Preliminary report on black sea turtle research activities undertaken by the UABCS/UBath/Earthwatch team at Laguna San Ignacio, BCS, Mexico, in June 2009.

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Abstract

This report summarises the black sea turtle research activities which took place in June 2009. There were four objectives to the reseach that summer. The first was to contribute to ongoing population monitoring efforts for this species in Baja California. The second was to determine the sea turtle mortality rates and causes of mortality in the San Ignacio area. The third was focused on determining what use the turtles make of the habitat in the lagoon, and the fourth on where they fit in the lagoon food web. Turtles were captured mostly in the upper reaches of the lagoon using closely monitored entanglement nets, processed ashore, then released close to where they were captured. Turtles were measured, weighed, and flipper tagged. Some were selected to be tracked using a surface buoy equipped with a VHF transmitter and GPS recorder. Two turtles were outfitted with a carapace-mounted underwater camera. Due to equipment failures, only one useful GPS track was obtained. Behaviour during this track was not different from that observed in previous years. Two underwater movies were obtained, demonstrating that the attachment method worked and that simple inexpensive (and therefore expendable) cameras are sufficient for recording the animals' behaviour. Stable isotope analysis was conducted, and preliminary results suggest that there are two feeding strategies present among the turtles in the lagoon: one focused entirely on eelgrass, and the other split between eelgrass and invertebrates. No correlations were found with any of the turtles' life history parameters.

Introduction

The East Pacific green, or black turtle (*Chelonia mydas*), a subpopulation of the green turtle (Bowen et al., 1992, 1993; Dutton et al., 1996; Karl et al., 1992; Karl, 1996), is listed as endangered on the IUCN Global Red List (IUCN, 2004). It has been protected in Mexico since 1990, when a total ban on sea turtle fisheries and use of sea turtle products was declared (Aridjis, 1990; Diario Oficial de la Federación, 1990). The black turtle is found in the Mexican Pacific during all life history stages and the coastal waters of the Eastern Pacific and Gulf of California provide important feeding and developmental habitat (Cliffton et al. 1982; Seminoff et al., 2002a,b; Nichols, 2003). One of the most important nesting beaches is located in Michoacán, Mexico, other nesting populations occur on the Galapagos Islands (Ecuador), and the Revillagigedos and Tres Marias Islands (Mexico) (Cliffton et al., 1982; Awbrey et al., 1984; Márquez, 1990).

The decline of the black turtle was mainly caused by commercial fisheries from the 1950's to the 1970's when Mexico contributed about 50% to the world's catch of sea turtles, mainly olive ridley (*Lepidochelys olivacea*) and black turtles (Márquez and Doi, 1973; Márquez et al., 1982; Márquez, 1990). At the same time, intense egg harvest severely impaired recruitment and accelerated the decline. As a consequence, the nesting population on the Mexican index beaches Colola and Maruata in Michoacán decreased by over 95% from the late 1960's to the late 1990's (Cliffton et al. 1982; Alvarado et al. 2001; Seminoff, 2004). In recent years, nesting has been increasing, and current levels are approaching those of the early 1980's (Alvarado-Diaz, pers comm.).

Several bays and lagoon systems along the coast of the Baja California Peninsula provide important habitat for black turtles (Pacific: Laguna Guerrero Negro, Laguna Ojo de Liebre, Laguna San Ignacio, Bahía Magdalena; Gulf of California: Bahía de Los Angeles, Bahía Concepción, Bahía de La Paz) (Nichols 2003; Seminoff et al., 2003; Koch et al., 2006). Black turtles recruit to these neritic foraging habitats in Bahía Magdalena at a carapace size of 35 – 40 cm (Brooks, 2005), similar to values reported for Hawaiian (Balazs, 1980) and Australian (Limpus et al., 1994) green turtles. They spend over 10 and possibly up to 20 years (Seminoff et al., 2002a; Nichols, 2003; Seminoff, 2004) in these developmental habitats where they feed mostly on sea grass and algae (Felger and Moser 1973; Seminoff et al., 2002b).

Laguna San Ignacio, famous for the gray whales that come there every year to breed, is an important fishing ground on the Baja California peninsula for many small-scale fisheries that target a large variety of fin- and shellfish (Carta Nacional Pesquera, 2004). Bottom set gill nets are commonly used for stingrays, halibut and other demersal fish species, and black turtles are a frequent, and usually welcome, bycatch. The black turtle is also targeted directly, as sea turtle meat is still considered a delicacy in the region, and poaching rates are high (Gardner and Nichols, 2001; Koch et al., 2006; Peckham and Nichols, 2002; Nichols, 2003). Mortality estimates for poaching and incidental bycatch are at least 200 black turtles per year for the nearby Bahía Magdalena region (>90% consumption) (Koch et al., 2006), and a consumption mortality of at least 7,800 black turtles per year has been estimated for the Baja California Peninsula (Nichols, 2003).

It is therefore imperative to gain knowledge on the population ecology of the black turtle on its neritic foraging grounds and to understand habitat use and foraging of the turtles, in order to inform the development of effective conservation strategies. It is also imperative to promote the sustainable use of sea turtles through sea turtle observation and science tourism, and give the black turtle a higher value alive than dead, a strategy that has worked extremely well with whale tourism.

Our goal is to understand the behavioural ecology of black sea turtles in a heretofore little-known part of their range. We have begun a study of their abundance, movements, behaviour, and use of habitat, which we will eventually assemble into a multi-layered GIS model which will also include information on the benthic and epibenthic biodiversity that supports the turtle population. This report is the first in what we intend to be an extended series of informal sea turtle reports for the Laguna San Ignacio Ecosystem Science Project, which brings together several subprojects, each focused on different aspects of this unique, fragile coastal ecosystem.

Research Objectives

Objective 1. Quantify the abundance of sea turtles in and around San Ignacio Lagoon. This objective is our contribution to ongoing monitoring being conducted by a large multi-institutional collaboration under the leadership of the Grupo Tortuguero de las Californias. Flipper tags are all individually coded, and data about capture and recapture of individual animals is recorded and submitted to a central database.

Objective 2. Determine sea turtle mortality rates and causes of mortality in the San Ignacio area. We will survey the beaches, desert and local landfill sites for carcasses to estimate how many turtles are being taken each year from, and how many are dying of natural causes in and around the lagoon. This will inform our assessment of the relative importance of habitat health in the lagoon area to turtle population trends. We will be looking to determine whether it is simply poaching and by-catch that is causing observed declines, or whether habitat degradation is also important.

Objective 3. Determine habitat utilisation patterns. It is known from local lore and incidental observations that the turtles make different use of the various parts of the lagoon. It is also known that the turtles use the lagoon primarily as a feeding and nursery area (Nichols 2003), though the details of what and how much they are eating still remain to be determined. Our objective is to quantify the turtles' use of each area in order to determine their relative conservation importance.

Objective 4. Determine the diet of black sea turtles in San Ignacio Lagoon. Black sea turtles are known to be primarily herbivorous as adults, but it is suspected that they are at least partly carnivorous as juveniles. Our objective is to determine the relative importance of each of the prey types in the turtles' diets in the lagoon.

Methods

Turtle capture

Turtles were captured with entanglement nets specifically designed for sea turtles. These nets have little weight on the lead line so entangled turtles can surface to breathe. Soaking time ranged from 10-

24 hours, and nets were monitored constantly for entangled turtles. Captured turtles were kept in the boat or in a shaded area and released at the capture location when the sampling was completed to allow for measurements to be completed and to avoid immediate recapture. Metal forester's calipers, small calipers and measuring tapes were used to measure straight carapace length and straight carapace width, curved carapace length and width, plastron length, total and partial tail length, to the nearest 0.1 cm. Weight was measured using a spring balance to the nearest kilogramme. Each turtle was examined for presence of fibropapilloma, parasites, injuries, and other signs of illness. After completing the measurements, turtles were tagged using metal Inconel tags (National Band and Tag Company, Newport, Kentucky), applied proximal and adjacent to the first large scale on each rear flipper (Balazs, 1999).

Turtle Mortality Surveys

Teams of staff and volunteers walked the beach along the south shore of the lagoon, where the prevailing winds tend to deposit turtle carcasses, and count what had washed up dead. Every turtle carcass encountered was examined for cause of death, measured and marked (spray painted). Additional surveys were done at sea, using a small open boat, and any floating dead turtle was likewise examined and marked.

Tracking using VHF/GPS tags

GPS-VHF telemetry was used to track turtles. The telemetry unit consist of a boat-shaped, floating unit (15 cm long, 7 cm diameter) containing a VHF transmitter, GPS unit, and battery pack. Tags were attached to the turtle using an 18 m monofilament line as a tether, and fixed to the carapace using a metal swivel set in epoxy cement (Brooks et al. 2003). VHF transmitters were 3 cm in length and 1 cm in diameter, and transmitted at 164-165 MHz. The GPS units (Sparkfun Electronics) recorded the position of the turtle every few minutes. Termination of the tracking period occurred when either the attachment broke under natural conditions, or the unit was removed from the turtle by pulling the monofilament line until it broke at the carapace attachment point.

TurtleCam

An underwater camera (Surf HERO: GoPro, Halfmoon Bay, CA) was built into a lightweight streamlined casing, which was equipped with a VHF transmitter, and affixed to the turtle using Trebor Extra strong mints, glued to the turtle's carapace using epoxy cement. The mints were included in the attachment to ensure the tag would release after a short while when the mint finally dissolved in the salt water. The camera tag was tethered to a VHF/GPS tag at the surface using the same weak-link monofilament attachment method.

Stable Isotope Analysis

Skin samples were obtained from the back of the turtles' necks (live and dead), rinsed in distilled water, and dried overnight in a 60C oven. Lipids were extracted from the samples using a petroleum ether mix and a soxhlet apparatus. The dried lipid samples were then combusted at 1000C and analysed using a continuous-flow isotope ratio mass spectrometer (Flash 1112 IRMS Delta C series EA Thermo Finnigan) at the Instituto de Investigaciones Oceanologicas, Universidad Autonoma de Baja California, in Ensenada. Samples of eelgrass, algae and invertebrates were also collected from various locations around the lagoon, washed in fresh water, dried in the oven, then pulverised, combusted at 1000C, then analysed in a continuous flow isotope ratio mass spectrometer at the University of California Stable Isotope Facility, Davis, California. Isotopic values are expressed relative to PeeDee Belemite (PDB) and Atmospheric Nitrogen (Air).

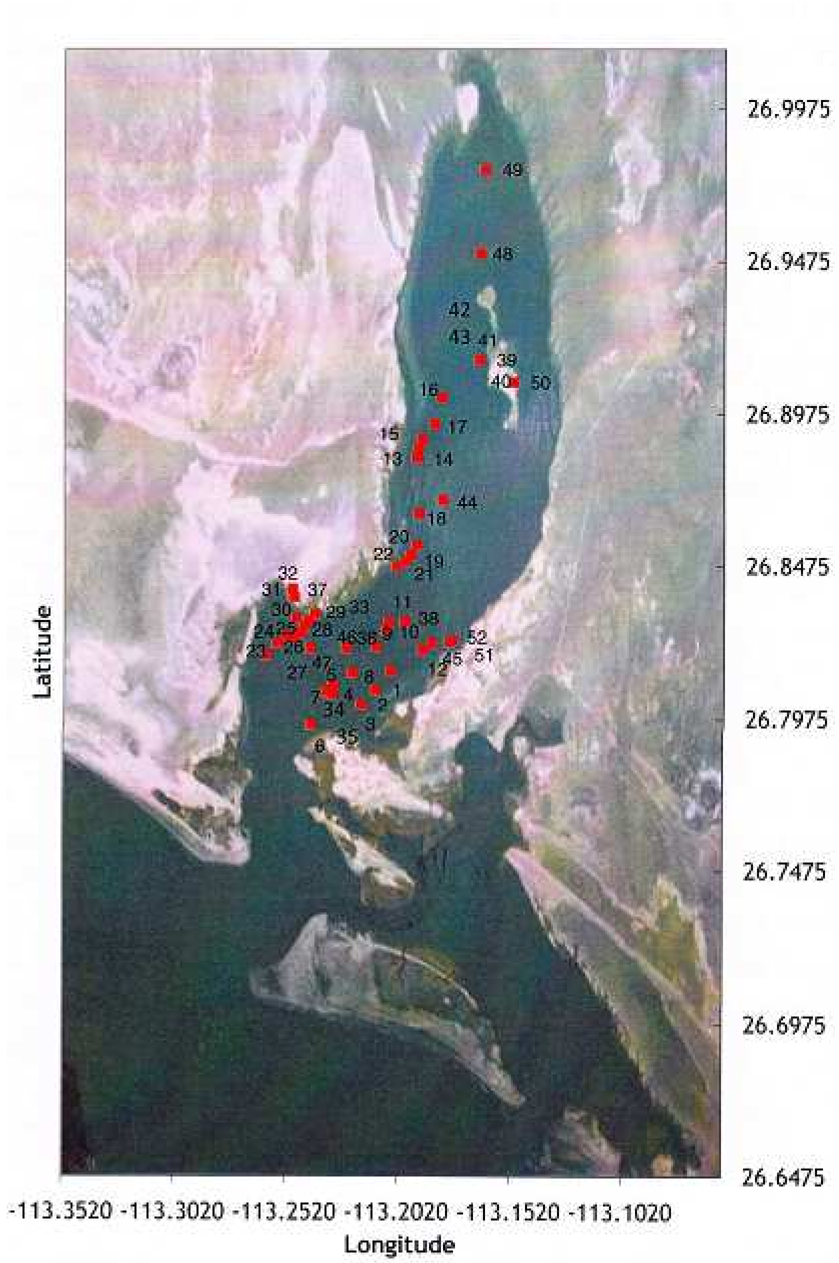

Figure 1. Eelgrass sampling sites, June 2008

Preliminary Results

VHF/GPS tracking

The 2008 summer field season was a frustrating one for the electronics team. Four tags were constructed, but one was flooded on its first deployment, and the other three only worked intermittently. Tags were deployed on 12 different individual turtles. One tag did record for over 24hrs, but the other deployments all malfunctioned in some way before a meaningful dataset could be obtained.

What is clear now, however, from several seasons of tracking turtles, is that the animals do not generally stray much from their capture sites, and that the areas at the northern end of the lagoon and east of Isla Pelicano are preferred sites.

TurtleCam

Due to the foreshortened field season and technical issues with the GPS tracking equipment, only two successful recordings were obtained using the prototype TurtleCam. Footage of breathing and swimming was obtained. Unfortunately the camera recording electronics were unable to record for long enough for the turtle to settle back into its natural pattern after the initial period of flight, and hence no observations of turtle feeding behaviour were made. Footage from the two recordings is posted on YouTube.com. The first, of turtle "Tolstoy" is at http://www.youtube.com/watch?v=Gowqqrj4Igs, while the second, of turtle "Trikki" is at http://www.youtube.com/watch?v=c7NU8y27eVA.

Mortality

Despite weekly beach walks throughout the month-long season, only two turtle carcasses were found on the south shore of the lagoon. Increase monitoring and enforcement efforts ensured that there were no illegal nets in the lagoon during the traditional guitarfish season, and hence the bycatch mortality was as good as non-existant.

Stable Isotopes

Figure 2 shows the stable isotope analysis results for eelgrass, sea pens, clams, barnacles, and sea turtles. It is obvious in the figure that there are two trophic levels in the prey items – they are quite distinct on the carbon axis, with eelgrass and algae forming one group, and the invertebrates the other. The turtle data crosses over between the two groups, suggesting that there are several feeding strategies present among the turtles in the lagoon – some are fairly obviously eelgrass consumers, while the rest likely have a more varied diet, which includes some non-negligible quantity of invertebrates. Our results do not show what type of invertebrate the turtles may be consuming, but they do show that in Laguna San Ignacio they are not the requisite eelgrass feeders the literature suggested they should be. Not shown here are the relationships with size and weight, none of which were significant. The only separation which might be present between the two feeding groups is that the live turtles in our sample were more likely to be eelgrass feeders, while the dead ones were primarily mixed diet animals. This suggests that there may be a bias in the guitarfish bycatch towards the latter animals, which makes sense in the light of where the guitarfish nets are set, namely in slightly deeper water, away from the eelgrass beds, which would be the areas where mixed-diet animals wold be transitting from one feeding area to another.

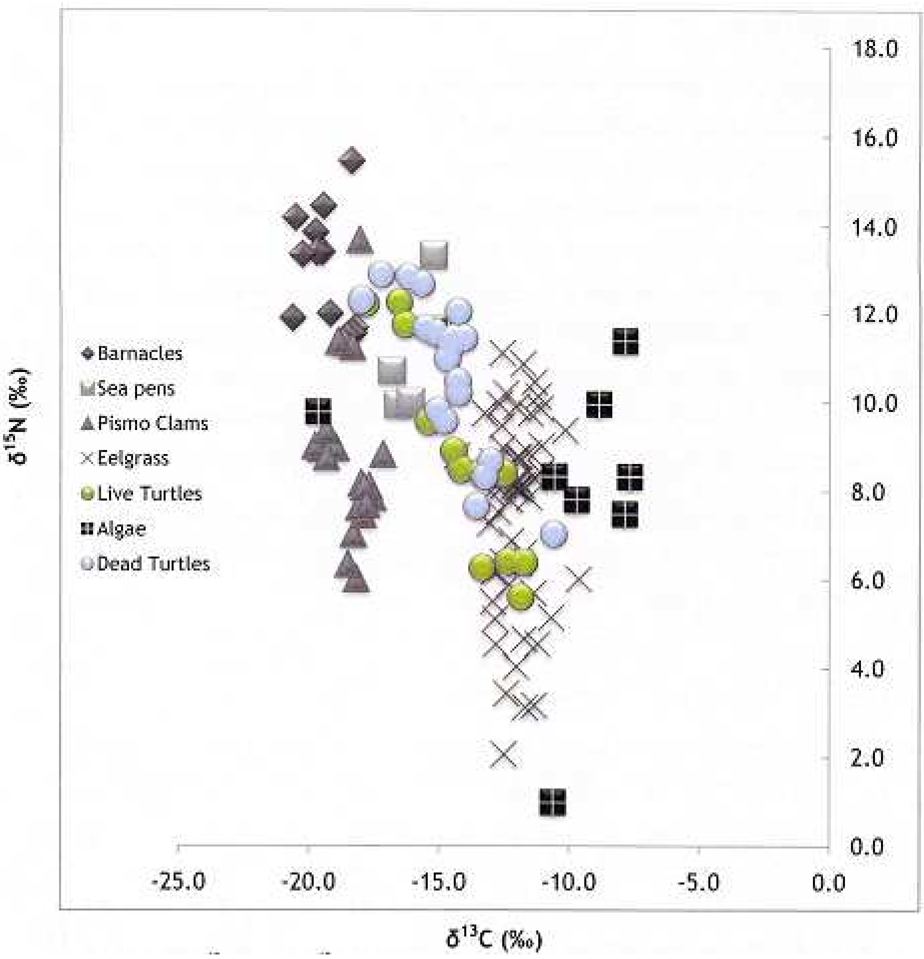

Figure 2. $\delta^{13}C$ versus $\delta^{15}N$ isotope levels of invertebrates, algae, eelgrass and sea turtles in Laguna San Ignacio, Mexico.

Discussion

The summer 2009 field season had to be foreshortened, in part due to the uncertainty caused by the H1N1 influenza scare in the spring of 2009, and as a consequence, there are not a lot of results to report.

The dead turtle discovery rate was down significantly on previous years, despite similar levels of survey effort. This was thanks to much reduced entanglements in fishing gear, which was in large part the result of increased vigilance on the part of the local authorities. From surveys of stranded animals in 2008, we estimated a total mortality of 962 sea turtles with a peak of 70% occurring during June. This high mortality was related to incidental fishery in set-nets used by fishers from San Ignacio fishing camps to illegally catch guitarfish and halibut (Koch and Mancini, 2009; Mancini and Koch, 2009). After this massive mortality, the Earthwatch team alerted local authorities which started a weekly patrol of the lagoon beginning in June 2009 (PROFEPA, pers. comm.). As a consequence, in 2009 only drift-nets were used to catch guitarfish which were checked every 30 minutes. This reduced significantly the number of stranded turtles that dropped from over 100 to only 2.

The 2009 VHF/GPS tracking effort was a disappointment. Equipment malfunctions plagued our efforts throughout the season this year, and we only have a single, incomplete track to show for it. The snippets of tracks that were obtained were entirely consistent with previous years, namely that the turtles don't move very much from their capture locations once the initial flight response has calmed down. Improvements to the tag design are already on the drawing board, and we expect a new set of tags to be ready, waterproof and test in plenty of time for the autumn field season.

The TurtleCam project is off to a good start. The simple technology applied during the 2009 summer season proved that it is possible to get footage from a free-swimming turtle, and that the tag can be deployed and recovered in a straightforward manner. The inexpensive release mechanism (using candies) worked, though improvements will obviously be necessary for the next season. The next prototype, already on the drawing board, will make use of the same camera, but include a larger memory card, so that more video can be recorded, and the timing circuit is being updated so that an initial delay can be included, to allow the turtle to get over the flight stage, and then a longer recording period can take place. Adjustments are also being made to the flotation of the camera buoy so that the turtle is not artificially brought to the surface by the buoyancy of the attachment.

The stable isotope analysis produced interesting results. There were no correlations with size, weight or capture location. It would seem therefore that there are two sympatric behavioural repertoires present in the lagoon turtles, namely a purely herbivorous repertoire, and a mixed-diet one. Interestingly the mixed-diet repertoire was more prevalent in the dead turtles and the herbivorous diet was the dominant one in the live captured ones. Our nets were set in and around eelgrass beds, while the guitarfish fishery concentrates on deeper water, so it is perhaps not surprising to see a difference in the feeding habits.

The observations raise more questions than they answer, and so our research will continue into the autumn this year, and into spring and autumn again next spring.

Publications

Refereed papers

Senko J, Lopez-Castro MC, Koch V, Nichols WJ (*in press*) Immature black turtles (*Chelonia mydas*) use multiple foraging areas off the Pacific coast of Baja California Sur, Mexico: first evidence from mark recapture data. ***Pacific Science***, accepted

Mancini A, Koch V (2009). Endangered species or local delicacy? Sea turtle consumption and black market trade in Baja California Sur, Mexico. ***Endangered Species Research*** **7**:1-10

Presentations

Koch V, Mancini A (2009). Does by catch mortality from artisanal gill-net fisheries present a major threat to endangered sea turtles? A case study from Northwest Mexico. Galapagos Science Symposium 2009, Puerto Ayora, Santa Cruz, Ecuador. 20-24th of July 2009

Senko J, Carthy R, Koch V, Megill WM, Templeton RP, Nichols WJ (2009) Fine scale diel movement and activity ranges of east Pacific green turtles at a coastal foraging area in Baja California Sur, Mexico. Poster presented to the 2009 International Sea Turtle Symposium, Brisbane, Australia.

Senko J, Koch V, Megill WM, Templeton RP, Mayoral R, Carthy R, Nickerson M, Nichols WJ (2008) Fine scale movement patterns of immature black turtles, Chelonia mydas, at a coastal foraging area in BCS, Mexico: Preliminary results. 2008 International Sea Turtle Symposium, Loreto, BCS, Mexico

Reports

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Kurth S, Megill WM, Yasue M (2007) Preliminary report on the epibenthic and benthic environment of San Ignacio Lagoon. Report prepared for the Laguna San Ignacio Wetlands Ecosystem Science Project. http://www.sanignacioecosystem.org/content/1/2/5.html

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Lewis AJ (2009) *The feeding ecology of black sea turtles (*Chelonia mydas*) in Laguna San Ignacio, Baja California Sur, Mexico.* MSc thesis, University of Bangor.

Senko J (in prep) Black sea turtles in San Ignacio. MSc thesis, University of Florida. (expected submission autumn 09)

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