BACHELOR THESIS

CAUSES OF ADULT SEA TURTLE MORTALITY IN FETHIYE (TURKEY) Summer 2015

Practical field course "Meeresschildkröten – Schutz von Meeresschildkröten in der Türkei. Projekt zu angewandtem Naturschutz"

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KURZFASSUNG

Wir besitzen auf der Erde eine enorme Artenvielfalt, die jedoch häufig durch anthropogene Einflüsse bedroht ist. Durch vermehrte Eingriffe des Menschen in Ökosystemen, etwa die Ausrottung von Schlüsselarten, entstehen häufig ungeahnte Probleme. Ein Beispiel wäre die unechte Karettschildkröte (*Caretta caretta*), die bereits zu den letzten sieben Meeresschildkrötenarten weltweit gehört.

Daher hat sich die Universität Wien in Zusammenhang mit türkischen Universitäten dem Schutz der an der Südost Küste der Türkei vorkommenden Meeresschildkrötenarten *Caretta caretta* und *Chelonia mydas* (Suppenschildkröte, Grüne Meeresschildkröte) verschrieben. Zu diesem Zweck wurden im Zeitraum Juni bis September 2015 neben allgemeinen Schutzaktionen auch sämtliche tote und verletzte Tiere entlang der Strände von Fethiye dokumentiert. Dabei wurden sowohl Daten über Größe, Geschlecht und Verletzungen als auch über mögliche Todesursache erhoben. Im Sommer 2015 wurden im Laufe des Projektes sieben tote *Caretta carettas* (zwei in Çaliş, zwei in Yaniklar. eine in Akgöl, eine im Hafen von Fethiye und eine weitere deren Fundort unbekannt ist) sowie zwei tote *Chelonia mydas* (eine in Çaliş, eine in Yaniklar) entdeckt. Drei Tiere wiesen Verletzungen am Kopf, Hals und Plastron auf, die auf beabsichtigte Gewalteinwirkungen zurückzuführen sind und eine starb vermutlich durch die Folgen einer Bootskollision. Von zwei weiteren toten Tieren fehlen uns Informationen über Art und Todesursache, da sie vor Eintreffen des Teams entsorgt wurden. Seit Beginn der Aufzeichnungen im Jahr 2000 kann ein stetiges Steigen der Todesrate aufgezeigt werden, dessen Höchststand in der diesjährigen Saison erreicht wurde. Daher ist es wichtig zu ermitteln welche Gründe für das Sterben der Tiere verantwortlich sind um zu zeigen wie sehr anthropogene Einflüsse die letzten Populationen der Erde schaden und um wichtige Maßnahmen zu ergreifen, damit diese faszinierenden Tiere auch in Zukunft Teil des marinen Ökosystems bleiben.

ABSTRACT

We have an unprecedented diversity of species on Earth, which is often threatened by anthropogenic influences. Increased human activities in many ecosystems, such as the extermination of keystone species, often create unforeseen problems with grave consequences. The loggerhead sea turtle (*Caretta caretta*) is a case in point. *Caretta caretta* is

one of the last seven sea turtle species worldwide which all rank among the most threatened animals on earth.

The University of Vienna, in cooperation with local Turkish universities, has committed to the protection of the sea turtle species *Caretta caretta* and *Chelonia mydas* (Green sea turtle), which both occur at the south-west coast of Turkey. This includes recording every dead or injured turtle washed ashore during a period from June to September 2015. Accordingly we collected all relevant data about the size, sex, injuries, stay of decay and the possible cause of death of each individual. In summer 2015, seven dead *Caretta carettas* (two in Çaliş, two in Fethiye, one in Akgöl, one in the harbor of Fethiye and one, which location is unknown) and two dead *Cheloniy mydas* (one in Çaliş, one in Yaniklar) were found in the course of the project. Three animals had injuries on the head, neck and plastron due to intentional violence and another one died presumably by the consequences of a boat collision. Two other dead sea turtles were discarded before the team arrived, that is why we have no information about species, sex or probable cause of death. Since the beginning of the recordings in 2000, a nearly constant increase of the mortality rate of sea turtles is evident, with a new peak this season. This makes it important to identify the reasons for the sea turtles mortality to show how much anthropogenic impacts harm this population and to better develop measures to ensure, that these fascinating animals continue to be part of the marine ecosystem. .

INTRODUCTION

Caretta caretta is a keystone species within the fauna of the Mediterranean Sea. This species is characterized by its massive head and jaw, which allows them to crack shells and carapaces of bivalves and crustaceans. The number of female loggerhead sea turtles nesting in the Mediterranean region amounts to approximately 2,500 individuals, with nearly 700 individuals visiting their nesting sites in Turkey (Spotila, 2004). According to the IUCN Red List, *Caretta caretta* and *Chelonia mydas*, which both occur in the Mediterranean, are already categorized as endangered species (IUCN, 2015). Even though marine turtles are robust, their populations have declined considerably within the last decades. The primary reason for the high mortal rates can be traced to human activities such as hunting, water sports within touristically used areas, commercial fishing and destruction of the natural habitat including nesting sites and foraging areas. Especially the loss of over 44,000 sea turtles in the Mediterranean Sea per year, which are caught as by-catch in trawl nets or by pelagic long lines, is the result of poorly controlled commercial fishing (Casale, 2011). The Turkish south coast is among the most common important nesting sites of Loggerhead sea turtles and Green sea turtles within the Mediterranean. During the breeding season, hundreds of female sea turtles migrate from open water to the coastal regions where they once were born. This behavior is called “philopatry” and is characteristic of all seven marine sea turtle species. The variation between the position of the former birthplace and the nesting site normally involves only a few kilometers (Bolten & Witherington, 2003). But by massive obstruction of coastal regions and beaches, the natural habitat and nesting sites of those endangered species has declined constantly. Construction work, vehicular traffic and various touristic uses on the seaside compress the beach sand and increase the destruction rate of sea turtle nests.

Most turtle nesting sites are well known and often overlap with holiday resorts, especially in the Mediterranean. Çaliş and Yaniklar are parts of the district Fethiye and popular vacation destinations for thousands of tourists every year. The two sites and their beaches differ. While Yaniklar is, for the most part, surrounded by natural beaches and forests, Çaliş beach is largely restricted by a promenade, thousands of tourists every year, bright lights of restaurants and bars and huge hotel complexes. Despite of countless disturbances, hundreds of female *Caretta caretta* remigrate to their breeding areas every year.

One of the main problems of the female turtles during breeding season is that they normally stay close to the beaches during daytime. This is no doubt where the most accidents involving turtles and boats happen.

The following report presents the data collected by students of the University of Vienna and the Hacettepe University in Ankara during the nesting season June-September 2015 in Fethiye, Turkey.

MATERIAL AND METHODS

Participants of the practical field course “Meeresschildkröten – Schutz von Meereschildkröten in der Türkei. Projekt zu angewandtem Naturschutz“ from the University of Vienna stayed during the period from 27 June to 12 September 2015 at the south-west coast of Turkey in two camps in Çaliş and Yaniklar.

In the course of morning and night shifts, the students monitored the main beaches of Çaliş and Yaniklar and examined them closely for nesting adult sea turtles and their tracks, but also recorded dead or injured individuals. Another important source of information regarding dead and injured turtles was the local residents and workers from the surrounded hotels and restaurants. Their support in the course of this project called our attention to many stranded sea turtles. This enabled fast and coordinated work, especially outside our regular workshifts.

The morning shift in Çaliş regularly began at 6 o'clock in the morning and included the monitoring route from the beginning of the promenade to Çaliş Tepe, which is a small hill between Yaniklar and Çaliş.

The nightshift began at about 10 in the evening. During the night we monitored the beach by walking parallel to the sea four times in 45 min. intervals. At the end of each route, we took a 15 min. break.

The most important equipment for our shiftwork was the data book with a data sheet, pencil and permanent marker for observation and collecting data, a camera to take photos of the stranded turtles, a measuring tape to measure the curved carapace length (CCL) and curved carapace width (CCW), a torch to check for injuries at night, a knife to cut off lines and nets of injured animals, and a walkie-talkie to stay in contact with the other colleagues to gather more information. These were stored in the prepared shift-backpack. Another important item was the sliding caliper, which we used to measure the straight carapace length (SCL) and straight carapace width (SCW) of adult dead or living sea turtles.

Once a stranded sea turtle was spotted, the animal was precisely measured (curved carapace length CCL and curved carapace width CCW, straight carapace length SCL and straight carapace width SCW) by participants of the practical field course, the sex (by examining the tail length) and species was determined (if possible) and the animal was checked for any external injuries that could have caused the death. We kept records about the condition of the dead sea turtle by taking photographs from the dorsal, ventral, anterior and posterior side of the turtle. To more precisely identify the turtle, we also checked for any tags, which are usually attached on the front flippers of the animal. Those tags indicate where the turtle was tagged and each tag has an individual number that can be used to retrieve important information about the turtle.

RESULTS

The result of this year's nesting season was eleven dead and one injured turtle that have been washed ashore in Akgöl, Yaniklar, Çaliş and Fethiye.

The first six dead turtles were recorded by Turkish colleagues from Hacettepe University from 6 to 21 June (i.e. before the Austrian team arrived in Turkey). In the months June and July three cadavers were discarded before the Turkish team arrived and because of that, it was not possible to take any measurements or to make a statement about the probable cause of death.

Turkish colleagues identified one dead sea turtle, which was discarded on 6 June, as a *Caretta caretta* on the basis of photos from a news article.

On 11 June 2015 at 9:30am Turkish colleagues found a dead male *Caretta caretta* on the beach in Yaniklar with a curved carapace length (CCL) of 63 cm and a curved carapace width (CCW) of 61 cm. The cause of death of this animal was unclear but it showed damage on the plastron and carapace plates were missing (Fig. 9).

On 12 June 2015 afternoon a dead female *Chelonia mydas* was found offshore in Yaniklar with a string tied around its neck, which was attached to a stone and the inner organs were pressed outside on the posterior side of the turtle. This individual probably got killed on purpose or died as a consequence of entanglement. The measurements showed a curved carapace length (CCL) of 79 cm and a curved carapace width (CCW) of 63 cm (Fig. 10).

On 20 June at about 12pm the second dead *Caretta caretta* was found inshore in the harbor of Fethiye by colleagues from the Haceteppe University. The sex and size of this animal were not recorded. This individual showed a deep propeller-cut through the carapace and plastron due to a boat crash and plastron plates were missing (Fig. 11).

A third *Caretta caretta*, which was found inshore in Çaliş, was heavy decomposed. Head and extremities as well as bone parts and the carapace were missing. Only bones and jelly-like muscle were left. Colleagues from the Turkish University were able to identify the species by examining the bones (Fig.).

On 4 July at 6:22pm we got informed by the staff from a local restaurant in Çaliş, that they found a dead *Chelonia mydas* inshore. This female turtle died proximately one week ago and showed a deep cut through the neck and two holes on the first costal plate and second vertebral plate. The cut through the neck could be caused by a line or hook and the two holes point to a hit with a blunt object. The curved carapace length (CCL) was 65 cm and the curved carapace width (CCW) was 63 cm. With the caliper we could measure the straight carapace length and width with a length of 57 cm (SCL) and a width of 46.5 cm (SCW) (Fig. 13).

On 21 July at 2:30pm a dead female *Caretta caretta* was detected inshore in Çaliş by tourists, who brought it on the beach. Four team members from the University of Vienna examined the cadaver closely and recorded a curved carapace length (CCL) of 64 cm, a curved carapace width (CCW) of 60 cm, a straight carapace length (SCL) of 58 cm and a straight carapace width (SCW) of 47.5 cm. This turtle exhibited drowning symptoms and additional evidence for directed violence against the head (Fig.).

On 25 July at 12:30pm a fresh dead female *Caretta caretta*, which probably died less than one week ago, was found at the Karaot Beach in Akgöl. The animal did not have any visible injuries. Due to the stay of decay, some carapace plates were missing and the lower beak came off. The curved carapace length (CCL) was 63 cm, the curved carapace width (CCW) was 58 cm, the straight carapace length (SCL) was 58 cm and the straight carapace width (SCW) was 45 cm (Fig.).

On 27 July at 1am one member of the University of Vienna and one member of the Hacettepe University found a male *Caretta caretta* which got air under the carapace and were not able to dive anymore. It also got its right front flipper entangled in a fisher net. By measuring the carapace they recorded a curved carapace length of 77 cm (CCL), a width of 69 cm (CCW), a straight carapace length of 73 cm (SCL) and a width of 52 cm (SCW). This animal was taken by DEKAMER Sea Turtle Rescue and Rehabilitation Center in Dalyan.

On 8 August at 6:50am five team members from Yaniklar found a dead female *Caretta caretta*, which was washed ashore near Botanika. Its carapace had a curved carapace length (CCL) of 63 cm, a curved carapace width (CCW) of 63 cm, a straight carapace length (SCL) of 59.6 cm and a straight carapace width (SCW) of 44.7 cm. This turtle had no external injuries, aside from the decomposed right rear flipper (Fig.).

Five out of eleven dead turtles during this breeding season were female. The sex of five cadavers could not be determined. One male *Caretta caretta* was found in Yaniklar. In more than 60% of the cases, the cause of death could not be determined because of the advanced state of decay and because three dead turtles were discarded before the team arrived (2 in June, 1 in July). The size of the carapace of this season dead and injured turtles range from a curved carapace length (CCL) between 77 to 63 cm and a curved carapace width (CCW) between 69 to 59 cm. Each dead or injured turtle, which we found this year, was not tagged.

Tab. 1: Recorded dead and injured sea turtles from 2000-2015 in Çaliş, Yaniklar, Akgöl, Öludeniz and Fethiye harbor
Tab. 1: aufgezeichnete tote und verletzte Meeresschildröten von 2000-2015 in Çaliş, Yaniklar, Akgöl, Öludeniz und der Hafen von Fethiye

Year	Species	Location	Date of find	Sex	Age	Injuries	Probable cause of death
2000	CC	F	31.07. – 31. 08.	f	a	alive, injuries on the head	injured by a blunt object
2001	CC	C	n.d.	f	a	swallowed fish hook	fish hook
2002	CC	F	n.d.	n.d.	n.d.	very decomposed, age and sex unknown	n.d.
	CM	F	n.d.	f	n.d.	bursted carapace, broken flipper	ship propeller
2003	CC	Y	04.09.	m	n.d.	decomposed and gnawed, especially in the skull area	n.d.
2004	CM	C	24.08.	m	j	small right hind limb; raw parts of bottom slide of throat	caught in a fisherman's net, drowned
	CC	F	late June	n.d.	n.d.	carapace torn open	ship propeller
2005	no dead turtles recorded						
2006	CC	C	June	f	a	right hind limb missing, perhaps hereditary	n.d.
	CC	C	19.08.	f	a	front extremity and eye missing	n.d.
	CC	C	25.08.	n.d.	n.d.	back part of body missing	n.d.
	CC	Y	July	m	n.d.	head and body skeletonized, hole in skull	ship propeller
	CM	C	September	f	j	one eye missing	n.d.
	TT	C	August	n.d.	n.d.	no external injuries	n.d.
2007	CC	C	07.08	m	a	head injuries, decomposed	collision with boat
	CM	C	05.08.	f	j	head injuries, parts of the flipper missing	killed by a human
	CM	C	02.09.	f	j	carapace torn open, injury extending down to the plastron	ship propeller
	CM	F	04.09.	m	a	still alive, no	alive

Year	Species	Location	Date of find	Sex	Age	Injuries	Probable cause of death
						external injuries, unable to dive	
2008	CC	Y	02.07.	m	n.d.	scars on top of head, cut on the side of the body, carapace damaged	boat accident
	CC	C	04.07.	f	n.d.	n.d.	n.d.
	CC	C	15.07.	m	n.d.	fishing line around neck, 80% of carapace missing	caught in fishing net
	CC	F	30.07.	n.d.	n.d.	n.d.	n.d.
2009	CC	C	04.08.	f	a	left flipper entangeled in a fishing net, fishing hook	caught in fishing net
	CM	C	05.08.	f	n.d.	n.d.	n.d.
2010	CC	Y	21.07.	f	a	decomposed	strike on the head
	TT	C	16.08.	n.d.	n.d.	hole in the carapace	ship propeller
2011	CC	C	24.07.	n.d.	a	decomposed, cuttings on carapace, head, three flippers and tail missing	boat collision
	CC	Y	27.07.	n.d.	a	hole in the carapace, head missing	strike on the head
	TT	C	June	n.d.	n.d.	decomposed, carapace injuries	n.d.
2012	CC	Y	03.07.	n.d.	j	decomposed, smashed head, holes in bones	killed by a human
	CC	F	03.07.	f	a	swallowed fish hook	fish hook, drowned
	CC	F	09.07.	f	a	swallowed plastic bag	plastic bag, starvation
	CC	C	12.07	f	a	swallowed plastic bag	plastic bag, starvation
2013	CC	F	23.06.	f	a	n.d.	drowned in fisher net
	CC	Y	27.06.	n.d.	n.d.	head and right flipper left	n.d.
	CC	F	28.06.	f	a	propeller damage	ship propeller
	CM	C	17.07.	f	a	left flipper was missing	drowned in fisher net
	CC	Ö	27.07.	n.d.	a	fisherline was around its left flipper	n.d.
	CC	C	01.08.	m	a	cut on carapace	drowned in fisher net
	CC	C	27.08.	f	j	decomposed; tail, eyes and half left front flipper were missing; piece of plastic in pharynx	n.d.
	CC	C	02.09.	m	n.d.	propeller damage, carapace was almost cut in half	ship propeller
	CM	Y	13.09.	m	a	cut on right side	ship propeller

Year	Species	Location	Date of find	Sex	Age	Injuries	Probable cause of death
2014	TT	Y	05.07.	f	a	n.d.	n.d.
	CC	C	18.07.	f	a	blood in nose and mouth	fish hook
	CM	C	26.07.	f	a	bruises, inner bleeding and bloody eyes	dynamite fishing
	CC	C	28.07	m	a	upper layer of carapace came off, back of carapace cut off, open wounds on carapace and thorax	ship propeller
	CC	F	26.08.	f	a	lower jaw missing, three holes in carapace, right front flipper entangled in a fishing net	shot after being caught in fishing line
2015	CC	n.d.	06.06.	n.d.	n.d.	n.d.	n.d.
	n.d. (propable TT)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	CC	Y	11.06.	m	a	turtle decomposed, damage on plastron	cause of death unclear
	CM	Y	12.06.	f	a	inner organs pressed outside	string around neck (and around a stone), killed on purpose
	CC	F	20.06.	n.d.	a	deep cut through carapace	boat collision
	CC	C	21.06.	n.d.	n.d.	turtle decomposed, head and extremities missing, only bones and dermis were left	n.d.
	CM	C	04.07.	f	a	deep cut on throat, two holes in carapace	cut on throat by lines or hooks, external forceful impact
	CC	C	21.07.	f	a	wound on neck, drowning symptoms	caught in net, drowned, hit on neck
	n.d.	F	22.07.	n.d.	n.d.	n.d.	n.d.
	CC	A	25.07.	f	a	lower jaw missing	n.d.
	CC	Y	27.07.	m	a	air under carapace, fisher net and hook around right front flipper	alive
	CC	Y	09.08.	f	a	rear flipper decomposed	n.d.

CC	*Caretta caretta*	C	Çaliş	f	female
CM	*Chelonia mydas*	Y	Yaniklar	m	male
TT	*Trionyx triunguis*	F	Fethiye	a	adult
		A	Akgöl	j	juvenile
		Ö	Öludeniz	n.d.	no data

DISCUSSION

The nesting season 2015 showed the highest number of stranded sea turtles found in the Fethiye area since the beginning of the monitoring by the University of Vienna. The most cadavers were found by tourists and local residents during the months June and July. One big problem this year was that three out of eleven stranded sea turtles were discarded before the team arrived. That is why important data about the size, sex and probable cause of death are missing.

Examining the numbers of stranded sea turtles over the last few years, reveals both, low numbers as well as high numbers of dead turtles. There were no dead turtle recorded in the years 2000 and 2005 while in the years 2006, 2013 and 2015 between six and eleven dead turtles were found in the Fethiye area. And only in the years 2000, 2007 and 2015 we recorded in each year one alive but injured turtle (Fig. 1). However, there is an increasing trend in the number of dead turtles. This data collection relies on the cooperativeness of the local people. The collaboration with our Turkish colleagues was also essential to more fully document as many stranded turtles as possible. Several reasons can explain the fluctuating values observed over the years and also point to the recorded numbers as being minimum values. This includes dead turtles not being washed ashore, turtles stranding along shorelines not visited by locals or tourists, and the relatively short monitoring period of the sea turtle teams.

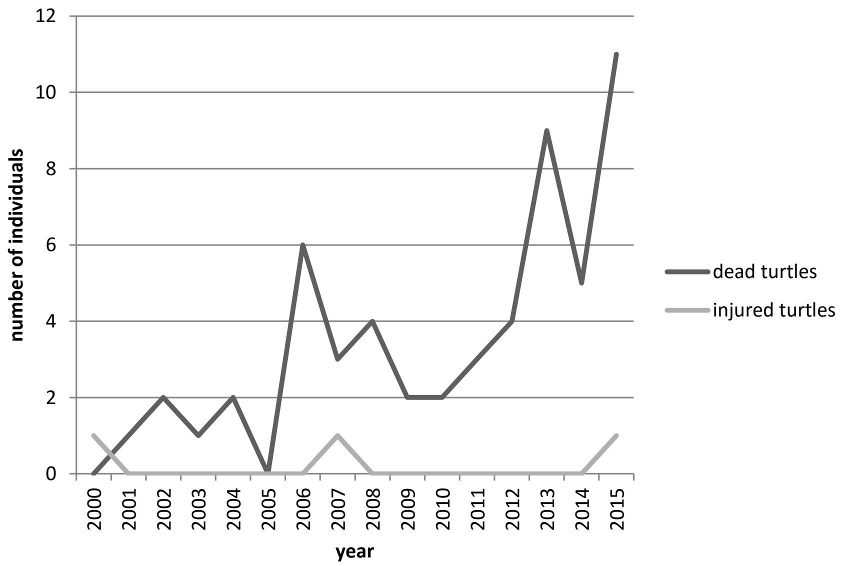

Fig. 1: Overview of the number of dead and injured turtles from 2000-2015
Abb. 1: Überblick über die Anzahl toter und verletzter Schildkröten von 2000-2015

The reasons for the sea turtle mortality ranged from boat collision to intentional killing by humans and dynamite fishing (Fig. 2). Since the year 2000, 13 sea turtles died from the effects of boat collisions. These individuals typically show a deep cut or cuts through the carapace, head or extremities. Studies show a high correlation between death rate of turtles and the speed of vessels. While 60% of the observed turtles were able to flee from vessels traveling at a speed of 4 km/h, only 4 % of marine turtles were able to flee from vessels traveling at 19 km/h (Hazel, et al., 2007).

The second largest threats of marine turtles in the Fethiye area are willful killings of sea turtles by humans and drowning after being caught in a fisher net or line. Depending on the sea turtle species, individuals may dive up to 1 to 5 hours before they need to take a breath (Lutz, et al., 1997). In this year's season we found one female *Chelonia mydas*, on 12 June, which was presumably killed on purpose (Fig. 10). This turtle had a long string tied around its neck and attached to a stone and was drowned in the sea. The inner organs of this animal were pressed outside.

Although in 2012 two individuals were recorded that swallowed plastic bags or other plastic material, this year we did not observe a similar situation. Nonetheless, ingestion of marine debris remains a key reason for mortality in sea turtles (Nelms, et al., 2015). In the gastrointestinal tract of 19 out of 54 loggerhead turtles (= 35.2%) in the Mediterranean, researchers found a high amount of plastic, Styrofoam, ropes and monofilament lines (Lazar & Gracan, 2011). As no autopsies were conducted on the stranded Fethiye individuals, this source of mortality cannot be ruled out.

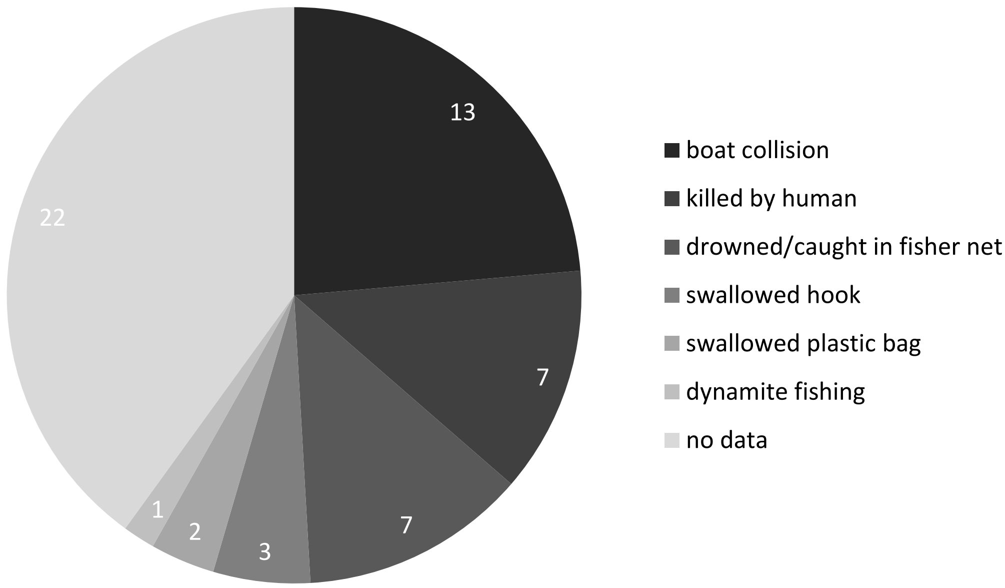

Fig. 2: The leading causes of death of sea turtles in Fethiye
Abb. 2: Die häufigsten Todesursachen von Meeresschildkröten in Fethiye

An explanation for the high rate of boat collisions is that Fethiye has a highly frequented harbor and hundreds of ships are used for tourist excursions. Sea turtles, which rise to the water surface to breath, are often noticed too late (or not at all) due to high vessel speed, and a collision cannot be prevented. Although the beaches of Çaliş and Yaniklar have the status of a special protected area, we recorded numerous infringements of regulations designed to protect turtles, for example speed boating directly along the beach, fishing and trespassing the beach at night. This calls for more and better enforcement by the authorities.

There are many strategies to reduce the high mortality rate of sea turtles and especially the species *Caretta caretta* and *Chelonia mydas* in the Mediterranean. About 30, 000 turtles get caught by Mediterranean bottom trawlers every year. One out of four turtles doesn’t survive the trawling process (Sala, et al., 2011) and that is why the TED (Turtle Excluder Device) should be better introduced in the Mediterranean to reduce the high mortal rate. A special clap mechanism in the trawling net saves turtles and other bigger marine species from drowning.

Sea turtles are robust animals and some individuals even survive serious accidents. Those injured animals usually get brought to rescue centers and stay there for several months or even years depending on the gravity of the injury.

DEKAMER

One of these Rescue Centers is located in Dalyan, Turkey. DEKAMER was founded in 2009 and also takes care of between 57-330 *Caretta caretta* nests on the 4.7-km-long beach of Dalyan each year (Mutlu, 2014). One problem this rescue center faces is the insufficient size of the quarantine tanks for adult turtles especially for those that remain there for several years. Many injuries of sea turtles at DEKAMER are representative for the main threats of those animals within the Mediterranean, like cuts made by propellers or lines and crushed skulls due to boat crashes (Fig. 4 - Fig. 7). Other important tasks for rescue centers are to inform locals and tourists about the problems and the threats of sea turtles and to extend the internal network with other rescue facilities and institutions to improve a better information exchange (Ullmann & Stachowitsch, 2015).

Since DEKAMER was founded, they had over 60 injured turtles at their rescue center. Those animals stay there between four months up to two years depending on the gravity of their injury. Before a sea turtle gets released to the wild they are tested in a 10 m high tank if they are able to catch and eat a living crab and, as a final point, brought back to the place where they once were found.

According to the numbers of sea turtles which stay or die at the rescue center, much less turtles died at the center in 2014 than the years before. Çisem Sezgin, a member of the DEKAMER Rescue Center, justified those numbers with the fact, that most turtles died before they arrived at DEKAMER and those do not get mentioned in the annual statistics.

A current acute case in DEKAMER Rescue Center is “AKUT-3” (Fig. 3), a *Caretta caretta* sea turtle whose lower jaw was cut off by a propeller during a boat collision. AKUT-3 was found 2014 in Bodrum. Thanks to modern 3D-printing technology, it was possible to reconstruct its jaw using titanium. During an operation, the new 3D printed lower jaw was successfully attached. But before AKUT-3 can be released to the wild, it has to show an active hunting behavior to ensure it can survive on its own (Sezgin, 2015).

Fig. 3: AKUT-3 in quarantine at DEKAMER (Photo: M. Saxinger)
Abb. 3: AKUT-3 in Quarantäne bei DEKAMER

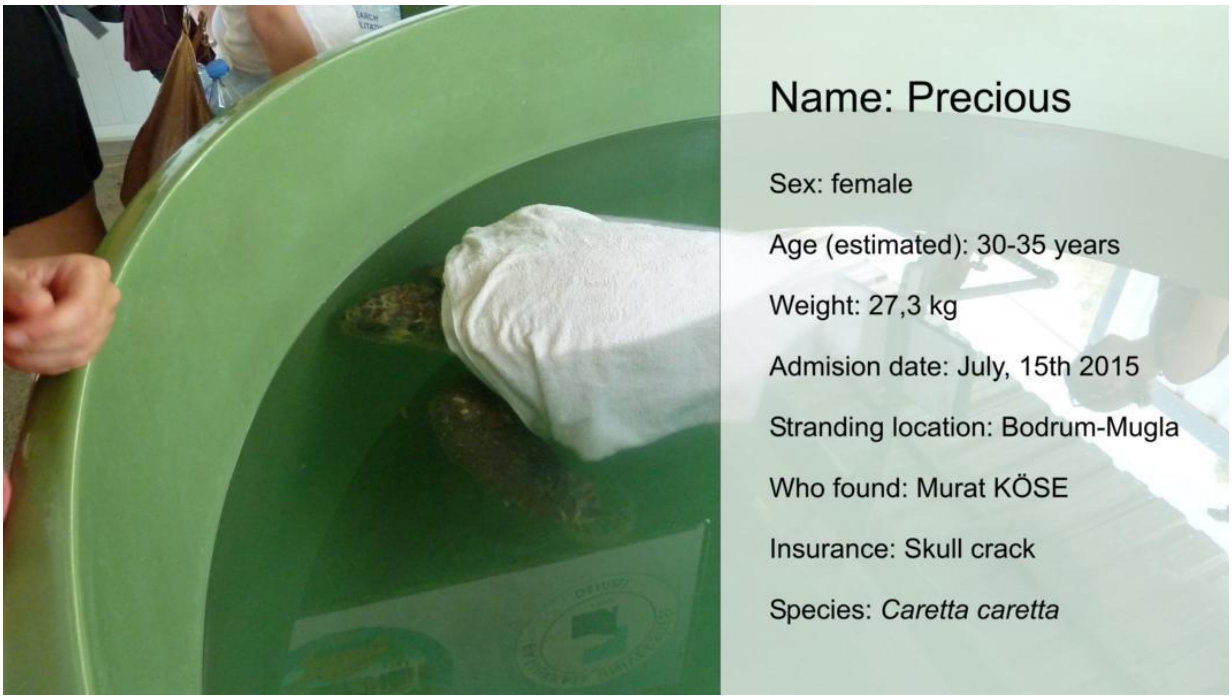

Fig. 4: injured female *Caretta caretta* at DEKAMER; Injury: skull crack (Photo: M. Saxinger)
Abb. 4: verletzte weibliche *Caretta caretta* in DEKAMER; Verletzung: Schädel gebrochen

Fig. 5: injured female *Caretta caretta* at DEKAMER; Injury: Skull crack (Photo: M. Saxinger)
Abb. 5: verletzte weibliche *Caretta caretta* in DEKAMER; Verletzung: Schädel gebrochen

Fig. 6: injured male *Caretta caretta* at DEKAMER; Injury: Carapace fracture as a result of a propeller (Photo: M. Saxinger)
Abb. 6: verletzte männliche *Caretta caretta* in DEKAMER; Verletzung: Carapax Fraktur als Folge eines Propellers

Fig. 7: injured male *Caretta caretta* at DEKAMER; Injury: Deep cut in left flipper as a result of fishing line entanglement (M. Saxinger)
Abb. 7: verletzte männliche *Caretta caretta* in DEKAMER; Verletzung: Tiefe Schnittwunde an der linken Flipper aufgrund einer Verstrickung in eine Angelschnur

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APPENDIX**:**

DEAD OR INJURED SEA TURTLES

Observer: …………………………   Stranding date and time: ……………………...

Species: *Caretta caretta* – loggerhead turtle ☐
Chelonia mydas – Green turtle ☐
Trionyx triunguis – Nile softshell turtle ☐
Other: ……………………….......

Stranding location: Offshore (beach) ☐   Inshore (sea, lake, river) ☐
Descriptive Location: …………………………………………………

Sex: undetermined ☐   Male ☐   Female ☐

How was sex determined: necropsy ☐   tail length (adult only) ☐

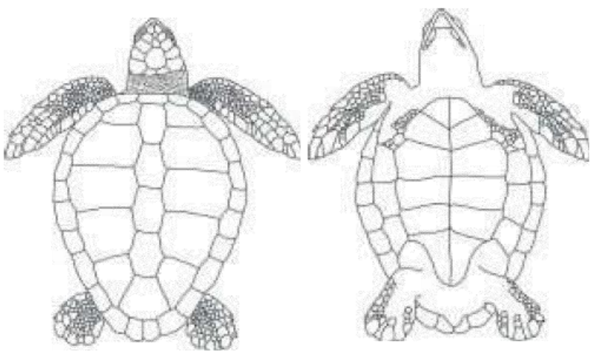
Condition: 1 alive ☐
2 fresh dead ☐
3 decomposed ☐
4 dried carcass ☐
5 skeleton bones only ☐

Tags: Checked for tags? Yes ☐   No ☐   Tagnumber: ……………………
Tag location: ……………………………………………………………………...
Return adress: ……………………………………………………………………

Carapace measurements: CCL ………………..   SCW ………………..
CCL ………………..   CCW ………………..

Photos taken?   Yes ☐   No ☐
Nr. of photos:

Mark wounds/abnormalities on diagrams and describe. Please also note if no wounds or abnormalities are found.



☐ holes / wounds made by gun
☐ deformations
☐ cuttings
☐ missing parts
☐ gear or debris entanglement
☐ propeller damage
☐ others

Fig. 8: Data sheet for dead and injured turtles
Abb. 8: Datenblatt für tote und verletzte Schildkröten

Fig. 9: dead male *Caretta caretta*; found: 11 June; cause of death unclear, damage on plastron (Photo: Uğur Sü)
Abb. 9: tote männliche *Caretta caretta*; gefunden: 11. Juni; Todesursache unklar, Schäden am Plastron

Fig. 10: dead female *Chelonia mydas*; found: 12 June; turtle was killed on purpose, string over neck and stone, inner organs pressed out (Photo: Uğur Sü)
Abb. 10: tote weibliche *Chelonia mydas*; gefunden: 12. Juni; gezielte Tötung der Schildkröte durch Menschen, Schnur um Hals und Stein gewickelt, innere Organe nach außen gedrückt

Fig. 11: dead *Caretta caretta* (sex unknown); found: 20 June at Fethiye harbor; plastron plates missing, deep cut through carapace; cause of death: boat collision (Photo: Uğur Sü)
Abb. 11: tote *Caretta caretta* (Geschlecht unbekannt); gefunden: 20. Juni im Hafen von Fethiye; Plastron Platten fehlten, tiefer Schnitt durch den Carapax, Todesursache: Bootkollision

Fig. 12: dead *Caretta caretta* (sex unknown); found: 21 June in Çaliş; heavy decomposed, only bones, dermis and jelly-like muscle left (Photo: Uğur Sü)
Abb. 12: tote *Caretta caretta* (Geschlecht unbekannt); gefunden: 21. Juni in Çaliş; stark verwest, nur Knochen, Haut und gelee-artige Muskulatur waren vorhanden

Fig. 13: dead female *Chelonia mydas*; found: 4 July; deep cut at neck, two holes in carapace; possible cause of death: hook or line slit the throat, Blunt force trauma? (Photo: M. Saxinger)
Abb. 13: tote weibliche *Chelonia mydas*; gefunden: 4. Juli; tiefer Schnitt durch Hals, zwei Löcher im Carapax; mögliche Todesursache: Schnittwunde verursacht durch einen Haken oder Leine, äußere Gewalteinwirkung mit stumpfen Gegenstand

Fig. 14: dead female *Caretta caretta*; found: 21 July; wound on back of head, drowning symptoms; possible cause of death: caught in net or line and drowned, hit on back of head (Photo: M. Saxinger)
Abb. 14: tote weibliche *Caretta caretta*; gefunden: 21. Juli; Wunden am Hinterkopf, Anzeichen von Ertrinken; mögliche Todesursache: Ertrunken durch Verfangen in Netz oder Leine, harter Schlag auf den Hinterkopf?

Fig. 15: dead female *Caretta caretta*; found: 25 July; some carapace plates and head plates missing (Photo: M. Saxinger)
Abb. 15: tote weibliche *Caretta caretta*; gefunden: 25. Juli; einige Carapax- und Kopfplatten abgelöst; Todesursache unklar

Fig. 16: dead female *Caretta caretta*; found: 8 August; right rear flipper decomposed (Photo: I. Laza)
Abb. 16: tote weibliche *Caretta caretta*; gefunden: 8. August; rechte hintere Flipper bereits stark verwest

Bachelor Thesis

Light pollution and its consequences for loggerhead sea turtles *Caretta caretta* along the beach promenade in Çalış, Fethiye, Turkey, and suggested improvements

Lichtverschmutzung und deren Konsequenzen für die Unechte Karettschildkröte *Caretta caretta* entlang der Strandpromenade in Çalış, Fethiye, Türkei und Verbesserungsvorschläge

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Bachelor of Science (BSc)

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KURZFASSUNG

Nach wie vor stellt die Lichtverschmutzung und deren Folgen vor allem in Calis Beach ein großes Problem für die Meeresschildkröte *Caretta caretta* dar. Es werden nach Mitternacht an vielen Stellen der Promenade die Lichter weder gänzlich abgedreht noch auf ein Minimum reduziert, des Weiteren befinden sich viele Menschen, Liegestühle und Sonnenschirme am Strand in der Nacht, obwohl dies ausdrücklich verboten ist. Es wurden daher die Lichtintensitäten der Gebäude gemessen und notiert wie viele Lichter verwendet wurden. Die Lichtintensität hat sich verglichen zu 2014 ein wenig erhöht, von 11.75 zu 13.53 Lux vor Mitternacht und von 3.70 zu 5.22 nach Mitternacht. Die Anzahl der verwendeten Lichter ist ein wenig gesunken, von 1204 Lichtern im Jahr 2014 zu 1162 in diesem Jahr. Auch auf der Höhe der Nester wurden die Lichtmessungen gemacht um anschließend zu überprüfen ob die Lichtverschmutzung etwaige Auswirkungen auf die Position der Nester habe bzw. ob die Anzahl der Tage bis zum ersten Schlupf mit der Lichtverschmutzung zusammenhängt. Hier konnte keine Korrelation gefunden werden, aber es war ersichtlich, dass die meisten Nester nach Mitternacht gelegt wurden. Danach wird auf die Berner Konvention, dessen Vertreter Ende Juli in Çalış Beach waren um die derzeitige Lage zu analysieren, eingegangen. Çalış Beach wurde ziemlich kritisiert bezüglich der gesamten Verschmutzung und der bisherigen Fortschritte im Naturschutz. Abschließend wurden Lösungsvorschläge ausgearbeitet.

ABSTRACT

The light pollution in Çalış Beach is still a major problem when it comes to conservation of the sea turtle *Caretta caretta*. The lights are still not switched off completely after midnight nor are they reduced to a minimum. In addition, there are still too many people, sunbeds and umbrellas on the beach at night, which distract and confuse the hatchlings when emerging from their nests. I therefore carried out light measurements of the buildings along the promenade and noted how many lights were used. The light intensity increased from average of 11.75 to 13.53 lux before midnight and from 3.70 to 5.22 lux after midnight, compared to 2014.The number of lights used decreased somewhat from 1206 lights in 2014 to 1162 this year. I also measured the light intensity at the site of the nests to determine whether the position of the nests correlates with the light intensity or with the number of days until the first hatch. There was no significant correlation, but it could be seen that most of the nests were laid after midnight. Then I mention the Bern Convention, whose representatives visited

Çalış Beach in late July to examine the current situation there. Çalış Beach received considerable criticism in the report, especially concerning overall pollution and the progress concerning conservation. Finally, I developed a plan for improving the situation.

INTRODUCTION

The loggerhead sea turtle *Caretta caretta* is an endangered species according to IUCN (2012) since 1996 due to the increase of anthropogenic threats. Urbanization like the construction of buildings and the resulting high tourism on or close to nesting beaches, the pollution of the beach and the pollution of the sea caused a decline in the total number of this world-wide distributed species. In this Bachelor thesis I focus on the human-made artificial light pollution and its effects on sea turtles, especially on hatchlings.

Normally, loggerhead turtles are sensitive to the visual spectrum between 320 nm and 700 nm and especially to the shorter wavelengths within this spectrum. For example, white light is a short-wavelength light, so the sea turtle hatchlings react positively phototactically, which means they are attracted to and move towards this light. An example is Fig. 1 (Appendix), which shows an ice cream stand with a very bright white light. In contrast to white light, sea turtle hatchlings show a negatively phototactic behaviour when exposed to yellow light, a so-called "xanthophobic response" (Witherington & Björndal, 1990).

Under natural conditions, the moonlight affects the sea-finding behaviour of loggerhead turtles. According to Berry et al. (2013), light pollution experiments showed the highest disruptive sea-finding behaviour during the new moon phase, because then the artificial lights were the only lights on which the hatchlings could orientate. In contrast, when there was full moon, the tested sea turtles showed normal sea-finding behaviour, and found the way to the sea quite easily. The same success was recorded for nests in shadowed places. Upon emerging, they showed normal sea-finding behaviour, but when they crawled out of the shadows they became confused, which was shown by running parallel to the waterline.

Additionally, to light cues, there are other factors affecting hatchling behaviour. Salmon et al. (1992) suggest that in in-situ experiments hatchlings, besides the orientation towards the brightest illumination, were affected by silhouettes, beach slope and the horizon. In these experiments, hatchlings were exposed to different situations of light, slope and silhouettes. Summarized, most of the experiments showed a group orientation away from the silhouette, away from the highest horizon elevation, and downslope orientation (when lights were switched off).

Disrupted sea finding behaviour is not only a problem on the beach itself. Hatchlings, after successfully arriving at the water, start to swim and normally use the waves for orientation (in the deeper zones and in the wave refraction zone they use the earth's magnetic field). But in the absence of waves and if the hatchling has already lost a lot of energy because of lengthy crawls on the beach, the hatchling loses its compass-setting process, which leads to a decrease of the ability to swim directly offshore (Lohmann & Lohman, 1996).

Caretta caretta turtles always come back to the same beach to lay their eggs, a phenomenon called "natal homing", "site fidelity", or "homing behaviour". They never change their nesting beach even when this beach has become severely disrupted (in the sense of urbanization). An experiment (Avens et al., 2003) showed that when loggerhead turtles were captured and brought to a different area of the sea, almost all turtles possessed the ability to determine their position and navigate back to the original area (even when they could not see where they were brought).

The nesting season of *Caretta caretta* is between May and September, at the same time when there is also the touristic high season in Çalış Beach. The female sea turtles come ashore and crawl on the beach until they find a place to dig the nest and lay their eggs. When the beaches are full of people and lights are shining from the promenade, this process becomes a challenge for the turtles.

Under normal, natural conditions, hatchlings hatch at night (mostly between around 8:00 pm and 2:00 am, but this can vary) and immediately try to find the way to the sea. If there are no artificial lights, they orient themselves with the help of the brightest light available, usually the moonlight or its reflection on the sea. When there is too much artificial illumination on the beachside, for example made by the outdoor lights of touristic properties like bars, restaurants, discotheques or indoor lights not blocked by curtains, the hatchlings have difficulty orienting themselves: the lights emitted from the buildings, termed "light pollution", distract and confuse them. They lose their orientation, and as a result can either run around in circles, or even move in the completely opposite direction towards the brightest light, which in Çalış Beach is on the promenade or on the street. As a result, hatchlings are crushed by cars, injured by people, or die because of predation. This is why we put cages over the nests.

During the day, they are open so the hatchlings can escape before being killed by the sun, and at night they are closed in order to prevent them from being misoriented or disoriented.

After the 1.5 km-long promenade there is the so-called “Picnic area”, a zone of the beach where it is officially forbidden, as on the other parts of the beach, to stay during the night. In general the beach in Çalış is declared as a Specially Protected Area (SPA), and it is forbidden to stay there from 8:00 pm until 8:00 am. Nevertheless, this area was almost every day and night full of people celebrating, drinking, eating and, worst of all producing severe light pollution with their own lamps and leaving behind large amounts of garbage. Additionally, a bright street lamp illuminated this area at night.

The unit lux (lx): Lux is the measure of luminance, or luminous Lux per unit area. It is a photometric unit, which means that not only the basic principles of energy and radiation are taken into account but also the physics of the (human) eye. For instance, one lux of yellow light appears to us much brighter than blue light, because our eye can pick up yellow colours better than other colours. The same holds true with white versus yellow light: white light is a short-wavelength light, so it is stronger than long-wavelength light and therefore white light appears brighter to us (and the turtles) than yellow light does. This is important for female sea turtles coming ashore and finding a nesting place, as well as for emerging hatchlings trying to orient themselves to find the sea.

The Bern Convention is a binding international legal instrument in the field of wildlife conservation and aims to conserve wild flora and fauna and their natural habitats, as well as the promotion of European co-operation in this field. On 28-30 July representatives of this convention visited Patara and Fethiye/Akgöl to examine the current situation there. As reported thereafter by MEDASSET, ongoing threats include buildings on the beachside, cars accessing the beach, litter, sand extraction and (motorised) water sports, which are still present in Çalış.

MEDASSET –the Mediterranean Association to Save the Sea Turtles- is an international environmental NGO and an observer-member to the Bern Convention. Medasset together with Medasset Greece both are active in the study and conservation of sea turtles and their habitats throughout the Mediterranean.

MATERIAL AND METHODS

In order to examine the light pollution on Çalış Beach, the light was measured along the 1.5 km-long promenade. This year, I again divided the promenade into 99 sections, each encompassing one restaurant/bar. The names of some restaurants and bars had changed from 2014. I started at Türkü Cadiri at the Fethiye-oriented end of the beach and completed the promenade survey at Aroma Beach Club (formerly called Caretta Beach Club) on the other end.

Firstly, I measured the emitted light at a distance of 6 m horizontally away from the light-emitting properties and 130 cm vertically from the ground. Additionally to the promenade, I also measured the light pollution of the beach beyond the promenade, up to our last nest CY 19 at the Sunset Hotel. On the way to CY 19 we came across the so-called “Picnic area”, which as mentioned above, is a zone of the beach almost always occupied by people picnicking (with their own lights), although it is forbidden (see Fig. 14 in the Appendix).

Secondly, I measured the emitted light at the site of the nests. I took data 10 cm and 130 cm above the nest and 10 cm above the waterline at the site of the nest. I only measured those nests designated “CY” and not of the so-called secret nests designated “CS” because we only know the data when the nests were laid (i.e. date and time of night) from the “CYs”. I wanted to determine whether the nest position chosen by the female sea turtles correlates with the light- intensity.

For comparison I divided the light measurements basically into 2 parts: One measurement was taken before midnight from 10pm until about 11:30pm, when all restaurants, bars and shops were open, and the second measurement took place after midnight, from 00:30 am on, when lights should be reduced to a minimum or shut down. The measurements took place on 31 August, on a Monday, and on 5 September, on a Saturday, in order to compare a day during the week and a day of the weekend.

Furthermore, the number of lights of each building were counted (only the lights visible from the outside and switched on that day). These values were compared to those from the last years.

The lights were measured with a lux-meter (Gossen Mavolux digital) like every year, with the mode on “Lux” and “200”. I always stood 6 ms away from the light-emitting properties, holding the white sensor abound 130 cm from the ground and in a vertical position. Any movement away or towards the light source or any different mode on the lux-meter caused a significant change in lux values, so it is important to stick to these settings. The photographs were taken with a Panasonic digital camera with the mode on "night scenery" and a Samsung mobile phone.

This year I asked three main questions and raised two corresponding hypotheses:

> 1st Question: Light intensity of buildings: Did the number of lights increase or decrease compared to 2014? Did the light pollution go up or down compared to 2014?
> 2nd Question: Is there a correlation between the position female sea turtles choose to lay their eggs and light intensity? → Hypothesis: The more light- intensive the site, the closer they lay their eggs to the sea (because they avoid too much light)
> 3rd Question: Does light intensity (before or after midnight) influence the time of hatching (by how many days)? → Hypothesis: The more light-intensive the site, the later they hatch because the hatchlings avoid (too much) luminance and therefore they need more time to exit the nest).

I used Microsoft Word for the text and Microsoft Excel for processing the data, calculating and creating graphs and tables, and for comparing the data with those from the last years.

At the end I present some suggestions for possible improvements for the current (bad) situation of Çalış Beach, together with the findings of the Bern Convention and MEDASSET.

RESULTS

The measurements (lux and number of lights) done this year for the 99 Calis promenade sections are presented in Table 1.

Tab. 1: All measurements along the promenade in 2015. The average lux as well as the sum of the counted lights were calculated. For clarity and simplification, I used the average value of each measurement, not “lux1”and “lux2” as in the past years. The marked rows are the highest values.
Tab. 1: Übersicht aller Messungen entlang der Promenade, 2015. Der Durchschnittswert von Lux und die Gesamtanzahl der gezählten Lichter wurden errechnet. Zur Vereinfachung wurden dieses Jahr die Durchschnittswerte jeder einzelnen Messung benutzt (also kein „Lux 1“ oder „Lux 2“ wie in vergangenen Jahren). Die markierten Reihen sind jene mit den höchsten Werten.

		31.8. Monday		**5.9. Saturday**		**nr of lights**
		10:00 PM	12:30 AM	10:00 PM	12:30 AM	
		Lux	Lux	Lux	Lux	
1	Türkü Cadiri	3,55	4,2	3,55	0	20
2	Krimoglu ismail	2,75	0,25	2,75	0	no data
3	Souvenir Shop	41,6	0,25	41,6	0	no data
4	Ice Cream Shop1	52,2	52,2	52,2	0	4
5	Haslam Misir 2	11,2	0,25	11,2	0	5
6	Mutlu Park	closed	closed	closed	closed	3
7	Restaurant Mutu 1	no data	no data	no data	no data	29
8	Restaurant Mutlu 1	2,85	0,8	4	0	9
9	Billiard Place	1,1	0,25	1,1	0	no data
10	House 1	0,4	0	0,4	0	16
11	Hamsi Bar	0,5	0,1	0,5	0	33
12	Manas Park Otel and Lounge	0,8	0,8	0,8	0	57
13	Indian Cuisine	no data	no data	no data	no data	no data
14	Anna Restaurant	16,25	11,75	16,25	0	15
15	Ice Cream Shop 2	31,95	31,95	31,95	0	7
16	Deniz Beach Hotel	13,45	4,2	13,45	0	9
17	Hotel Simsek	12,5	0,25	12,5	0	14
18	Ice Cream Shop 3	27,25	15,5	27,25	0	5
19	Hotel Berlin	4,4	0,25	4,4	0	5
20	Fruit Smoothie	27,5	0,25	27,5	0	12
21	Haslama Misir 3	no data	no data	no data	no data	4
22	Er-Öz-Hotel	7,85	0,25	7,85	0	17
23	Gül Market	11,6	0,25	11,6	0	8
24	Motto	3,3	0,25	3,3	0	12
25	Bella Mammas/Delta Hotel	10,9	0,25	10,9	0	18
26	Cadianda	33,4	0,25	33,4	0	6
27	Loca Bar/Milano Clothing Shop	25,6	21,3	29,3	0	20
28	Hotel and Restaurant Adrian	8,3	1,2	8,3	0	1
29	Eyül Optik	18,7	1,6	18,7	0	20
30	Beach House	14,6	10,3	14,6	0	9

Tab. 2: All measurements along the promenade in 2015. The average lux as well as the sum of the counted lights were calculated. For clarity and simplification, I used the average value of each measurement, not “lux1”and “lux2” as in the past years. The marked rows are the highest values.
Tab. 1: Übersicht aller Messungen entlang der Promenade, 2015. Der Durchschnittswert von Lux und die Gesamtanzahl der gezählten Lichter wurden errechnet. Zur Vereinfachung wurden dieses Jahr die Durchschnittswerte jeder einzelnen Messung benutzt (also kein „Lux 1“ oder „Lux 2“ wie in vergangenen Jahren). Die markierten Reihen sind jene mit den höchsten Werten.

		31.8. Monday		**5.9. Saturday**		**nr of lights**
		10:00 PM	12:30 AM	10:00 PM	12:30 AM	
		Lux	Lux	Lux	Lux	
31	Nil Bar and Restaurant	10,7	8,4	10,7	0	15
32	Azure Properties	8,4	2,2	8,4	0	12
33	Bambu Bar 1	3,5	2,25	3,5	0	16
34	Bambu Bar 2	4,7	1,3	4,7	0	14
35	McDonald's Ice Cream	20,1	22,4	22,4	0	10
36	Café Soul	15,1	0,25	15,1	0	25
37	Intersky Tourism Agency	16	2,1	16	0	10
38	La Casa di Mamma Ristorante	13,6	5,6	13,6	0	10
39	Tattoo Selim	27,2	10	27,2	0	8
40	Souvenir Shop 1	36	10	50	0	8
41	Seaside Travel Agency	38,3	2,8	38,3	0	20
42	Serkul Restaurant 2	30,7	0,25	30,7	0	30
43	Serkul Restaurant 1	22,35	0,25	22,35	0	32
44	George's	17,4	0,7	8,6	0	16
45	Enya Restaurant	8,1	0,6	8,1	0	6
46	The Palms Restaurant/ Hotel Idee	16,65	0,5	16,65	0	37
47	Souvenir Shop 2	37,5	36	37,5	0	15
48	Focus Travel Agency	40,2	40,2	40,2	0	27
49	Calis Taxi	26,7	17	26,7	17	10
50	Sugar Daddy Ice Cream	23	15	23	0	4
51	Café Green	20,5	12,9	20,5	0	11
52	Calis Bazar	12	0,25	12	0	2
53	Funpark Entrance/Snack Bar	12	0,25	12	0	4
54	Calis Food Restaurant	no data	no data	no data	no data	no data
55	Mado	18	0,25	18	0	17
56	Mado Fruit Bar	15,7	0,25	15,7	0	5
57	Calligraph/Painter	13,2	9,2	13,2	0	1
58	Entrance Dogan Market	11,4	5,8	11,4	0	6
59	Candy Floos	16	0,25	16	0	1
60	Souvenir Shop 3/Clothing Shop 1	no data	no data	no data	no data	11
61	Sevda	13,7	8,6	13,7	0	9
62	bracelet- seller	8,3	3,5	not here	not here	1
63	Waffle Shop	3,65	0,25	3,65	0	6
64	Lighthouse Lounge and Bar	4,95	4	4,95	0	32
65	Okyanus Restaurant	3,7	2,75	3,7	0	13
66	artist (Austrian)	7,2	closed	7,2	closed	2

Tab. 3: All measurements along the promenade in 2015. The average lux as well as the sum of the counted lights were calculated. For clarity and simplification, I used the average value of each measurement, not “lux1”and “lux2” as in the past years. The marked rows are the highest values.
Tab. 1: Übersicht aller Messungen entlang der Promenade, 2015. Der Durchschnittswert von Lux und die Gesamtanzahl der gezählten Lichter wurden errechnet. Zur Vereinfachung wurden dieses Jahr die Durchschnittswerte jeder einzelnen Messung benutzt (also kein „Lux 1“ oder „Lux 2“ wie in vergangenen Jahren). Die markierten Reihen sind jene mit den höchsten Werten.

		31.8. Monday		**5.9. Saturday**		**nr of lights**
		10:00 PM	12:30 AM	10:00 PM	12:30 AM	
		Lux	Lux	Lux	Lux	
67	Rent a Bike	2,4	0,25	9,8	0	2
68	1905 Pub/ Hotel Area	2,45	2	2,45	0	27
69	Haslama Misir 4/Waffle Shop	1,6	0,25	closed	closed	1
70	Rose Bar	4,6	3,5	4,6	closed	14
71	Bar and Restaurant Ögretmenvi	0,25	0,25	shut down	0	1
72	Beatles	19,4	0,25	19,4	0	9
73	Varil	15,6	2,2	15,6	0	1
74	Merhaba Restaurant	16	0,25	16	0	12
75	Clothing Shop 2	17,95	0,25	17,95	0	13
76	Mendos	8	5,5	10	0	4
77	Calis Beach Restaurant	15,7	0,25	15,7	0	13
78	Günes Restaurant/ Sunset	14,05	0,25	14,05	0	19
79	Secil Clothing Shop	12,6	0,25	12,6	0	11
80	Secil Market	28,2	8,8	28,2	0	11
81	Travel Center	30	10	30	0	5
82	Seketur Open House	closed	closed	closed	0	5
83	La Spezia/Hotel Seketur	closed	closed	closed	closed	closed
84	Caretta Info Desk	1,1	closed	1,1	closed	2
85	Keyif Café	5	3,6	5	3,5	25
86	Take Away Ej's	5,5	1,9	5,5	0	4
87	Callisto	5,5	5,5	5,5	0	12
88	Lee's Bar	6	6	6	0	10
89	X-Factor (Hotel Ceren)	4,5	4	4,5	0	7
90	House 2	1,4	1,4	1,4	1,4	4
91	Turkuaz Market	8,95	closed	8,95	closed	3
92	Bahame Bar	7,15	closed	5,1	closed	7
93	Bar/ Restaurant Meinl	5	0,25	5	0	3
94	Hotel Yasmin/Bar	7,7	0,25	7,7	0	14
95	Malhun Restaurant /Hotel	6,75	3,7	6,75	0	22
96	Hotel Letoon 1	7,65	1,1	7,65	0	13
97	Hotel Letoon 2	4,9	3	4,9	1,1	34
98	House 3	0,8	0,5	0,8	0,5	6
99	Aroma Beach Club	3,5	3,5	3,5	3,5	44
	Average/sum:	**13,53**	**5,22**	**14,10**	**0,32**	**1162**

The highest lux-value was recorded from the first Ice Cream Shop (52.2) at the beginning of the promenade, followed by 2 other Ice Cream Shops (31.95 and 27.25), the Fruit Smoothie Bar (27.5), Cadianda (33.4), Souvenir Shop 1 (36), Seaside Travel Agency (40.2), Serkul Restaurant 2 (30.7), Souvenir Shop 2 (37.5), Focus Travel Agency (40.2), and Çalış Taxi (26.7). The average lux- value on 2 September (Saturday) before midnight was a little higher than the average lux- value on 31 August (Monday) before midnight.

Tab. 4: light measurements on the beach starting from the end of the promenade (after Aroma Beach Club) up to our last CY 19 nest. Lights were not counted. Measurements done on 31 August.
Tab. 2: Lichtmessung am Strand, ab dem Ende der Promenade (nach Aroma Beach Club) bis zu unserem letzten CY 19 Nest. Die Lichtanzahl wurde nicht ermittelt. Gemessen wurde am 31. August.

		Lux	Lux
100	Yücel Hotel	2	0
101	Yonük	0,6	0
102	Güven Beach	8,6	0
103	Korsan Beach	5	0
104	Last Stop	9,7	9,7
105	Beach Bar	3,6	0
106	Hotel Sunset	3,6	0
	Average:	**4,73**	**1,39**

Compared to the lux- values of the beach promenade these values are quite low. The average lux-value of all the buildings, from 1-106, was 12.90 before midnight and 4.93 after midnight.

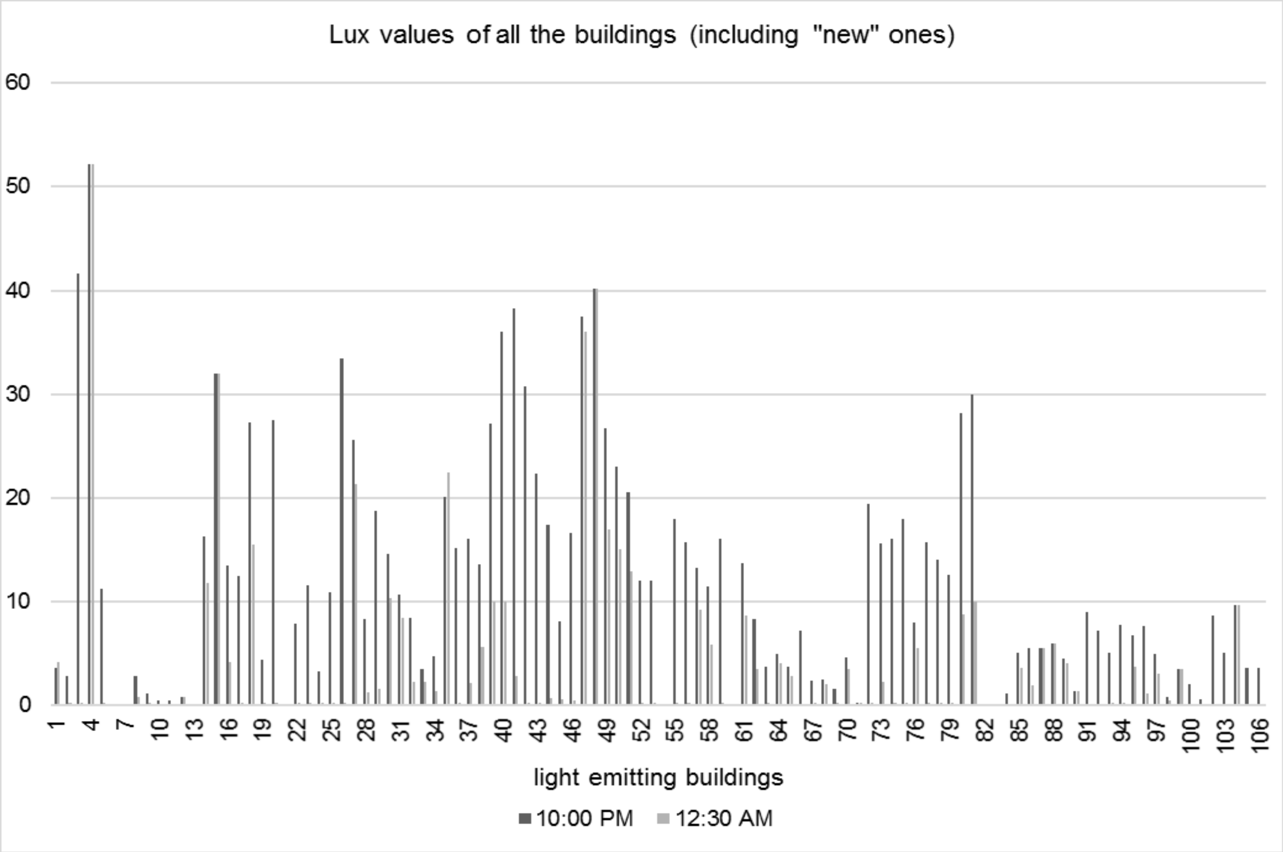

Fig. 1: The lux- values of all the buildings on 31 August before and after midnight
Abb. 1: Die Lux-Werte aller Gebäude/Geschäfte, aufgenommen am 31.August, vor und nach Mitternacht:

1 Ice Cream Shop 1

2 Souvenir Shop

3 Focus Travel Agency

4 Seaside Travel Agency

5 Souvenir Shop 2

6 Souvenir Shop 1

7 Cadianda

8 Ice Cream Shop 2

9 Serkul Restaurant 2

10 Travel Center

11 Secil Market

12 Fruit Smoothie Bar

13 Ice Cream Shop 3

14 Tattoo Selim

15 Calis Taxi

16 Milano Clothing Shop

17 Sugar Daddy Ice Cream

18 Serkul Restaurant 1

19 Café Green

McDonald’s Ice Cream

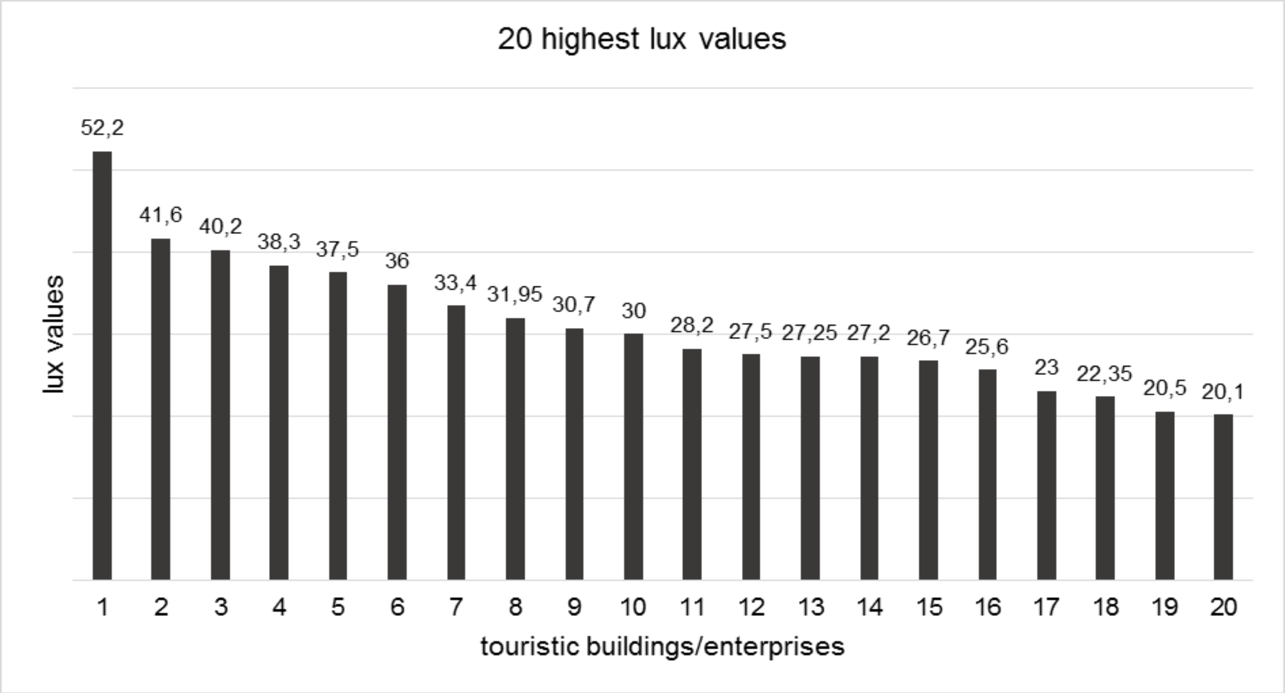

Fig. 2: 20 highest values, ordered from high to lower values. The numbers 1- 20 on the X- axis represent the touristic buildings/enterprises listed below.
Abb. 2: Die 20 höchsten Werte, absteigend angeordnet. Die Zahlen 1- 20 auf der X- Achse repräsentieren die touristischen Gebäude.

The highest lux value (52.2) was measured at the Ice Cream Shop 1 (see Fig. 1 in the Appendix) at the beginning of the promenade. followed by the neighbouring Souvenir Shop (Fig. 2), Focus Travel Agency (Fig. 5), Seaside Travel Agency (Fig. 11) and so on. I put selected photographs in the Appendix to illustrate how much light these selected buildings/enterprises emitted.

Question Nr. 1

<u>Did the light intensity of the buildings or enterprises decrease or increase compared to 2014?</u>

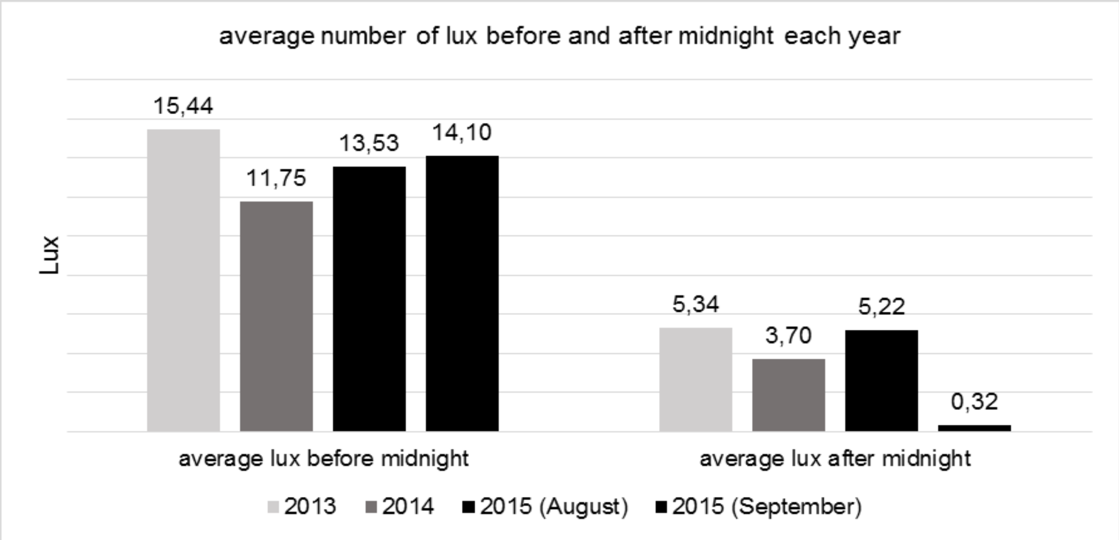

Fig. 3: Average lux-values before and after midnight, measurements on 31 August as well as 5 September 2015 compared to the years 2013 and 2014. Only the data of sections 1-99 were used in this graph.
Abb. 3: Lux- Durchschnittswerte vor und nach Mitternacht, gemessen am 31. August und am 5. September 2015, im Vergleich zu den Jahren 2013 und 2014. Nur die Daten von Sektoren 1 bis 99 wurden verwendet.

Yes, the average lux before midnight increased from 11.75 (in 2014) to 13.53 in August and 14.10 in September (2015). The average lux after midnight increased in August from 3.70 (in 2014) to 5.22, but in September the corresponding values decreased from 3.70 to 0.32. The lux-values before midnight were always higher than after midnight.

Did the number of used lights go up or down compared to 2014?

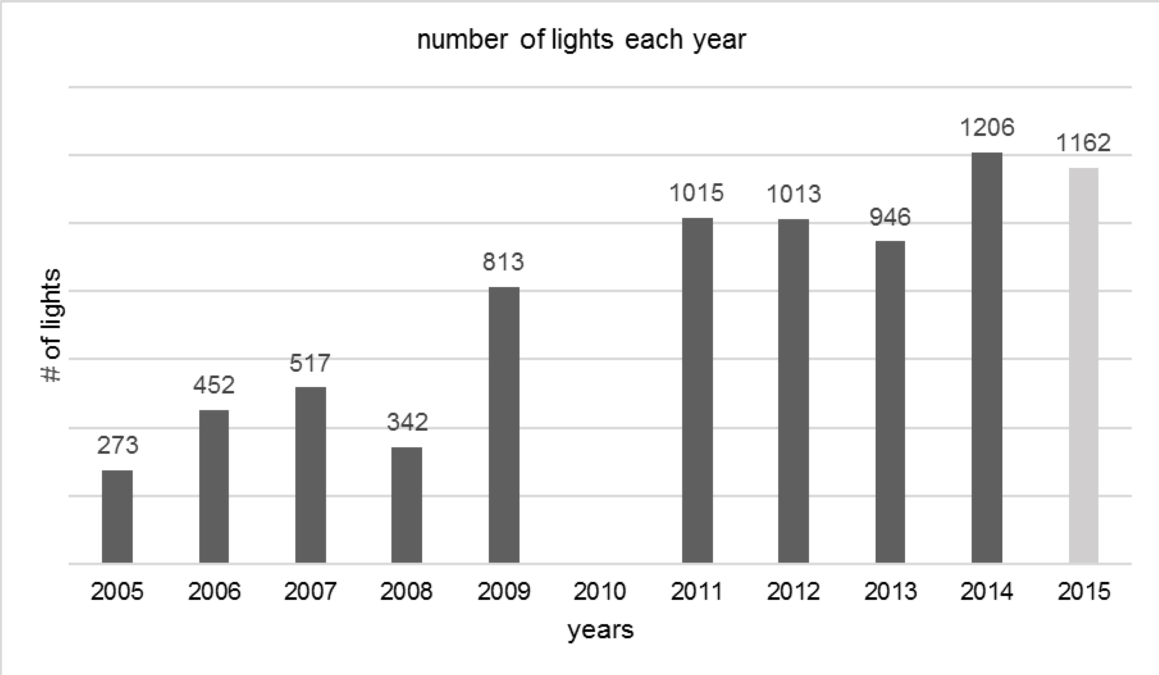

Fig. 4: Number of lights counted from 2005 until 2015. In 2010: no data collected.
Abb. 4: Anzahl der Lichter von den Jahren 2005 bis 2015. 2010: keine Daten ermittelt.

The number of lights this year slightly decreased from 1206 lights in 2014 to 1162, a decrease of 44 lights. As mentioned above, only the lights which were visible from the outside and which were switched on at that day were counted.

Conclusion: The light- intensity at Çalış Beach increased compared to last year, whereas the number of lights decreased (both slightly).

Question Nr. 2:

Is there a correlation between the position female sea turtles choose to lay their eggs and light intensity? The related hypothesis is: The more light- intensive, the closer they lay their eggs to the sea (to avoid too bright light).

Here, I only used the data of the "CY" nests. The background and the reason why I carried out this survey was that female sea turtles, when coming ashore and digging their nests, should prefer darker areas over bright ones. The greater the distance to the sea, the closer they are to the artificial light, if there is any. I therefore tried to determine if the position of the nests correlates with light intensity or, in other words, if the lux values are high, do the females stay closer to the sea to avoid light.

Tab. 3: Lux values at the nest sites, starting from the first nest on the promenade at the Adrian hotel up to the last nest (CY 19) at Sunset Hotel. On the right hand side: distance to the sea where the nests were laid and the corresponding buildings/enterprises. Grey-marked cells: highest lux- values and nests at the Picnic area. Measurements were done on 2 September 2015, divided into "before" and "after" midnight. The lights were firstly measured 10 cm and 130 cm above the nests and then 10 cm above the waterline (at the site of the nests).
Tab. 3: Lux-Werte auf der Höhe der Nester, ab dem ersten Nest auf Höhe des Adrian Hotels bis zum letzten Nest (CY 19) beim Sunset Hotel. Rechts: Distanz zum Meer von den Nestern mit den dazugehörigen Einrichtungen. Grau- markierte Reihen: höchste Werte und die Nester auf der Picknick- Area. Die Messungen wurden am 2. September 2015 gemacht und in „vor Mitternacht" und „nach Mitternacht" eingeteilt. Die Lichter wurden zuerst 10 cm und 130 cm über dem Nest und dann 10 cm über der Wasserlinie gemessen.

CY	**2.9. before midnight**			**2.9. after midnight**				
	10 cm	**130 cm**	**at water**	**10cm**	**130cm**	**at water**	**dist. to sea (m)**	**location**
7	0,6	4,9	2,1	0,4	0,5	0,5	10,5	Hotel Adrian
13	1,9	2,3	1,6	0,5	0,6	0,5	8,3	Beachhouse
8	0,3	2,3	1,5	0,5	0,6	0,5	14,7	Lighthouse
5	8,1	12	2,3	1,1	1,3	0,6	11,2	painter (Austrian)
18	0,2	0,3	1	0,4	0,4	0,4	16,4	Beatles
17	0,4	1,8	0,8	0,4	0,4	0,4	7,56	Mendos
2	0,8	1,1	0,6	0,4	0,4	0,4	10,5	Callisto
3	0,4	0,5	0,4	0,4	0,4	0,4	8,8	Lee's Bar
14	0,4	0,5	0,4	0,4	0,4	0,4	18,3	Hotel Ceren
12	0,6	0,5	0,4	0,4	0,4	0,3	16,1	Letoon
6	0,4	0,5	0,3	0,3	0,3	0,3	21,7	Aroma Beach
9	0,3	0,5	0,3	0,3	0,3	0,3	27,1	Aroma Beach
11	1,6	1,8	0,3	0,2	0,2	0,2	30	Beskaza
1	0,3	0,3	0,3	0,3	0,3	0,2	16,8	Beskaza
16	1,6	1,8	0,8	0,2	0,2	0,2	31	Picknick area
4	1	1	0,8	0,2	0,2	0,2	11,2	Picknick area
15	1	0,9	0,8	0,2	0,2	0,2	20,67	Picknick area
10	1,2	1,3	0,8	0,2	0,2	0,2	8,2	Picknick area
19	0,6	0,6	0,4	0,1	0,1	0,1	23,2	Hotel Sunset

The highest values are at nests CY 5 (8.1 lux at 10 cm and 12 lux at 130 cm) and CY 13 (1.9 at 10 cm and 2.3 at 130 cm). CY 5 showed the highest value: an Austrian painter was located there and his lights directly shone to the nest. The nest CY 19 never hatched, probably because it was incorrectly marked. The lux-values at the waterline are almost all very low. Overall, I could not find any significant correlation here.

Question Nr. 3:

The 3rd question was: Does light intensity (before or after midnight) influence the time of hatching (by)? → Hypothesis: The more light-intensive the site, the later they hatch because the hatchlings avoid (too much) luminance and therefore they need more time to exit the nest).

Tab. 4: Values as in Table 3, but the lux-values are compared to the number of days needed for the 1st hatch (right-hand side). „No data": no natural hatch occurred because we dug into the nest.
Tab. 4: Werte wie Tabelle 3, jedoch wurden die Lux-Werte mit der Anzahl der Tage bis zum ersten Schlupf verglichen (rechte Seite). „No data:" kein natürlicher Schlupf, da wir in das Nest reingruben.

CY	**2.9. before midnight**			**2.9. after midnight**			
	10 cm	**130 cm**	**at water**	**10cm**	**130cm**	**at water**	**# days 1st hatch**
7	0,6	4,9	2,1	0,4	0,5	0,5	47
13	1,9	2,3	1,6	0,5	0,6	0,5	48
8	0,3	2,3	1,5	0,5	0,6	0,5	52
5	8,1	12	2,3	1,1	1,3	0,6	50
18	0,2	0,3	1	0,4	0,4	0,4	63
17	0,4	1,8	0,8	0,4	0,4	0,4	no data
2	0,8	1,1	0,6	0,4	0,4	0,4	59
3	0,4	0,5	0,4	0,4	0,4	0,4	54
14	0,4	0,5	0,4	0,4	0,4	0,4	45
12	0,6	0,5	0,4	0,4	0,4	0,3	no data
6	0,4	0,5	0,3	0,3	0,3	0,3	49
9	0,3	0,5	0,3	0,3	0,3	0,3	48
11	1,6	1,8	0,3	0,2	0,2	0,2	48
1	0,3	0,3	0,3	0,3	0,3	0,2	57
16	1,6	1,8	0,8	0,2	0,2	0,2	49
4	1	1	0,8	0,2	0,2	0,2	56
15	1	0,9	0,8	0,2	0,2	0,2	45
10	1,2	1,3	0,8	0,2	0,2	0,2	no data
19	0,6	0,6	0,4	0,1	0,1	0,1	no hatch

No significant correlation between the lux values (10 cm and 130 cm above the nest) and the number of days until the 1st hatch was found.

Tab. 5: Lux- values and the approximate time when the nests were laid.
Tab. 5: Lux- Werte verglichen mit der ungefähren Zeit der Eiablage.

CY	2.9. before midnight			2.9. after midnight			
	10 cm	**130 cm**	**at water**	**10cm**	**130cm**	**at water**	**time when nest laid**
7	0,6	4,9	2,1	0,4	0,5	0,5	no data
13	1,9	2,3	1,6	0,5	0,6	0,5	after midnight
8	0,3	2,3	1,5	0,5	0,6	0,5	no data
5	8,1	12	2,3	1,1	1,3	0,6	no data
18	0,2	0,3	1	0,4	0,4	0,4	at ca. 5:50am
17	0,4	1,8	0,8	0,4	0,4	0,4	before midnight
2	0,8	1,1	0,6	0,4	0,4	0,4	no data
3	0,4	0,5	0,4	0,4	0,4	0,4	no data
14	0,4	0,5	0,4	0,4	0,4	0,4	no data
12	0,6	0,5	0,4	0,4	0,4	0,3	after midnight
6	0,4	0,5	0,3	0,3	0,3	0,3	no data
9	0,3	0,5	0,3	0,3	0,3	0,3	no data
11	1,6	1,8	0,3	0,2	0,2	0,2	around midnight
1	0,3	0,3	0,3	0,3	0,3	0,2	no data
16	1,6	1,8	0,8	0,2	0,2	0,2	at midnight
4	1	1	0,8	0,2	0,2	0,2	no data
15	1	0,9	0,8	0,2	0,2	0,2	after midnight
10	1,2	1,3	0,8	0,2	0,2	0,2	after midnight
19	0,6	0,6	0,4	0,1	0,1	0,1	after midnight

Here, I wanted to test if female turtles prefer to come ashore before midnight when it is brighter or after midnight when it is dark, more or less. A slight trend can be observed: Most of the nests were laid after midnight (CY 13, CY 12, CY 15, CY 10 and CY 19) except CY 17 (laid before midnight) or around midnight (CY 11 was laid around midnight and CY 16 at midnight). Nonetheless, no correlation could be found between the lux-values and the time when the nests were laid. This result might change if more data had been collected.

In conclusion:

The number of lights decreased compared with 2014, whereas the lux- values increased (both before and after midnight). There is no correlation between the position of the nests and the lux-values, but most of the nests were laid after midnight. There is no correlation between the lux-values and the number of days until the 1st hatch, or between the time when the females came ashore and the lux values.

DISCUSSION

In 2015, in sum 30 nests were laid in Çalış (including the secret nests). Compared to last year, when 39 nests were laid, this is a decrease in the number of nests (9). 12 nests were located along the promenade, 18 nests from Aroma Beach Club on until the Surf Café, which represents the end of our nesting beach zone.

The 1st question was to determine how the light situation has changed compared to last years.

The number of lights decreased from 1206 to 1162 lights (Table 6), a slight decrease.

Note that this number is somewhat subjective because the lights deemed "visible" by the respective observer may not fully correspond from year to year. Moreover, it remains unclear whether small, weak bulbs should be counted as well, as they may only minimally or nor at all affect the turtles' behaviour. This problem is difficult to solve: one approach would be to specify the number of meters back from the promenade in which the lights would be counted (inside and outside of restaurants, bars, etc.), but even this difficult-to-do approach would not include large lamps outside this range but clearly visible from the promenade and beach.

The average lux-values increased before midnight from 11.75 to 13.53 (Table 5) and after midnight from 3.70 to 5.22 (compared with 2014).

Fig. 1 and Fig. 4 show that there is little difference between the lux-values in August before midnight (13.53) and September before midnight (14.10). This means that the light pollution on the promenade remains strong throughout the nesting season. Special attention should be given to the Ice Cream Shop at the beginning of the promenade: Its lux-value of 52.2 is not only the highest, but these lights were not shut down or reduced after midnight.

The average lux-values after midnight were always lower than before midnight, the low value of 0.32 from the measurement on 5 September after midnight can be explained in that it was already towards the end of the touristic high season and so many localities were closed after midnight.

Importantly, lux-values can differ considerably at one and the same site and time: one step away or towards the light source or any change of the angle or the height of the measuring instrument (sensor) changes the lux-value immediately. Also the high light emissions of some buildings influenced their neighbouring buildings. In the future, this would call for very specific guidelines and specifications for the taking the measurements.

The 2nd question was if the emitted light correlates with nest positions:

Tab. 7, showing the lux- values at the site of the nests, reveals no significant correlation. At nest CY 5 I measured the highest lux value because an Austrian painter positioned himself on the wall of the beach rather than on the promenade. His lamps directly illuminated the nest. The distance of the nest from the sea was 11.2 m (total distance between sea and wall: ca. 17 m). Although we do not know the date when the nest was laid, it was probably before this painter arrived. This light pollution therefore threatened the hatchlings rather than the adult female.

The nests on the Picnic area (CY 16, CY 4, CY 15, and CY 10) were distributed randomly, some close to the sea, some far away. CY 6 and CY 9 were further from the sea, possibly because at that area (around Aroma Beach club) there was less light emitted. The same holds true for CY 11: It showed low lux-values but a high distance to the sea. Overall, however, there is no significant correlation between the lux values and the distance to the sea. Successfully determining such a correlation would probably involve a more rigorous methodology including recording the light situation on the night when the females came ashore.

The hypothesis related to this question was: The more light intensive, the closer the female turtles lay their eggs near the sea. This hypothesis can be falsified (at least this year).

The 3rd question was if the emitted light correlates with the time of hatching (before or after midnight, after how many days).

Tab. 8 shows no significant correlation between the emitted light and the time of hatching.

The range is from 45 to 63 days, which is normal. The highest value of 63 days is at nest CY 18.The comparison when the female sea turtles came ashore (“before midnight” versus “after midnight”) showed that they prefer to dig the nests after midnight, when it is darker. The two nests CY 15 and CY 10, both located at the Picnic area hatched after midnight; CY16, also at the Picnic area, hatched at midnight. The hypothesis – The more light-intensive, the later they hatch – can be falsified (at least this year).

The conventions

An important convention for Çalış Beach is the Bern convention

From 28 to 30 July 2015, beaches in Fethiye/Akgöl, including Çalış Beach, were inspected by a delegation concerning litter and pollution on the beach as well as other anthropogenic impacts. According to Casale (2010), Patara and Fethiye are key nesting sites for Mediterranean loggerhead sea- turtles. The report "Presumed Degradation of nesting beaches in Fethiye, Patara, Akgol (Turkey)", Casale 2015, see below, states that Çalış is downgraded from a low level to high level of threats. The most important reasons for that were the reduced area of the beach along the promenade (limited by a wall) and the almost 24/7 presence of humans there. The permanent presence of beds, wooden floors, cars sunbeds and umbrellas is stated as serious habitat degradation. The high light pollution was mentioned too. These are citations from the most important part of the report:

"The nesting habitat (i.e. the beach area features that should allow nesting activity by adult females and incubation of eggs) appears to be degraded from low to high levels depending on the coastal tract. The worst tract is the southern one (Çalış) where a long promenade (with a concrete wall) has permanently limited the width of the beach, which in some tracts is left rather narrow. This limits the choice of the nesting female in terms of nest location and related parameters (e.g. temperature) and makes nests more vulnerable to be inundated during storms…."

"The current level of anthropogenic threats occurring on the beach is very high, with such an impact to be comparable to a habitat degradation. In my opinion, in most of the Çalış tract the activity of nesting females is greatly affected by reduced available area where to nest and by human presence at night. For the intense light pollution and human presence, the natural hatchling recruitment to the sea may be severely affected, and it is probably the main reason why nests must be caged, rather than for predation.…."

Concerning light pollution:

"Light pollution is intensive in several tracts, especially in Çalış. The entire promenade, and as a consequence the beach just a few meters apart, is completely illuminated by several types of lights (street lamps, shops, bars, restaurants). From where nests are, the promenade is extremely bright and the beach is well illuminated. Other lights (streets lamps, bar, discos on the beach) are along the Çalış coast west to the promenade. Altogether, these many and different light sources create an artificial bright horizon that in my opinion represents a high level of light pollution which can disorient the hatchlings…"

Thus, Çalış Beach is very seriously affected by humans and there is still a lot of work to do to reduce the anthropogenic threats and impacts.

In December 2011, Medasset published a report of the NGO "Marine Turtle Conservation in the Mediterranean" about the situation in Çalış Beach after it submitted a complaint in 2009 to the Bern Convention about the severe situation of Çalış. Again, besides all the other problems of pollution, the severe light pollution was mentioned too (Medasset, 2011).

Quick and easy improvements:

First of all, the restaurants and bars should close around midnight. If they remain open, the owners should at least reduce the lights to a minimum. Tourism and the economy would not suffer, and it would reduce one major source of disturbance for the turtles.
Sunbeds, umbrellas and carpets should be stacked at the wall or even behind it, where the promenade begins. No one needs a sunbed or an umbrella at night.
More signs should be installed because many people are apparently unaware of the turtles' situation.
White lights should be exchanged to yellow, red or even darker lights. The street lamps on the promenade provide sufficient light for the people.
Food stalls, for example Haslama Misir should be located on the promenade, not on the wall and shade the light bulbs. They did not even partly cover the white light bulbs they used. The same counts for the Austrian painter, whose lights directly shone to the nest (CY 5).
Lights shining on the beach such as street lamps can be easily reduced if they are painted black on the side facing the beach. In Çalış Beach at least most of the street lamps were already partially tinted in this manner.
Fig. 6 in the Appendix shows the light situation of the restaurant "Hamsi Bar". This is a positive example of how this problem can be tackled. They used different coloured lights (no white light), and hid them behind branches. The lux value was very low here and there was still enough light for the tourists.
Another positive example is Manas Otel Park and Lounge (Fig. 10): They used orange dimmed light, still enough for the tourists and again less problematic for the turtles.

Fig. 1 shows the Ice Cream Shop at the beginning of the promenade, emitting 52.2 lux and not shutting it down after midnight. This is unnecessary and unacceptable: When I took some photographs the seller became nervous and switched off some lights (but only briefly).

Fig. 8 shows the second Ice Cream Shop, also emitting excessive light (31.95 lux). One possible, simple solution would be to hang the lights a bit higher so that they are blocked from the beach by the branches. The seller at this shop apologized when I talked to him and promised for next year that he would hang his lights differently (→ "to be continued", please keep an eye out for this shop).

Both of the travel agencies – Focus Travel Agency and Seaside Agency – also used excessive, especially white light (Fig. 5 and 9). The Seaside Travel Agency could shut down at least one light: 4 lights are too much (Fig. 9).

Technical improvements: (Witherington & Martin, 2003)

Usage of opaque curtains, roofing, and facades: These would at least shield some lights from the beach.

Usage of red or orange light: it is just in a very small part of the turtles' visible range, but for humans it would be enough (for an example see Fig. 10).

Usage of focused lights, shining only in the direction of the promenade (Fig. 17)

Usage of low-pressure sodium vapour lighting (Fig. 18): this yellow light would not affect the sea turtles' behaviour and additionally does not use much energy. It is also better for our eyes and can be sold as "romantic".

Usage of ground-mounted floodlighting, but only if it is directed away from the beach and towards the promenade (Fig. 22 above).

Usage of sign lighting from top to down: Just if the light is covered on the side shining to the beach this lighting works well.

Usage of ceiling-recessed down lighting with baffles to eliminate lateral light. This would be a very good solution as the lateral, disturbing light could be minimized. Additionally it is not very expensive (Fig. 19 above)

Usage of louvered step lighting: This lights could be installed at the wall to the beach, so the light would not reach the beach but solely the promenade (Fig. 21 above)

Usage of wall-mounted down lighting: This would be the best solution especially for balconies visible from the sea.

For parking lots: fully hooded floodlights, which can light accurately and directively (Fig. 20).

Natural improvements

Let vegetation grow at the wall. Hatchlings avoid silhouettes/shadows, so if there was something dark behind them they would more likely crawl towards the sea.
Do not change the beach slope: The beach slope should be kept as it is, as turtles use it for orientation.

For the future:

When we worked at our information booth, we realized that most people did not know much about sea turtles, some of them did not even know that they nest in Çalış Beach. In order to spread more information, we could prepare presentations about sea turtles, conservation and the situation in Çalış for hotels. Since I realized that especially families showed a high interest in this field, we could focus on hotels with a lot of families.

ACKNOWLEDGEMENTS

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APPENDIX

Fig. 1: Ice Cream Shop at the beginning of the promenade, with the highest lux- value (52.2).

Abb.1: Der Eisverkäufer am Beginn der Promenade mit dem höchsten Lux- Wert (52.2).

Fig. 2:...and the neighbouring Souvenir Shop.

Abb. 2: .. und der benachbarte Souvenir Shop.

Fig. 3: Beach House. A restaurant and club, not closing after midnight.

Abb. 3: Beach House, ein Restaurant und ein Club, nach Mitternacht nicht geschlossen.

Fig. 4: Our exemplary information booth: one shaded lightbulb only.

Abb. 4: Unser exemplarischer Infostand mir nur einer beschatteten Lichtquelle.

Fig. 3: The focus travel agency Focus Tours uses excessive white light bulbs, and additionally lighted signs.

Abb. 5: Die Focus Travel Agency. Benutzt werden intensive weiße Lichtquellen und dazu

Fig. 4: the Hamsi Bar. A low lux value, no white lights (the white ones on the picture are TV- screens) and all the lights were shaded. Good job!

Abb. 6: Die Hamsi Bar. Niedriger Lux- Wert, keine weißen Lichter (das Weiße welches man hier sehen kann sind Fernsehbildschirme) und alle Lichter waren abgeschattet. Gut gemacht!

Fig. 5: A house at the end of the promenade. No opaque curtains are used here.

Abb. 7: Ein Haus gegen Ende der Promenade. Keine blickundurchlässigen Vorhänge wurden benutzt.

Fig. 6: another Ice Cream Shop, emitting excessive light. Using 4 bulbs, none of which were shaded (for example by the branches).

Abb. 8: Ein weiterer Eisverkäufer welcher zuviel Licht emittiert. Benutzt wurden 4 Glühbirnen, keine davon war abgeschattet (z.B. durch die Äste).

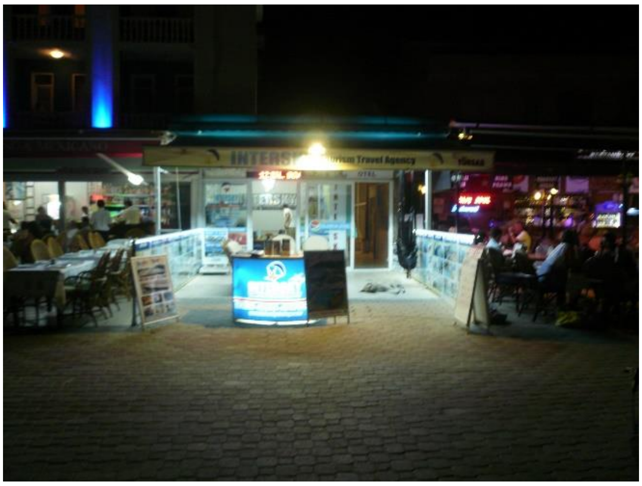

Fig. 7: the Intersky Travel Agency. Excessive and unnecessary light.

Abb. 9: Die Intersky Travel Agency. Viel intensives und unnötiges Licht.

Fig. 8: The Manas Park Otel and Lounge. The yellow lights considerably decreased the lux- value.

Abb. 10: Manas Park Hotel und Lounge. Die gelben Lichter senken eindeutig den Lux-Wert.

Fig. 9: the Seaside Travel Agency. They used downwardly directed lights, which is a step in the right direction.

Abb. 11: Seaside Travel Agency. Benutzt wurden nach unten gerichtete Lichter. Ist zumindest ein Schritt in die richtige Richtung.

Fig. 10: Calis Taxi, open day and night. The neon lights emit a lot of light, and this configuration could be improved.

Abb.12: Calis Taxi, Tag und Nacht geöffnet. Die Neonlichter emittieren sehr viel Licht. Diese Lichtkonfiguration könnte verbessert werden.

Fig. 11: Tattoo Selim
Abb. 13: Tattoo Selim

Fig. 12: one of the signs at the picnic area.
Abb. 14: Eines der Schilder am Anfang der Picknick- Area.
Photo: S. Wagner

Fig. 13: One of the Haslama Misir's. The two bare bulbs, emitting white light, are the poorest option.
Abb. 15: Einer der Haslama Misir’s. Die 2 unbedeckten weißen Lichter sind die schlechteste Option.

Fig. 14: The Aroma Beach Club at the end of the promenade. The blue lights are thought to influence sea turtles less.

Abb. 16: Aroma Beach Club am Ende der Promenade. Die blauen Lichter sollen die Schildkröten weniger beeinflussen.

Fig. 17: focussed light.

Abb. 17: Fokussiertes Licht
http://www.beachsidelighting.com/directionals/l-011.html

Fig. 18: low pressure sodium vapor light.

Abb. 18: Sodium Vapor Licht

www.daviddarling.info

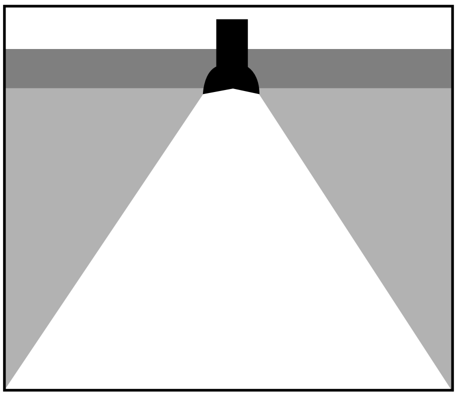

Fig. 19: ceiling recessed down lighting with baffles.

Abb. 19: An der Decke nach unten gerichtetes Licht mit Seitenabschirmung. (Reference = Witherington & Martin, 2003)

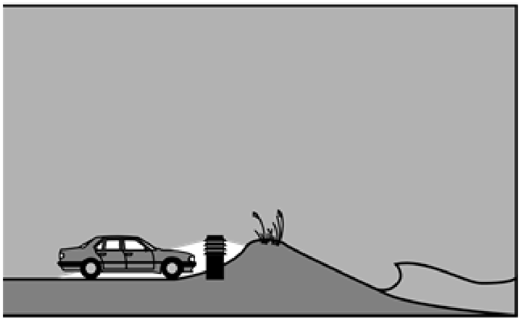

Fig. 20: hooded floods for parking cars

Abb. 20: Abgeschirmte Flutlichter für parkende Autos.

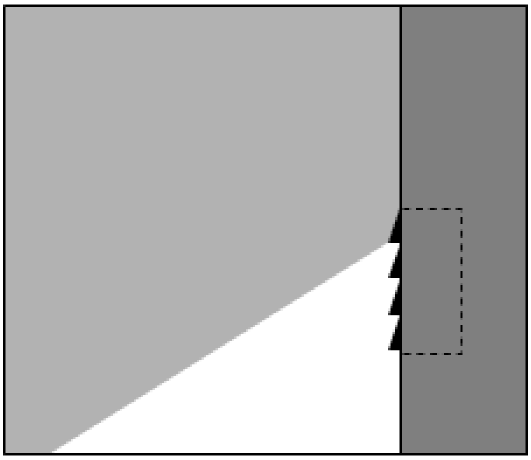

Fig. 21: louvered step lighting.

Abb. 21: Vergittertes Schrittlicht.

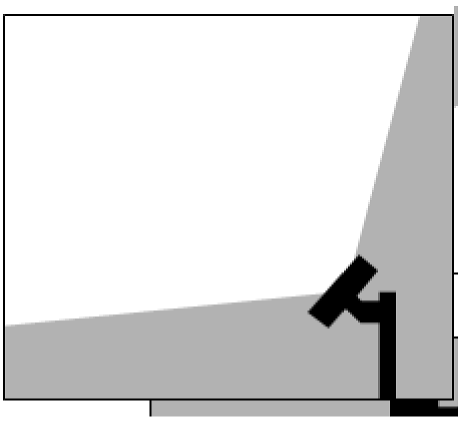

Fig. 22: ground mounted floodlighting

Abb.22: Am Boden montiertes Flutlicht.

Bachelor Thesis

BEACH LITTER UNDER PARASOLS ALONG CALIŞ BEACH, FETHIYE, TURKEY

STRANDVERSCHMUTZUNG UNTER SONNENSCHIRMEN ENTLANG DES STRANDS VON CALIŞ, FETHIYE, TURKEY

Jasmin Helnwein

Aspired academic title

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KURZFASSUNG

Meeresverschmutzung zählt heutzutage zu den größten Umweltproblemen weltweit. Meistens gelangt Müll über den Strand durch biologische und anthropogene Einwirkung in die Meere. Auch in Caliş, Fethiye, ist Strandverschmutzung ein wichtiges Thema. In dieser Studie wurde unter zehn Sonnenschirmen an vier Tagen Müll gesammelt, in Kategorien eingeteilt, gezählt und gewogen, um ein aktuelles Bild über die Verschmutzung zu erhalten. Außerdem hatten fünf der zehn Schirme einen kleinen Mistkübel befestigt. Damit wurde getestet, ob sich unter den Schirmen mit Mistkübeln mehr Müll befindet, als unter solchen Schirmen, die keine haben. Die Ergebnisse zeigen, dass es einen Unterschied zwischen den Schirmen an der Menge, aber nicht im Gewicht gab. Es wurden insgesamt 2568 Stück Müll mit einem Gewicht von 1031 g gefunden. Dies entspricht 40 Stücke/m². Die häufigsten Bestandteile des gefundenen Mülls waren Restmüll, Biomüll und Plastik. Unter Restmüll fiel jener Müll der in den anderen Kategorien nicht zu geordnet werden konnte, z.B. Zigaretten oder Styropor. Mit 90% waren Zigarettenstummeln der häufigste vorkommende Restmüll. Es gibt verschiedene Möglichkeiten, um die Probleme der Müllverschmutzung einzugrenzen. Eines wäre regelmäßige Strandsäuberungsaktionen, aber auch z.B. im Rahmen des International Coastal Cleanup Day. In Caliş werden am Strand verschiedene Arten von Mistkübeln aufgestellt, aber zum Teil sind sie zu klein, schadhaft oder werden nicht regelmäßig geleert. Eine gute Lösung wäre, den Bewohner und Lokal-/Hotelbetreiber die Probleme von Umweltverschmutzung deutlicher zu machen und ihnen Möglichkeiten zu zeigen, wie man dagegen vorgehen kann, wie z.B. richtiges recyceln.

ABSTRACT

Marine pollution is one of the biggest environmental problems worldwide. In most cases wastes reach the sea over the beach through biological and anthropological processes. Beach litter is also an important issue in Caliş, Fethiye. In this study, waste was collected under ten parasols over four days, categorized in waste components, counted and weighd for a snapshot view of beach litter. Five of the ten parasols had a small waste basket. Accordingly, I also tested if there was more waste under parasols without versus with waste baskets. The results revealed a difference between the two types of parasols in waste quantity, but not in weight. I collected 2568 waste items with a weight of 1031 g. This corresponds to 40 items/m². The most frequent items of the collected waste were residual waste, organic waste and plastic. Cigarette butts made up 90% of residual waste. There are various methods to reduce marine pollution, for example regular beach cleanups but also in the framework of the International

Coastal Cleanup Day. Along Caliş beach, different types of waste baskets are installed, but sometimes they are too small, broken or not emptied frequently enough. One solution could be to better communicate the problems of environmental pollution to residents and operators of hotels and bars and to show possibilities how they can reduce waste, for example by recycling.

INTRODUCTION

Marine pollution is defined as an "direct or indirect anthropogenic introduction of substances or energy into the oceans (or estuaries), resulting in a negative effect, such as the endangerment of human health, the obstruction of economic use of the oceans (i.e. fisheries) and the reduction in water quality or recreational value" by the IOC (Intergovernmental Oceanographic Commission). Every year around 7 million tons of marine litter of anthropological origin reaches the oceans, making this a major economic and environmental problem worldwide (Valavanidis & Vlachogianni 2011). Marine litter is a serious pollution problem in rivers, lakes, seas and coastlines. Because of ocean dumping, wind-blown solid waste and container spillage, debris particles can be ingested by marine organisms such as marine reptiles and mammals, seabirds and fish and may increase the probability of death by different injuries (Tomás et al. 2002). Nearly 80% of the marine debris is plastic items. Plastic can accumulate in the sea and is has a slow biodegradability. The can also transfer toxic substance to marine habitats and can constitute a threat to the health, productivity and biodiversity of the marine environment (Valavanidis & Vlachogianni 2011). Plastic waste and cigarette butts are the most common forms of waste. Studies found that different toxins such as arsenic, nicotine or heavy metals were released into the environment by thrown-away cigarette butts. In every form, smoked cigarette butts with tobacco, smoked cigarette filters and unsmoked cigarette filters (both without tobacco), are toxic to marine organism (Slaughter et al. 2011). For example a concentration of 0.125 cigarette butts per liter is lethal for *Daphnia* (Register 2000). Sea turtles, in our case the loggerhead sea turtle (*Caretta caretta*), are effected by litter, not just in the sea in the adult stage: hatchlings on their way to sea are also highly threatened by garbage at the beach (Triessnig et al. 2012). Especially *Caretta caretta* ingest more debris than other sea turtles because of their habitats and feeding behavior (Tómas et al. 2002). Marine debris can kill loggerhead sea turtles directly (entanglement), but also indirectly: it can displace food in the gut, affecting the nutrient gain and thus growth or reproduction (Tómas et al. 2002).

In the last few decades, Caliş beach in Fethiye has become a popular touristic area, and numerous hotels, bars or other locations have been built along the beach. Accordingly, the number of inhabitants and tourists has increased over time. This has also meant an increase in waste. In Caliş many residents and tourists sit in the evening under parasols on the beach. They meet friends, drink, eat or just chill. Many do not properly dispose of their garbage but, instead, leave it on the beach. To avoid beach litter, some beach areas or parasols have waste baskets. Their effect has never been quantified, but many are too small or broken. So it is possible that this waste reaches the sea and becomes marine litter/debris through wind or human activity.

MATERIAL AND METHODS

For this project, beach litter waste was collected under ten umbrellas. Five umbrellas had cans as a waste baskets, the other five did not had such baskets. These umbrellas were located to the left and right of the Caliş Taxi stand along the promenade in Caliş. On the right side (viewed from the promenade) there were parasols without waste baskets, on the left side parasols with waste baskets. The first parasols on both sides were the first parasols examined for the experiment. Then, every fifth subsequent parasol was examined in both directions (Fig. 1).

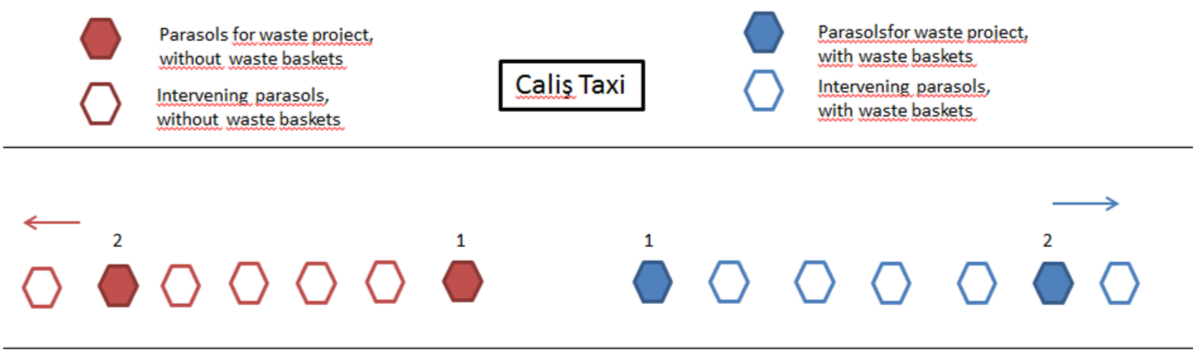

Fig. 1: The selected umbrellas. The red ones are without waste buckets, the blue ones with waste buckets. The waste was collected under and around the full-colored umbrellas, and every fifth one was taken.
Abb. 1: Die ausgewählten Schirme. Die roten sind ohne Mistkübel, die blauen mit. Der Müll wurde unter und um den ausgemalten Schirmen gesammelt, dafür wurde jeder fünfte Schirm genommen.

The collected area around and under the parasols was 4x4 m (=16 m²). A line was drawn in the sand to demarcate this area. Every beach litter item inside the square was collected and put into a bag for later analysis at the camp. Waste outside the line was ignored. The sunbeds were pulled outside of the area to simplify collection. Waste on the sunbeds was not collected. At the parasols with waste baskets, the baskets were checked for their content. I classified the waste in the bucket into three categories: empty till few (1), half-full (2), full (3). The collected litter was placed into separately marked bags (e.g. LoK (Liege ohne Kübel) was for parasols without buckets, LmK (Liege mit Kübel) for parasols with waste baskets). Accordingly; LmK 5 means parasol with waste basket number five, i.e. the last one in the series. I conducted the experiments on four days (14.8, 20.8, 26.8 & 30.8) around 5:30-6:30 am. The same ten parasols were always examined. In the camp the beach litter was classified into different waste categories (Tab. 1). Cigarettes butts were placed in the residual waste category, but were counted and weigh separately. For every category the waste was counted and weigh (PSM 150 scale ± 0.1 g by DIPSE) for every parasol. The number and weight of the different waste types were summed up for total weight and amount. The results were entered in Excel. Graphs were created for a time curve and comparison between parasols with waste baskets and parasols without waste baskets. Table 4 & 5 shows the amount and weight of the different waste types and cigarettes.

Tab. 1: Waste categories with collected examples.
Tab. 1: Müllkategorien mit Beispielen

waste categories	examples
residual waste	cigarette butts, Styrofoam, everything else
plastic	bottles, bottle tops, packaging, plastic utensils...
paper	newspaper, cards…
organic waste	stones in fruits, St. john's-bread (carob), mussels, fruit waste, sunflower seeds…
metal	crown caps, cans, aluminum foil…
glass	shards
wood & cork	Popsicle sticks, bottle corks…

RESULTS

After the experiment the waste was counted and weighed and the results were entered in an Excel table (Tab. 4 & 5). From these data the total quantity and weight for all four days together and for each single day were initially calculated. Residual waste was always one of the top beach litter categories in Caliş; of these nearly 90% are cigarette butts. Also organic waste was abundant on the beach. Plastic has, proportional to the total quantity, the highest total weight (Tab. 2 & 3). The total quantity increased, and day four was the strongest day, but the total weight was decreased. Here the strongest day was day one (Fig. 2). Using these data the quantity and weight per m² was calculated. This yielded 4 items/m² and 2 g/m² on average under parasols.

Tab. 2: Total quantity [qty] and weight [g] of waste categories for each day. Cigarettes are part of residual waste.
Tab. 2: Gesamtmenge [qty] und Gewicht [g] von jeder Müll-Kategorie für jeden einzelnen Tag. Zigaretten sind Teil des Restmülls.

	Day 1 14.08.2015		**Day 2 20.08.2015**		**Day 3 26.08.2015**		**Day 4 30.08.2015**	
	quantity [qty]	weight [g]	quantity [qty]	weight [g]	quantity [qty]	weight [g]	quantity [qty]	weight [g]
residual waste	356	120.7	262	75.7	278	80.1	210	54.5
cigarettes	337	103.6	245	70.6	253	68.5	198	52.6)
plastic	47	236.4	29	37	43	20.1	30	28
paper	34	38.7	31	9.5	25	4.8	19	3.4
organic waste	145	47.3	254	43.6	279	84.6	478	43
metal	10	25.7	3	26.3	12	20.5	8	7.8
glass	2	2.1	1	4.4	1	0.8	0	0
wood & cork	0	0	7	11.9	2	2.3	2	2.4

Tab. 3: Total quantity [qty] and weight [g] of the waste categories (sum for all four days). Cigarettes are part of residual waste.
Tab. 3: Gesamtmenge [qty] und Gewicht [g] der Müll-Kategorien für alle vier Tage zusammen. Zigaretten sind Teil des Restmülls.

	total	
categories	**quantity [qty]**	**weight [g]**
residual waste	1106	331
cigarettes	1033	295.3
plastic	149	321.5
paper	109	56.4
organic waste	1156	218.5
metal	33	80.3
glass	4	7.3
wood & cork	11	16.6

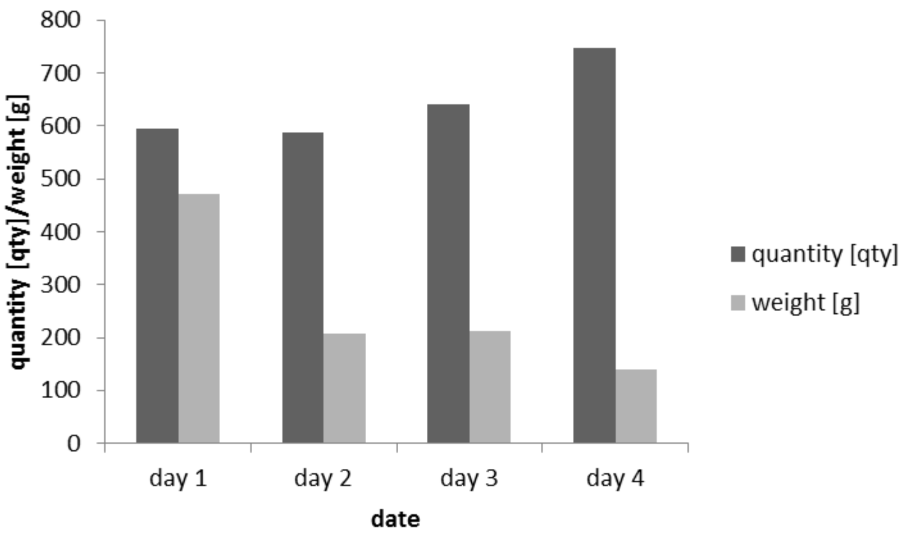

Fig. 2: Total quantity [qty] and weight [g] of beach litter of four days (day 1=14.08.2015, day 2=20.08.2015, day 3=26.08.2015, day 4=30.08.2015)
Abb. 2: Gesamtmenge und Gewicht des Mülls an vier Tagen (Tag 1-14.08.2015, Tag 2-20.08.2015, Tag 3-26.08.2015, Tag 4-30.06.2015)

The comparison of parasols with and without waste baskets showed no clear difference in overall numbers and weights, but the different waste categories did differ. The quantity of waste under parasols with waste baskets was higher in the categories residual waste such as cigarettes, and organic waste. Under parasols without baskets, plastic and paper were somewhat more abundant. Based on weight, the results for residual waste and cigarettes were similar as for quantity. More residual waste items showed a heavier weight. Interestingly, the plastic and organic waste was heavier under parasols with waste baskets. Plastic showed the biggest difference between parasols with and without baskets. Metal, glass, wood and cork were found in low quantities and weight (Fig. 3 & 4). Based on the low values for these categories it is not possible to determine a difference between parasols with waste baskets and parasols without. Nonetheless, a Mann-Whitney-U-Test was done for total quantity and total weight of all four days. The results were for quantity $z = -2.015$ and weight $z = -1.420$, with $\alpha = 5\%$ and an interval [-1.96; +1.96]. This means that there is a significant difference in quantity between parasols with waste baskets and without waste baskets, because $z = -2.015$ is not in the interval [-1.96; + 1.96]. There is a greater quantity of beach litter under parasols without baskets, because the median of LoK is 69 and LmK is 41.5. For weight $z = -1.420$ is in the interval [-1.96; +1.96] and there is no significant difference in weight between parasols with waste baskets or without.

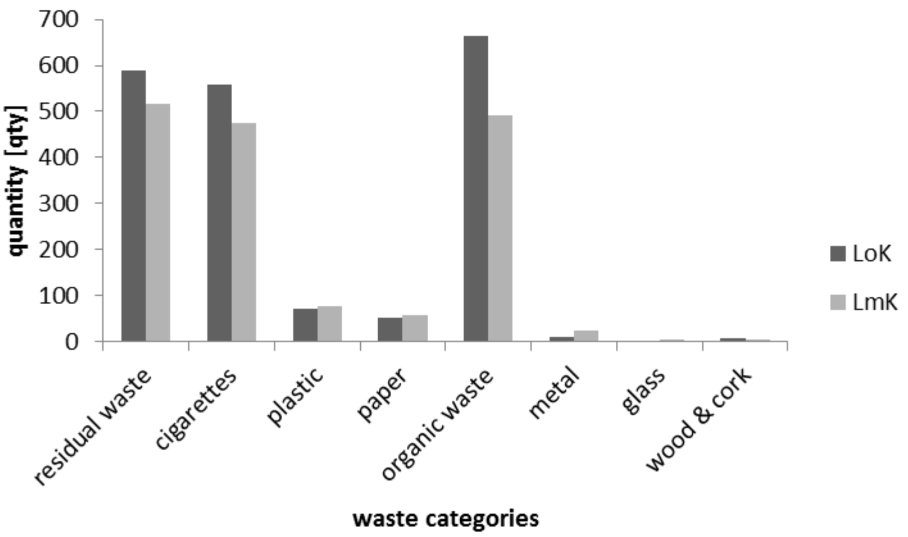

Fig. 3: Parasols with (LmK) and without (LoK) waste baskets: quantity categorized in different waste categories.
Abb. 3: Vergleich der Müllmenge von Sonnenschirmen mit (LmK) und ohne (LmK) Mistkübel unterteilt in die verschiedenen Müllkategorien.

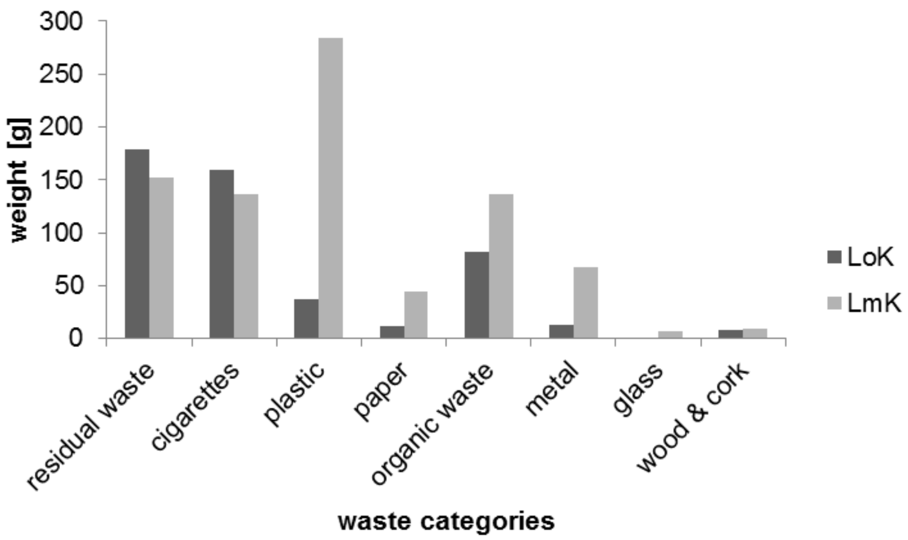

Fig. 4: Parasols with (LmK) and without (LoK) waste baskets: weight based on the different waste categories.
Abb. 4: Vergleich der Müllgewichts von Sonnenschirmen mit (LmK) und ohne (LmK) Mistkübel unterteilt in die verschiedenen Müllkategorien.

For a correlation between beach litter around a parasol and the fill of the waste basket, I quantified the amount of waste into fill categories. The median of the quantity showed a increase with the fill of the waste basket. If the waste basket was full, there was a higher amount of litter around the parasol. But the average value showed that at half-full waste baskets the most litter was on the beach itself (Tab. 4).

Tab. 4: Quantity [qty] of waste classified in fill categories of waste baskets (1= empty-few, 2=half-full, 3=full), average and median.
Tab. 4: Anzahl [qty] des Mülls eingeteilt in Füll-Kategorien der Mistkübeln (1= leer-wenig, 2= halb voll, 3= voll), Mittelwert und Median.

	fill categories		
	1	**2**	**3**
	96	39	84
	65	149	72
quantity	35	44	13
[qty]	39	44	63
	36	47	
	39	32	
	33	24	
	20	209	
Average	45	74	58
Median	38	44	68

DISCUSSION

Many people typically mean more garbage. In Caliş beach, a popular touristic area, waste was collected under parasols with waste baskets and without waste baskets to determine if waste baskets are a solution against waste and could improve the overall litter situation along the beach. Beach litter components vary in different studies and regions, but the most abundant components are plastic, cigarette butts and organic waste (Ariza et al. 2008). These abundance results were also confirmed in this study (Tab. 2 & 3). On each of the four days, an average of 642 pieces of waste and 257.9 g were found per day. That is around 4 items/m² and 2 g/m². This is a high number of items, but the weight is not heavy beacuse in most cases the items were small and light. On other beaches there are lower densities: Japan 3.41 items/m² (Kusui & Noda 2003), Panama 3.6 items/m² (Garrity & Levings 1993), Mexico 1.5 items/m² (Silva-Iñiguez & Fischer 2003) or Gulf of Oman 0.44 to 6.01 items/m² (Claereboudt 2004). The higher density in Caliş beach probably reflects that fact that the waste was collected directly under and around parasols. For example at day 4, 478 pieces of organic waste were collected, but that category weighed just 43 g. This is equivalent to only 0.1 g per piece (Tab. 5). This is because most of the organic waste were small sunflower seeds (but in high amounts). This is a popular snack in Turkey. One explanation for this is that at day 1 the waste of many days or even weeks was under the parasols. At day 2, however there was just waste of six days (the gap between the first and second sampling). Between day 3 and day 4 this time gap was only four days. Note, however, that most large and easily visible items were removed by beach cleaning personnel every day. This can clearly bias the actual amounts and types I collected in the present study. Accordingly, the amounts I collected probably reflect a single day/night accumulation more than several days of accumulation between my experiments, at least for larger items. Smaller items, in turn, are more likely to reflect accumulations over time. Why the time curve of total quantity increased is unclear. Maybe the trash was lighter despite the high amount (Fig. 2).

Among beach litter, mostly plastic and nets are dangerous for sea turtles. For hatchlings it is nearly impossible to escape from cups, canisters or nets, because crawling backwards are not typical motor pattern (Triessnig et al. 2012). Those that cannot reach the sea become exhausted and die. On the beach area where beach litter was collected for this study, such waste types were not found. I did find plastic bottles or cans, but they were too small for hatchlings to enter inside (Tab.1, 4 & 5). Because Caliş beach is a touristic beach, the beach was cleaned every morning or in the night by cleaning stuff. Examining other beach areas like the picnic area revealed more waste such as many plastic bags full of garbage, plastic bottles, organic waste, etc. (Fig. 5 & 6). Ultimately, however, almost every type and size of waste can reach the sea and be ingested by (or entangle) marine organisms like adult sea turtles, in our case *Caretta caretta*. Because of photochemical, mechanical and biological processes, marine debris is ultimately broken down into smaller sizes, which has increasing effects in food webs and the ecosystem (Reisser et al. 2013). Through several processes, toxins can be released and delivered into organisms by ingestion or endocytosis (Reisser et al. 2013). If marine debris, specifically microplastic, is ingested by small organism, like zooplankton, it can be transferred into the food web and affect the health of the food web, ultimately even humans (Reisser et al. 2013). With the occurrence of more beach litter and waste debris, the occurrence of debris ingestion by turtles is also increasing. Some studies showed that sea turtles, especially the loggerhead, demonstrate resistance against debris ingestion and it does not affect them lethally (Tomás et al. 2002). A recent review, however, points out that lethal ingestion is probably a widespread occurrence (Nelms et al. 2015). Dietary dilution, a sub-lethal effect of debris ingestion, affects sea turtles in the long-term (Tomás et al. 2002). In this study, cigarette butts were clearly the biggest component in residual waste, nearly 90% (Tab. 2, 3, 4 & 5). Cigarette butts are the most common type of litter worldwide and 4.5 trillion cigarette butts are thrown away yearly all over the world (Slaughter et al. 2011). They amount to around 38% of all roadside garbage (Register 2002). Cigarettes contain more than 400 chemicals and over 50 of them are known to be carcinogenic to humans, including pesticides, herbicides, fungicides or insecticides (Slaughter et al. 2011). Nicotine is one of the most powerful insecticides and the deadliest plant product in pure form (Register 2002). It is highly soluble in waster and can be absorbed through skin in its pure form (Register 2002). Cigarette filters absorb these chemicals and can be easily leached out by water (Register 2002); nicotine, arsenic and heavy metals can be released into the environment by thrown-away cigarette butts (Slaughter et al. 2011). To determine how toxic cigarette butts are, some studies tested the LC 50 (lethal concentration that kills 50% of a sample population) of *Daphnia magna* (Register 2002) and freshwater and marine fish (Slaughter et al. 2011). In the freshwater environment a concentration of 0.125 cigarette butts per 1l water is lethal to *Daphnia* (Register 2002). From smoked cigarette butts (filter + tobacco) the LC 50 is 1 butt/l for freshwater and marine fish.

There are different methods to combat the big problem of beach and marine litter. The Ocean Conservancy organizes the international cleanup day every year. In 2014, 560 000 volunteers collected 16 000 000 pounds trash along 13 000 miles of coastlines. The top ten of items collected is similar to the most often found components at Caliş beach: 1. Cigarette butts, 2. Food wrappers, 3. Beverage bottles (Ocean Conservancy; 2015). In May 2015 a patent about a beach device by R. Thompson was published. It is designed to remove seaweed and beach litter in a sea turtle friendly way, by pulling of “S” shaped tines across the surface in a non-invasive manner which does not damage turtle nests (Thompson 2015). But a negative effect is that this construction has to be pulled by tractor or similar vehicle. Such heavy vehicles must drive over the beach, which compacts sand over the turtle nests and the eggs (Fig. 7).

At Caliş beach, waste baskets are variously placed along the beach or under parasols, like in this study, to reduce beach litter. In comparison between parasols with and parasols without waste baskets, there was a significant difference in the amount of the waste, but no difference in its weight (Fig. 3 & 4). One problem is that the waste baskets are small cans and they are full when a single bottle is placed inside (Fig. 12). One can was half filled with stones. This makes it difficult to say if those small waste baskets really help to reduce beach litter. Comparing the average of amount of waste in the waste basket with the waste under parasols, it is not possible to determine that there is more or less beach litter at a full or empty waste basket, but if you compare the median of amount of waste, there is more waste under parasols when waste baskets are full (Tab. 4). At other beach areas and in front of beach bars there are different types of waste baskets. They are made of plastic or clay, but are often broken, fallen over or not emptied (Fig. 8-11). One solution for waste problems is to have many waste baskets or an appropriate size. A second, parallel strategy would be to educate the residents and tourists. They have to recognize how to collect and recycle and how waste can damage the ocean, the whole environment and their health.

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APPENDIX

Table 5: Collected waste under umbrellas 1-5 with and without waste baskets (LmK & LoK) on day 1 (14.08) and day 2(20.08), categorized in waste types, quantity [qty] and weight [g]. Cigaretts are part of residual waste.
Tabelle 5: Gesammelter Müll unter den Schirmen 1-5 mit und ohne Mistkübel (LmK & LoK) an Tag 1 (14.08) und Tag 2 (20.08), eingeteilt in Müllarten, Menge [qty] und Gewicht [g]. Zigaretten sind Teil des Restmülls

day1 14.08.2015	**categories**	**quantity [qty]**	**weight [g]**	**day2 20.08.2015**	**categories**	**quantity [qty]**	**weight [g]**
LoK 1				**LoK 1**			
	residual waste	59	20.5		residual waste	39	11.5
	cigarettes	56	15.3		cigarettes	37	11
	plastic	4	2.3		plastic	3	1.1
	paper	3	0.6		paper	4	1.4
	organic waste	38	2.4		organic waste	63	7.4
	metal	0	0		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	1	3
LoK 2				**LoK 2**			
	residual waste	35	10.3		residual waste	25	8
	cigarettes	34	9.9		cigarettes	24	7.8
	plastic	5	1		plastic	1	0.5
	paper	3	0.5		paper	6	0.4
	organic waste	9	8.3		organic waste	4	0.5
	metal	0	0		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LoK 3				**LoK 3**			
	residual waste	24	7.6		residual waste	24	9.1
	cigarettes	23	7.5		cigarettes	29	8.5
	plastic	0	0		plastic	5	2.2
	paper	1	0,3		paper	2	1.1
	organic waste	13	1.5		organic waste	36	3.8
	metal	0	0		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LoK 4				**LoK 4**			
	residual waste	37	12.9		residual waste	16	5.6
	cigarettes	31	9.9		cigarettes	14	4.3
	plastic	2	1.7		plastic	1	0
	paper	2	1.4		paper	4	2.3
	organic waste	8	0.9		organic waste	16	0.8

Table 5: Collected waste under umbrellas 1-5 with and without waste baskets (LmK & LoK) on day 1 (14.08) and day 2(20.08), categorized in waste types, quantity [qty] and weight [g]. Cigaretts are part of residual waste.
Tabelle 5: Gesammelter Müll unter den Schirmen 1-5 mit und ohne Mistkübel (LmK & LoK) an Tag 1 (14.08) und Tag 2 (20.08), eingeteilt in Müllarten, Menge [qty] und Gewicht [g]. Zigaretten sind Teil des Restmülls

day1 14.08.2015	**categories**	**quantity [qty]**	**weight [g]**	**day2 20.08.2015**	**categories**	**quantity [qty]**	**weight [g]**
	metal	1	1.4		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	2	1.3
LoK 5				**LoK 5**			
	residual waste	28	8.6		residual waste	15	4.1
	cigarettes	28	8.6		cigarettes	13	4
	plastic	0	0		plastic	1	6.9
	paper	5	0.5		paper	0	0
	organic waste	31	9.6		organic waste	34	2.4
	metal	0	0		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LmK 1				**LmK 1**			
	residual waste	26	7.9		residual waste	45	10.5
	cigarettes	25	7.8		cigarettes	43	10.3
	plastic	6	2.9		plastic	5	17.2
	paper	5	4.9		paper	8	3
	organic waste	2	12.9		organic waste	90	19.6
	metal	0	0		metal	0	0
	glass	0	0		glass	1	4.4
	wood & cork	0	0		wood & cork	0	0
LmK 2				**LmK 2**			
	residual waste	61	19.3		residual waste	22	6.9
	cigarettes	58	17.5		cigarettes	20	6.6
	plastic	2	1.7		plastic	0	0
	paper	2	0.4		paper	2	0.3
	organic waste	0	0		organic waste	5	7.9
	metal	0	0		metal	2	0.6
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	4	7.6
LmK 3				**LmK 3**			
	residual waste	35	15.5		residual waste	28	8.8
	cigarettes	34	11		cigarettes	27	8.4
	plastic	7	53.1		plastic	5	4.8
	paper	5	26.8		paper	0	0

Table 5: Collected waste under umbrellas 1-5 with and without waste baskets (LmK & LoK) on day 1 (14.08) and day 2(20.08), categorized in waste types, quantity [qty] and weight [g]. Cigaretts are part of residual waste.
Tabelle 5: Gesammelter Müll unter den Schirmen 1-5 mit und ohne Mistkübel (LmK & LoK) an Tag 1 (14.08) und Tag 2 (20.08), eingeteilt in Müllarten, Menge [qty] und Gewicht [g]. Zigaretten sind Teil des Restmülls

day1 14.08.2015	**categories**	**quantity [qty]**	**weight [g]**	**day2 20.08.2015**	**categories**	**quantity [qty]**	**weight [g]**
	organic waste	20	2.5		organic waste	3	0.7
	metal	5	17.3		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LmK 4				**LmK 4**			
	residual waste	28	10.3		residual waste	24	5.1
	cigarettes	28	10.3		cigarettes	17	3.8
	plastic	11	58.2		plastic	4	2.9
	paper	5	1.2		paper	3	1
	organic waste	1	2.9		organic waste	1	0.3
	metal	2	2.7		metal	1	25.7
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LmK 5				**LmK 5**			
	residual waste	23	7.8		residual waste	24	6.1
	cigarettes	20	5.8		cigarettes	21	5.9
	plastic	10	115.5		plastic	4	1.4
	paper	3	2.1		paper	2	0
	organic waste	23	6.3		organic waste	2	0.2
	metal	2	4.3		metal	0	0
	glass	2	2.1		glass	0	0
	wood & cork	0	0		wood & cork	0	0

Table 6: Collected waste under umbrellas 1-5 with and without waste baskets (LmK & LoK) on day 3 (26.08) and day 4 (30.08), categorized in waste types, quantity [qty] and weight [g]. Cigarettes are part of residual waste.

Tabelle 6: Gesammelter Müll unter den Schirmen 1-5 mit und ohne Mistkübel (LmK & LoK) an Tag 3 (26.08) und Tag 4 (30.08), eingeteilt in Müllarten, Menge [qty] und Gewicht [g]. Zigaretten sind Teil des Restmülls

day3 26.08.2015	**categories**	**quantity [qty]**	**weight [g]**	**day4 30.08.2015**	**categories**	**quantity [qty]**	**weight [g]**
LoK 1				**LoK 1**			
	residual waste	27	10.1		residual waste	31	8.4
	cigarettes	24	6.2		cigarettes	30	8
	plastic	13	3.8		plastic	4	7.7
	paper	1	0		paper	4	0.4
	organic waste	62	5.8		organic waste	36	2.4
	metal	1	1.3		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	2	2.3		wood & cork	0	0
LoK 2				**LoK 2**			
	residual waste	18	5.3		residual waste	17	4.5
	cigarettes	18	5.3		cigarettes	13	3.3
	plastic	5	3.8		plastic	8	2.8
	paper	0	0		paper	1	1.3
	organic waste	9	0.3		organic waste	44	1.5
	metal	1	3.2		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	1	1.3
LoK 3				**LoK 3**			
	residual waste	45	13.3		residual waste	48	13.4
	cigarettes	43	12.9		cigarettes	47	13.4
	plastic	6	2.2		plastic	6	0.7
	paper	4	0		paper	1	0
	organic waste	52	4.1		organic waste	53	3.4
	metal	4	5.8		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LoK 4				**LoK 4**			
	residual waste	32	8.1		residual waste	15	3.8
	cigarettes	31	7.9		cigarettes	14	3.8
	plastic	2	0.2		plastic	2	0.4
	paper	3	0.2		paper	5	0.9
	organic waste	48	7.1		organic waste	9	0.2
	metal	0	0		metal	2	0.6
	glass	0	0		glass	0	0

Table 6: Collected waste under umbrellas 1-5 with and without waste baskets (LmK & LoK) on day 3 (26.08) and day 4 (30.08), categorized in waste types, quantity [qty] and weight [g]. Cigarettes are part of residual waste.

Tabelle 6: Gesammelter Müll unter den Schirmen 1-5 mit und ohne Mistkübel (LmK & LoK) an Tag 3 (26.08) und Tag 4 (30.08), eingeteilt in Müllarten, Menge [qty] und Gewicht [g]. Zigaretten sind Teil des Restmülls

day3 26.08.2015	**categories**	**quantity [qty]**	**weight [g]**	**day4 30.08.2015**	**categories**	**quantity [qty]**	**weight [g]**
	wood & cork	0	0		wood & cork	0	0
LoK 5				**LoK 5**			
	residual waste	31	7.7		residual waste	23	5.5
	cigarettes	27	6.5		cigarettes	22	5.3
	plastic	1	0		plastic	2	0
	paper	1	0.2		paper	2	0.1
	organic waste	41	15.3		organic waste	58	4
	metal	1	0.6		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LmK 1				**LmK 1**			
	residual waste	45	12.7		residual waste	20	5.1
	cigarettes	39	10.2		cigarettes	19	5.1
	plastic	7	6.1		plastic	1	14.2
	paper	9	2.5		paper	4	0.4
	organic waste	35	3.9		organic waste	57	4.2
	metal	0	0		metal	1	1.3
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	1	1.1
LmK 2				**LmK 2**			
	residual waste	30	11		residual waste	22	5.7
	cigarettes	29	9.7		cigarettes	21	5.7
	plastic	2	1.4		plastic	3	13
	paper	2	0.5		paper	0	0
	organic waste	10	44.3		organic waste	11	5.8
	metal	0	0		metal	3	3.8
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LmK 3				**LmK 3**			
	residual waste	27	5.3		residual waste	19	4.4
	cigarettes	22	5		cigarettes	18	4.3
	plastic	2	0.2		plastic	1	0
	paper	4	1.3		paper	0	0
	organic waste	10	2.2		organic waste	9	15

Table 6: Collected waste under umbrellas 1-5 with and without waste baskets (LmK & LoK) on day 3 (26.08) and day 4 (30.08), categorized in waste types, quantity [qty] and weight [g]. Cigarettes are part of residual waste.
Tabelle 6: Gesammelter Müll unter den Schirmen 1-5 mit und ohne Mistkübel (LmK & LoK) an Tag 3 (26.08) und Tag 4 (30.08), eingeteilt in Müllarten, Menge [qty] und Gewicht [g]. Zigaretten sind Teil des Restmülls

day3 26.08.2015	**categories**	**quantity [qty]**	**weight [g]**	**day4 30.08.2015**	**categories**	**quantity [qty]**	**weight [g]**
	metal	3	6		metal	1	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LmK 4				**LmK 4**			
	residual waste	15	3		residual waste	10	2.5
	cigarettes	13	2.6		cigarettes	10	2.5
	plastic	2	1.2		plastic	1	0.9
	paper	0	0		paper	1	0.2
	organic waste	0	0		organic waste	0	0
	metal	2	3.6		metal	1	2.1
	glass	1	0.8		glass	0	0
	wood & cork	0	0		wood & cork	0	0
LmK 5				**LmK 5**			
	residual waste	8	3.6		residual waste	5	1.2
	cigarettes	7	2.2		cigarettes	4	1.2
	plastic	3	1.2		plastic	2	0
	paper	1	0.1		paper	1	0.1
	organic waste	12	1.6		organic waste	201	6.5
	metal	0	0		metal	0	0
	glass	0	0		glass	0	0
	wood & cork	0	0		wood & cork	0	0

Figure 5: Beach litter (plastic bags), often blown into vegetation, near Sport Café (Photo: S. Wagner)
Abbildung 5: Strandverschmutzung (Plastikbeutel) in der Nähe des Sport Café (Foto: S. Wagner)

Figure 6: Beach litter, mostly glass bottles, cigarette butts and plastic bags, at the picnic area (Photo: K. Schmölz)
Abbildung 6: Strandverschmutzung in Form von Glasflaschen, Zigarettenstummels und Plastikbeutel bei der Picknick Area (Foto: K. Schmölz)

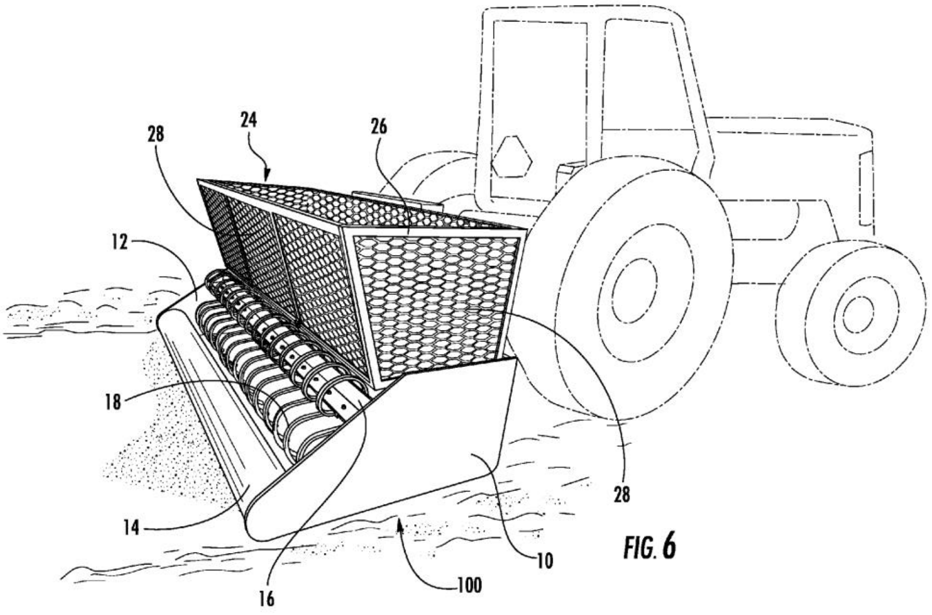

Figure 7: Sea turtle friendly beach cleaning device (from: R. Thompson)
Abbildung 7: Meeresschildkröten freundlicher Strandreinigungsapparat (R. Thompson)

Figure 8: Small waste basket made of clay on a table between two sunbeds (Photo: K. Schmölz)
Abbildung 8: Mistkübel aus Ton auf einen Tisch zwischen zwei Sonnenliegen (Foto: K. Schmölz)

Figure 9: Plastic waste basket on a different beach area (Photo: K. Schmölz)
Abbildung 9: Plastikmistkübel an einen anderen Strandabschnitt (Foto: K. Schmölz)

Figure 10: Fallen over full waste basket made of clay with plastic bottles and a full plastic bag (Photo: K. Schmölz)
Abbildung 10: Umgefallener voller Mistkübel aus Ton mit Plastikflaschen und einem vollen Plastikbeutel (Foto: K. Schmölz)

Figure 11: Empty waste baskets made of clay along a beach area with sunbeds in front of a major hotel complex (Photo: K. Schmölz)
Abbildung 11: Leerer Tonmistkübel entlang eines Strandabschnitts mit Sonnenliegen vor einem großen Hotelkomplex (Foto: K. Schmölz)

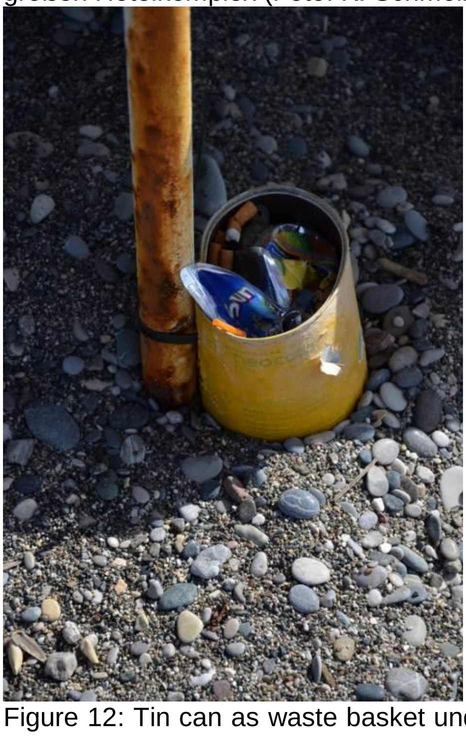

Figure 12: Tin can as waste basket under the tested parasols. It is full with plastic and cigarette butts (Photo: K. Schmölz)
Abbildung 12: Dose als Mistkübel unter den getesteten Sonnenschirmen. Er ist voll mit Plastik und Zigarettenstummeln (Foto: K. Schmölz)

Bachelor Thesis

Dead late embryos of *Caretta caretta* on the nesting beaches of Yaniklar and Akgöl in Fethiye, Turkey, 2004-2014

Spätes Embryonensterben von *Caretta caretta* auf den Niststränden von Yaniklar und Akgöl in Fethiye, Türkei, 2004-2014

Thomas Schobesberger

Aspired academic title
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ABSTRACT

The purpose of the present study was to determine the levels of loggerhead sea turtle late embryonic mortality from 2004 to 2014 in Yaniklar and Akgöl, Fethiye, Turkey. Three to five days after the last hatch of a nest, an excavation was performed. Overall, 54,586 eggs were deposited in 710 examined nests, and 37,968 eggs (69.6%) hatched successfully. Fertilized eggs were classified into three groups: early, middle and late embryonic stages. The highest number of dead late embryos (n = 493) was found in 2008 and the lowest (n = 117) in 2004. In 2008 the mean number of dead late embryos per nest was 7.6 and thus the highest in the entire 11 years. The lowest number of dead late embryos per nest was found in 2005 (3.4). The number of dead late embryos per nest ranged from 0 to 70, with a mean of 0.1 to 31.3 per nest. In 2008 dead embryos (40.1%) as well as the dead late embryos (9%) was highest. The lowest percentage of dead embryos was in 2010 (7.7%) and the lowest percentage of dead late embryos (4.4%) was in 2005. Embryonic mortality was higher at early (11.3%, n = 6272) than at late (5.9%, n = 3314) and middle (1.2%, n = 634) stages. Furthermore, the data analysis shows that the total number of dead early embryos and the dead early ratio fluctuated in 2- year steps.

ZUSAMMENFASSUNG

Das Ziel der vorliegenden Studie war den Anteil der späten embryonalen Sterblichkeit der Unechten Karettschildkröte von 2004-2014 in Yaniklar und Akgöl, Fethiye, Türkei zu bestimmen. Drei bis fünf Tage nach dem letzten Schlupf eines Nestes wurde die Excavtion durchgeführt. Insgesamt wurden 54586 Eier in 710 Nestern untersucht, davon schlüpften 37968 (69,6%) Junge erfolgreich. Befruchtete Eier wurden in drei Gruppen eingeteilt: frühe, mittlere und späte embryonale Entwicklungsstadien. Die höchste Zahl der toten späten Embryonenstadien (n = 493) wurde im Jahr 2008 festgestellt und die niedrigste (n = 117) im Jahr 2004. Im Jahr 2008 war die durchschnittliche Anzahl der toten späten Embryonenstadien pro Nest 7,6 und damit die höchste in den gesamten 11 Jahren. Die niedrigste Zahl ist im Jahr 2005 (3,4) gefunden worden. Der Minimum und Maximum Bereich erstreckte sich von 0 bis 70 tote späte Embryonenstadien pro Nest, mit einem Mittelwert von 0,1 bis 31,3 pro Nest. Im Jahr 2008 war sowohl der Anteil der toten Embryonenstadien (40,1%) als auch der Anteil der toten späten Embryonenstadien (9%) am höchsten. Der höchste Prozentsatz an toten Embryonenstadien war im Jahr 2010 (7,7%) und der niedrigste Prozentsatz an toten späten Embryonenstadien war (4,4%) im Jahr 2005. Die embryonale Sterblichkeit war in den frühen

Stadien (11,3%; n = 6272) höher als in den späten (5,9%; n = 3314) und den mittleren (1,2%; n = 634) Stadien. Darüber hinaus zeigt die Datenanalyse, dass die Gesamtzahl der toten frühen Embryonenstadien und die relative Anzahl der toten frühen Embryonenstadien in Schritten von jeweils 2 Jahren schwankten.

INTRODUCTION

The loggerhead turtle is the most common sea turtle species in the Mediterranean Sea (Broderick et al., 2002). According to IUCN Red list categories, *Caretta caretta* is classified as endangered (Broderick & Godley 1996).

Almost all nests laid by *Caretta caretta* occur in the eastern basin, especially in Greece, Libya, Cyprus and Turkey (Canbolat 2004). The average annual number of loggerhead nests in the Mediterranian Sea is 5,031, of which 1,366 nests (27.2 %) per season are laid in Turkey (Margaritoulis et al. 2003). Thus, the Turkish coastline is the third most important nesting area for *Caretta caretta* after Greece and Libya in the entire Mediterranean area (Canbolat 2004). Recently a total of 22 important nesting sites in Turkey were listed. In Fethiye (one of these major nesting sites) a monitoring program - a cooperation between the University of Vienna and different Turkish partner universities - was initiated in 1994. Key data about nests, hatchlings and encountered adult females of *Caretta caretta*, as well as about anthropogenic disturbances were collected. Fethiye Beach has a relatively high proportion of male-producing nests (35%-40% of the hatchlings were males during the period 2000-2002) than other Turkish beaches (Dalyan, Patara and Kızılot) and therefore represents one of the main beaches in Turkey (Kaska et al. 2006). In 1988 Fethiye Beach was designated a Special Protection Area (SPA) (Özdemir 2008).

Only female sea turtles leave the sea to lay their eggs on the beach (Bolten et al. 1998). In the Mediterranean Sea, female loggerhead turtles prefer sandy beaches, such as those of Yaniklar and Akgöl in Fethiye (Miller et al. 2003). In Turkey the average number of eggs per clutch is 93 eggs, with a range from 23-134 eggs (Geldiay et al. 1982). Incubation requires approximately 2 months, during which time the sea turtle embryo grows from a few cells to a fully formed organism capable of independent existence (Ackerman 1997). Since 1985 (Miller 1985) it is accepted that there are 31 stages of embryological development for *Caretta caretta*. According to Özdemir et al. (2008) the embryonic period is a critical period in the life of sea turtles because they are exposed to a range of biotic and abiotic factors. Nest site factors can affect embryonic development and mortality, especially gas exchange, salinity, temperature, humidity or water potential, rainfall and tidal inundation (Ackerman 1997).

The purpose of the present study was to determine the levels of loggerhead sea turtle late embryonic mortality from 2004 to 2014 in Yaniklar and Akgöl, Fethiye.

MATERIAL AND METHODS

In the nesting periods 2004 to 2014, nest excavations were carried out during the morning shifts. Morning shifts started at around 5:30 and consisted of at least 2-3 persons, who walked along the beach in a parallel line, one walking along the waterline, one in the middle of the beach and the third close to the vegetation. All the nests were controlled for hatchling tracks, especially when the approximate hatching date approached (after 40 days). Hatchling tracks were counted and followed, checking if the tracks reached the sea or whether the hatchlings were lost, caught in driftwood or debris, or were predated. Sometimes so-called secret nests were found during the morning shifts; this refers to nests that were made before the beaches were monitored and therefore were not yet recorded. Secret nests were noticed by the appearance of hatchling tracks on the beach. In this case the tracks were counted and followed back to their origin.

All data, including a triangulation, a sketch of the nest, and the number of the secret nest, were noted on a standardized data sheet. Three to five days after the last hatch of a nest, an excavation was performed. The nests were carefully dug up until the first egg shells were encountered and then the first measurement (depth to top eggs, Fig. 9) was taken. Then the content of the egg chamber was removed. Dead hatchlings, dead hatchlings stuck in eggs, empty shells and still closed eggs were sorted and counted. Still living hatchlings were released immediately or taken back to the camp.

Furthermore, the closed eggs were opened and differentiated in unfertilized eggs, fertilized eggs and undefinable eggs. Unfertilized eggs (Fig. 11) were determined by the missing blastoderm and/or missing blood cells. Fertilized eggs were classified into three groups: early, middle and late embryonic stages. Early embryonic stages (Fig. 1) are those with blastoderms and/or small, unpigmented embryos (<1 cm), middle embryonic stages (Fig. 2) are those with embryos having already pigmented eyes but unpigmented carapace and extremities (1-2 cm), and late embryonic stages (Fig. 3) are those with fully pigmented but not hatched hatchlings (>2 cm). An egg that could not be assigned to a particular stage was counted as an undefinable egg. Finally, all previously excavated materials were put back into the nest (Fig. 15, 16) and covered with sand. All data were entered into standardized paper data sheets and processed with Microsoft Excel.

Fig. 1: Early embryonic stage with blastoderm
Fig. 1: Frühes embryonales Stadium mit Keimscheibe (Photo: T. Schobesberger)

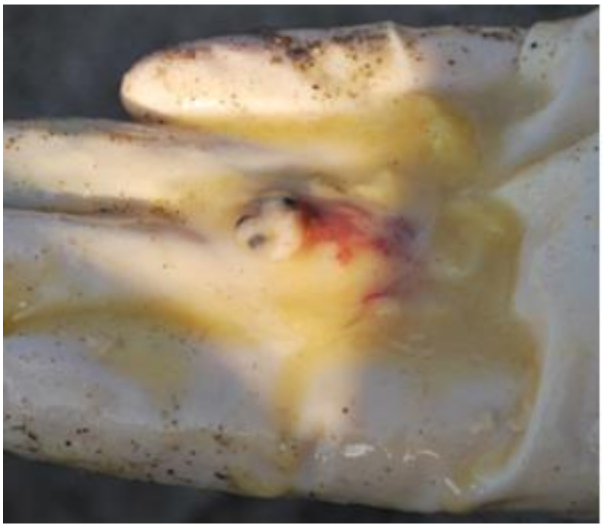

Fig. 2: Middle embryonic stage (twins)
Fig. 2: Mittleres embryonales Stadium (twins) (Photo: T. Schobesberger)

Fig. 3: Late embryonic stage
Fig. 3: Spätes embryonales Stadium
(Photo: T. Schobesberger)

RESULTS

A total of 54,586 eggs were deposited in 710 examined nests, whereby 37,968 eggs (69.6%) hatched successfully. 1,669 eggs (3.1%) were predated (e. g. dogs, jackals) and the 10,594 unhatched eggs were opened to determine the stage of embryonic development. Of these eggs, 374 eggs (0.8%) were classified as undefinable embryos and 10,220 (19.2%) contained dead embryos. Embryonic mortality was higher at early (11.3%, n = 6272) - than at late (5.9%, n = 3314) stages. The lowest percentage (1.2%, n = 634) of dead embryos were at the middle stage. The summarized data (Tab. 2, 3, 4, 5) of all excavations at Yaniklar and Akgöl between 2004 and 2014 are included in the Appendix. The total number of dead late embryos is shown in Tab 1. The highest number of dead late embryos (n = 493) was found in 2008 and the lowest (n = 117) in 2004. In 2008 the mean number of dead late embryos per nest was 7.6 and thus the highest in the entire 11 years. The lowest number was recorded in 2005 (3.4).

Tab. 1: Total number of dead late embryos of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl, Fethiye, between 2004 and 2014.
Tab. 1: Gesamtanzahl der toten späten Embryonen der Unechten Karettschildkröte (*Caretta caretta*) in Yaniklar und Akgöl, Fethiye zwischen 2004 und 2014.

Year	N	Mean/Nest	(min-max)	± SD
2004	117	4.0	(0-15)	4.3
2005	247	3.4	(0-14)	3.6
2006	236	4.8	(0-27)	3.2
2007	418	5.8	(0-23)	5.7
2008	493	7.6	(0-42)	8.8
2009	319	4.4	(1-30)	5.0
2010	287	4.0	(0-35)	7.4
2011	173	3.9	(0-38)	7.4
2012	411	5.5	(0-70)	12.0
2013	382	6.1	*	*
2014	231	3.9	(0-19)	4.6
Total	3314			
Mean	301.3	4.9	(0.1-31.3)	5.6

*no data

The minimum and maximum ranged from 0 to 70 dead late embryos per nest, with a mean of 0.1 - 31.3 (Tab. 1). Figure 4 shows the total number of dead embryos compared to the total number of dead late embryos. In 2008 the total number of dead embryos (n = 2197) as well as the total number of dead late embryos (n = 493) was highest. In 2011 the total number of dead embryos (n = 314) and the total number of dead late embryos (n = 117) in 2004 was the lowest.

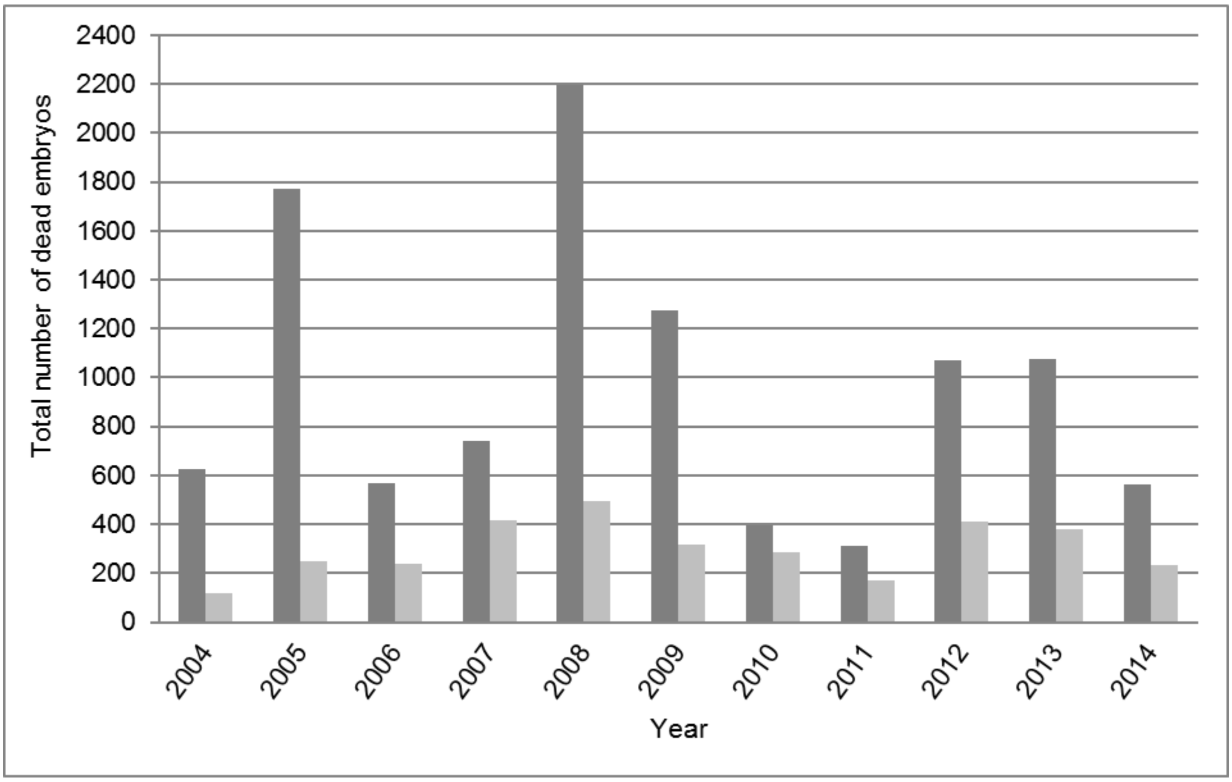

Fig. 4: Total number of dead embryos (dark grey) and total number of dead late embryos (light grey) of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl, Fethiye between 2004 and 2014.
Abb. 4: Gesamtanzahl der toten Embryonen (dunkelgrau) und Gesamtanzahl der toten späten Embryonenstadien (hellgrau) der Unechten Karettschildkröte (*Caretta caretta*) in Yaniklar und Akgöl, Fethiye zwischen 2004 und 20014.

Figure 5 shows the total dead embryo ratio compared to the dead late embryo ratio. In 2008 the percentage of dead embryos (40.1%) as well as the percentage of dead late embryos (9%) was highest. The lowest percentage of dead embryos was in 2010 (7.7%) and the lowest percentage of dead late embryos (4.4%) was in 2005.

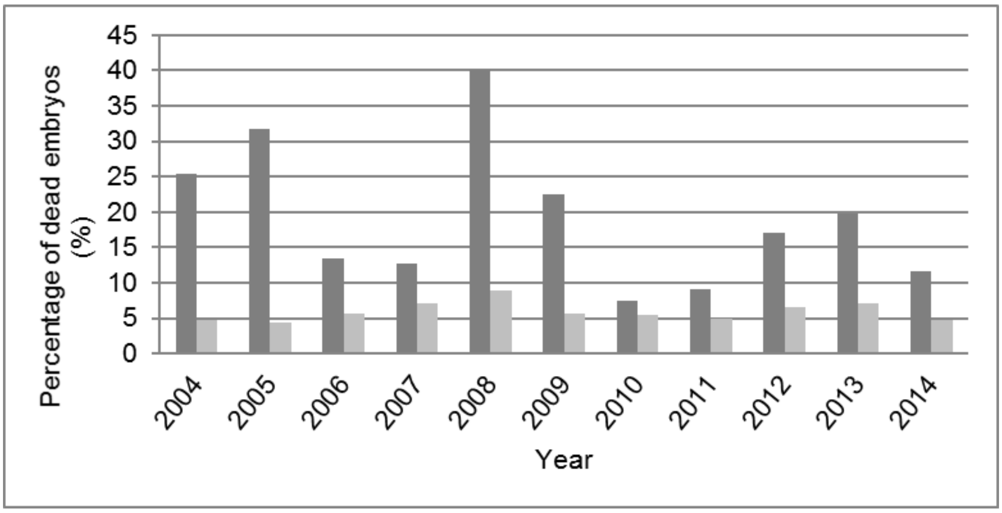

Fig. 5: Percentage of dead embryos (dark grey) and dead late embryos (light grey) of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl, Fethiye between 2004 and 2014.
Abb. 5: Anteil der toten Embryonen (dunkelgrau) und Anteil der späten toten Embryonenstadien (hellgrau) der Unechten Karettschildkröte (*Caretta caretta*) in Yaniklar und Akgöl, Fethiye zwischen 2004 und 2014.

For better illustration the percentage of dead embryos is shown separately in Figure 6.

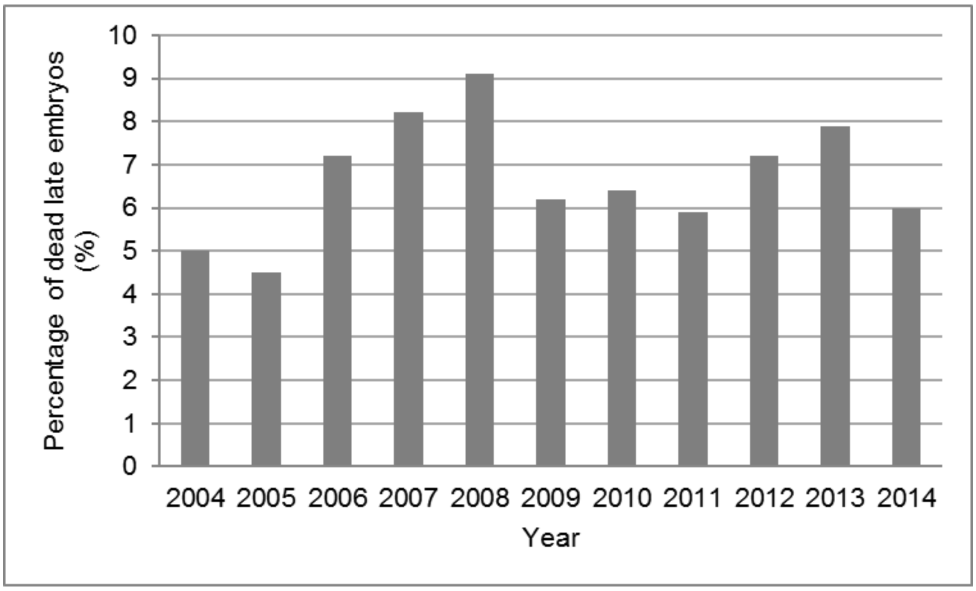

Fig. 6: Percentage of dead late embryos of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl, Fethiye between 2004 and 2014.
Abb. 6: Anteil der späten toten Embryonenstadien der Unechten Karettschildkröte (*Caretta caretta*) in Yaniklar und Akgöl, Fethiye zwischen 2004 und 2014.

DISCUSSION

This study shows that the total number of dead embryos as well as the total number of dead late embryos (Fig. 4, Tab. 2) in Yaniklar and Akgöl between 2004 and 2014 fluctuated considerably. 2004 and 2005 must be evaluated separately: they had a significant number of undefinable embryos (Tab. 2, 3), pointing to unknown but potentially higher absolute and the relative numbers of dead embryos and dead late embryos. In all years the size of the embryos was used as a classification criterion. The distinction between intra-oviducal death and early embryonic death (before the formation of blood isles) within eggs that have been in the nest chamber for 60 or more days is difficult (Miller 1997). The size of the embryos can be a hint for classifying the fertilized eggs but is not the crucial criterion (Jopp & Adrion 2014).

The percentage of embryos that hatched in Yaniklar and Akgöl (69.6%) in the period 2004-2014 is almost the same as in the period 1984-2002 in the Bay of Laganas, Zakynthos island, Greece (66.6%) (Margaritoulis 2005). Also the relative numbers of dead middle (1.2%) and dead late (5.9%) embryos are almost the same as in the period 2004-2005 at Fethiye (middle = 1.2%, late = 5.8%) (Özdemir 2007). Thus, it is likely that embryo size, as an additional criterion, does not distort the overall data of the middle and late embryonic stages. Many studies point out that anthropogenic disturbances have a high impact on embryo development. For example, Casale and Margaritoulis (2010) argue that the global temperature increase could be a determining factor because higher incubation temperatures are likely to increase the level of embryo/hatchling mortality. The heavy metal contaminants in eggshells, yolk and embryonic livers of loggerhead turtles from Turkey have also already been investigated as potential disturbance factors (Kaska & Furness 2001).

It would, of course, be interesting for future studies on the mortality of embryos to use all 31 stages of embryological development for *Caretta caretta* (Miller 1985) to determine more precisely which stages are most affected. This, however, would be associated with a high financial cost because a laboratory and the corresponding equipment would be needed. Furthermore, it would be interesting to determine whether there is a correlation between embryonic mortality and the position of the eggs in the nest.

The data analysis shows that the total number of dead early embryos (Fig. 7) and the dead early levels (Fig. 8) fluctuating in 2-year steps. It would be interesting to further investigate the validity of this type of pattern in the future.

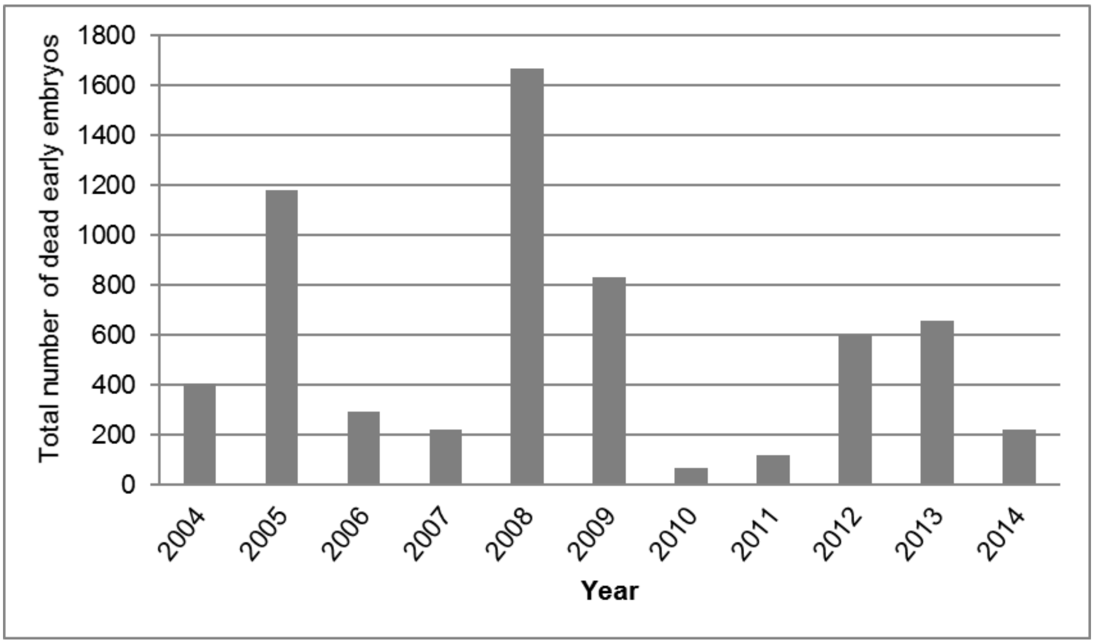

Fig. 7: Total number of dead early embryos of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl, Fethiye between 2004 and 2014.
Abb. 7: Gesamtanzahl der toten frühen Embryonenstadien der Unechten Karettschildkröte (*Caretta caretta*) in Yaniklar und Akgöl, Fethiye zwischen 2004 und 20014.

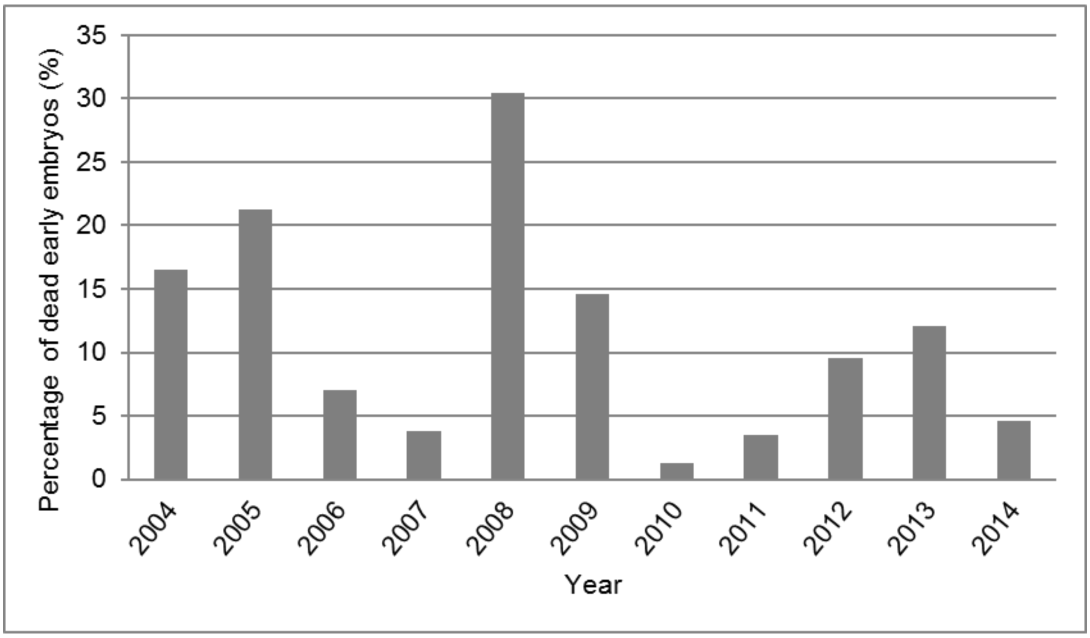

Fig. 8: Percentage of dead early embryos of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl, Fethiye between 2004 and 2014.
Abb. 8: Anteil der frühen toten Embryonenstadien der Unechten Karettschildkröte (*Caretta caretta*) in Yaniklar und Akgöl, Fethiye zwischen 2004 und 2014.

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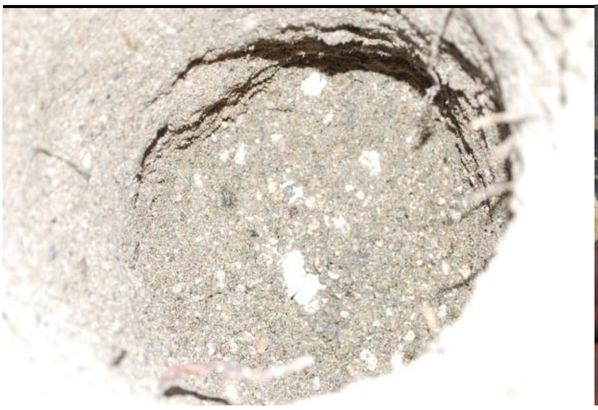

Fig. 9: Egg chamber.
Abb. 9: Eikammer.
(Photo: T. Schobesberger)

Fig. 10: On the left side closed eggs and on the right side opened egg shells during the excavation
Abb. 10: Auf der linken Seite geschlossene Eier und auf der rechten Seite geöffnete Eischalen während einer Excavation.
(Photo: T. Schobesberger)

Fig. 11: Unfertilized egg.
Abb.11: Unbefruchtetes Ei .
(Photo: T. Schobesberger)

Fig. 12: Late embryonic stage.
Abb. 12: Spätes embryonales Stadium.
(Photo: T. Schobesberger)

Fig.13: Fungi-infested embryo (late embryo).
Abb.13: Von Pilz befallener Embyro (spätes Entwicklungsstadium)
(Photo: T. Schobesberger)

Fig.14: Embryo infested by dipteran larvae.
Abb.14: Von Dipteren-Larven befallener Schlüpfling.
(Photo: T. Schobesberger)

Fig. 15: Late embryos and empty egg shells after excavation.
Abb. 15: Spätes embryonales Stadium und leere Eischalen nach einer Excavation.
(Photo: T. Schobesberger)

Fig. 16: Empty egg shells after excavation.
Abb. 16: Leere Eischalen nach einer Excavation.
(Photo: T. Schobesberger)

Tab. 2: Summary of the excavation data of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl between 2004 and 2014.
Tab. 2: Zusammenfassung der Excavation Daten von Unechten Karettschildkröten (*Caretta caretta*) von Yaniklar und Akgöl von 2004 bis 20014.

	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Yaniklar/	Number of nests	36	70	61	89	67	72	72	44	75	63	61	710
Akgöl	Total nu. of eggs	2453	5559	4207	5829	5480	5690	5291	3462	6299	5430	4886	54586
	Average nu. of eggs per nest	68.1	79.4	69.0	65.5	81.8	79.0	73.5	78.7	84.0	86.2	80.1	76.8
	Predated eggs	99	395	400	9	0	446	0	0	9	161	150	1669
	Unfertilized eggs	23	72	521	774	58	118	767	550	606	410	850	4749
	Empty shells	1705	3702	2719	4358	3225	3841	4112	2598	4620	3785	3303	37968
	Total nu. of dead embryos	625	1770	567	740	2197	1276	393	314	1073	1074	565	10594
	Dead early embryos	406	1182	294	221	1666	833	68	120	603	655	224	6272
	Dead middle embryos	32	37	37	101	38	124	38	21	59	37	110	634
	Dead late embryos	117	247	236	418	493	319	287	173	411	382	231	3314
	Dead undefinable embryos	70	304	0	0	0	0	0	0	0	0	0	374

Tab. 3: Relative numbers of the excavation data of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl between 2004 and 2014.
Tab. 3: Die relativen Zahlen der Excavation Daten der Unechten Karettschildkröten (*Caretta caretta*) von Yaniklar und Akgöl zwischen 2004 und 2014.

	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Yaniklar/	Predated eggs	4.0	7.1	9.5	0.15	0.00	7.84	0.00	0.00	0.1	3.0	3.1	3.2
Akgöl	Unfertilized eggs	0.9	1.3	12.4	13,3	1.1	2.1	14.5	15.9	9.6	7.6	17.4	8.7
	Empty shells	69.5	66.6	64.6	74.8	58.9	67.5	77.7	75.0	73.3	69.7	67.6	69.6
%	Total dead embryos	25.5	31.8	13.5	12.7	40.1	22.4	7.4	9.1	17.0	19.8	11.6	19.2
	Dead early embryos	16.6	21.3	7.0	3.8	30.4	14.6	1.3	3.5	9.6	12.1	4.6	11.3
	Dead middle embryos	1.3	0.7	0.9	1.7	0.7	2.2	0.7	0.6	0.9	0.7	2.3	1.2
	Dead late embryos	4.8	4.4	5.6	7.2	9.0	5.6	5.4	5.0	6.5	7.0	4.7	5.9
	Dead undefinable embryos	2.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8

Tab. 4: Fertilized embryo ratios of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl between 2004 and 2014.
Tab. 4: Die befruchteten Embryo-Verhältnisse von Unechten Karettschildkröten (*Caretta caretta*) von Yaniklar und Akgöl zwischen 2004 und 2014.

	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Yaniklar/	Empty shells + total no. dead	2330	5472	3286	5098	5422	5117	4505	2912	5693	4859	3868	4414.7
Akgöl	Empty shells (%)	73.2	67.7	82.7	85.5	59.5	75.1	91.3	89.2	81.2	77.9	85.4	79.0
	Total dead (%)	26.8	32.6	17.3	14.5	40.5	24.9	8.7	10.8	18.9	22.1	14.6	21.0
	Dead early embryos (%)	17.4	21.6	9.0	4.3	30.7	16.3	1.5	4.1	10.6	13.5	5.8	12.3
	Dead middle embryos (%)	1.4	0.7	1.1	2.0	0.7	2.4	0.8	0.7	1.0	0.8	2.8	1.3
	Dead late embryos (%)	5.0	4.5	7.2	8.2	9.1	6.2	6.4	5.9	7.2	7.9	6.0	6.7
	Dead undefinable embryos (%)	3.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8

Tab. 5: Dead embryo ratios of loggerhead turtles (*Caretta caretta*) at Yaniklar and Akgöl between 2004 and 2014.
Tab. 5: Tote Embryonen-Verhälnisse von Unechten Karettschildkröten (*Caretta caretta*) zwischen 2004 und 2014.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Dead early embryos (%)	65.0	66.8	51.9	29.9	75.8	65.3	17.3	38.2	56.2	61.0	39.7	51.5
Dead middle embryos (%)	5.1	2.1	6.5	13.7	1.7	9.7	9.7	6.7	5.5	3.5	19.5	7.6
Dead late embryos (%)	18.7	14.0	41.6	56.5	22.4	25.0	73.0	55.1	38.3	35.6	40.9	38.3
Dead undefinable embryos (%)	11.2	17.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6

Bachelor Thesis

Temperature measurements and its influence on the hatching success of *Caretta caretta* in Çaliş Beach and Yaniklar, Fethiye, Turkey 2015

Temperaturmessungen und deren Einfluss auf den Schlüpferfolg von *Caretta caretta* in Çaliş Beach und Yaniklar, Fethiye, Türkei 2015

Madeleine Hofreiter

Aspired academic title

Bachelor of Science (BSc.)

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Department of Limnology & Bio-Oceanography, University of Vienna

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KURZFASSUNG:

Das Ziel der Vewendung von Tinytags war die Nesttemperatur im Vergleich mit der Luftemperatur zu messen und eine Korrelation zum Schlupferfolg zu finden. Jedoch wurde der Schlupferfolg durch andere Faktoren, wie Schimmelbefall und Predation durch einen Schakal, beeinflusst Ein weiteres Nest beinhaltete nur unbefruchtete Eier, wodurch kein direkter Zusammenhang gefunden werden konnte. Daher wurde vermehrt auf den Abstand zum Meer und die Tiefe der Eihöhle, und dessen Beeinflussung der Temperatur eingegangen. Es wurden 3 Tinytags in Nester gelegt, davon zwei in Calis und einer in Yaniklar, zusätzlich wurden zwei künstliche Eikammer als Kontrolle für die beiden Nester in Calis angelegt, mit unterschiedlichem Abstand zum Meer. Auffällig wurde, dass ein größerer Abstand zum Meer eine Veränderung der Temperatur von bis zu 2 °C verursachen kann. Viel wichtiger jedoch ist die Tiefe der Eihöhle. Ist die Eihöhle nicht tief genug, kann im Nest keine konstante Temperatur erreicht werden. Im Fall von CY18 zum Beispiel wurde ein Schlupferfolg von nur 2,4 % gemessen obwohl alle Eier befruchtet waren: die meisten Eier starben in verschiedenen embryonalen Stadien.

ABSTRACT:

The aim of deploying Tinytags was to compare the nest temperature with the air temperature and to find a correlation with hatching success. The hatching success, however, was influenced by different factors such as mouldy eggs and predation by a jackal. One nest only contained unfertilized eggs, so no correlation could be found. I therefore more closely examinedat the distance to the sea and the depth of the egg chamber and their influence on the temperature. Three Tinytags were put into nests, two of them in Calis and one in Yaniklar, additonally two artificial egg chambers as a control were made for the two nests in Calis, with different distance to the sea. Noticeable was that a higher distance to the sea influenced the temperature in the clutch by up to 2 °C. More important, however, was the depth of the egg chamber. If the egg chamber is not deep enough, no stable temperature can be achieved in the clutch. In the case of CY18, for example, we recorded a hatching success of 2.4 %. Although all the eggs were fertilized, most died in different embryonic stages.

INTRODUCTION

From 27 June until 12 September 2015 the Seaturtle Course Austria-Turkey took place in Calis and Yaniklar, near Fethiye in Turkey. Calis Beach and Yaniklar are both protected sea turtle nesting beaches, where mainly *Caretta caretta* and, very rarely, *Chelonia mydas* nest. The team from the University of Vienna consisted of 22 students, who worked together with students of the Hacheteppe University of Ankara. The aim was to monitor the beaches, help adult *Caretta caretta* find a proper place to nest on the tourist beaches of Calis and Yaniklar, and to help the hatchlings find their way to the sea.

Calis is a small, very touristic place, near the town Fethiye, located in the south of Turkey, on the Mediterranean Sea. Due to the Mediterranean climate, the average temperature between June and September is around 30 °C with normally not even one rainy day. Rain mainly falls during the winter months (RTL interactive GmbH 2015).

In the Mediterranean Sea, two different species of sea turtle nest: *Caretta caretta* (Loggerhead turtle) and *Chelonia mydas* (Green turtle). Both are classified as endangered. Especially *Caretta caretta* nests at Calis Beach.

The Loggerhead sea turtle is distributed in the Atlantic, Indian and Pacific Ocean and in the Mediterranean Sea. *Caretta caretta* is considered by the IUCN (International Union for Conservaton of Endangered Species) as an endangered species due to the threats listed in the paragraph below (Wikimedia Foundation Inc.). Loggerheads can reach a length up to 120 cm and a weight of 110 kg. *Caretta caretta* can be distinguished by its massive big head with a strong jaw and the carapax is relatively flat and heart-shaped. Additionally, they have 5 central and 5 costal scutes, and 11-13 marignal scutes; the nuchal scute is broad and is in direct contact with the first costal scute. Their main food sources are jellyfish, crabs, algae, corals, fish and sponges, which makes them food generalists. After laying their nest, the incubation time takes up to 72 days. After the hatchlings reach the sea, it needs another 20 years until they are old enough to reproduce. Within those 20 years and afterwards as well *Caretta caretta* is facing a lot of different human-induced dangers and risks, as mentioned below, which makes it nowadays so difficult for them to obtain a stable population.

Due to the fact that Calis a very popular tourist location, *Caretta caretta* is increasingly losing the opportunity to find a proper place for nesting along the beach. When laying a nest, loggerhead turtles face numerous problems including people taking photographs with flashes and trying to touch them. This can cause them to return back to sea prematurely. Also sunbeds and umbrellas can blockade their path along the beach to find a proper nesting place. Additonally, not only on the beach, but even in their natural habitat, the sea, they are threatened due to marine pollution, marine debris such as plastic bags that resemble jellyfish, fishers killing them inadvertently (bycatch) or with intent, and motor boats hitting them (causing deep cuts of blunt force trauma). After successfully laying a nest, there are more problems coming up for *Caretta caretta*. The whole promenade is full with lights of restaurants, hotels and bars: hatchlings, which orientate themselves towards the brightest point (normally the moonlight reflecting on the water) to find their way to the sea, crawl into the wrong direction. Here they can become exhausted, dry out, or be killed by predators. Therefore the teams from Hacettepe University (Ankara) and the University of Vienna try to protect the adult turtles while laying their nests and later on also protect the hatchlings by helping them to find the right direction into the sea.

MATERIAL AND METHODS

Tiny Tags are produced by a company called Gemini, which was formed in 1984 in Chichester (UK). The first temperature data logger was produced in 1992. Tiny Tags have since been further developed and are now able to measure not only the temperature, but also CO_2 content or moisture. These advancesmake them useful not only for biological applications, but also in libraries, museums and agriculture.

Tiny Tags are powered by ½AA 3.6V Lithium batteries, which should be changed every year to guarantee the functionality of the data logger. The Tinytags can be buried in the sand on the beach as their plastic containers are resilient against salt and moisture. The small size (34 mm diameter, 54 mm height) and low weight, (30 g) makes it easy to use them in sensitive environmental conditions without actually influencing them. Data loggers are able to measure temperature from -40 °C up to +85 °C. We programmed them to take a measurement every 72 minutes at an accuracy of +/- 0.01 degrees. After taking the measurments, a normal USB cable and the Tinytag Explore Software are needed to transfer the data from the Tinytag to the computer. The program shows a date-temperature-diagram which is easy to export to an Excel spreadsheet (Tinytag by Gemini Data Logger).

The Tiny Tags I used for my project, were programmed to measure the temperature every 72 minutes. In total I had 5 Tinytags, which I took with me to Calis on 18 July 2015. All of them were protected by film canisters. After arriving in the camp I put them directly into the refrigerator, so later on I was able to immediately recognize, from the data in the spreadsheet, when each data logger was put into the clutch. The Tinytags were put into three different clutches, two in Calis and one in Yaniklar. After wrapping them up additionally into plastic bags, they were dug in on the morning after the nest was laid. This yielded measurements for the complete incubation time. The small Tinytags were put on the top of the eggs (about 20-30 cm depth, except TT6 at 14 cm), in order not to change the position of the eggs or risk influencing the hatching success. After putting the data loggers into the clutch, the excavated sand was used to carefully close the nest. Figure 1 shows how a Tinytag was put into nest 41 in Yaniklar.

After each clutch finished hatching, the Tinytag was taken out of the clutch and put directly back into the refrigerator. The temperature drop on the spreadsheet enabled me to immediately recognize when the measurments stopped and the incubation time was over.

Additionally to the two nests containing a Tinytalk in Calis, two artificial “control” nests were dug for the remaining two Tinytags . The control nests had the same position as the actual nests, but the distance to the sea was different. In the case of nest CY17 (DTS: 7.56 m) the control nest was further away from the sea (DTS: 14 m), in case of nest CY18 (DTS: 23.3 m) the distance to the sea of the control nest was shorter (10.9 m). This approach enabled me to determine whether it makes any difference for the temperature in the clutch if the nest is closer to the sea or not.

As the sex determination of sea turtles depends on the temperature, this would have a high impact on the sex ratio. At at temperature of 29.9 °C, only female hatchings will develop, under 29.9 °C only male hatchlings. The second third of the incubation time is the actual time at which the temperature determines the sex of the hatchings.

To be able to correlate the temperature of the clutch and the surrounding air temperature, we took measurements of the air temperature with a digital thermometer at 6 am, 12 noon and 10 pm directly at the beach. We collected the data for the complete time of the course in our data folder. Later on I transferred those data into Excel and correlated the ambient temperature with the Tinytag data from the different clutches, to see if there are any coherences.

RESULTS:

Nest CY17 with Tinytag 4

The clutch CY17 was laid on 19 July 2015 around 10:30 pm. The wind conditions were calm. The turtle had a SCL (straight carapax length) of 78 cm and a SCW (straight carapax width) of 45 cm. The track width was 45 cm; the inner track width measured only 13 cm, which shows that this was probably a young female. There were no deformations observed, but epibionts were present on the upper carapace. The turtle laid the nest close to the sea. The DTS (distance to the sea) was only 7.56 m. On the morning after, 20 July 2015, around 6 am we opened the clutch to put Tinytag 4 inside. Again we measured the DTS, which at this time was 8.20 m, and also the depth of the top of the eggs, where we put the Tinytag (26 cm).

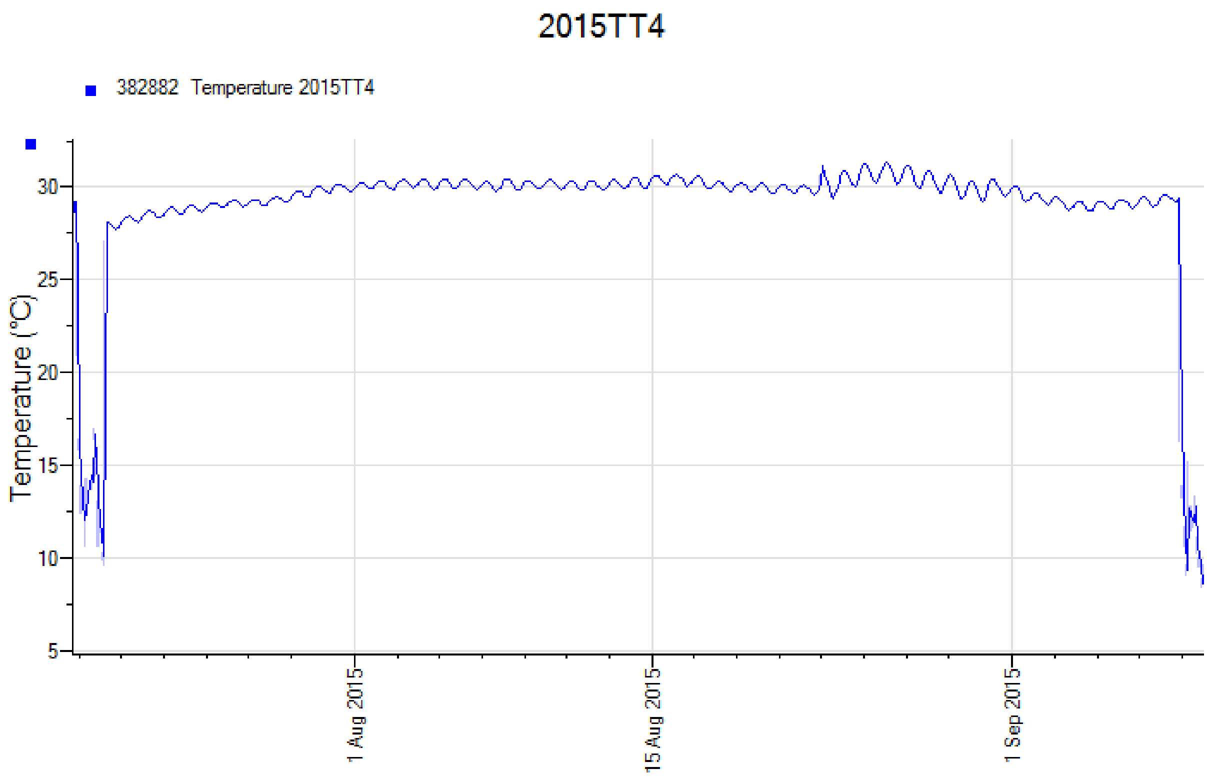

Fig. 2: The temperature measurments of clutch CY17.
Abb. 2: Temperaturmessungen des Nests CY17.

Figure 2 shows the temperature shift from the refrigerator at the beginning (9.5 °C). Beginning on 20 July the temperature begins to show the typical day-night fluctuation: each day the nest temperature increases during the day and sinks at night. Overall, the temperature increases during July and then remains relatively stable for most of August. Conspicuously, temperature suddenly rose on the 22 August 2015 and remained stable for about 10 days at an average of 30.3 °C. Moreover, the temperature fluctuations during these 10 days is stronger than previously. After the 10 days the temperature dropped back to an average value of 29.9 °C, which is close to its orignal average of 30.1 °C. The reason for that temperature change in the clutch is probably that the nest got moist on 21 or 22 August, as mentioned in the field notes. This can happen because the water level is quite dynamic and can suddenly cover parts of the beach which were previously dry. Additionally, the intensity of the waves can change as well and flood different parts of the beach to this interpretation, water has a higher heat storage capacity than air, explaining why the temperature of wet sand is higher than that of dry sand. An alternative explanation is that the waves removed or compacted the topmost sand layer, leaving the topmost eggs and the data logger closer to the sand surface and subjecting them to stonger daily temperature fluctuations. Note also that the subsequent measuremensts were already in September, when the surrounding weather conditions already changed and the weather was getting cooler compared to mid-July until early August. Therefore it is not surprising that the average temperature after the unexpected temperature rise never reached the average values before the rise. The total average temperature of the clutch was 29.8 °C.

TT4 & air temperature:

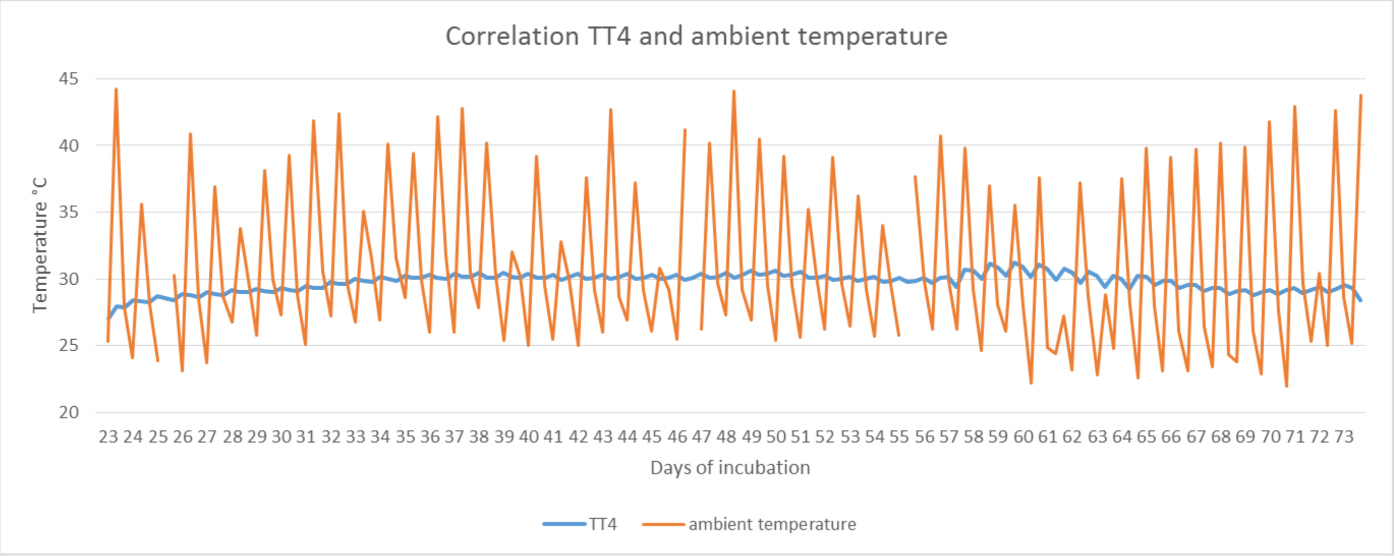

Figure 3: Temperature of the clutch measured by Tinytag 4 and the air temperature.
Abb. 3:Temperatur des Nests (Tinytag 4) und die Lufttemperatur.

Figure 3, which combines the measured air temperature and the temperature of TT4, clearly shows that the temperature in the clutch is extremly constant compared to the ambient air temperature. A closer examination reveals that with the rising air temperature the temperature in the clutch also slowly rises, but by far does not influence the nest temperature as much as I expected.

TT4 in CY17 and TT3 in control nest:

On 8 August 2015 around 4 pm we dug the control nest including Tinytag number 3. The position of the control nest was the same as the position of CY17, except that its DTS was 14 m, around 6 meters further away from the sea than CY17. The depth of the chamber was around 36 cm. We have not dug the control nest on the same day as the actual nest because we were still hoping for another turtle to come to the beach to lay another nest. As the last nest was laid on 27 July we used the remaining Tinytags for control nests.

Figure 4 shows the difference between the two Tinytags number 3 and 4. This highlights that on 22 September the nest got moist and the temperature rose. This is supported by Tinytag 3, which values did not rise around 22 September. Accordingly, we can assume that the outside temperature wasn´t the reason for the temperature rise of TT4.

This experiment gives an idea of what an impact the DTS has on the temperature of the clutch. The average temperature of TT4 is 29.9 °C, the average temperature of TT3 is 31 °C: this could make a big difference on the sex ratio of the total clutch. The difference, in this case 1.1 °C, could change the sex of the whole clutch.

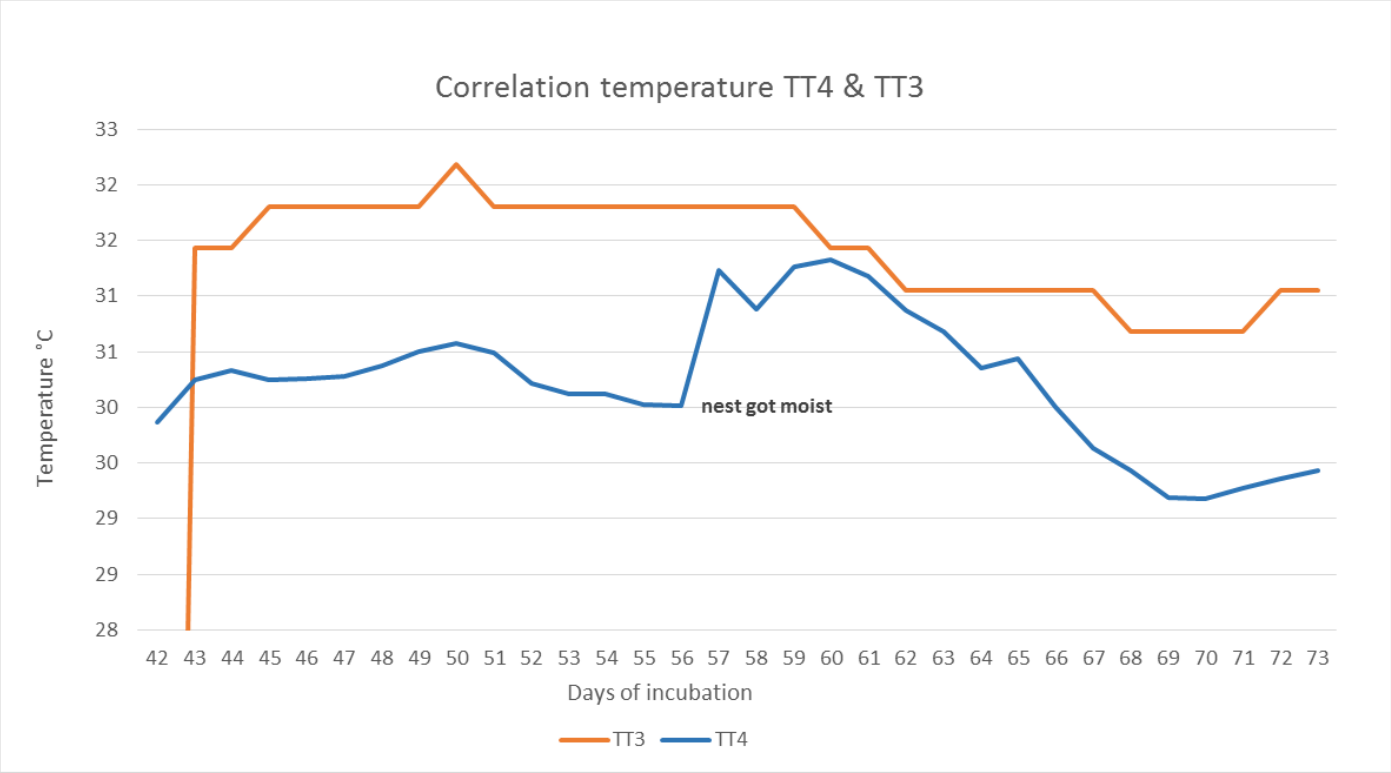

Fig. 4: Comparison between the data of Tinytag 4 in CY17 and the Tinytag 3 in the control nest; Abb. 4: Vergleich der Daten des Tinytag4 in CY17 und den Tinytag 3 im Kontrollnest.

Hatching success of CY17:

The aim of my temperature investigations was to find out if there is any difference in the hatching success correlating with the measured temperature. In the case of CY17 the nest was excavated on the 8 September 2015, after a total incubation time of 51 days. As a dog started to dig up the nest on that day, our team took a closer look at the nest, noticed the moist sand and a bad odor. Normally one should wait until 60 days after the clutch was laid to open it up and check on the eggs, but the smell and moisture led to an early excavation. The excavation showed a total of 63 eggs, all of them unfertilized. No parasites or mould was observed. Our interpretation is that the turtle that laid the eggs was still a young adult and therefore produced only unfertilized eggs. The size of the adult turtle, already mentioned above, supports this assumption.

Nest CY18 with Tinytag 6:

The nest CY was laid on 27 July 2015 around 2:00 am. The wind conditions were calm. The turtle had a SCL of 72 cm and a SCW of 51 cm, the CCL (curved carapax length) measured 76 cm and the CCW (curved carapax width) 68 cm. The track width was 53 cm and the inner track width to 17 cm. Compared to the turtle that laid CY17, all these measurements show that this turtle was a larger and older. No deformations or epibionts were present. The clutch had a DTS of 23.3 m, of which 21.3 m were in the dry zone and 1.9 m in the wet zone.

The Tinytag was put into the nest on 28 July 2015, during the morning shift, around 8:00 am. Again the Tinytag was put on the top of the eggs, where we measured only 14 cm from the top of the eggs to the surface. This could be because, according to the field notes, the turtle was exhausted.

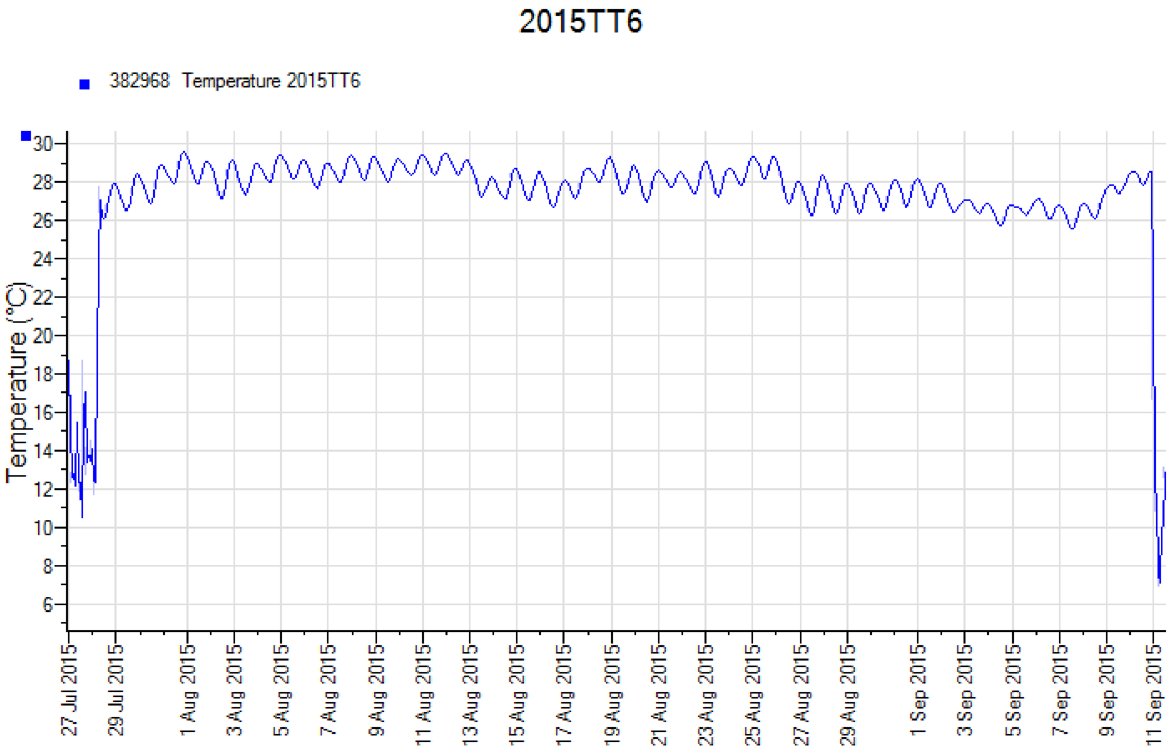

Fig. 5: Measured temperature of TT6 in CY 18, from 27 July 2015 until the 11 September 2015;
Abb. 5:Temperatur von TT6 gemessen in CY18, vom 27. Juli bis 11. September.

The temperature of TT6 began and ended with temperatures under 20 °C, reflecting the time spent in the refrigerator (Fig. 5). The typical day-night amplitude is visible, but in this case the small distance to the top the eggs is clearly evident. The night-day difference in temperature is much more influenced by the ambient temperature and therefore the daily amplitude is much higher compared to CY17. The average temperature in the clutch was 27.9 °C, which is actually quite low, especially compared to the CY17 where the average temperature was 29.9 °C although CY17 was much closer to the sea. My interpretation is that due, to the shallow nest, the temperature during the night strongly influenced the temperature in the chamber, and the whole clutch never experienced a nearly constant and higher temperature that would keep the eggs warm even during the night.

TT6 and air temperature:

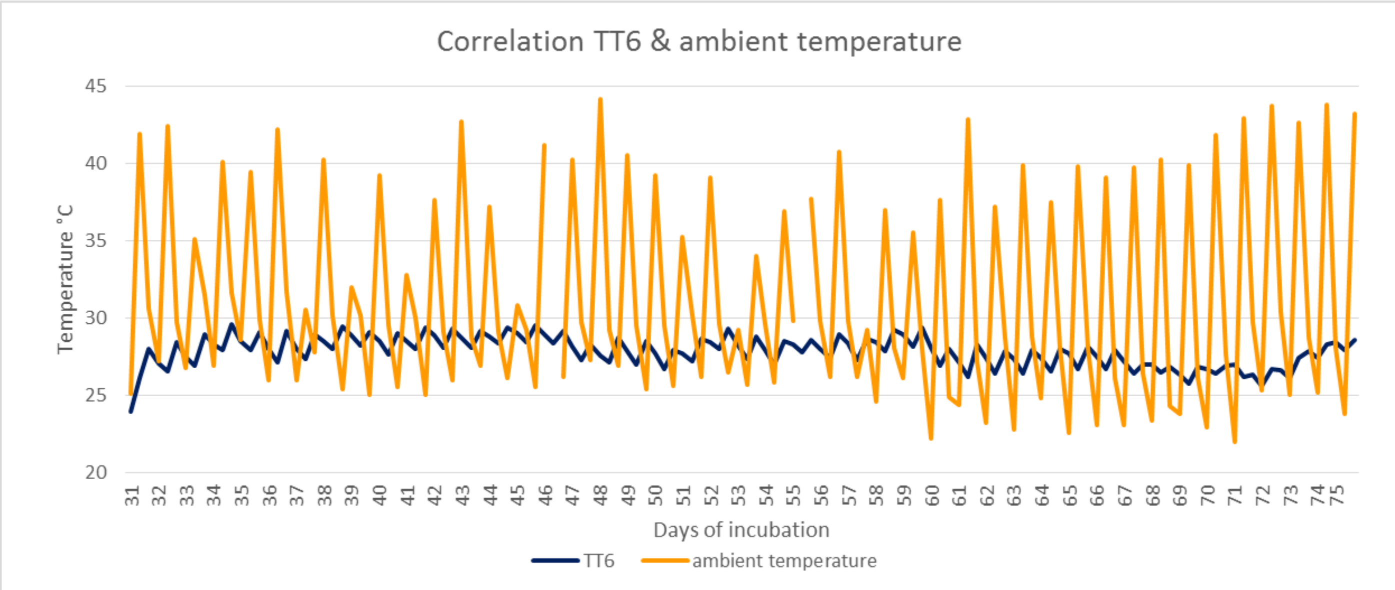

Fig. 6: Correlation between the airtemperature and the temperature of TT4;
Abb.6: Korrelation zwischen der Lufttemperatur und der Temperatur des TT4;

Figure 6 shows how the air temperature influences the temperature in the clutch. It supports my interpretation that the temperature during the night cooled down the temperature in the clutch. Especially in the beginning, there are a few nights in which the temperature in the clutch was as low as the outside temperature.

TT6 in CY18 and TT5 in control nest:

For the nest CY18 we have also dug a control nest. Again it had the same position as the actual nest but in this case it was closer to the sea, with a DTS of 10.9 m, 12.4 m closer to the sea as CY18. It was also dug in on 8 August 2015. The egg chamber had a depth of 34 cm, 20 cm deeper than the one of CY18.

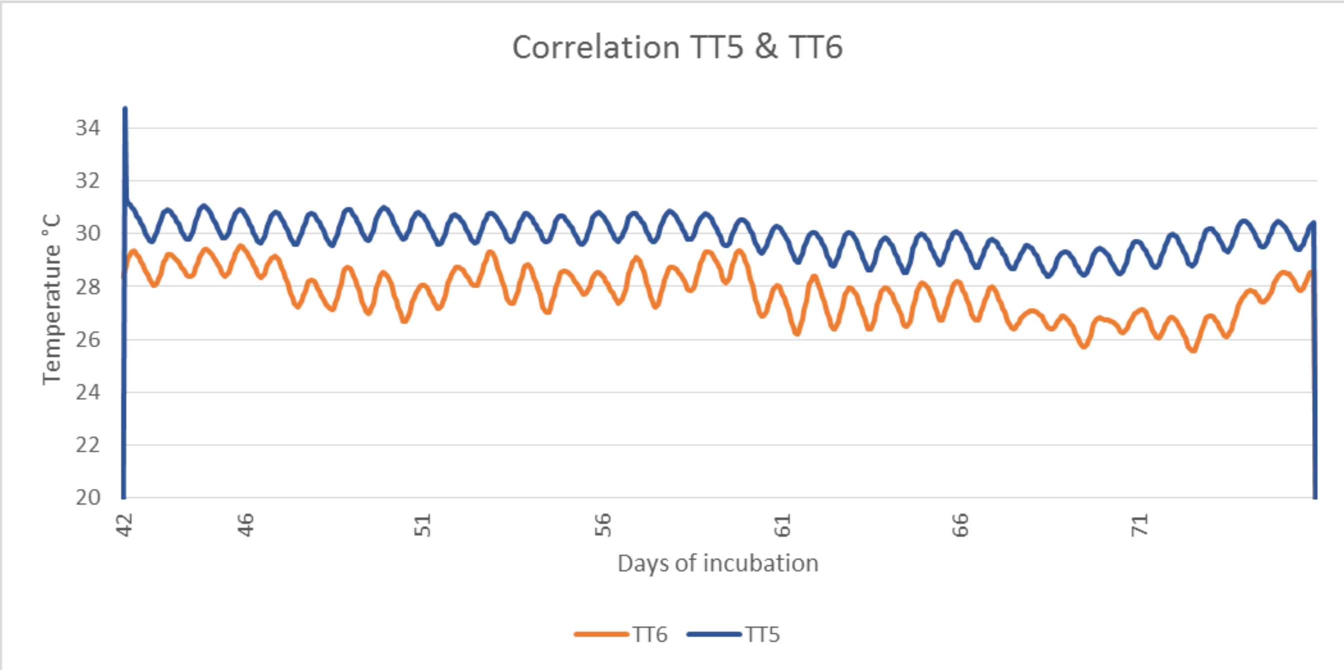

Figure 7: Comparison between temperature in CY18 and temperature in control nest;
Abb. 7: Vergleich der Temperaturen in CY18 und der Temperatur im Kontrollnest.

Figure 7 shows how the depth of the egg chamber influences the temperature in the clutch, because even though the TT5 was over 12 m closer to the sea, it measured a constantly higher temperature in the clutch. This is because TT5 was buried 20 cm deeper in the sand than TT6. Even the daily amplitude of the TT5 is clearly not as high as that of TT6 and shows a more constant temperature over the total measurement time. The average temperature of TT6 was 27.9 °C and the average temperature of TT5 was 29.9 °C, which is a difference of 2 °C for the complete measuerment time. Again, that difference can change the sex ratio of the complete clutch and highly influence the success rate.

Hatching success:

On 20 September 2015, two hatching tracks were found and were assumed to have reached the sea. On 24 September 2015, after 4 days without any hatchings leaving the clutch, the nest was excavated. There was a total number of 82 eggs in the nest, whereby only two were empty egg shells.

28 eggs were in an early embryonic stage, 32 eggs in a middle embryonic stage and 20 eggs in a late embryonic stage. Importantly, all 80 of these eggs were already mouldy. The unsuccesful hatching rate is probably the result of abiotic influences as the fluctuating

temperature in the clutch. As the sand layer over the eggs was very thin, the temperature in the clutch was extremely dropping during the night. Perhaps those short cool periods in the nest made it impossible for the embyros to fully develop. Additonally the average temperature is not rising during August, rather it is slowly sinking, although the ambient temperature is rising. The reason for the mould is not obvious. The clutch was too far away from the sea to become inundated by waves and it never rained during the incubation time; furthermore, no moisture in the nest was reported, which would have supported mould. The likeliest reason is that many of the embryos were already dead for a longer period of time and the decay process led to mould development.

Nest CY 41 with Tinytag 2 in Yaniklar:

Tinytag number 2 was dug into nest number Y41 in Yaniklar on the 1 August 2015. The nest was laid on 28 July 2015. Unfortunately the turtle itself was not seen, so no information about it is available. The DTS measured 12.1 m, of which 7.8 m are part of the dry zone, 2.7 m of the moist zone and 1.6 m of the wet zone. A predation cage was used to protect this nest. Unfortunately the distance to the top of the eggs was not measured.

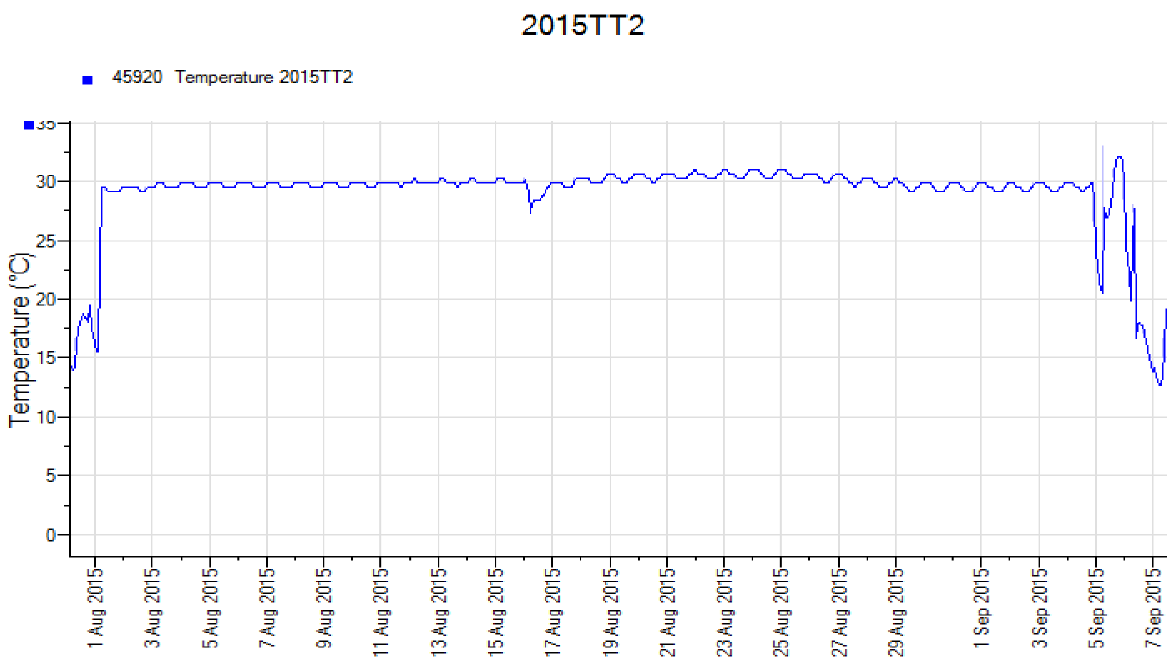

Fig. 8:Temperature measurments of TT2 in the nest Y41;
Abb. 8:Temperatur-Messungen des TT2 im Nest Y41.

Tinytag number 2 was taken out of the fridge and put into the nest during the morning shift, around 7 am (Fig. 8). For the whole measurment time the temperature is very constant, with an average of 29.7 °C. On the 16 August 2015 the temperature fell to 27.4 °C at around 7 am. I couldn´t find any specific notes for the morning shift of the 16 August 2015, but I suspect that the Yaniklar team opened the nest to check if everthing is alright, perhaps after a predation attempt and closed it afterwards, as the temperature wentback to its original value and remained constant again.

On the 5 September 2015, the temperature reached its lowest value of 20.6 °C and afterwards immediately jumped to 32.2 °C. The reason for this is a jackal that predated the complete clutch and dug out the Tinytag as well. This happened during the night, when the temperature was very low, and until the Tinytag was found on the sand surface the temperature already rose to over 30 °C. Afterwards the Tinytag was taken back to the refrigerator.

TT2 and air temperature:

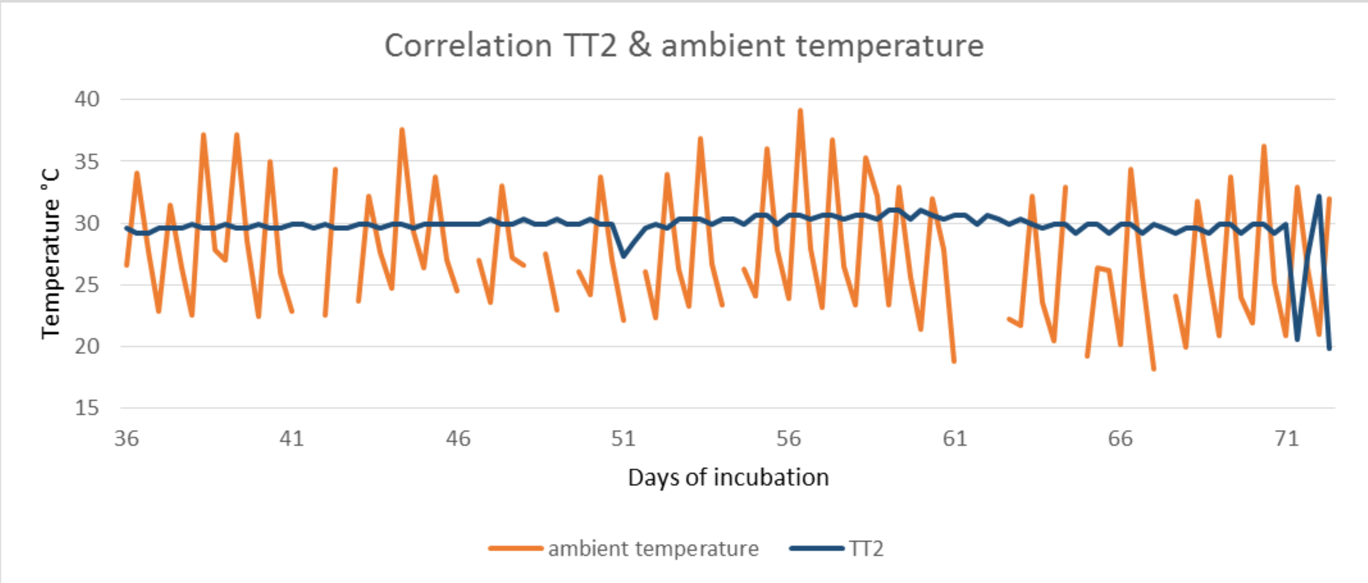

Fig. 9: Correlation between the air temperature and the temperature measured by TT2;
Abb. 9: Korrelation zwischen der Lufttemperatur und der gemessenen Temperatur des TT2;

Figure 9 shows a similar correlation between air temperature and (Fig. 3). The temperature in the clutch is minimally influenced by the day and night rhythm of the ambient temperature and remained very constant for the incubation time. Unfortunately, the clutch was predated by a jackal and therefore we don´t have any measurments for distance between the top of the eggs and the surface. The bottom of the egg chamber, was 50 cm deep. The deep egg chamber may explain the constant temperature. As we do not have any data about the depth in which the Tinytag was dug in, we can only assume from the bottom of the egg chamber, that the distance to the top of the eggs was average, around 20-30 cm.

Hatching success:

This nest was predated by a jackal, even though a predation cage was used. It was predated twice, the first time on the 4 September 2015, when 28 predated eggs were found, second time on the 5 September 2015 when the remaining 33 predated eggs and the Tinytag 2 lying outside were observed. Accordingly, no conclusions can be drawn about the hatching success as influenced by temperature.

DISCUSSION:

My aim was to find out what impact ambient temperature has on the temperature in the clutch, and how this could influence the hatching success. Unfortunately, none of the three nests had a proper hatching success as all three were influenced by factors other than the temperature: CY 17 contained only unfertilized eggs, CY18 had mouldy eggs inside, and CY 41 from Yaniklar was predated by a jackal.

Nonetheless, my study clearly underlined that the air temperature, compared to every Tinytag, showed a much higher day/night difference. The highest measured ambient temperature during the period when Tinytags were used was 39.2 °C in Yaniklar and 44.1 °C in Calis; and lowest values were 18.8°C in Yaniklar and 22.0 °C in Calis. This is a difference of 20.4 °C in Yaniklar and 22.1° C in Calis.

Tab. 1: The lowest and highest measured temperatures of all 5 Tinytags.
Tab.1: Vergleich der höchsten und niedrigsten gemessenen Werten aller 5 Tinytags.

Tinytag	highest temperature	lowest temperature	difference
TT6	29,6 °C	25,6 °C	4,0 °C
TT5	31,0 °C	26,0 °C	5,0 °C
TT4	31,3 °C	27,0 °C	4,3 °C
TT3	31,8 °C	29,9 °C	1,9 °C
TT2	31,1 °C	27,4 °C	3,7 °C

Table 1 shows that the temperature gap between the highest and lowest measured temperature of the Tinytags during the incubation time is beween 1.9 °C and 5.0 °C. This demonstrates that the temperatures in the different nests are extremely constant compared to the outside temperature.

This is because the temperature of the sand is influenced by short-term changes of the air temperature only until about 25 cm depth. (Blanck E. 2013, pp. 259) The egg chambers normally have a depth of down to 50 cm, where only long-term (seasonal) changes in ambient temperature can significantly influence the nest. Therefore, nest temperature drops somewhat with the falling temperature in September. This situation also explains the very instable temperature of CY18, as the eggs were covered only by a 14 cm sand layer and therefore were highly influenced by the day/night rythm of the air temperature. Accordingly, the nesting success was very bad: although all eggs were fertilized, except for two hatchings all the others stopped to develop at a certain embryonic stage.

Nevertheless, my experiment and the Tinytag data of the showed it is not the temperature alone that influences the clutch. Rather, it is the depth of the egg chamber which ensures a constantly warm temperature during the whole incubation time. As the comparison of CY17 and the control nest shows, the DTS does have an influence on the temperature: the clutch closer to the sea is around 1 °C cooler. More importantly, CY18 and the control nest show that even if one clutch is further away from the sea, and therefore expected to have a higher temperature, has still the lowest measured temperatuere (25.6 °C) and and also the most fluctuating temperature in case that the egg chamber is not deep enough. This is suprising as the logical assumption would be that, the thinner the layer of sand over the eggs, the warmer it must be, but according to the measured data, the highest measured temperature in CY 18 is 29.6 °C which is still the lowest compared to the other nests.

The fact that the turtle which laid nest CY18 was exhausted shows how important it is to make it as easy as possible for the turtles to come out on the beach and lay their nest. For sea turtles it is extremely strenuous to come on to the beach and crawl longer distances before finding a proper place for their clutch. The more sunbeds and umbrellas blocking the beach, the more difficult it becomes for the turtle to find its way on the beach. Furthermore, people on the beach at night can scare the turtles and cause them th return to the sea prematurely, especially when people try to touch the turtle or take photographs with flashes. Every further attempt by the turtle to come out to the beach and dig a nest makes it more and more exhausted and makes it harder to dig a proper egg chamber that is deep enough for a succesfull development of the embryos.

Following this line of arguments, it is very important to protect Calis Beach for *Caretta caretta* more than it is currently being done. Sunbeds and umbrellas need to be put away during the night and, even more important, visitors should be banned from walking around on the beach after 8:00 pm and until 8:00 am. This calls for informing tourists and residents about *Caretta caretta* and their nesting behaviour on Calis Beach, as many people are not aware of the fact that sea turtles are coming to the beach during the night to lay their eggs. It yalso calls for many more and stricter controls for Calis Beach in order to maintain an appropiate nesting habitat for *Caretta caretta*.

Another broader aspect which needs to be taken in account is the further development of the climate. As is generelly accepted, that the temperature is slowly rising due to the greenhouse effect and this can further influence the sex ratio of sea turtle clutches. As already mentioned above, a temperature change of 1 °C can already cause the difference between male and female hatchings. Rising temperature would mean that the balance of female and male hatchings will change to the benefit of females. Therefore, scientists are already thinking about solutions for that issue, for example Annette Broderick from the University of Exeter: If turtles do not adapt to increasing temperatures, by changing when and where they nest, it may be necessary to develop mitigation strategies, for example to move clutches to cooler locations that produce a balanced sex ratio (Tinytag from Gemini Data Logger). Moving clutches, however, is a time-consuming task because the eggs need to be taken out of their original environment and put into a new, artificial nest. Moreover, the eggs are not allowed to be turned and must be put into the new nest in the same order as they were taken out of the original clutch. Such moved clutches (hatcheries) are not necessarily successful. This is an issue that, which will need many more observations over the next decades to better determine how intense the influence of the rising air temperature will be and whether it is necessary to take further action on sea turtle nesting beaches.

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APPENDIX

Fig.1: Tinytag put into Nest 41 in Yaniklar on the 1 August 2015 around 6:30 am.
Abb. 1: Tinytag wurde ins Nest 41 in Yaniklar gegeben am 1. August 2015 um ca. 6:30.
(Photo: I.Svalina)

Bachelor Thesis

Measurements of adult sea turtle tracks in Çaliş. Overview of the last six years of successful and unsuccessful emergence in Çaliş in Fethiye, Turkey

Messungen adulter Meeresschildkrötenspuren in Çaliş. Überblick der letzten sechs Jahre an erfolgreichen und erfolglosen Landgängen von Çaliş in Fethiye, Türkei

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Aspired academic title
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ZUSAMMENFASSUNG:

Im Zuge des Meeresschildkröten Projekt Praktikums an der Universität Wien, in Zusammenarbeit mit der Hacettepe Universität Türkei, wurde im Zeitraum von 27 Juni bis 12 September 2015 in Calış, bei Fethiye, Daten über die unechte Karettschildkröte (*Caretta caretta*) und ihr Habitat erhoben. In dieser Bachelorarbeit werden die Daten der letzten 6 Jahre herangezogen und überprüft, wie viele erfolgreiche bzw. erfolglose Landgänge im Jahr 2015 im Vergleich zu den vorigen Jahren stattgefunden haben. Außerdem wird die Korrelation zu Laufdauer und die Distanz zum Meer behandelt. Im Jahresüberblick der letzten 21 Jahre konnte eine starke Fluktuierung der Anzahl der Nester beobachtet werden. 2012 bis 2014 konnte eine steigernde Nestanzahl beobachtet werden, wobei das Jahr 2015 wieder einen Abstieg der Nestanzahl von 31 Nester zeigt.

Abseits der Promenade ist die Gesamt-Spurenlänge und die Distanz zum Meer deutlich länger als die Messdaten entlang der Promenade. Im Jahr 2015, war die durchschnittliche Distanz zum Meer der Nester entlang der Promenade 13,33 m und 22,57 m abseits der Promenade und die durchschnittliche Spurenlänge der Nester zum Meer an der Promenade betrug 30,77 m und abseits der Promenade 49,68 m.

ABSTRACT

In the framework of the sea turtle course of the University of Vienna, in cooperation with Hacettepe University, Turkey, data on the loggerhead turtle (*Caretta caretta*) and their habitat were recorded in the period 27 June to 12 September 2015.

As part of this thesis, I analyzed the data of the last 6 years from Çaliş and determined how many successful and unsuccessful emergences there were from 2009 to 2015. Over the last 21 years, the number of nests fluctuated strongly. 2012 to 2014 was an increasing rate with the highest number of 38 nests, 2015 were only 31 nests counted and shows a decreasing number of 31 nests.

Offside the promenade, the total track length and the distance to the sea were significantly longer than the measured data along the promenade. In 2015 the average distance to the sea from the nests was 13.33 m along the promenade and 22.57 m offside the promenade. The averages track length along the promenade was 30.77 m and off the promenade 49.68 m.

INTRODUCTION

In the Mediterranean Sea, three sea turtle species can be found: the green turtle (*Chelonida mydas*), the leatherback sea turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*). All three species are on the red list and are listed as endangered and vulnerable by the IUCN (International Union for Conservation of Nature and Natural Resources). They are also protected under CITES (Convention on International Trade in Endangered Species of wild Fauna and Flora) (Broderick & Godley 1996). Fethiye is one of six special protected areas (SPAs). The Bern Convention defines the SPAs as places with wild flora and fauna and their natural habitats, especially those that are endangered and vulnerable.

In the east Mediterranean Sea, the loggerhead sea turtle (*Caretta caretta*) is one of 7 endangered sea turtle, with a population of about 5000 individuals (Demetropoulus & Hadjichristophorous 1995). After female turtles mature at about 20 years, they return to the beach where they had hatched and lay eggs in a nesting cycle of 2-4 years (Dodd 1988). They can dig up to 3-6 nests per nesting season (Spotila 2004). The nest site selection behavior of female sea turtles is influenced by several additional conditions. The turtle considers this variety of factors when deciding where to lay nests. These include high sand quality, easy accessibility, and few terrestrial predators (Mortimer, 1982, cited in Salmon, 1995).

On beaches, there may be many barriers for turtles making emergence and finding a suitable nest site difficult. A further disturbance factor is the rambling construction of sanitary installations and hotels and hogs a large nesting area.

In a period from 27 June to 12 September, a district in Fethiye, Çaliş Beach (Fig. 1), was monitoring by 20 Austrian und 3 Turkish students of a nature conservation course. Çaliş Beach has been monitoring since 1994 in cooperation with various Turkish universities. Austrian students collected data on nests, tracks, adult female loggerhead turtle and hatchlings, light pollution, temperature as well as anthropogenic disturbances such as litter and sunbeds on the beach.

This bachelor thesis focuses on the data of the last 6 years of emergences of adult female sea turtles in correlation to successful and unsuccessful nesting attempts. I also examined possible causes of changes.

MATERIAL AND METHODS

Fig. 1: Çaliş Beach next to Fethiye with the promenade part and offside the promenade. (Photo: Google Maps)
Abb. 1: Çaliş Beach bei Fethiye mit Promenade und abseits der Promenade. (Foto: Google Maps)

The main work consisted of monitoring and collecting data on the activity of the sea turtles. Everyday we conducted a morning and a night shift in which students walked the entire length of the beach.

The monitored area was a beach part named Çaliş Beach. It is about 3 km long with a strongly illuminated promenade (Fig. 1). A long sandy zone, a pebble zone and a rock zone characterize this beach.

The whole beach is subject to touristic use. The promenade part of the beach and a short sector offside the promenade is filled with bars, hotels and restaurants. This beach sector is exposed to strong light pollution and many tourists. During nighttime, visitors are on the beach, often making noise and leaving their wastes on the sand. All these factors impede turtles from laying nests without stress.

The beach is between 20 m and 30 m wide; at Keyif Café the beach becomes wider. An about

1.5 m high stonewall from Mutlu Hotel to Aroma Beach Club separated the promenade from the beach. The promenade zone ends at Aroma Beach, although this is followed by a section with a stone wall and a series of bars and hotels. After Beskaza Beach Bar, no walls exist and the beach becomes wider and extends to the street.

Night shift:

The whole night shift route along the beach was walked for times and required at least 4 hours (ca 22:00 p.m. until 02:00 a.m.) The starting point was in front of Mutlu Hotel and ended near the Surf Cafe.

The observers (typically 3 persons) patrolled side by side at a short distance from each other along the beach to check the whole beach area and not to miss any emerging adult turtle, hatchling or track. If an observer spots a turtle, the team sat or lay down on the sand and waited until she laid her eggs. After the turtle digs its nest, it makes its way back to sea. At this point it was measured and also tagged. 2015 were five sea turtles tagged.

The straight carapace width (SCL), length (SCW) and the curved length (CCL) and width (CCW) were measured with a tape rule and a wooden caliper and the data were recorded in a field documentation book. After the turtle re-entered the sea, the length of the track, distance to sea, inner and outer flipper width, number of body pits and the potential nest were documented.

Morning shift:

The morning shift started at 06:00 also in front of Mutlu Hotel and covered the whole beach. These shifts normally ended at about 08:00.

In the morning, typically only 2 observers patrolled the beach, documented new tracks and triangulated every nest to determine whether the position of the protective cages was still correct. Every track was recorded, regardless of the nesting success.

For my bachelor thesis I collected certain data from the sea turtles. The total track length was measured with a 50-m measuring tape. We started at the point where the turtle left the sea and ended at the point of re-entrance. To document the distance to the sea, which was measured in a straight line from the waterline of the beach to the nest or if no nest was built, to the bottom of the track. Body pits were also counted and documented in the field book. Afterward, all data were transferred to data sheets for later analyses.

Back in Austria, all data of the last 6 years on adult female tracks were examined to analyze the tracks in correlation to the distance to the sea. Tables were made for successful and unsuccessful nesting attempts, track length, distance to sea and body pits.

……………..............2015 Observer:…………………….……………

ADULT/NEST/TRACK

Date:……………… Time:………………..	Nest Nr.:…………..	Track Nr.: ……………..
Tag Nr.: L / R Straight measurements: SCL ……. SCW ……… Curved measurements: CCL ……. CCW ………. Epibionts …………….…… Deformations………….……	Shape of track dry zone(1) moist zone(2) wet zone(3)	Total track length:……………….. Track width:……………………..… Nr. of body pits: ……….………… Nest Dist. to sea: ………………. Beach zones 1:…………………m (dry) 2:..………….…....m (moist) 3:…………………..m (wet) Hatchery Yes No

Exact position of the nest:

Notes: vegetation, substrate type (sand, pebbles > 2mm, cobbles > 64 mm)

Fig. 2: Data sheet 2015 for nest, tracks and adults sea turtles.
Abb. 2: Datenblatt 2015 für Nest, Spur und adulte Schildkröten

RESULTS

In 2015 we found 31 nests in the breeding season on Çaliş. Beach. Twelve of these nests were so-called "secret nests". That means that the adult turtles were not observed during egg deposition and the nest were first found when hatchlings emerged. For the present study, secret nests were irrelevant because they lacked total track length data.

In 2015 the high number of nests (31) is higher than the 20-year long-term average (Fig. 3). Since 1994 the number of nests fluctuated strongly. Stronger nesting seasons were recorded in 1994, 1996, 1999, 2004, 2007, 2010, with the highest peak (38 nests) in 2014 (Fig. 3).

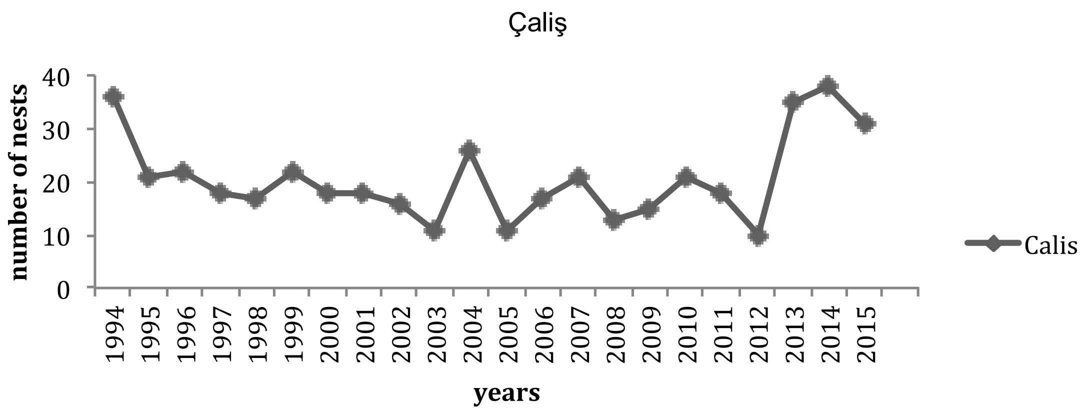

Fig.3: Long-term trend in the number of nests in Çaliş Beach from 1994 to 2015. The line shows a decreasing trend.
Abb. 3: Langzeitanzahl an Nester in Çaliş Beach von 1994 bis 2015. Die Linie zeigt einen absteigenden Trend.

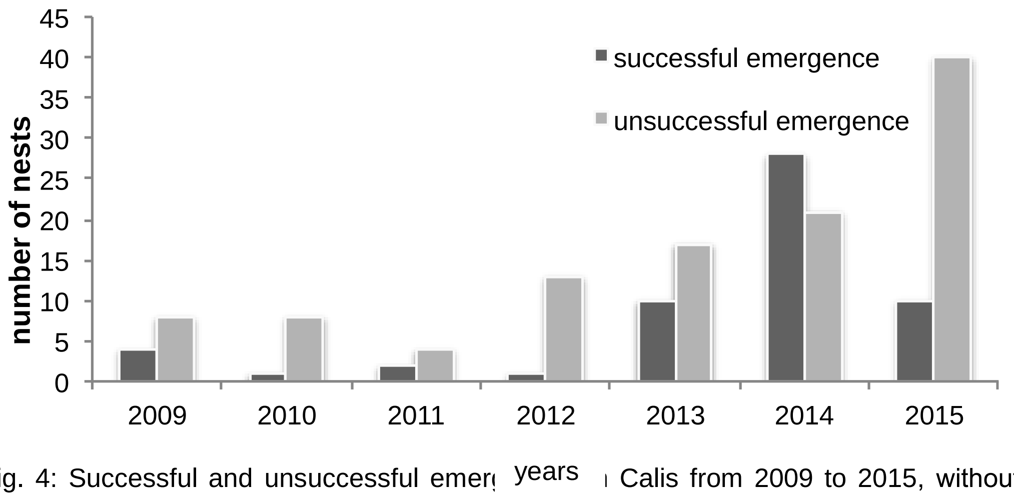

Fig. 4: Successful and unsuccessful emer[illegible] Calis from 2009 to 2015, without 'secret' nests and without data before 27 June.

Abb.4: Erfolgreichen und erfolglosen Landgänge von 2009 bis 2015, ohne ‚secret' Nester und ohne die Daten vor dem 27 Juni.

Over the last six years *Caretta caretta* much more often came on beach without an unsuccessful oviposition. Range: 43% - 93% unsuccessful emergences of the year 2009 to 2015. 2014 is an exception: there were more successful (28) emergence than unsuccessful (21) ones. (Fig. 4)

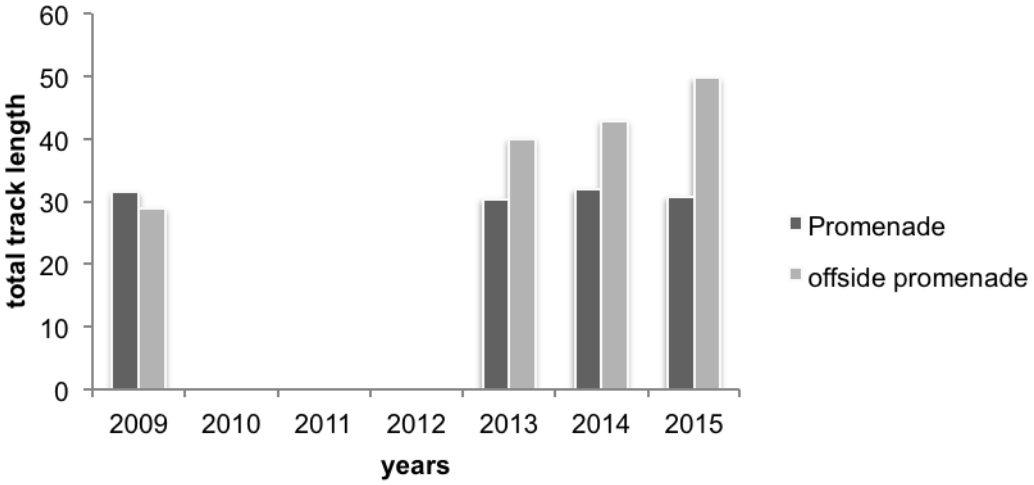

Fig. 5: Average total track length over the last six years (2009-2015). Black bars: all emergences with nests in front of the promenade. Grey bars: all nests offside the promenade. 2010 to 2012: no data or only one measurement so that no average track length can be calculated.

Abb. 5: Durchschnittliche Gesamtspurenlänge über die letzten sechs Jahre (2009-2015). Schwarzer Balken: alle Landgänge mit Nestablage an der Promenade. Grauer Balken: alle Nester außerhalb der Promenade. 2010 bis 2012: keine Daten oder nur eine Messung, sodass kein Durchschnittswert ermittelt werden kann.

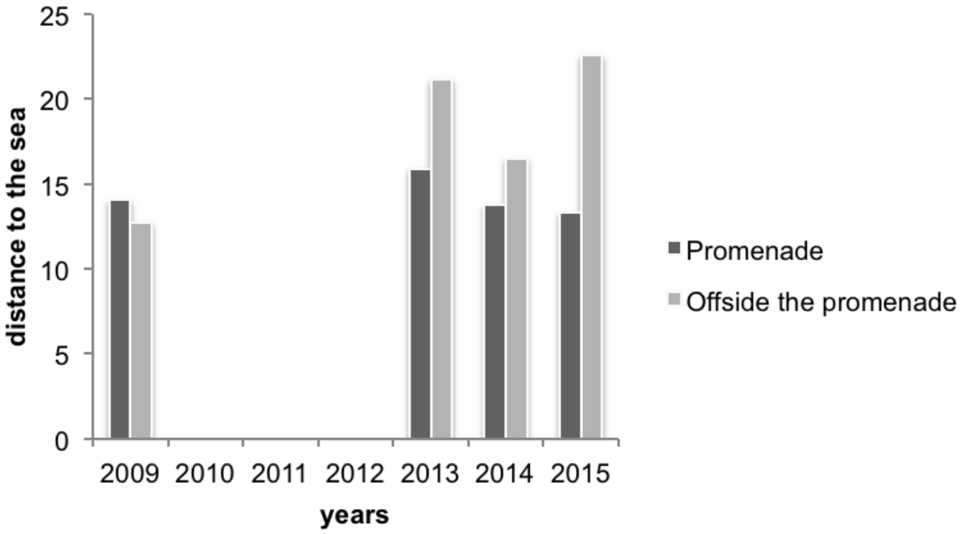

Fig. 6: Average distance of nest to the sea over the last six years (2009-2015). Black bars: all emergences with nests in front of promenade. White bars: all nests offside promenade. 2010 to 2012: no data or only one measurement so that no distance to the sea can be calculated.

Abb. 6: Durchschnittlichen Distanz zum Meer über die letzten sechs Jahre (2009-2015). Schwarzer

Balken: Alle Landgänge mit Nestablage an der Promenade. Weißer Balken: Beinhaltet alle Nester außerhalb der Promenade. 2010 bis 2012: keine Daten oder nur eine Messung, sodass kein Durchschnittswert ermittelt werden kann.

Table 1: Successful emergences Çaliş Beach 2009. Average distance to sea (d.t.s) of tracks with nest along the promenade 14.04 m, total track length 31.5 m. Average d.t.s offside promenade 12.7 m, total track length 28.8 m.
Tabelle. 1: Erfolgreiche Landgänge in Çaliş Beach 2009. Durchschnittliche Distanz zum Meer der Spuren entlang der Promenade 14.04, totale Spurenlänge 31.5 m. Durchschnittliche Distanz zu Meer außerhalb der Promenade 12.7 m, totale Spurenlänge 28.8 m.

Nest Nr.	Total track length (m)	Distance to sea (m)	Body pits
Cy 01	9.1	4.76	0
Cy 02	26.09	12.26	0
Cy 03	28.8	12.7	1
Cy 04	59.3	25.1	2

Three of four emergences were located in front of the promenade (from Türcu Cadir to Aroma Beach Club), only one nest offside the promenade (from Aroma Beach Club to Calis Tepe) (Fig. 1). The average distance to the sea over the two beach zones did not differ considerably. (d.t.s.: promenade: 14.04 m, offside prom.: 12.7 m)

Tab. 2: Unsuccessful emergence on Calış Beach 2009 (n.d.: no data) (*original value incorrect, therefore simply doppled the total track length for the sake of calculation)
Tab. 2: Erfolglose Landgänge in Calış Beach 2009 (*Originalmessugen inkorrekt, dafür Verdoppelung der totalen Spurenlänge aus Rechengründen)

Track Nr.	Track length (m)	Distance to sea (m)	Body pits
01	17*	8.5	1
02	n.d.	9.4	2
03	n.d.	19.9	2
04	n.d.	29.2	3
05	42.6	21.3	0
06	37.47	16	2
07	105.5	41.5	9
08	14.8*	5.7	0

There were eight unsuccessful emergences in 2009 with a track length between 17 m and 105.5 m. The longest distance to the sea 41.5 m, the shortest 5.7 m. The body pit number was between 0 and 9. The longest track length had the greatest number of body pits (Tab. 2).

Tab. 3: Tab. 3: Successful emergences in Çaliş Beach 2010. The distance to sea (d.t.s) along the promenade was 14,20 m, total track length 32,3 m.
Tab. 3: Erfolgreiche Landgänge in Çaliş Beach 2010. Distanz zum Meer entlang der Promenade 14.20, totale Spurenlänge 32,3 m.

Nest Nr.	Total track length (m)	Distance to sea (m)	Body pits
Cy 09	32.3	14.2	1

The one-recorded nest, the other 20 nests were `secret` nests, with track length information in

2010 was Cy09: the track length is only slightly longer than twice the distance to the sea, indicating a relatively straight path to the nesting site and back (Tab. 3). The other 20 nests were `secret` nests or were observed from turkey students before we came to Calis Beach.

Tab. 4: Unsuccessful emergences on Çaliş Beach 2010 (* explanation see Tab. 2)
Tab. 4: Erfolglose Landgänge in Çaliş Beach 2010 (*Erklärung siehe Tab. 2)

Track Nr.	Track length (m)	Distance to sea (m)	Body pits
01	74.4	29.7	2
02	16.3	6.9	0
03	9.5	3.9	0
04	124.4	43.4	3
05	92.9	37.1	1
06	52.2	26.1	1
07	139.8*	n.d.	1
08	119	29.6	2

There were eight unsuccessful emergences in 2010 with a track length between 139.8m and 9.5 m. The longest distance to the sea 43,4 m, the shortest 3,9 m. The body pit number was between 0 and 3. The longest track length had the greatest number of body pits (Tab. 4).

2011 a total number of eighteen nests were found in Çaliş Beach. 16 of them were `secret` nests, only two Caretta caretta sea turtles were observed, but no total track length was measured, the distance to the sea from the two nests were 21.3 m and 20,9 m.

Tab. 5: Unsuccessful emergences on Çaliş Beach 2011
Tab. 5: Erfolglose Landgänge in Çaliş Beach 2011

Track Nr.	Track length (m)	Distance to sea (m)	Body pits
1	256.8	73.5	1
2	5.4	n.d.	0
3	54.6	27.3	1
4	10.5	5.2	0

There are four unsuccessful emergences in 2011 with a track length between 256.8 m and 5.4 m. The longest distance to the sea 73.5 m, the shortest 5.2 m. The number of body pits were between 0 and 1. (Tab.5).

Tab. 6: Successful emergences Çaliş Beach 2012. The distance to sea (d.t.s) of the track with nest along the promenade was 26,30 m, total track length 57,20 m.
Tab. 6: Erfolgreichen Landgänge in Çaliş Beach 2012. Distanz zum Meer der Spur entlang der Promenade 26,30 m, totalen Spurenlänge 57,20 m.

Nest Nr.	Total track length (m)	Distance to sea (m)	Body pits
Cy 01	57.2	26.3	2

Only one nest was located in front of the promenade and no nest offside the promenade. The other nine nests were all `secret` nests with no track length and distance to sea measurements. The sea turtle had a total track length from 57.2 m and went 26.3 m away from the sea and made two body pits (Tab. 6).

Tab. 7: Unsuccessful emergences on Çaliş Beach 2012 (*explanation see tab. 2)
Tab. 7: Erfolglose Landgänge in Çaliş Beach 2012 (*Erklärung siehe Tab. 2)

Track Nr.	Track length (m)	Distance to sea (m)	Body pits
1	53.8	29	0
2	10	n.d.	n.d.
3	59.3	35	0
4	53.1	26	0
5	44	18	0
6	48.3	17.8	0
7	65	24	0
8	39.3	13.5	2
9	53.2*	26	0
10	52.8	25.8	0
11	52.4	24.3	0
12	47.7	20.1	2
13	43.2	21.6	1

There were thirteen unsuccessful emergences in 2012 with a total track length between 65 m and 10 m. The longest distance to the sea was 35 m and the shortest was 13.5 m. The body pit numbers were between 0 and 2 (Tab. 7).

Tab. 8: Successful emergence Çaliş Beach 2013. Average distance to sea (d.t.s) of tracks with nest along the promenade was 15.9 m and the average total track length was 33.3 m. Average d.t.s offside the promenade was 21.9 m. (*explanation see tab. 2)
Tab. 8: Erfolgreichen Landgänge in Çaliş Beach 2013. Durchschnittliche Distanz zum Meer der Spuren entlang der Promenade betrug 15.9, Spurenlänge 33.3 m. Durchschnittliche Distanz zum Meer außerhalb der Promenade 21.9 m. (*Erklärung siehe Tab. 2)

Nest Nr.	Total track length (m)	Distance to sea (m)	Body pits
Cy 18	31.5	14.8	0
Cy 19	39.5	18.6	0
Cy 20	47*	20.8	0
Cy 21	54.8	23	2
Cy 22	55.1	25.8	0
Cy 23	29.1	13.2	1
Cy 24	37.4	18.4	1
Cy 25	20.3	8.2	0
Cy 26	27.8	13.6	2
Cy 27	21.4	9.8	0

Ten of 35 tracks with nesting were observed. Twenty-two nests were located in front of the promenade and thirteen nests offside the promenade (Tab. 8).

Tab. 9: Unsuccessful emergences on Çaliş Beach 2013 (n.d.: no data) (* explanations see tab. 2)
Tab. 9: Erfolglose Landgänge in Çaliş Beach 2013 (* Erklärung siehe Tab. 2)

Track Nr.	Track length (m)	Distance to sea (m)	Body pits
01	21.4	10.6	0
02	10*	5	0
03	30.9	15.1	0
04	37.7	17.6	0
05	n.d.	29.6	3
06	30	18.4	1
07	46.6	23.56	1
08	57.6	29.14	1
09	46.8	19	0
10	50.25	25	0
11	n.d.	13	0
12	17.9	10.5	0
13	24.3	12.6	0
14	n.d.	20	1
15	n.d.	28.9	1
16	39.8	19.9	1
17	28	16.5	1

There were seventeen unsuccessful emergences in 2013 with a track length between 57.6 m and 10 m. The longest distance to the sea was 29.6 m and the shortest was 5 m. The body pit number was between 0 and 3 (Tab. 9).

Tab. 10: Successful emergence Çaliş Beach 2014. Average distance to sea (d.t.s) from tracks with nest along the promenade 13.8 m, total track length 31.96 m. Average d.t.s offside the promenade 16.49 m, total track length 42.85 m. (n.d.: no data)
Tab. 10: Überblick der erfolgreichen Landgänge in Çaliş Beach 2014. Durchschnittliche Distanz zum Meer der Spuren entlang der Promenade 13.8, totalen Spurenlänge 31.96 m. Durchschnittliche Distanz zum Meer außerhalb der Promenade 16.49 m, totalen Spurenlänge 42.85 m.

Nest Nr.	Total track length (m)	Distance to sea (m)	Body pits
Cy 11	26.4	11.1	1
Cy 12	30.8	16.5	0
Cy 13	55.4	17.1	0
Cy 14	23.2	16.1	1
Cy 15	n.d.	17.6	0
Cy 16	32.2	13.	0
Cy 17	n.d.	7.4	n.d.
Cy 18	39.7	20.5	2
Cy 19	28.6	17.2	0
Cy 20	23	11.2	0
Cy 21	28.6	11.8	1
Cy 22	33	14.6	0
Cy 23	36.6	15.41	2
Cy 24	54	25.1	2
Cy 25	n.d.	20.1	n.d.
Cy 26	n.d.	28.17	n.d.
Cy 27	n.d.	n.d.	n.d.
Cy 28	20.2	12.6	0
Cy 29	n.d.	n.d.	n.d.
Cy 30	81.1	18.1	0
Cy 31	n.d.	n.d.	n.d.
Cy 32	n.d.	22.2	n.d.
Cy 33	n.d.	13.43	n.d.

Tab. 10: Successful emergence Çaliş Beach 2014. Average distance to sea (d.t.s) from tracks with nest along the promenade 13.8 m, total track length 31.96 m. Average d.t.s offside the promenade 16.49 m, total track length 42.85 m. (n.d.: no data)
Tab. 10: Überblick der erfolgreichen Landgänge in Çaliş Beach 2014. Durchschnittliche Distanz zum Meer der Spuren entlang der Promenade 13.8, totalen Spurenlänge 31.96 m. Durchschnittliche Distanz zum Meer außerhalb der Promenade 16.49 m, totalen Spurenlänge 42.85 m.

Nest Nr.	Total track length (m)	Distance to sea (m)	Body pits
Cy 34	n.d.	11.8	n.d.
Cy 35	n.d.	15.75	n.d.
Cy 36	n.d.	n.d.	n.d.
Cy 37	n.d.	16.15	n.d.
Cy 38	n.d.	22	n.d.

Eight of 38 tacks with nesting were found in front of the promenade, whereas six tracks with nesting were located offside the promenade. (Fig.10). The average distance to sea from the nest at the promenade 13.8 m and the average distance to sea offside the promenade was 16.49 m. The distance to the sea was 16.4% longer than the distance to the sea at the promenade.

Tab. 11: Unsuccessful emergence on Çaliş Beach 2014 (n.d.: no data)
Tab. 11: Erfolglose Landgänge in Çaliş Beach 2014

Track Nr.	Track length (m)	Distance to sea (m)	Body pits
1	n.d.	37	1
2	33.5	15	1
3	16.5	8	0
4	52	19.5	2
5	39.7	18	4
6	21	9.8	2
7	21.1	9.8	1
8	48.8	22.3	2
9	33.5	16	0
10	45	19.7	0
11	39.3	18.3	0
12	64.2	25	1
13	25.7	12.5	1
14	28.2	16.2	0
15	74.2	25.9	1
16	49.1	21.8	n.d.
17	13.7	6.6	0
18	71	33.3	0
19	25.3	12	0
20	n.d.	15.5	0
21	54.3	24.1	0

There were 21 unsuccessful emergences in 2014, with a track length between 74.2 m and 21 m. The longest distance to the sea was 37 m and the shortest was 6.6 m. The body pit numbers ranged between 0 and 4 (Tab. 11).

Tab. 12: Successful emergence in Çaliş Beach 2015. Average distance to sea (d.t.s) from tracks with nest along the promenade 13.33 m, total track length 30.77 m. Average d.t.s offside the promenade 22. 57 m, total track length 49.68 m.

Tab. 12: Erfolgreiche Landgänge in Çaliş Beach 2015. Durchschnittliche Distanz zum Meer der Spuren entlang der Promenade 13.8 m, totale Spurenlänge 30.77 m. Durchschnittliche Distanz zum Meer außerhalb der Promenade 22.57 m, totale Spurenlänge 49.68 m.

Nest Nr.	Total track length (m)	Distance to sea (m)	Nr. of body pits
Cy 10	16	8.2	1
Cy 11	68	30	3
Cy 12	31	16.1	1
Cy 13	19.7	8.3	2
Cy 14	51.3	18.3	1
Cy 15	44.8	20.67	0
Cy 16	67	31	2
Cy 17	17.35	7.56	1
Cy 18	34.5	16.4	1
Cy 19	51.6	23.2	2

Five of 10 tracks were located in front of the promenade and also five tracks with nesting were located at the offside the promenade. The average distance to sea in front of the promenade 13.33m, the average distance to sea offside the promenade was 22.57 m (Tab. 12).

Tab. 13: Unsuccessful emergence on Çaliş Beach 2015
Tab. 13: Erfolglose Landgänge in Çaliş Beach 2015

Track Nr.	Track length (m)	Distance to sea (m)	Body pits
1	36.42	15.8	2
2	80.5	15.4	3
3	25.3	11.14	2
4	42.5	19.8	3
5	11.3	5.3	0
6	15.3	7.2	0
7	40.74	19.85	12
8	43.4	18.9	0
9	15.12	7.25	1
10	36.3	17.4	1
11	65.6	28.6	1
12	25.8	15.9	1
13	56	28.1	1
14	36.2	14.4	2
15	52.9	17.5	2
16	17.72	7.71	0
17	62	28.5	1
18	57.8	26.6	1
19	29.5	15.9	1
20	47.16	20.9	2
21	20.16	9.2	0
22	103.1	43.5	2
23	47.8	22.6	0
24	27.7	11.9	1
25	14.9	6.7	0
26	20.5	9.4	0
27	13.37	7.85	0
28	20.2	9.8	0
29	43.9	23.33	1
30	23.5	10.8	1
31	n.d.	10.5	0
33	14.2	7.4	1
34	11.4	4.6	0
35	10.1	4.5	0
36	28.7	17.2	0
37	18.6	10.2	0
38	41.99	18.4	0
39	55	26.6	0
40	21.6	n.d.	0

There are 17 unsuccessful emergences in 2013, with a track length between 103.1 m and 11.3 m. The longest distance to the sea was 43.5 m and the shortest was 4.5 m. The body pit number was between 0 and 3. One turtle (number 7) was special with 12 body pits. (Tab. 13)

DISCUSSION

Loggerhead sea turtles are known for their philopatry (i.e. migration from nesting areas and return) and show a high degree of nesting site fidelity (*sensu* Carr 1975). They also tend to renest in relatively proximity during successive nesting attempts within the same nesting season. Loggerhead turtles prefer sandy, wide open, calm and dark nesting beaches that are easy to reach. The research challenge is to identify the characteristics of the beach to which the females respond positively. They can dig an egg chamber and lay eggs (positive) or returns to sea without nesting (negative).

In summer 2011, 16 of 18 nests were secret nest. Two of these emergences were documented: only the track length of 21,3 m and 20.9 m was measured.

In 2012, one sea turtle tack was recorded with the total track length and the distance to sea. Since 2013, the total track length and the distance to the sea offside the promenade was longer then in 2009 (Fig. 5).

The longer the nests distance to the sea, the longer the total track length. As well can be observed, that the track length offside the promenade got larger over the last years. (Fig. 5, Fig. 6). By virtue of the deterated beach state, because of waste, sunbeds, and carpets, sea turtles need much more time to find an optimal digging place to lay their eggs and have therefore a bigger distance to crawl. In a few cases the track length correlates with the number of body pits. The longer the total track length, the more body pits will be done (Tab. 2, Tab. 4). Because of the bad beach state, turtles have to search longer for an optimal oviposition and make therefore more bod pits. Offside the promenade, the turtles have a much bigger area to search for the right nesting sand and are not confronted with walls that hinder their way. But offside the promenade, there are also many more stones and a harder substrate, which makes digging much difficult, so they have to search longer over a longer length.

There are many parameters that determine where a turtle lays her eggs. These include the character of the beach and the distance to the sea (Spotila et al. 1987). The site should be easily accessible from the ocean, have enough sand cohesion to allow nest construction and the temperature conditions should be optimal for egg development. (Mortimer 1990).

When the loggerhead sea turtle leaves the sea, it crawls a few meters on the beach and observes its surroundings. During this phase the loggerheads are easily disturbed by activity on beach, like tourists with flashlights or hindrances on the beach. In such cases the turtle often turns back to the sea and searches for a better nesting place. Alternatively, the turtle may crisscross the beach in search of an optimal site, which is reflected in long total track lengths of up to 257 m without laying nests (Tab. 5).

From 10 to 75% of loggerhead nesting attempts are unsuccessful on many beaches (Dodd 1988). Some reasons include anthropogenic alteration of the beach environment such as placing structures on the beach (with tractors), removal of the vegetation and increasing lighting from bars and hotels.

Often it is unknown why a turtle aborted a nesting attempt; sometimes the female is deterred from nesting by “factors known only to the turtle” (Dodd 1988). A sea turtle may return 2-4 times to the same beach in one season trying to make an oviposition (Fig. 4).

At the promenade the turtles revealed a much shorter distance to the sea and track length. The wall can be viewed as a disturbance factor (with regard to the distance to the sea) or even as a positive influence, considering that the turtle can find a site on a more restricted beach area. Moreover, at the promenade the sand is much softer, lacks stones and is flatter than offside the promenade. These good conditions for nesting are offset by the many hotels, bars and sanitary facilities. Tourists and their flashlights on the beach at night are also disturbance factors here. Artificial lighting along the beachfront reduces the number of nesting sea turtles relative to beach areas free of light (Ehrhart et al. 1996; Witherington 1992). Additional disturbance factors are sunbeds, parasols and waste such as bottles and plastic. All these factors are causes for so many unsuccessful landings.

Overall, a lot of tourists don´t know that Çaliş Beach is a protected area and that it is a sea turtle nesting beach. Much more information should be given to tourists and local residents. A good start is the *Caretta caretta* information desk, where tourists and other interested people can get information about the turtles and their protection, but it is definitively not enough. The Austrian participation in the sea turtle monitoring efforts started twenty-one years ago. So hopefully we can see the start of increasing nesting activities in the next years, i.e. if the hatchlings that the teams helped to reach the sea long ago now begin to return to Fethiye in in larger numbers.

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BLAUER KREIS supported us as in past years – thank you! EMTEC provided us with turtle-shaped flash devices, Pirata Del Viento, a Viennese artist, supported us with hand made screen printed cloth bags.

Without all the above support, it would be difficult to conduct such a long-term project in the framework of a university course – and only long-term efforts can help protect endangered species and habitats as well as provide vital scientific data needed for conservation efforts.

In Fethiye, a series of hotels and restaurants in Çalış provided us with free dinners every evening: Rebin Beach Hotel, Pelin Hotel, Golden Moon Hotel, Günes Hotel, Idee Hotel, Delta Hotel, Cenk Bey Hotel, Mutlu Hotel, Eröz Hotel, Aymes Hotel, Sevi Hotel, Nil Restaurant, Mendos Hotel, Malhun Hotel, Orient Hotel, Bahar Hotel & Area Hotel – just to name a few. Thanks to Mrs. Sevim for arranging!

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Lukas Fuxjäger

……………..............2015 Observer:……………………..………………

ADULT/NEST/TRACK

Date:………………. Time:………………..		Nest Nr.:…………..	Track Nr.: ……………..
Tag Nr.: L R Straight measurements: SCL ……. SCW ……… Curved measurements: CCL ……. CCW ………. Epibionts …………………. Deformations……………….	Shape of track dry zone(1) moist zone(2) wet zone(3)		Total track length:……………….. Track width:……………………… Nr. of body pits: …………………. Nest Dist. to sea: ……………….. Beach zones 1:..…………………m (dry) 2:..……………….....m (moist) 3:…………………..m (wet) Hatchery Yes No

Exact position of the nest:

Notes: vegetation, substrate type (sand, pebbles > 2mm, cobbles > 64 mm)

....................2015
HATCHING-DATA

Nest Nr:................ Nest Date:………………… Incubation Time:………………….. Observer:………………………………………

Emerging days	1	2	3	4	5	6	7	8	Total
Hatch date									
Hatch time (start)									
Number of tracks									
Hatchlings reaching the sea									
Predated hatchlings									
Predated eggs									
Dead due to sun/heat									

Other observations and remarks:

Nest excavation: Date:.......…………….. Time :……..…………….… Observer:……………………………………………

Empty shells	
Hatchlings still living inside nest	
Dead hatchlings in nest	
Unfertilized eggs	
Total Nr. of fertilized eggs:	

Early-embryonic stage (<1 cm)	
Mid.-embryonic stage (>1 cm <2cm)	
Late-embryonic stag (> 2cm)	

Total Nr. of eggs	
Total Nr. of empty shells	
Total Nr. of hatchlings reaching the sea	

Depth: top eggs	
Bottom of chamber	
Diam. of chamber	
Nest dist. to sea	

Insects ets. in nest:

Dead or injured sea turtles 2015

Observer: ……………………………….. Stranding date and time: ………………

Species: *Caretta caretta*- loggerhead turtle □
Chelonia mydas- Green turtle □
Trionyx triunguis – Nile softshell turtle □
Other:…………………………….

Stranding location: Offshore (beach) □ Inshore (sea, lake, river) □
Descriptive Location:…………………………………………………

Sex: undetermined □ Male □ Female □

How was sex determined: necropsy □ tail length (adult only) □

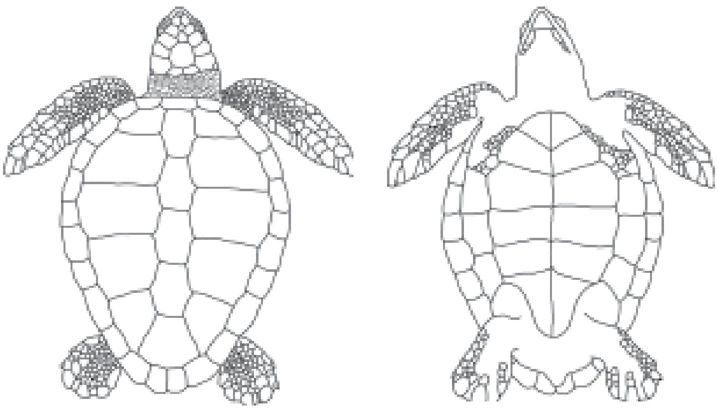
Condition: 1 alive □
2 fresh dead □
3 decomposed □
4 dried carcass □
5 skeleton bones only □

Tags: Checked for tags? Yes □ no □ Tagnumber:……………………………...
Tag location:……………………………………………………………...............
Return adress:………………………………………………………………….

Carapace measurements: SCL ………………….. SCW…………………………
CCL …………………… CCW………………………….

Photos taken? Yes□ no□
Nr. of photos:

Mark wounds/abnormalities on diagrams and describe. Please also note if no wounds or abnormalities are found.



□ holes/ wounds made by gun
□ deformations
□ cuttings
□ missing parts
□ gear or debris entanglement
□ propeller damage
□ others:

Notes:

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