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## **Head Injury Rehabilitation of Sea Turtles - The Positive Side of a Negative Conundrum**

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Sick and injured sea turtles from all over Greece are admitted to the Sea Turtle Rescue Centre (STRC) in Athens, for medical treatment, rehabilitation and release. Since establishment in 1994, 36 of the 113 sea turtles (*Caretta caretta* and *Chelonia mydas*) admitted have had traumatic head injuries. Another 24 exhibited old or healing head injuries secondary to another trauma. This indicates that over 50% of all sea turtles, which pass through the STRC,

have suffered from an injury to the head region, at some stage of their life. A turtle with trauma to the head region has a recovery chance of 46%, in contrast to 84% for turtles without trauma to the head region.

For each sea turtle admitted, information on size, weight, general physical condition and injuries is collected. Medical care, weight change, nutrition and behaviour are recorded during rehabilitation. The data, for head trauma

cases admitted from 1994 to 1998, have been analyzed to determine factors that may indicate survival, during the rehabilitation period.

**Factors That Determine Head Trauma Survival**

1. *Turtle size* affects head trauma survival, as indicated by the data (Fig.1). When the curved carapace length (CCL) is less than 50 cm, 78% of head trauma cases survive. Recovery is limited to 22% above CCL 50 cm. Juvenile turtles seem to adapt faster to a captive environment. This may be due to lower stress levels (Owens, 1996), and greater immuno-efficiency, in the absence of reproductive hormones (Rosenthal & Mader, 1996). Young turtles are much more responsive to treatment, which leads to a faster recovery. This combined with an increased growth rate allows faster healing. Adult turtles are easily stressed by all aspects of rehabilitation, which delays recovery.

2. *Weight change* of head trauma turtles that survived showed an average weight loss of 6% in the first two weeks and 1% in week three. Those that died had an average weight loss of 6% in week one, 18% in week two and 8% in week three. Head trauma turtles, (of equivalent CCL) on arrival had the same weight, but did not have the same fate. Weight of a turtle on arrival does not indicate survival chances, however weight change during the first three weeks could be used to indicate survival. Stress induced by captivity, causes voluntary fasting of turtles and subsequent weight loss, which leads to the inability to digest and utilize nutrients (Klingenberg, 1996). This results in immuno-suppression and a fall in metabolic rate, creating an opportunity for pathogenic invasion (Rosenthal & Mader, 1996) - which further stalls recovery.

3. *Location of the head injury* affects survival. 29% of head injuries occurred in the frontal region; 26% to the eyes and nares; 24% in the frontoparietal/parietal region; 21% to the temporal, post ocular and jaw regions. An injury located behind the midline of the frontoparietal scute (Fig.2, 'area.1') resulted in 100% death. Penetration of the cranial vault results in direct damage to the brain. If an injury occurs anterior to this region (Fig.2, 'area.2'), survival increases to 48%. In this area the brain is superficial, between the nares and eyes on the centreline, with no cranial vault protecting the optic and olfactory areas. There is a risk that injury in this region can cause permanent damage, with additional impairment at the cerebral or higher areas (personal communication R. George, DVM). If the injury is limited to the 'area 3' (Fig.2) there is 100% recovery chance. However if such an injury arises in combination with frontal/frontoparietal damage, survival is reduced.

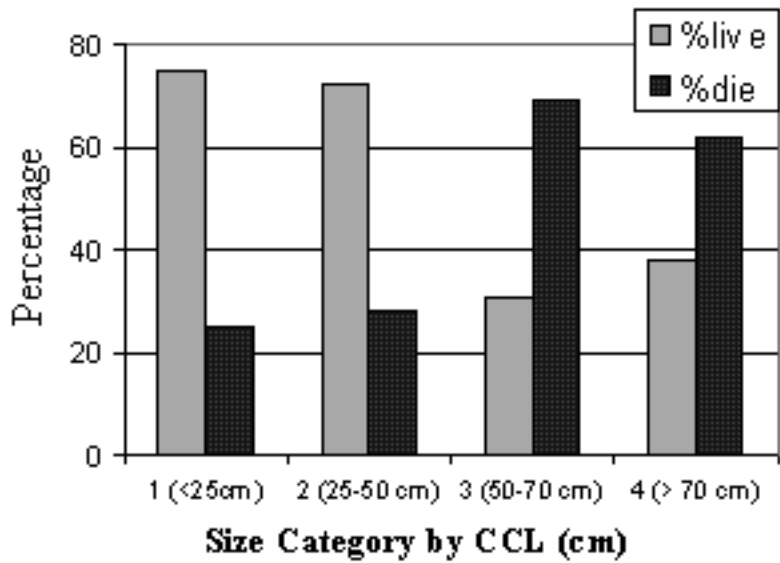


Figure 1. Head injury survival by size categories, 1994-1998.

4. *Additional injuries*, that occur before and after admittance for rehabilitation, such as epidermal lesions, provide primary routes for opportunistic pathogenic infection (George, 1996). Only 15% of turtles exhibited damage limited to the head region; 30% had one additional trauma type; while 55% had more than one trauma type. Such injuries include body or flipper lesions, carapace or plastron abrasion, or ingestion of foreign materials. 82% of STRC head trauma cases were initially unable to dive as a result of trauma or respiratory related problems. Of those that recovered, all regained their ability to dive and were released. 58% of head trauma cases expressed ocular infection or damage on arrival. All that recovered regained sufficient vision to be released. The extent of damage

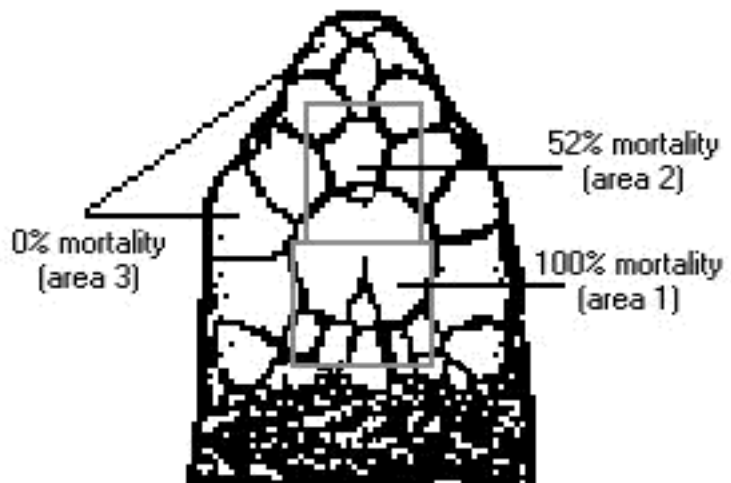


Figure 2. Acute and superficial head trauma areas of a loggerhead turtle.

caused by each additional injury has not been quantitatively evaluated here, nor the degree of susceptibility to pathogenic infection. *Pseudomonas* spp. is a gram-negative bacterium, which has been frequently isolated in head trauma cases at the STRC. It proves fatal if not identified and eliminated at an early stage. It initially appeared in cases as an ocular discharge, spreading to all epidermal surfaces and leads to extensive plastron degeneration. This environment allows the rapid establishment of respiratory disorders, which cause a high turtle mortality rate (Glazebrook *et al.*, 1993).

### Head Trauma Rehabilitation

Head trauma rehabilitation, at the STRC, takes 134 days on average. Death of a turtle occurred within the first 24 days. On arrival, head injury turtles are provided with effective medical and nutritional support to combat pathogenic invasion. Treatment includes a combination of intra-muscular systemic antibiotics, and topical antibiotics that are applied to the site of injury with a semi-permeable adhesive wound dressing, Tegaderm™. There is usually further deterioration of the tissues in the area surrounding the injury site. This is replaced by healing tissue, which eventually hardens into a new outer layer. This surface is usually darker and less smooth than the original tissue type. The turtle's epidermal surfaces are cleaned daily to avoid the body harboring and spreading infectious pathogens.

Surfaces with abrasions or lesions, ocular and nasal excretory surfaces, the oral cavity, urine and feces are monitored daily. If a change in color or texture of the epidermis, secretions or excreta occurs, microbiological analysis is used to identify and combat pathogens.

Radiographic evaluation and blood analysis are also important in evaluation of rehabilitation. Turtles are kept in seawater pools at a temperature range of 21°C to 29°C, which are sterilized daily with chlorine to reduce bacteria growth. A turtle that is weak and/or suffering from respiratory tract problems, is kept in minimum water or dry with seawater applied to the head (eyes and nares) and body at regular intervals. This avoids exhaustion of the turtle and possible drowning. Once the turtle's breathing improves and it is stronger it is placed in deeper water.

Head trauma turtles are initially given intracoelomic rehydration fluids. This also reduces the risk of damage to the renal portal system as dehydration increases the nephro-toxicity of drugs applied to help defend the body against pathogen invasion (Klingenberg, 1996). Depending on the size and stress levels of each turtle, they are placed on a liquid diet which is passed into the stomach via a tube (Campbell, 1996). If the turtle voluntarily swallows, a food bolus is placed at the back of the oral cavity. As the turtle recovers, aid in feeding is gradually reduced, until the turtle can eat without assistance. In this phase of recovery the turtle becomes more active with regular diving attempts, until it successfully rests on the bottom of the pool.

### Discussion

In 1998 the STRC successfully rehabilitated 46% of head trauma cases, which was double the success of all previous years combined. Analysis of head injury data collected from 1994 to 1998 indicates that success could be determined by:

- size of turtle, younger turtles had greater rehabilitation success
- weight change, in the first three weeks of treatment indicate survival
- injury location, in front of the frontoparietal midline gave increased recovery and
- additional injuries increase risk of pathogen infection and mortality.

An optimal environment is required for successful rehabilitation of head trauma cases. This includes the ability to provide optimum temperature levels, high nutritional provision, correct active and preventative medical care, in a low stress environment. These factors combined, aid recovery by increasing immunity and decreasing the risk of fatal infection by opportunistic pathogens.

Initial diagnostic evaluation of head trauma cases should not be used to conclusively determine each turtle's chance of survival, as there are a number of factors, which cannot be quantitatively assessed. Such factors include health and nutritional state of the turtle prior to injury, period of stranding before being found, depth of injury, degree of secondary injuries and susceptibility to infection. The rehabilitator must be able to assess the recovery progress of each turtle over a period of time, via weight analysis and response to drug therapy. A centre which can fulfill husbandry, sanitation and nutrition requirements for head trauma cases, can successfully rehabilitate and release sea turtles suffering from head trauma injuries into the wild.

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