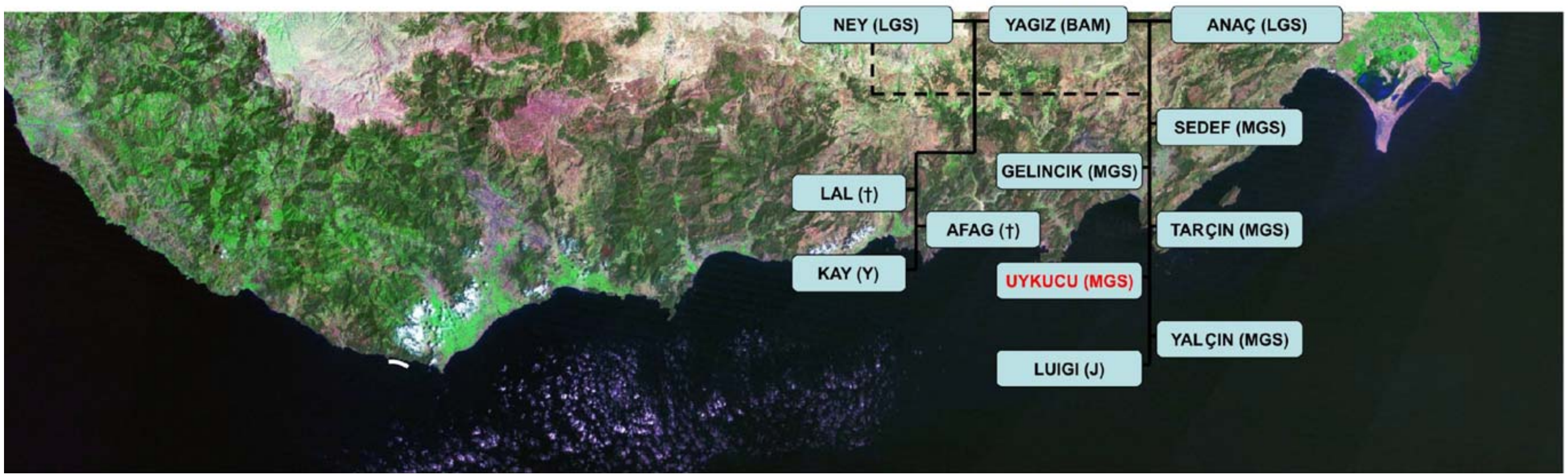
Seal Name: Yalçın
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 5.15
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 09.11.2000
Category at first sight: Y
Present Category: MGS



Appendix 29: Identification Card 22

ID CARD-22

Seal Name: Uykucu
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 4.34
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 29.08.2001
Category at first sight: P
Present Category: MGS

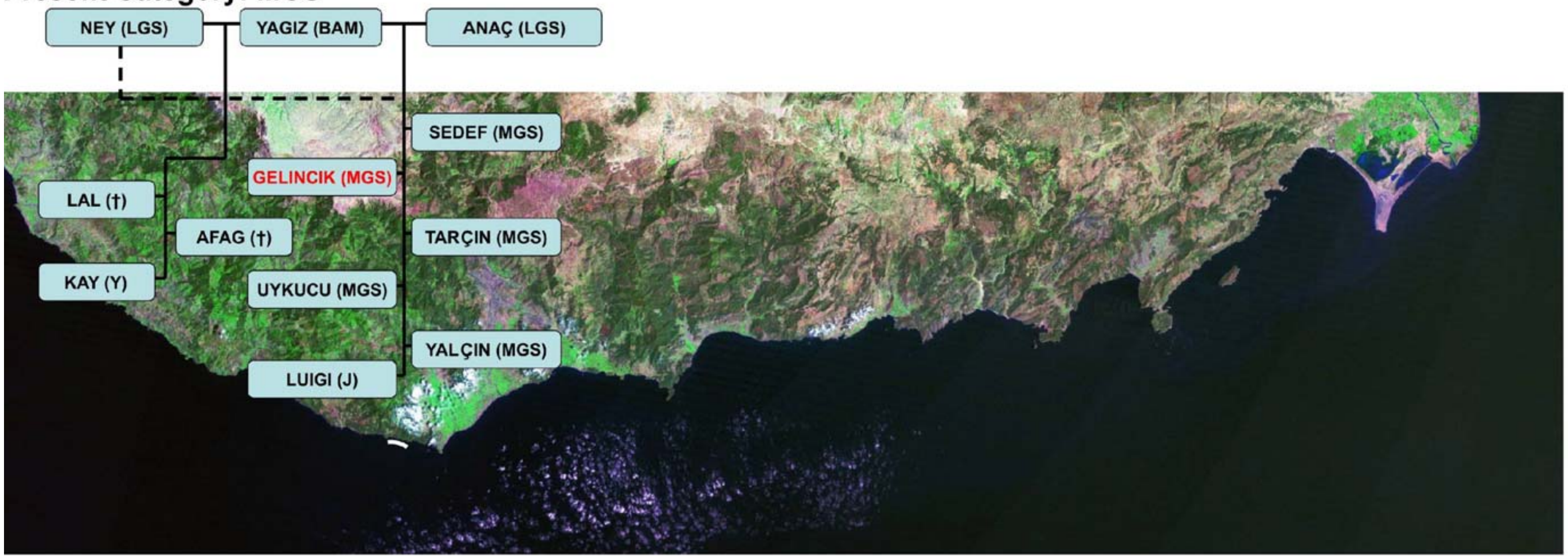


Appendix 30: Identification Card 23

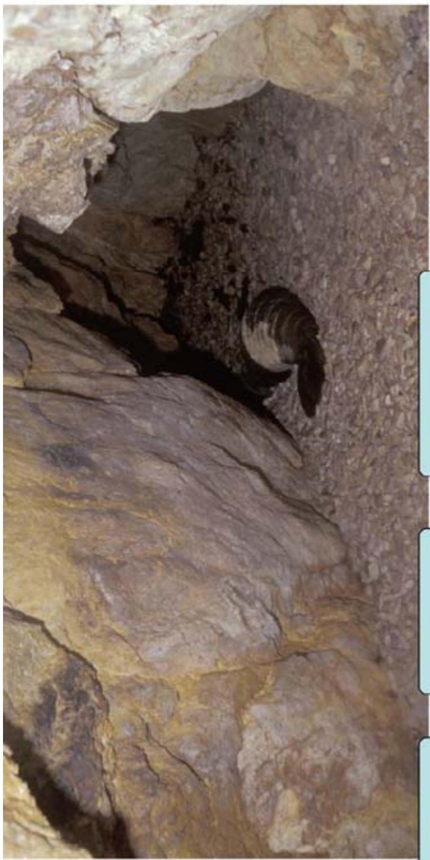
ID CARD-23

Seal Name: Gelincik
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 4.34
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 29.08.2001
Category at first sight: P
Present Category: MGS

Picture is not available

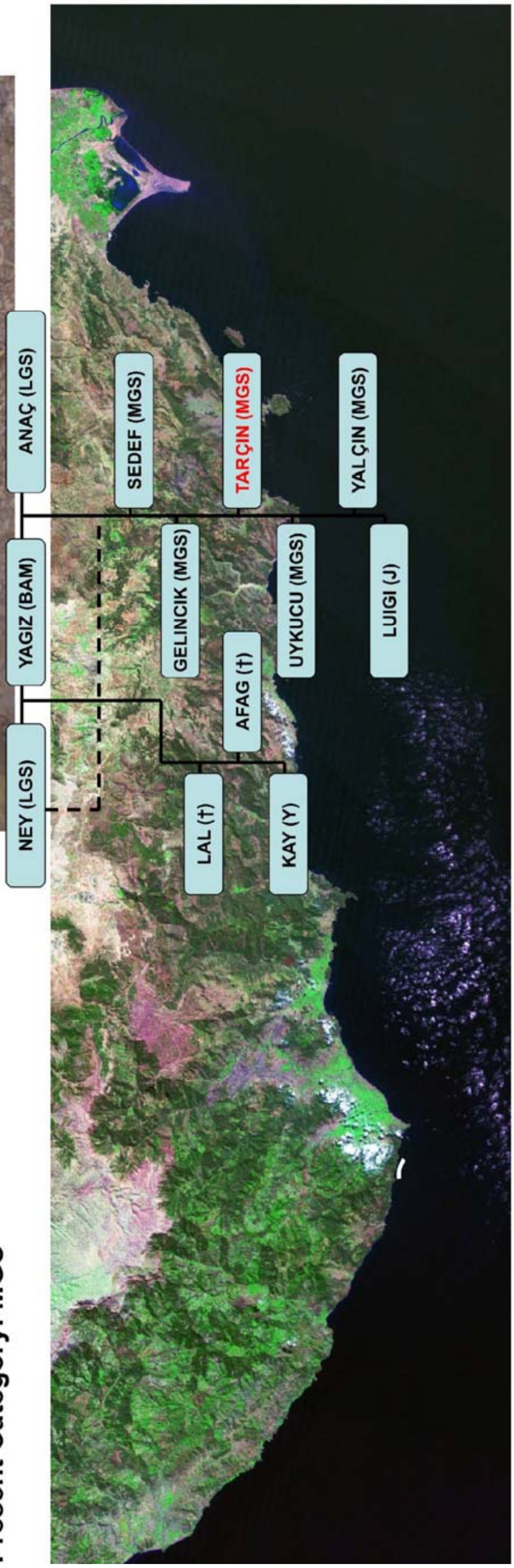


Appendix 31: Identification Card 24



ID CARD-24

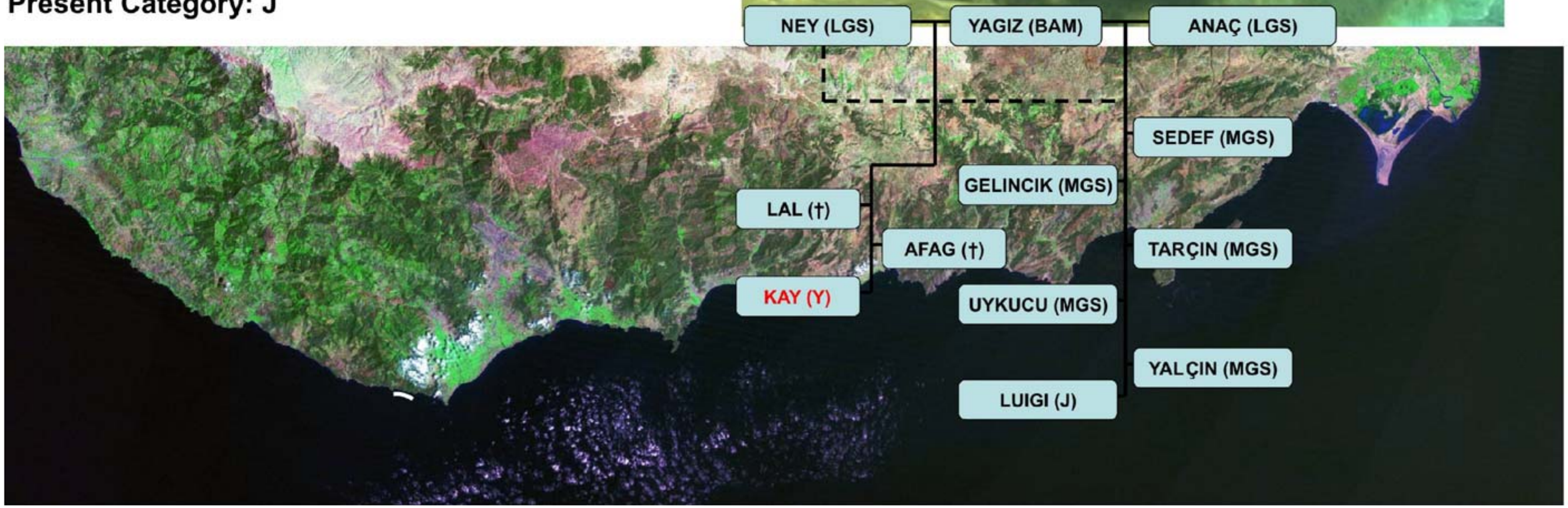
Seal Name: Tarçın
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 3.24
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 6.10.2002
Category at first sight: P
Present Category: MGS



Appendix 32: Identification Card 25

ID CARD-25

Seal Name: Kay
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 1.26
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 26.09.2004
Category at first sight: P
Present Category: J

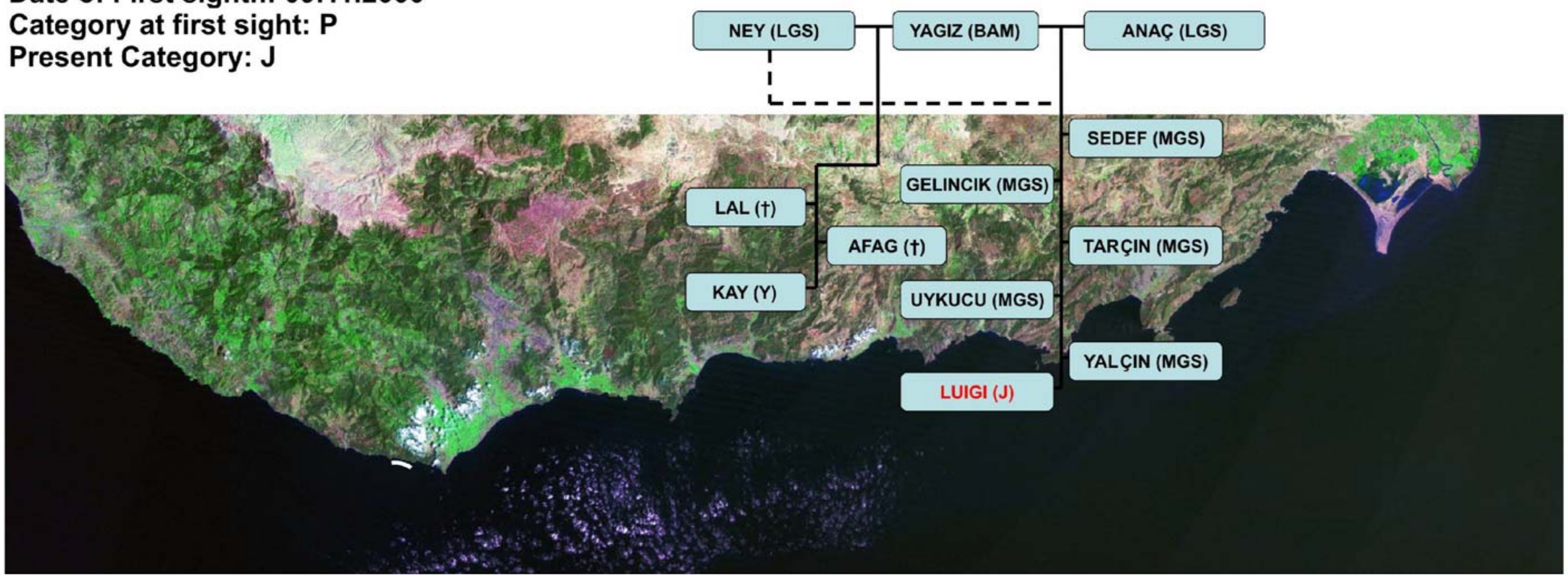


Appendix 33: Identification Card 26

ID CARD-26

Seal Name: Luigi
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 1.09
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 09.11.2000
Category at first sight: P
Present Category: J

Picture is not available



Appendix 34: Identification Card 27

ID CARD-27

Seal Name: Rane
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 1.08
Home Range: Around Kizilliman
Date of First sight: 1.12.2004
Category at first sight: P
Present Category: J

Family Tree is not available

Appendix 35: Identification Card 28

ID CARD-28

Seal Name: Levant
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 0.19
Home Range: Around Kızılliman
Date of First sighth: 22.10.2005
Category at first sight: P
Present Category: Y

Picture is not available

Family Tree is not available

Appendix 36: Identification Card 29

ID CARD-29

Seal Name: Tahta
Sex: Male
Morphology:
Age (Estimated Minimum in 2005): 0.13
Home Range: Around Cape Anamur and Melleç
Date of First sighth: 12.11.2005
Category at first sight: P
Present Category: P

Picture is not available

Family Tree is not available

Appendix 37: Identification Card 30

ID CARD-30

Seal Name: Lamas
Sex: Female
Morphology:
Age (Estimated Minimum in 2005): 0.02
Home Range: Around Kızılliman
Date of First sighth: 22.12.2005
Category at first sight: P
Present Category: P

Picture is not available

Family Tree is not available