Republic of Turkey Ministry of Environment and Forestry
Environmental Protection Agency for Special Areas

CONSERVATION AND MONITORING PROJECT OF SANDBAR SHARKS *(Carcharhinus plumbeus)* IN BONCUK BAY, GÖKOVA SPECIAL ENVIRONMENTAL PROTECTION AREA

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Preface

To get into action so as to protect, develop and rehabilitate the fertility of the spring of land, coast, river, lake and sea within the Special Environmental Protection Areas by considering international conservation conventions and environmental legislations, conducting research and studies are among the duties of our institution, the Environmental Protection Agency for Special Areas (EPASA).

In this context, our institution has executed projects during 2008 in Special Environmental Protection Areas so as to determine the population trends of rare, endangered and vulnerable animal and plant species, to take cautions preventing extinction and to make proposals for their conservation. The Conservation and Monitoring Project of Sandbar Sharks (Carcharhinus plumbeus) in Boncuk Bay, Gökova Special Environmental Protection Area is one of them.

In this project, current status of sandbar sharks in Boncuk Bay - the most important nursery ground known in Turkey, is determined and the threats against the species are assessed. Within the framework of the project, several brochures have been prepared and distributed for public awareness, in addition to the book entitled "Conservation and Monitoring Project of Sandbar Sharks *(Carcharhinus plumbeus)* in Boncuk Bay, Gökova Special Environmental Protection Area".

This study shows that Boncuk Bay has been still holding the feature of being the unique breeding area of the sandbar sharks in Turkey. Hence, conservation of Boncuk Bay in Gökova Special Environmental Protection Area is of vital importance in terms of the sustainability of the species. Our agency will act with this understanding as we have done so far.

It will be possible to monitor the population of the species in Gökova Bay in the next years with the data obtained from this study and to determine the changes and take necessary measures in due time. Moreover, both this publication and the other materials within the project will contribute to the conservation and presentation of the sandbar sharks.

I wish to thank to all participants involved and helped to prepare and publish this valuable book.

Ş. Önder KIRAÇ
Director of EPASA

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1. Introduction

The Mediterranean is a semi-enclosed sea, covering an area of approximately 2.5 million km^2 (about 0.8% of the total marine area of the world). It is generally regarded as an oligotrophic sea, where the trophic potential of the western basin is much higher than the eastern basin (Stergiou *et al*., 1997). Despite of its relatively small dimension when compared to world's oceans, one of the fundamental features of the Mediterranean is the presence of large variety of species, representing 5.5% of the world marine fauna (Farrugio *et al*., 1993).

In his monumental work, Nelson (1994) indicated the presence of 24618 valid fish species in the world, including 815 elasmobranch fishes (sharks & rays). The number has currently reached up to ≈ 31000 species, with 1120 sharks and rays (see Fishbase, Froese & Pauly, 2008). There are almost 700 fish species inhabiting the Mediterranean Sea, but the precise number of sharks and rays is a matter of dispute. Quignard & Tomasini (2000) listed 86 elasmobranch fishes, while the number is probably 84 according to Serena (2005). In a recent study reviewing the conservation status of Mediterranean chondrichthyan fishes, Cavanagh & Gibson (2007) reported 80 species, but nine of them are either infrequent or their presence is questionable due to taxonomical problems. Even though the Mediterranean constitutes less than 1% area of world's seas, it is possible to find almost 6.5% of the global elasmobranch fauna in the region, which makes it very significant in terms of biological diversity (see also Table 1).

Table 1. Percentage of elasmobranch fishes (sharks & rays) in different parts of the Mediterranean Sea (Data mainly compiled from Quignard & Tomasini, 2000 and Bilecenoglu *et al.* 2002).

Locality	∑ number of fishes	∑ number of elasmobranch fish	% of elasmobranch fish
World	31000	1120	3.6
Mediterranean Sea	700	71	10.1
Gulf of Lion	352	61	17.3
Northern Africa	422	71	16.8
Adriatic Sea	402	52	12.9
Gulf of Gabès	267	54	20.2
Levant Basin	415	57	13.7
Mediterranean Sea (TR)	400	61	15.3
Aegean Sea (TR)	405	58	14.3
Sea of Marmara (TR)	249	33	13.3
Black Sea (TR)	152	8	5.3

Bioecology of sharks and rays of the Mediterranean is among the most poorly known and least understood of all marine fishes, which is also the case for rest of the world. Scientific results on key life history parameters are available only for a few species that are subjected to target fisheries. The available data on elasmobranches reveal that there is a great variation in biological characteristics, i.e. litter sizes among viviparous species may range from 1 to 300, age at first maturity can vary between 2 years to 25 years and life span maybe as short as 7 years to as long as 75 years (Fowler *et al*., 2005). As a result, life history parameters (such as age, growth, abundance, distribution, reproduction, mortality etc.) of sharks possess great importance for the sustainability of the existing populations.

Many shark species are commercially exploited for their skin, fins, meat and also jaws in several countries (especially of the Atlantic and Pacific), and the total landings are now in a declining trend parallel to the significantly increased fishing pressure. Total capture fishery production of cartilaginous fish in the world has steadily increased from half millions tonnes during 1970's to 600000 tonnes in 1980's,

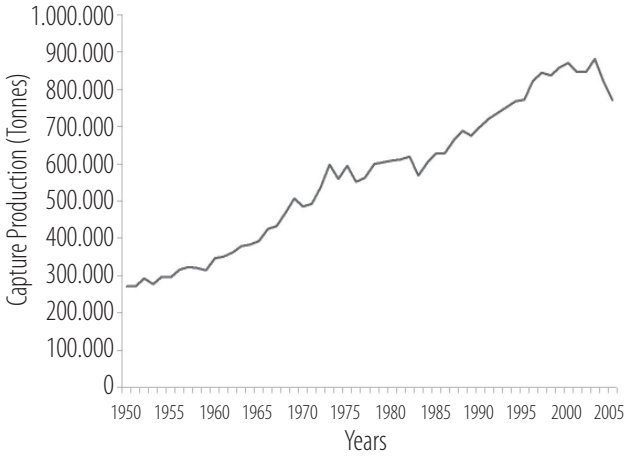

Figure 1. Capture production of cartilaginous fishes in the world, between 1950 and 2005 (source: FAO, 2007)

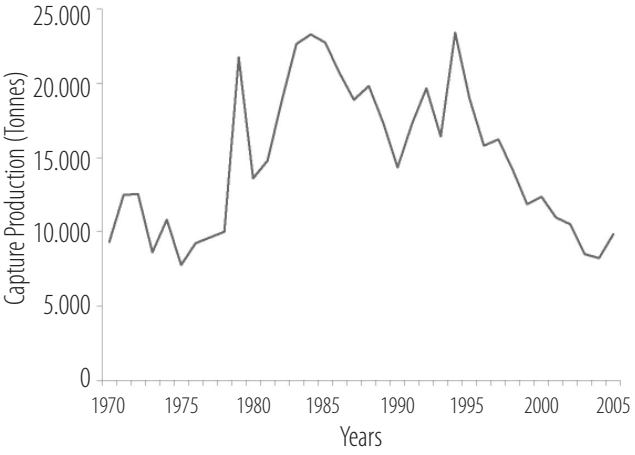

Figure 2. Capture production of cartilaginous fishes in the Mediterranean and Black Seas, between 1970 and 2005 (source: FAO, 2007)

which reached up to over 800000 tonnes during the last decade (Figure 1). The decline in Mediterranean catches is also evident, which sharply decreased by at least 50% since the mid 1990's (Figure 2). It is worth mentioning that the FAO fishery statistics reflect only the commercially exploited species and at least 50% of the global elasmobranch catch constitutes bycatch or discard, which are not mentioned in the official statistics (Stevens *et al*., 2000).

Sharks have been scarcely studied along Turkish coasts, where majority of the information deals with their distribution (see Bilecenoglu *et al*., 2002; Kabasakal, 2002). Among 36 shark species reported from Turkey (Fricke *et al*., 2007), population biology data is available for a few species such as spiny dogfish shark - *Squalus acanthias* (Avşar, 2001; Filiz & Mater, 2002; Düzgüneş *et al*., 2006), smallspotted catshark - *Scyliorhinus canicula* (Cihangir *et al*., 1997; Kabasakal, 2001; Filiz & Mater, 2002), bluntnose sixgill shark - *Hexanchus griseus* (Kabasakal, 2004) and smoothhound - *Mustelus mustelus* (Filiz & Mater, 2002). Considering that 28 shark species of Turkey are listed in IUCN red list categories (see the regional assessment by Fricke *et al*., 2007), there is currently an urgent need of species-specific research that will supply essential biological data to form concrete basis for further conservation actions.

The attitude presented by the Environmental Protection Agency for Special Areas (EPASA) of Ministry of Environment and Forestry (Republic of Turkey) stands to be a pioneering enterprise, who has been supporting scientific research on *Carcharhinus plumbeus* inhabiting the Boncuk Bay (Gökova specially protected area) since 2006 (Ergün, 2008). At certain periods of the year, sandbar sharks regularly come to Boncuk Bay for breeding and the region has attracted international interest, since it is one of the two well known (together with northwestern Atlantic) nursery grounds of the species. Unfortunately, the local people around the region could not recognize the uniqueness of these sharks, which are threatened by artisanal fishery activities and waste waters released by various boats.

2. The Study Area – Boncuk Bay

Boncuk is a "v" shaped small sheltered bay of Gökova Gulf (Figure 3), which was assigned as a special environmental protection area since 1988 (determined and declared by the Decree of Cabinet of Ministers number 88/13019 and date 12.06.1988).

The bay is accessed through the parting way to Sedir (Cleopatra) Island on the highway to Marmaris. Nearest settlement is Çamlı Village (Marmaris), located 9 km far from Boncuk Cove. There is a private run camping site close to the bay, where visitors can accommodate.

The bay has a coastline of approximately 4 km, and its western part is facing the open sea. Sharks are generally observed in the northern section of the bay, which is mainly a rocky habitat. The rocks in this part extend vertically to the sea, reaching up to 6 meters of depth. As you go from the shore to the open sea, the sea ground steeply descends with a deep wall. While the sea depth ranges between 3 to 6 meters at the shore, it reaches to 15 meters when you go 5 meters away from the shore. The depth at the middle of the bay is approximately 60 meters. This suddenly deepening structure and steep rocks on the shore create a convenient environment for sandbar sharks to roam and to escape when they are scared. Another distinctive feature of the area is the fresh water springs dispersing into the sea.

Figure 3. Map showing the locality of Boncuk Bay in Turkey

3. General Information on Sandbar Sharks

3.1. Taxonomy

Carcharhinus plumbeus was first described from the Adriatic Sea in 1827 (as *Squalus plumbeus*), by the Italian naturalist Giovanni Domenico Nardo (1802-1877). Since then, several names were used in the classification of sandbar sharks, such as *Carcharias* (*Prionodon*) *milberti* Müller & Henle (ex Valenciennes) 1839; *Lamna caudata* DeKay, 1842; *Squalus caecchia* Nardo, 1847; *Carcharias* (*Prionodon*) *japonicus* Temminck & Schlegel, 1850; *Carcharias obtusirostris* Moreau, 1881; *Carcharias stevensi* Ogilby, 1911; *Carcharhinus latistomus* Fang & Wang, 1932; *Eulamia plumbeus* Fowler, 1936; *Galeolamna dorsalis* Whitley, 1944.

The generic name *Carcharhinus* is derived from the Greek words "karcharos = sharp" and "rhinos = nose". Species name, *plumbeus*, has a meaning of "made of steel, heavy" in Latin. The current systematic position of the species is as below (Eschmeyer, 2008):

Classis: Elasmobranchii
Order: Carchariniformes
Family: Carcharhinidae
Genus: Carcharhinus Blainville, 1816
Species: Carcharhinus plumbeus (Nardo, 1827)

3.2. Common Names

A total of 110 common names are listed for *C.plumbeus* in Fishbase (Froese & Pauly, 2008). In English language, sandbar shark is the most commonly used name, which is also accepted by FAO. However, it is also possible to encounter other English names such as brown shark (Cuba, USA), queriman shark (Guyana) and thickskin shark (Australia, Indonesia, Malaysia). The following names are used in other languages: arenero, cazón, tiburón aletón (Spanish), tauro glis (Catalan), barriga-dágua, cação-baleeiro, marracho de milberto, tubarão-cinzento (Portuguese), kum köpekbalığı, büyük camgöz, camgöz (Turkish), pas trupan (Croatian), sivi morski pes (Slovenian), braunhai (German) carcharias, karcharynos tefros, skylópsaro, staktocarcharias (Greek), jarjur, kelb gris, qarsh rmâdy (Arabic), kelb griz (Maltese), manô (Hawaiian), mejirozame (Japanese), pas sivonja (Serbian), peshkagen i hirte (Albanian), requin gris (French), sandbankhaai (Afrikaans), squalo grigio (Italian), zandbankhaai (Dutch), and zarlacz brunatny atlantycki (Polish).

3.3. Geographical Distribution

Carcharhinus plumbeus is a wide ranging coastal species in tropical and temperate regions (Figure 4). The worldwide distribution pattern of the species is presented below, based on information given by Compagno (1973, 1984, 1998, 2002), Bonfil & Abdallah (2004), together with some new range expansion records published thereafter:

- *Western Atlantic*: Southern Massachusetts to Florida, northern and western Gulf of Mexico, Bahamas, Cuba, Nicaragua, Costa Rica, Venezuela and southern Brazil.
- *Eastern Atlantic*: Portugal, Spain, Morocco, Madeira, Senegal, Cape Verde Islands, Gulf of Guinea, Zaire. The species also occurs at the Canary islands (Brito, 1991), but its presence in the vicinity of Azores is questionable (Branstetter, 1984; Compagno, 1984).
- *Mediterranean*: All through the coastline, except for the Sea of Marmara and Black Sea.
- *Western Indian Ocean*: South Africa, Madagascar, Mozambique, Tanzania, Mauritius, Seychelles, Red Sea, Gulf of Oman.
- *Western Pacific*: Vietnam, China (including Taiwan Province), Japan, Indonesia (Aru Island),

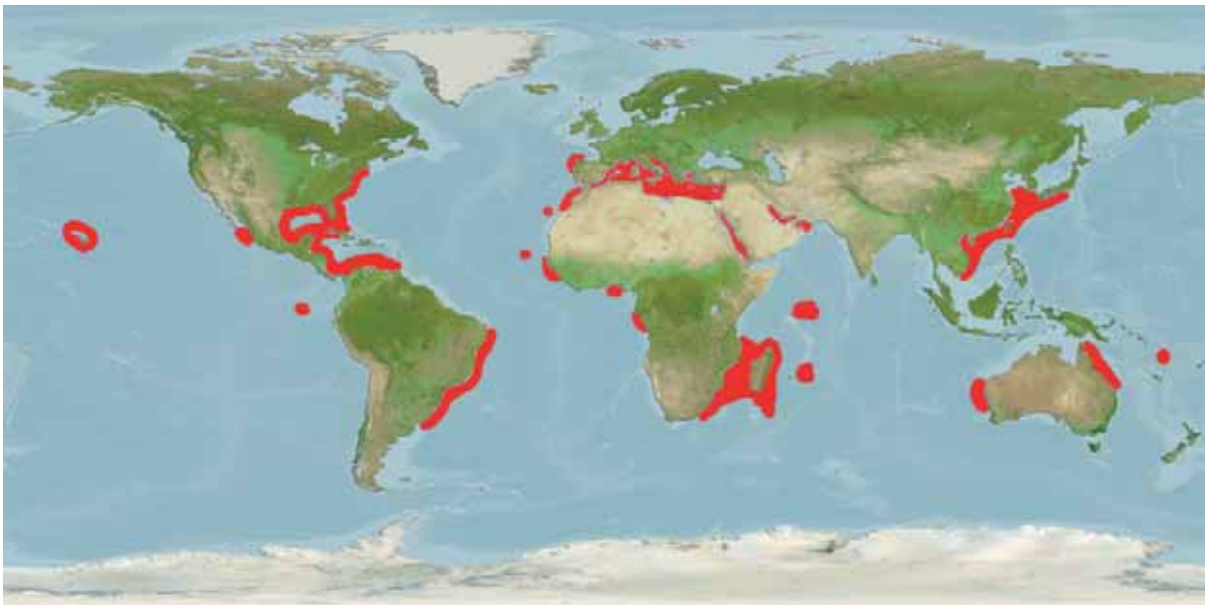

Figure 4. Worldwide distribution of the sandbar shark

Australia (Queensland, Western Australia), New Caledonia. An occurrence record has recently been given from Korea by Kim *et al*. (2005, in Froese & Pauly, 2008).

- *Central Pacific*: Hawaiian Islands.
- Eastern Pacific: Records of sandbar sharks from the eastern Pacific has long been regarded as doubtful (see Compagno, 1984, 1998 etc.). Occurrence of the species in Galapagos and Revillagigedo Islands is just mentioned by Grove & Lavenberg (1997, in Froese & Pauly, 2008).

The sandbar shark is currently the most abundant coastal shark species in the western north Atlantic, where tagging and genetic studies suggest that *C.plumbeus* from Cape Cod (Massachusetts, USA), to the northern Yucatan peninsula in Mexico comprise a unit stock separate from the population reported from Trinidad to Brazil (Fowler *et al*., 2005). Springer (1960) hypothesized that the separate eastern Atlantic population of this shark was capable of contributing to the South American population via migration with the equatorial current across the Atlantic, which remains to be proven by tagging (Compagno, 1984).

3.4. Morphological Characters

The family Carcharhinidae (requiem sharks) includes over 50 species belonging to 12 genera worldwide, where the genus *Carcharhinus* has the highest number of species (31 sp.) (Fowler *et al*., 2005; Froese & Pauly, 2008). In the Mediterranean Sea, eight species of *Carcharhinus* was reported (Cavanagh & Gibson, 2007), five of which are known from the Turkish coasts (Bilecenoglu *et al*., 2002). Status and occurrence of some species, i.e. *C.longimanus* and *C.obscurus*, are still questionable in Turkey and should not be regarded as the part of local ichthyofaunal composition until evidence (based on a captured specimen) is obtained.

All members of the genus *Carcharhinus* have relatively stout bodies, with maximum total lengths varying from 1 to 4 m. Snout shape differs among species, from blunt and rounded to triangular and narrowly pointed. Spiracles are always absent (except for the tigershark, *Galeocerdo cuvieri*). There are typical well developed precaudal pits, above and below the caudal peduncle. First dorsal fin is generally triangular and always larger than the second dorsal fin. Pectoral fins are variably in shape from long and slender to short and broad. Caudal fin is well developed, where the upper lobe is nearly twice length of the lower lobe.

The following combination of morphological characters distinguish *C.plumbeus* from all of its Mediterranean congeners: Snout short and bluntly rounded, its length less than mouth width; wide mouth parabolic in ventral view; first dorsal fin high and triangular, its origin just over the pectoral bases; height of first dorsal fin (more or less) equals to the distance from eye to third gill-slit; fourth and fifth

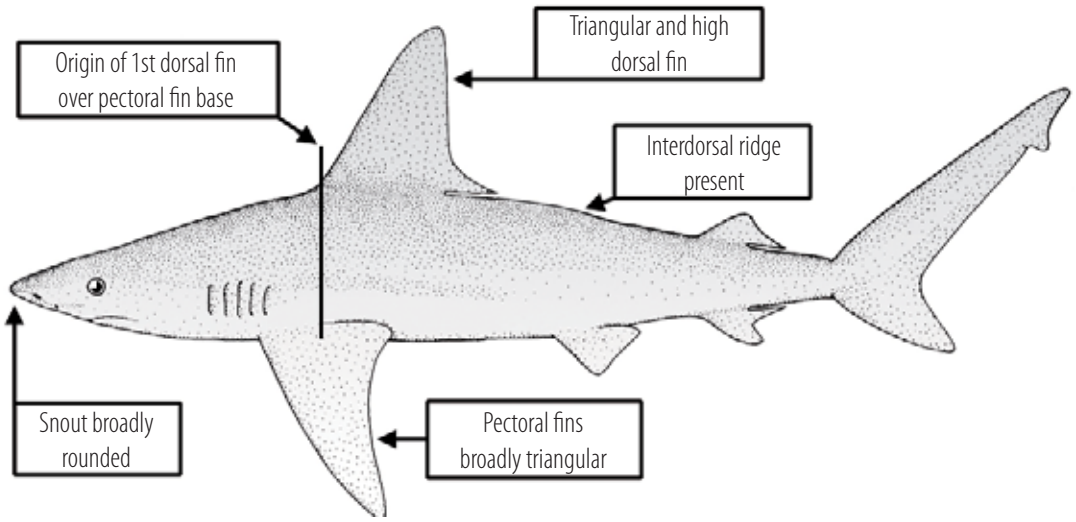

Figure 5. Characteristic features of *Carcharhinus plumbeus*

gill slits over pectoral fin base; second dorsal fin origin over anal fin origin; pectoral fins broadly triangular and long; a narrow interdorsal ridge present (see also Figure 5, 6 and 7).

The teeth shape of sandbar sharks differ in each jaws. Upper teeth are serrated, erect and broadly triangular, while the lower teeth are narrower (awl-shaped) and more finely serrated (Figure 8).

Maximum size of *C.plumbeus* is 225 cm for males and 248 cm for females (Capapé,1984). In some literature (for example Compagno, 1984; Bauchot, 1987, etc.), the maximal length was given as 300 cm, which is generally regarded as questionable (see also Table 2). The heaviest specimen ever recorded weighed 117.9 kg (Froese & Pauly, 2008), but mature males and females generally weigh around 50 and 60 kg, respectively. Published papers to date indicates that females are always larger and heavier than the males.

Color of the body is gray-brownish above and white below. Posterior edges and tips of fins are often dusky, but there are no conspicuous markings on the body. An inconspicuous white band can sometimes be seen on the flank.

Figure 6. Lateral view of sandbar shark (Photograph: Tahsin Ceylan©/SAD)

Figure 7. Front view of sandbar shark (Photograph: Tahsin Ceylan©/SAD)

3.5. Habitat

The sandbar shark is essentially a bottom dwelling marine species, which prefers shallow coastal waters of the continental shelf. It is normally not seen at the surface with first dorsal fin out of the water. Observations of individuals below 100 m is occasional (Fowler *et al*., 2005), but the species may occur at depths down to 280 m (Serena, 2005). According to Compagno (1984), *C.plumbeus* is common at bay mouths, in harbours, inside shallow muddy or sandy bays, and at river mouths, but tends to avoid sandy beaches and the surf zone, coral reefs and rough bottom, and the surface. Observations made in Boncuk Bay since 2006 revealed that the species is mostly found over rough, rocky bottoms, in contrast with the above mentioned statement (Figure 9).

Adults are migratory and generally congregate offshore, whereas neonates and juveniles inhabit coastal nursery areas during summer months (Costantini & Affronte, 2003).

3.6. Nursery Grounds

Shark nurseries are areas where gravid females give birth (or lay eggs) and where the newborns spend their first months or years of life. Coastal nursery areas are well documented in the western Atlantic from Cape Cod to Cape Canaveral, including Chesapeake Bay, Bulls Bay, Delaware Bay (Merson & Pratt, 2001) and possibly in the northeastern Gulf of Mexico (Carlson, 1999). Recent studies point out a possible nursery ground also at the Pernambuca coast of Brasil (Hazin *et al*., 2007). There is still no concrete data on the usage of offshore waters as pupping grounds.

Boncuk Bay is probably the most famous nursery area for the sandbar sharks in the entire Mediterranean Sea, which is known since at least 1990's (Öztürk, 2006). Over 100 specimens have been photo-identified between 2001 and 2004, based on scars and other markings on their body, and birth of a sandbar shark was filmed for the first time (Clo & Sabata, 2004). Since 2006, the governmental projects coordinated by Environmental Protection Agency for Special Areas have been continuing.

Some recent researches indicate other possible nurseries throughout the Mediterranean. Costantini & Affronte (2003) collected six neonatal specimens with total lengths ranging 46.5 to 68.8 cm in the northern Adriatic Sea, whose data was supported by a previously captured gravid female (200 cm

Figure 8. Dentition of *Carcharhinus plumbeus* (upper and lower jaw, respectively). Jaws belong to a specimen of ca. 150 cm, incidentially captured by local fishermen of Iskenderun bay (eastern Mediterranean Sea) (Photograph: Murat Bilecenoğlu©/SAD).

in total length and 70 kg in weight) from the same area with nine living embryos. Lipej *et al*. (2004) also reported two juvenile specimens caught in the waters off Piran (north Adriatic).

Along the Tunisian coast, the sandbar shark is commercially captured throughout the year, particularly in Gulf of Gabès during the summer. Based on samplings carried out between 2001 and 2004, a total of 14 gravid females of *C.plumbeus* (containing 96 embryos) and 120 neonates were obtained from Gulf of Gabès by Bradai *et al*. (2005), which indicates the favorable conditions for reproduction.

Apart from possible nursery grounds in northern Adriatic and the Gulf of Gabès, an additional nursery along Turkish coasts is likely to occur, which should be examined meticulously by further studies. The sandbar shark neonates (with total lengths of 60-70 cm) have regularly been captured by the bottom trawlers in Iskenderun Bay, although in small quantities, since 1996 (M.Bilecenoglu, unpub.

Figure 9. A sandbar shark observed over a rocky substrate in Boncuk Bay (Photograph: Tahsin Ceylan©/SAD)

data). The *C.plumbeus* neonate (57 cm total length) captured from a depth of 15-20 m off Yumurtalık coasts (Başusta & Erdem, 2000) and further observations of the species in the same area by Kabasakal (2002) provides support for the possibility of another sandbar shark nursery ground in Turkey. The locations of nursery areas in rest of the world (other than those given in Figure 10) are not well known.

3.7. Age and Growth

Sandbar sharks are typical *k*-strategists, with long life span, large body size, low fecundity and delayed maturity. However, there are reports that the species grows faster under captivity conditions (Compagno, 1984). Several scientific papers have concentrated on the age of *C.plumbeus*; but the

Figure 10. Documented nursery grounds of *Carcharhinus plumbeus* in the world

results obtained are generally incomparable due to estimates based on different ageing techniques (i.e. tag/recapture data versus vertebral ageing). Casey & Natanson (1992) reported tagged sandbars estimated to be 22 (155 cm fork length, FL), 32 (157 cm FL), and over 40 years old (185 cm FL) at recapture; the 22-year old individuals was determined to be immature. The same researchers also suggested that sandbar sharks may live more than 50 years.

In a study conducted along northern Taiwan waters, the oldest individuals were 19.8 (187 cm total length) and 20.8 (210 cm total length) years old, for males and females, respectively (Joung *et al*., 2004). Mean growth rate calculated for Taiwan-caught sandbar sharks was 22.2 cm/year (0–1 year), 18.7–11.2 cm/year (2–5 year), 9.5–4.8 cm/year (6–10 year), and 4.1–2.1 cm/year (11–15 year). The sandbar shark age estimates from Hawaiian waters using vertebrae revealed that females attain to a maximum age of 23 (196 cm total length and 146 cm precaudal length) and males to 19 (179 cm total length and 128 cm precaudal length) (Romine *et al*., 2006). According to Sminkey & Musick (1996), it seems reasonable to consider the maximum age for sandbar sharks to be about 30 years, on the basis of vertebral data obtained from their previous studies. Fowler *et al*. (2005) also suggested a similar value and mentioned that the longevity is likely to be at least 35 years.

3.8. Reproduction

Similar to other members of the genus *Carcharhinus*, sandbar shark is viviparous with a yolk sac placenta, bringing forth live young rather than laying eggs. Females reproduce every two or three years, with a gestation period of 12 months at most. The litter size ranges between 1 – 14 (commonly between 5 – 12) and there is a positive correlation between the litter size and the total length of the mother, which means larger females produce larger litters (Compagno, 1984). An exceptional case was reported from the Tunisian coast, where a 192 cm total length pregnant female was carrying 16 embryos (Saidi *et al*., 2006).

Mating occurs in the spring and summer in various populations. The males persistently follow and bite the female in the back until they swim upside down, then mate with both claspers (Compagno, 1984).This courtship behaviour generally leaves a permanent scar on the female body.

The size of young at birth varies among different localities, ranging from 56 to 75 cm total length with pups averaging 60-65 cm in most parts of the world (Fowler *et al*., 2005). Size at birth is much smaller in the Mediterranean Sea (45 – 65 cm) (Saidi *et al*., 2005).

Length at first maturity varies among different localities (Table 2). Concerning the Mediterranean Sea, smallest mature females had total lengths of

Table 2. A review of length at first maturity data of sandbar sharks, together with maximum total lengths from different regions of the world (L*m* = length at first maturity; L*max* = maximum length; * = precaudal length).

L*m* (cm)		L*max* (cm)		Region	Reference
Male	Female	Male	Female		
180		250		W. Atlantic (USA)	Bigelow & Schroeder (1948)
179	183	226	230	W. Atlantic (USA)	Springer (1960)
180	177	213	220	W.Indian Ocean (Mauritius)	Wheeler (1962)
192	185	204	234	W. Atlantic (USA)	Clarke & Schmidt (1965)
190		-	-	Mediterranean (Italy)	Bini (1967)
163	190	226	247	W. Indian Ocean (S.Africa)	Bass *et al.* (1973)
176		-	-	W. Indian Ocean (Red Sea)	Baranes & Ben-Tuvia (1978)
184	189	190	203	W. Atlantic (Gulf of Mexico)	Branstetter (1981)
180	185	223	229	E. Atlantic (Senegal)	Cadenat & Blache (1981)
166	170	225	248	Mediterranean (Tunisia)	Capapé (1984)
139*	184*	233*	270*	Western N. Atlantic	Casey *et al.* (1985)
130	144	300		Mediterranean Sea	Bauchot (1987)
156	158	-	-	W. Pacific (Australia)	Stevens & McLoughlin (1991)
130		-	-	E. Pacific (Galapagos)	Grove & Lavenberg (1997)
130	147	249		Adriatic Sea	Lipej *et al.* (2004)
155	166	194	219	Mediterranean (Tunisia)	Saidi *et al.* (2005)
170	179	226	234	Atlantic	Fowler *et al.* (2005)
131	144	172	190	Central Pacific	Cope (2006)
180	183	226	234	N. Atlantic	Cope (2006)
167	169	191	199	Indian Ocean	Cope (2006)
165	185	179	225	E.Atlantic (Senegal)	Diatta *et al.* (2008)

144 cm (Bauchot, 1987), 147 cm (Lipej *et al*., 2004) and 166 cm (Saidi *et al*., 2005).

3.9. Feeding Habits

Results of stomach content analysis of sandbar sharks obtained from different regions of the world reveal that the species is primarily piscivorous, foraging both in the water column and near the bottom.

Teleosts occurred in 98% of the stomachs of *C.plumbeus* in the Atlantic (Bowman *et al*., 2000), 88% in Australia (Stevens & McLoughlin, 1991) and 71% in Hawaii (Papastimatiou *et al*., 2006). Feeding activity occurs all through the day, but more actively at night (Compagno, 1984). The prey items differ largely among the geographical locality and the size of the shark, where sandbar sharks generally consume the available organisms in a specific habitat.

In a study carried out at the western north Atlantic by Ellis (2003), 65 species were identified from sandbar shark stomachs, including preys from 28 fish families, 12 crustacean families, 6 elasmobranch families and 2 cephalopod families. Sharks of the small size group (< 60 cm precaudal length) mainly consumed crustacean preys, which shifts to fish preys in larger sharks. The Hawaiian population of *C.plumbeus* also exhibited a teleost fish based feeding strategy, consuming fish preys from 27 families, and crustaceans and mollusks to a lesser extend (Papastimatiou *et al*., 2006).

The daily ration and seasonal prey consumptions rates of sandbar sharks from the Atlantic was studied by Dowd *et al*. (2006), who predicted the species to consume 124000 kg of prey during their 4.5 month stay in the nursery ground.

4. Overview of the Boncuk Bay Survey

4.1. Aims of the Project

The main objectives of the project titled "The Protection and Monitoring of Sandbar Sharks *(Carcharhinus plumbeus)* in Boncuk Bay, Gökova Special Environmental Protection Area" are as follows:

- Determining the occurrence and distribution patterns of *C.plumbeus* within the survey area, using *in situ* observation techniques,
- Determining the possible threats on local sandbar shark population,
- Processing all the observation and threat data using GIS (global information system) on 1/25000 scale maps,
- Forming an inventory of photographs and video recordings taken from the region,
- Preparing a book and a brochure to be used in public awareness studies.

4.2. Methodology

Field surveys were carried out with the help of 22 volunteers selected among the participants of Prof. Dr. Erdoğan Okuş Science Camp, organized by the Underwater Research Society between 14 and 30 June 2008. The study was mostly based on underwater observations made by skin diving teams formed of 2 or 3 divers, beginning from 07:00 to 17:00 within the area limited by 5 buoys (Figure 11).

Figure 11. The observation area in Boncuk Bay, marked by 5 buoys (Photograph: Nilay Akça©/SAD)

Figure 12. General view of the camp site (Photograph: Umut Aksu©/SAD)

Each shark observation was noted on PVC plates, including information of date, observation hour, approximate length of the specimen (individuals > 150 cm were regarded as sexually mature), sex (if determined) and possible distinguishing characters of specimens (i.e. scars or other markings on the body). All data obtained were analyzed in the camp area, separately by diving teams (Figures 12-13).

The GIS constructed for the surveys was based on a parcel system (Figure 14), where both diving observations made in different periods of the days and the possible threats could be processed. This

Figure 13. Data entry in the camp, after each dive (Photograph: Haluk Camuşcuoğlu©/SAD)

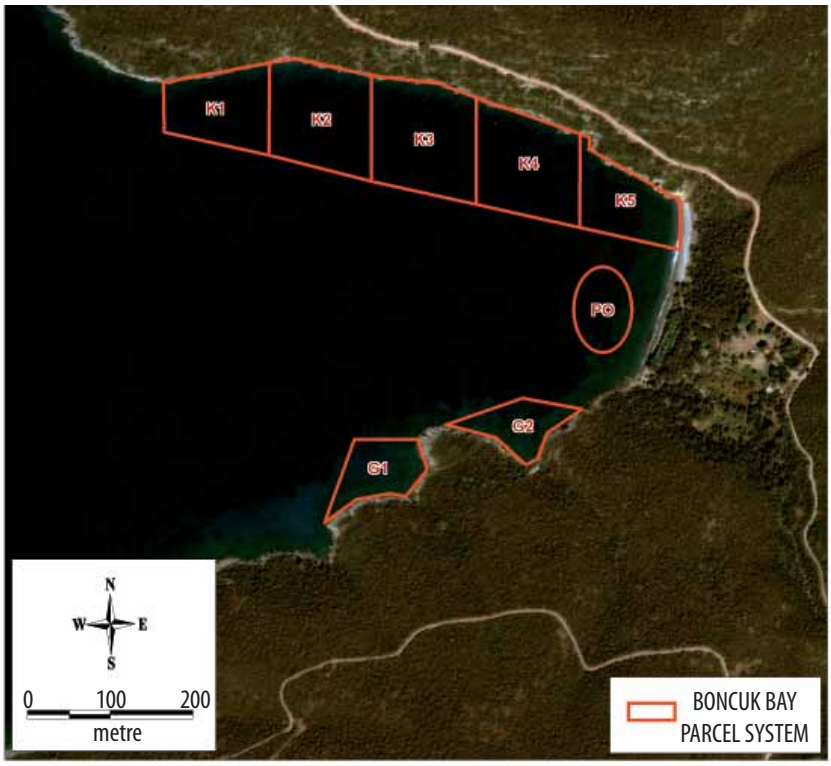

Figure 14. The parcel system used in Boncuk Bay (image from Quickbird satellite)

approach enables a further comparison of the 2008 field surveys with results of previous studies conducted at the area.

4.3. Results

A total of 85 skin dives were performed in Boncuk Bay, where sandbar sharks were observed 125 times, either as single individuals or in small schools. Six of the sharks were smaller than 150 cm total length, the rest composed of mature males and females. According to the frequency of observations made between 14 June and 30 June 2008, majority of the shark sightings were concentrated within 5 days (15 – 19 June) representing nearly 75% of the total observations (Figure 15).

A sharp decrease in the number of sightings appeared after 21 June, and only a few individuals were present within the study area thereafter. No sharks could be sighted during 25, 29 and 30 June. Majority of the sandbar sharks were seen during early hours of the day (Figure 16). Almost 67% of the sightings were made between 07:00 and 11:00 (see also Figures 17-22).

The innermost part of Boncuk Bay (indicated as PO in Figure 12, an area with *Posidonia oceanica* meadows) and the two southern stations (G1 and G2 in Figure 12) were rarely used by the sandbar sharks, in aggreement with results of previous observations.

Possible threats on the Boncuk Bay ecosystem and the sandbar sharks were determined by regular field observations. Two main threats was obvious; the waste waters released by various boats (which penetrate to the area by the breezes) and the hobby fishing activities in the bay (Figures 23-24).

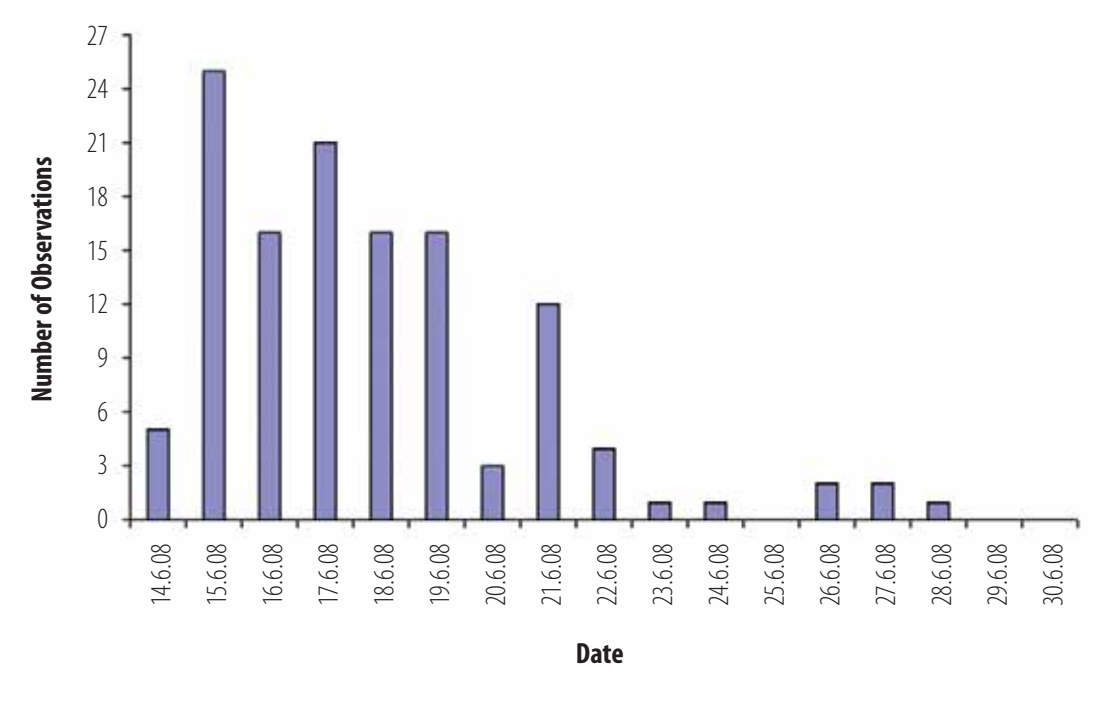

Figure 15. Frequency of sandbar shark observations during the surveys

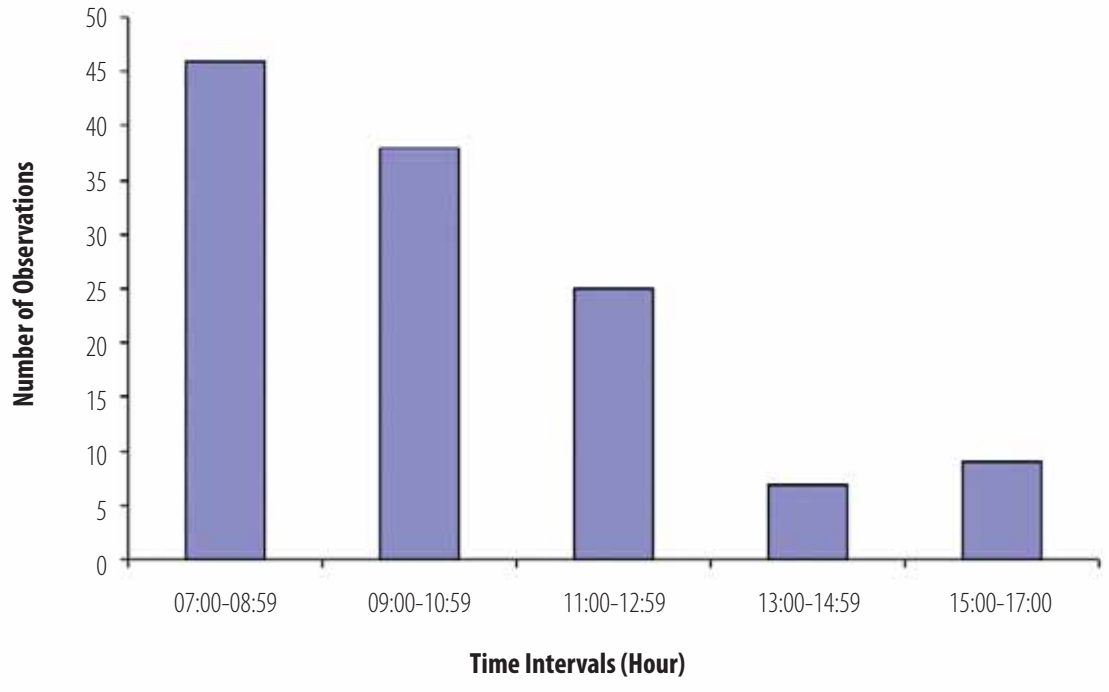

Figure 16. Frequency of sandbar shark observations within time intervals of the day

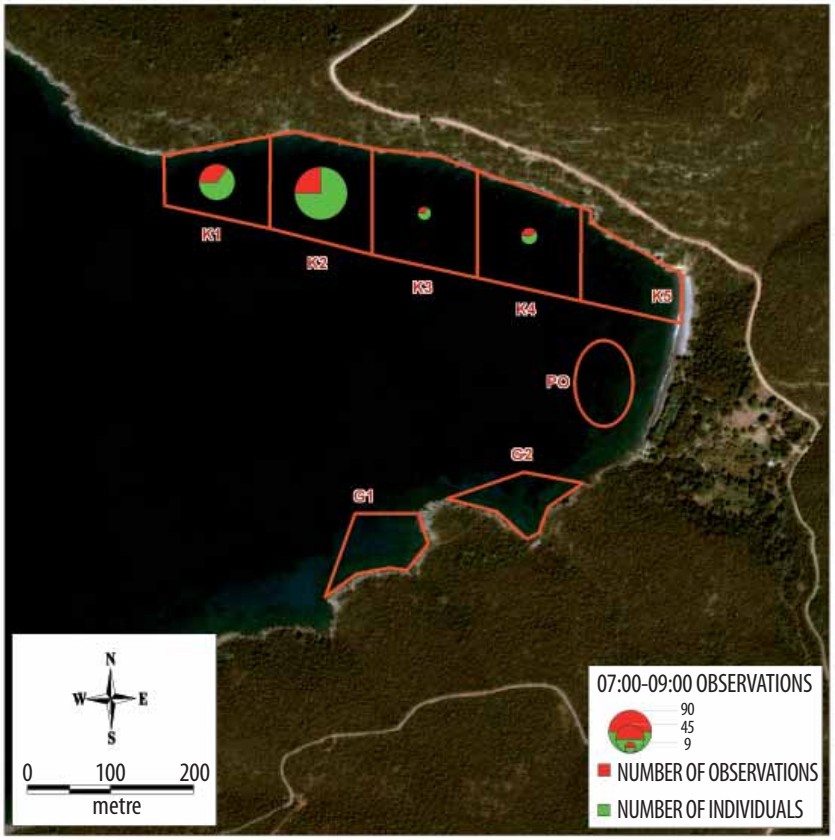

Figure 17. Number of individuals observed between 07:00-09:00

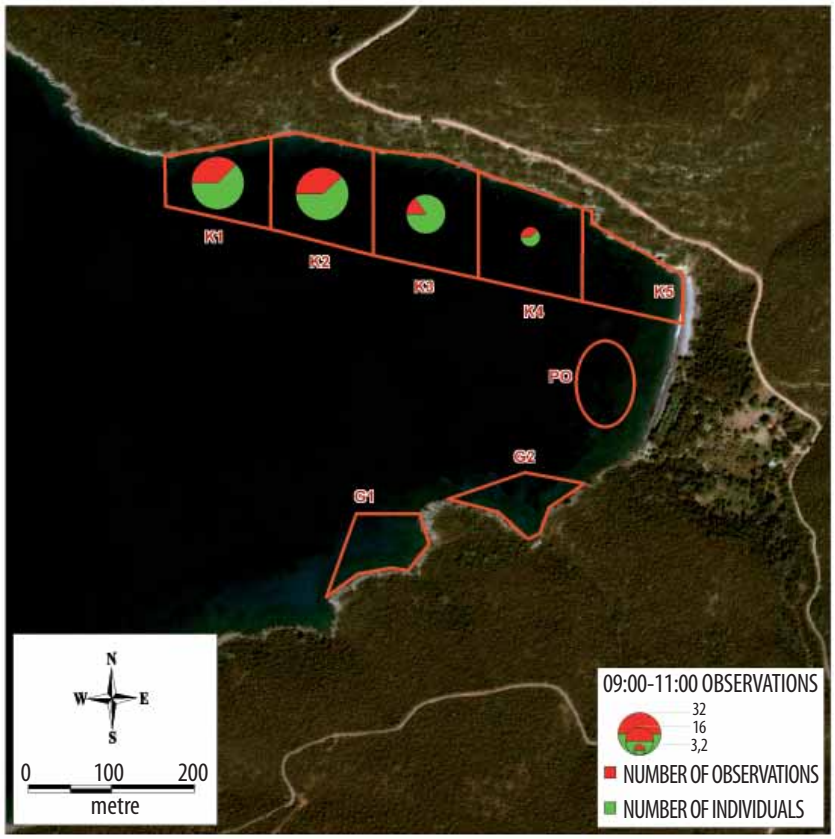

Figure 18. Number of individuals observed between 09:00-11:00

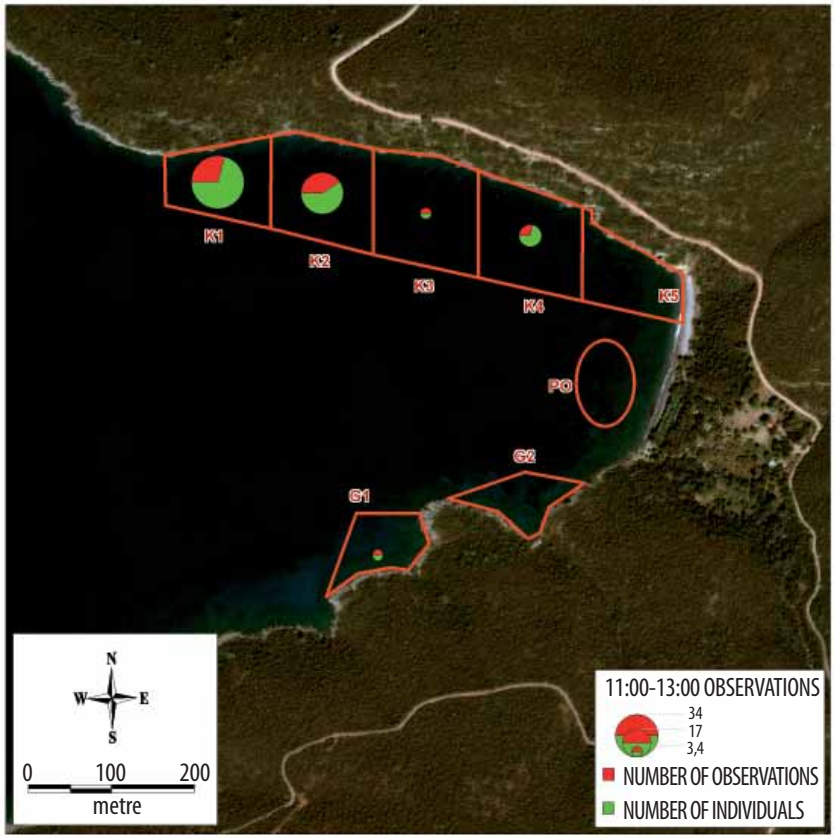

Figure 19. Number of individuals observed between 11:00-13:00

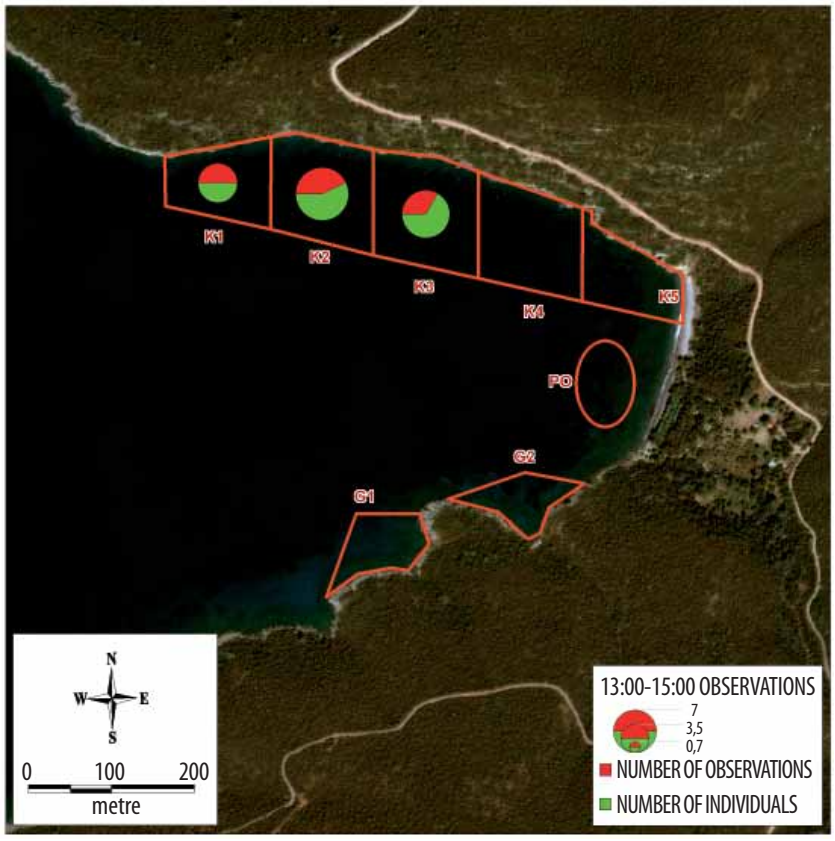

Figure 20. Number of individuals observed between 13:00-15:00

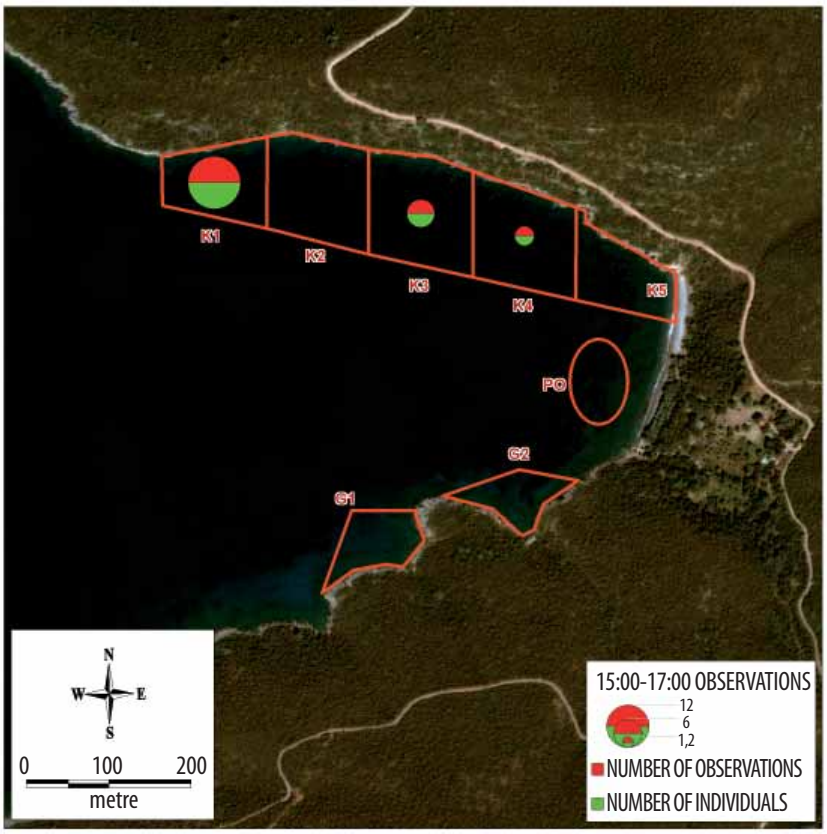

Figure 21. Number of individuals observed between 15:00-17:00

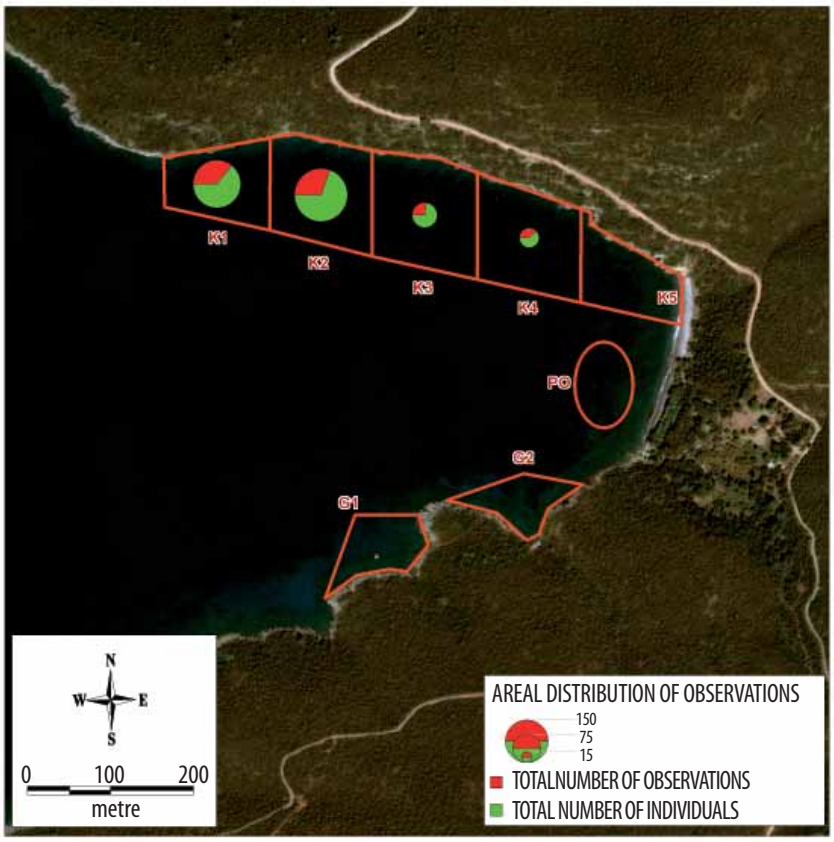

Figure 22. Total daily observations made in Boncuk Bay

4.4. Threats

Possible threats on the Boncuk Bay ecosystem and the sandbar sharks were determined by regular field observations. Two main threats were obvious; the waste waters released by various boats (pollutant penetrate to the area by breezes) and the artisanal fishing activities in the bay (Figure 23, Appendix 1). Although a specific biodiversity study concerning the Boncuk Bay does not exist, it seems that the area is rich in terms of fish and other invertebrates that are preyed by the sharks (see Appendix 2).

Local fishermen intensely hunt in the bay with fishing lines and fishing baskets. Moreover, artisanal fishing boats are observed coming from the front parts of Domuz Peninsula, situated on the northwest of the bay, and sometimes to the middle parts of the bay. All kind of small scale fishing activities is likely to disturb the sharks that come for reproduction. As a part of public awareness studies, the locals are informed on the status of sandbar sharks in Boncuk Bay, with explanations on how to prevent existing threats.

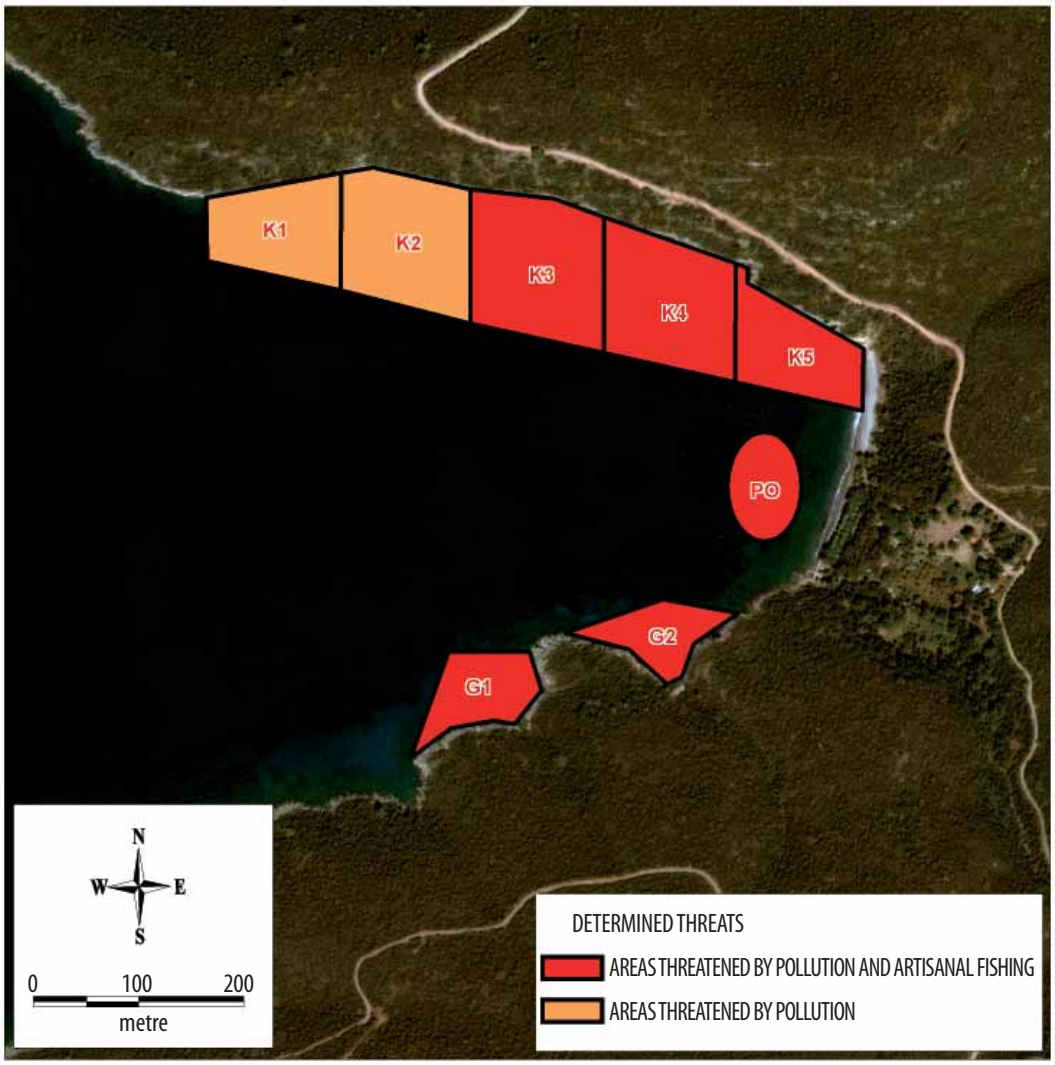

Figure 23. Distribution of the determined threats among parcels in Boncuk Bay

5. Conservation Status

The IUCN Red List classifies sandbar sharks as Lower Risk/Near Threatened at the world level and the stocks in northwestern Atlantic as Lower Risk/Conservation Dependent (Camhi *et al.* 1998).

In the Mediterranean Sea, a regional assessment by IUCN Red List Criteria was recently published, which all 71 Mediterranean species of sharks, rays, and chimaeras (cartilaginous fishes) were categorized (Cavanagh & Gibson, 2007). This report listed 42% (30 species) of these species within "threatened categories", of which 18% are Critically Endangered, 11% Endangered and 13% Vulnerable. Another 18% (13 species) were assessed as Near Threatened while a lack of information led to 26% (18 species) being classified as Data Deficient. Only 14% (10 species) are considered to be of Least Concern.

The Red List status of Turkish ichthyofauna (marine and freshwater) was presented by Fricke *et al.* (2007),

Table 3. The IUCN Red List status of all shark species of Turkey, in comparison with the Mediterranean and the world (CR – critically endangered; EN – endangered; VU – vulnerable; NT – near threatened; DD – data deficient; TM – threatened migrant) (data from Fricke *et al.,* 2007; Cavanagh & Gibson, 2007).

		Red List Status	
Species	***Turkey***	***Mediterranean***	***World***
Heptranchias perlo (Bonnaterre, 1788)	DD	VU	NT
Hexanchus griseus (Bonnaterre, 1788)	VU	NT	NT
Carcharias taurus Rafinesque, 1810	CR	CR	VU
Odontaspis ferox (Risso, 1810)	CR	EN	DD
Carcharodon carcharias (Linnaeus, 1758)	CR	EN	VU
Isurus oxyrinchus (Rafinesque, 1810)	TM	CR	NT
Lamna nasus (Bonnaterre, 1788)	CR	CR	VU
Cetorhinus maximus (Gunnerus, 1765)	TM	VU	VU
Alopias vulpinus (Bonnaterre, 1788)	EN	VU	DD
Alopias superciliosus (Lowe, 1841)	*EN*	*DD*	*NE*
Galeus melastomus Rafinesque, 1810	VU	LC	NE
Scyliorhinus canicula (Linnaeus, 1758)	VU	LC	LC
Scyliorhinus stellaris (Linnaeus, 1758)	EN	NT	NE
Galeorhinus galeus (Linnaeus, 1758)	DD	VU	VU
Mustelus asterias Cloquet, 1821	DD	VU	LC
Mustelus mustelus (Linnaeus, 1758)	DD	VU	LC
Mustelus punctulatus Risso, 1827	DD	DD	NE
Carcharhinus altimus (Springer, 1950)	EN	DD	NE
Carcharhinus brevipinna (Müller&Henle, 1841)	EN	DD	NT
Carcharhinus limbatus (Valenciennes, 1841)	*EN*	*DD*	*NT*
Carcharhinus melanopterus (Quoy & Gaimard, 1824)	DD	-	-
Carcharhinus plumbeus (Nardo, 1827)	EN	EN	NT
Prionace glauca (Linnaeus, 1758)	TM	VU	NT
Sphyrna tudes (Valenciennes, 1822)	TM	-	-
Sphyrna zygaena (Linnaeus, 1758)	TM	VU	NT
Etmopterus spinax (Linnaeus, 1758)	VU	LC	NE
Oxynotus centrina (Linnaeus, 1758)	VU	CR	NE
Dalatias licha (Bonnaterre, 1788)	DD	DD	DD
Centrophorus granulosus (Schneider, 1801)	VU	VU	VU
Centrophorus uyato (Rafinesque, 1810)	*VU*	-	-
Squalus acanthias Linnaeus, 1758	EN	EN	VU
Squalus blainville (Risso, 1827)	EN	-	-
Echinorhinus brucus (Bonnaterre, 1788)	DD	DD	DD
Squatina aculeata Cuvier, 1829	CR	CR	EN
Squatina oculata Bonaparte, 1840	CR	CR	EN
Squatina squatina (Linnaeus, 1758)	CR	CR	CR

which should be considered as a baseline for further studies. A total of 36 shark species was evaluated according to Red List categories (Table 3), including an additional category (TM - threatened migrant), which does not appear in IUCN categories, defining a species that would fall under the categories EN or CR but occurs in the area only as a straggler, and where the main threat may occur outside the area. The sandbar shark is regarded as endangered both in Turkey and the Mediterranean.

Sharks are commercially exploited in several countries, but the consumption of shark meat in the internal market of Turkey is considerably low, where majority of the captured fish are exported. The capture production of sharks in Turkey made a peak during 1979 (majority consisted of *Squalus acanthias*), which drastically decreased later and showed moderate variations from 1436 to 2880 tonnes between 1990 and 2000 (FAO, 2007). The population size of sandbar sharks along Turkish coasts is unknown due to lack of scientific studies, but the species can be regarded as rare. There is no data that *C.plumbeus* was ever subjected to target fisheries in Turkey, although it was sometimes captured by bottom trawlers as a bycatch and frequently discarded.

The fisheries of sandbar sharks in Turkey are currently prohibited, based on the fishery bulletin published by General Directorate of Protection and Control, Turkish Ministry of Agriculture and Rural Affairs (bulletin no. 2/1 and 2/2, valid through 01.09.2008 to 31.08.2012). Moreover, all kinds of trawl fishing and purse seining are forbidden by law in the easternmost part of Gökova Gulf, which are important restrictions for the conservation of sandbar sharks (Figure 24).

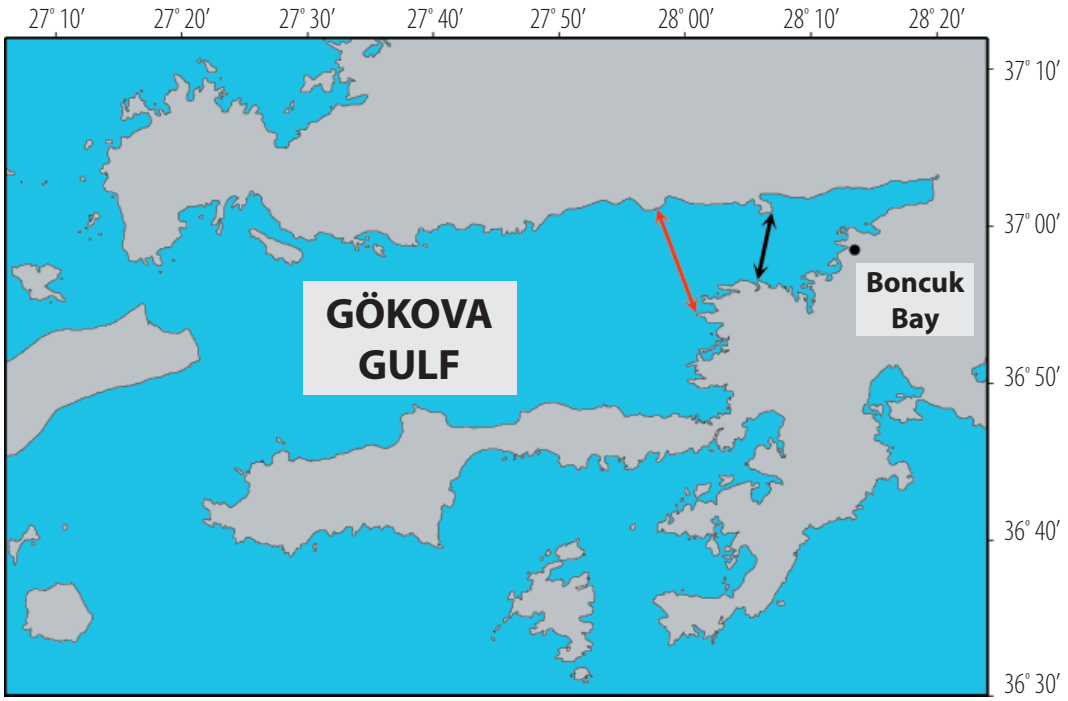

Figure 24. Map showing the restricted areas for commercial fishery activities in Gökova Gulf. All kinds of trawl (eastern part of the red line) and purse seine fisheries (eastern part of the black line) is prohibited by law.

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We believe that this study will greatly contribute to the conservation and promotion of the Sandbar shark that has historical value and of vital importance in Gökova Bay conservation studies. Hence, we would like to present our thanks to the Project Executant Assoc. Prof. Dr.Murat BİLECENOĞLU who executed the project with great ambition on behalf of the Underwater Research Society (SAD),

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Environmental Protection Agency for Special Areas

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Examples of threats observed in Boncuk Bay

Boat released wastes in Boncuk Bay (Photograph: Burak Özkırlı©/SAD)

Touristic boats passing through the area (Photograph: SAD©)

Some Examples of Fish and Invertebrates Inhabiting Boncuk Bay

Echinaster sepositus - Red Starfish (Tahsin Ceylan©/SAD)

Bothus podas – Wide-eyed Flounder (Tahsin Ceylan©/SAD)

Dasyatis pastinaca – Common Stingray (Tahsin Ceylan©/SAD)

Echeneis naucrates – Live Shark-sucker (Tahsin Ceylan©/SAD)

Hypselodoris picta – Nudibranch (Tahsin Ceylan©/SAD)

Chromis chromis – Damselfish (Umut Aksu©/SAD)

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