Environmental Enrichment at ARCHELON's Sea Turtle Rescue Centre: Preliminary Results on Behaviour and Diving Condition

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Introduction

The term 'environmental enrichment' (EE) refers to the concept that describes how the environments of captive animals can be changed for the benefit of the inhabitants (Young 2003). It is a dynamic process, which is based on the animals' behavioural biology and natural history aiming to enhance their welfare (BHAG 1999). Specifically, the goals of implementing EE programmes are to increase the range or number of normal (i.e. wild) behaviour patterns, the behavioural diversity, the positive utilisation of the environment and the ability to cope with challenges as well as to reduce the frequency of abnormal behaviours (Shepherdson 1989; Chamove & Moodie 1990; Young 2003). Many different methods of EE can improve animal welfare, and five major types have been identified; social, occupational, physical, sensory and nutritional enrichment (Bloomsmith et al. 1991).

EE programmes have been mainly applied to mammals and birds, while studies on other taxa, for example reptiles, are falling behind (Bachetti et al. 2024). Research on some species which are wide-ranging and opportunistic feeders shows that they are liable to develop abnormal behavioural patterns when confined, such as stereotypic swimming or pacing (Carlstead et al. 1991; Kreger et al. 1998), as well as self-mutilation behaviour (Burghardt et al. 1996). In captivity, it has been suggested that sea turtles can often develop stereotypical swimming patterns (Higgins 2003). Therefore, sea turtles in aquariums and rehabilitation centres should be provided with opportunities to display their natural behaviours. Furthermore, they may have special needs due to previous or current injuries or diseases. These needs should be addressed to create a safe and healthy environment for them and EE can contribute towards this. For all the above-mentioned reasons, EE is recommended for improving sea turtle welfare and reducing stereotypic behaviours in captivity (USFWS 2019). However, little information exists on the effectiveness of EE to sea turtles undergoing rehabilitation (Diggins et al. 2022; Escobedo-Bonilla et al. 2022). Consequently, EE programmes and studies of their effectiveness on sea turtles in aquaria and rehabilitation centres are vital.

Objectives of the EE research project at ARCHELON's Sea Turtle Rescue Centre (STRC): The first scientifically designed project with a detailed recording of EE's effects on sea turtles at ARCHELON's STRC ran for two consecutive years (2016 and 2017) during the releasing period (i.e. usually May to December). The objectives of this research project were:

I. To determine potential behavioural effects of deployed environmental enrichment devices (EEDs).
II. To determine if there is a decrease in interest and habituation to the EEDs.
III. To determine if EEDs can act as diving motivators in order to ascertain a potential effect on turtle diving condition, as well as a potential way of assessing the level of their problem in diving.

The research project was focused only on sea turtles that were on the final stage of rehabilitation. This was decided in order to avoid causing potential stress to the individuals that still had a lengthy rehabilitation period ahead of them. Several turtles that experienced no other symptoms than problems in their diving

ability were also included in the study since they were considered as candidates for release.

Methodology

Overview of the project plan and data collection: The project's duration was four months (August – December) during the first year and two months (August – October) during the second year. In this article, we present a subset of 4 out of 17 study loggerhead sea turtles (*Caretta caretta*) all of which were recovering from head injuries. We collected data using waterproof cameras on tripods that were placed near the tanks where the individuals were kept. Data were collected during the morning, before the start of the rehabilitation routine. Specifically, the sessions started exactly 30 min after the sunrise each day. The purpose of this was to have a fixed recording period that was not based on time but on daylight conditions, since it is known that sea turtles are sensitive to them (Kamrowski et al. 2012). For each turtle that was part of the project, the first 20-minute recording session was without EE (under ordinary conditions) followed immediately by a 20-minute session with the EED placed in the tank (Young 2003; Therrien et al. 2007).

The EE programme: Three different EEDs were presented to each turtle that was part of the study; a surface-floating wooden platform, a mid-water floating plastic ball tied to a small rock and a non-buoyant PVC pipe with small holes where food was placed (Fig. 1). These devices were designed to be species-specific through the consideration of previous studies (Therrien et al. 2007; Lloyd et al. 2012) and the different types of EE (Young 2003). Each EED was presented for five consecutive days to every turtle. Consequently, 15 days were required to present all three items to each turtle. The EE programme was aligned to the 17 days a turtle was kept in a large, pre-release, tank, as defined by relevant protocols. The turtle was allowed to acclimate to the tank for two days before the EE trials were initiated. Furthermore, the tanks' water inflows were turned off during data recording sessions since they could act as tactile EE because of their resemblance to "waterfalls" (Therrien et al. 2007; Lloyd et al. 2012). All devices were chlorinated and cleaned when they were presented to a different turtle in order to avoid potential transmission of microorganisms. The EEDs were tested safe to use with turtles prior to the trials taking place.

Data analysis: In order to record turtle behaviour, focal sampling was used as a sampling rule with continuous data recording (Martin & Bateson 2007). To prevent bias, the order in which the items were presented to the individuals was based on a pseudo-randomised setup. Two 20-minute sessions for 15 days provided a 10-hour dataset for each turtle from which the behavioural data was analysed, and behavioural categories were defined (Therrien et al. 2007) (Table 1). Behavioural categories "Orientation" and "Focused behaviour" were observable only when EE was present. For every session, the total amount of time spent in each of the categorised behaviours was determined. The recordings were analysed using the INTERACT programme (INTERACT®8.1, Mangold International, Amstorf, Germany). The total time spent in each behavioural category for all the turtles that were part of the analysis was combined and then each category was compared in the presence and absence of EE. In addition, the total time recorded as Focused behaviour was compared between the first (Day 1) and the fifth (Day 5) day that the same EED was presented to the turtles.

Table 1. Behavioural categories and their definition

Behavioural Categories	Definition
Resting	Periods of inactivity - turtle remains at the same place, all 4 flippers not moving, considering it after 30 seconds
Random Swimming	Turtle swims in ways other than pattern swimming
Pattern Swimming	Swimming in repetitive patterns, considering it after the 3rd repetition
Repetitive behaviour	A repetitive, invariant behavioural pattern with no obvious goal or function, considering it after the 3rd repetition
Focused behaviour	Turtle comes into contact with the devices and investigates them
Orientation	Turtle orients towards device through a directed movement that is in line with the item but not coming into contact with it
Diving	Head and part of the carapace underwater along with movement of front flippers and inclination towards front
Out of sight	Any time the animal is not seen during the recordings
Non-categorised behaviour	Any time the animal is not involved in a defined behaviour

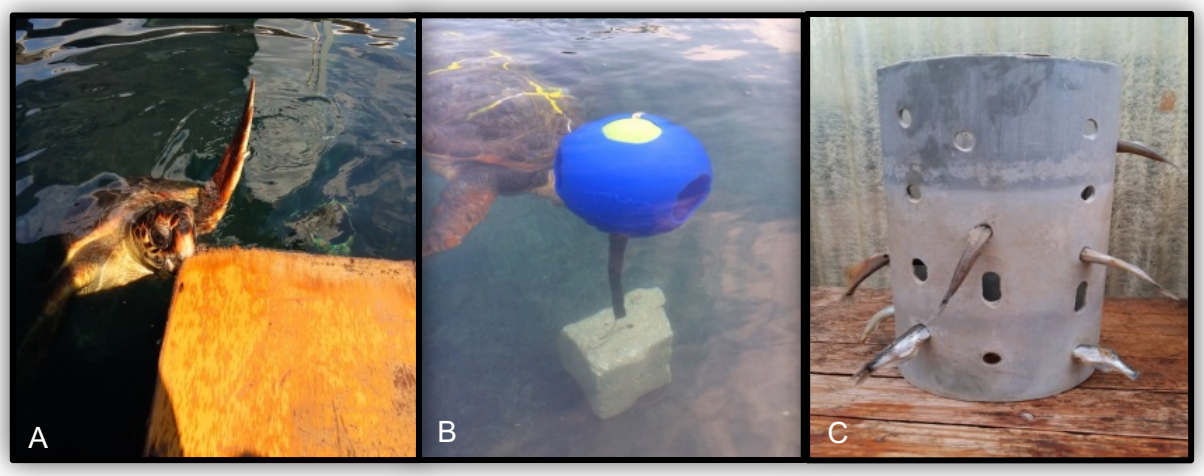

Figure 1. The EEDs that were used in the research project. A: wooden platform. B: ball tied to rock C: PVC pipe with holes where the food was placed.

Data regarding turtle diving condition was also analysed from the recordings. Dive attempts were defined by the proportion of the carapace length that was underwater during the attempts. The carapaces of all the turtles that took part in the study were divided into four equal parts and marked with yellow paint to aid quantification of the dive attempt. The paint was used was ecological, unscented and water based (Smaltolux Hydro – ecological polyurethane acrylic water-based enamel). To examine if the EE can be used as a potential motive to dive, the total number as well as the duration of diving attempts was determined. These data were compared between the sessions with and without EE.

Statistical analysis: The total time spent (in seconds), the percentages of the duration and the mean values were calculated for each behavioural category for all four sea turtles. Only descriptive statistics are presented due to the small sample size in the subsample of turtles included herein.

Results

Effect of EE in sea turtle behaviour: The total time spent in each behavioural category was combined for all the turtles that were part of the analysis in order to compare each category in the absence and presence of EE and determine the behavioural effect of EE. In the absence of EE random swimming was the behavioural category with the highest percentage

(62.4%), compared to focused behaviour (45.0%) in the presence of EE (Fig. 2). When EE was present, resting and repetitive behaviour were not recorded (0%) while pattern swimming was considerably low (less than 0.1%) compared to the percentage of this behavioural category when EE was not present (5.5%) (Fig. 2). Mean duration of the behavioural categories varied dramatically between turtles in the presence or absence of EE (Fig. 2).

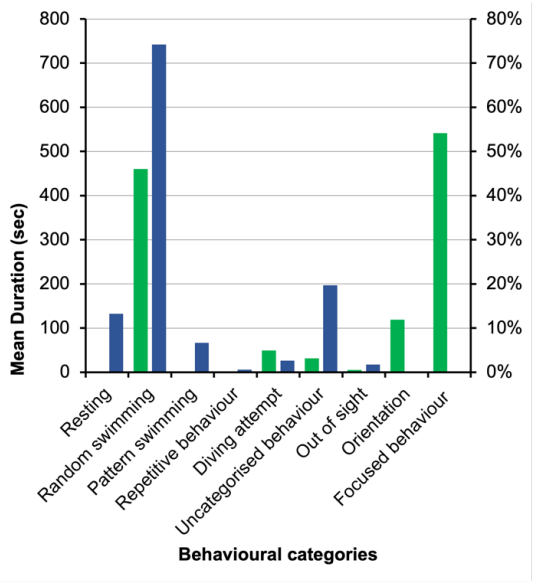

Figure 2. The mean duration and percentage of time of each behavioural category in the absence and presence of EE. Green bars = with EE. Blue bars = without EE.

Focused behaviour when presenting the same EE: The total time recorded as focused behaviour exhibited by the turtles was calculated for the five consecutive days that the same EED was presented to them (Fig. 3). Regarding the ball and the pipe, focused behaviour was less on the fifth day than the first, whereas the opposite was true for the platform. However, the changes in behaviour did not display consistent daily trends (Fig. 3).

Number and duration of diving attempts: The total number of diving attempts when the EE was present (n = 455) was more than double compared to when EE was absent (n = 195). The duration of the diving attempts was almost double in the sessions with the EEDs (2911 s) compared to the duration in the sessions without the EEDs (1516 s).

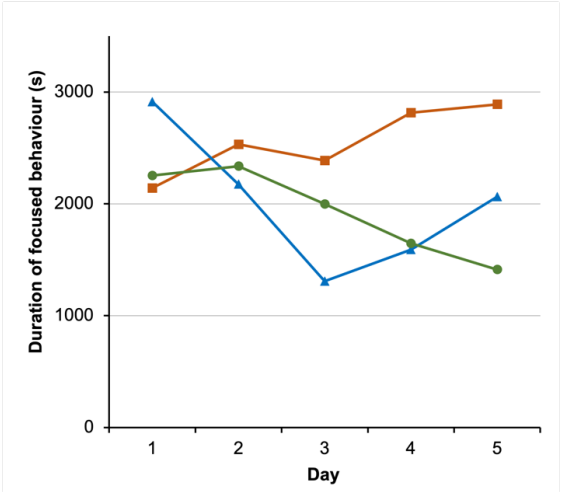

Figure 3. Average daily duration of focused behaviour in sea turtles towards each enrichment item that was presented for five consecutive days. Squares = Platform. Triangles = Ball tied to rock. Circles = Pipe with food.

Discussion

Assessment of the effect of EE on sea turtle behaviour: The results indicate that the EE has a positive effect in the behaviour of sea turtles. No resting and no repetitive behaviours were observed during the sessions with EE. Moreover, the duration of the pattern swimming was considerably low in EE sessions compared to the sessions without EE. Focused behaviour, which was observable only when EE was present, indicated that almost half of the recording time the sea turtles were interacting with the EE items. So far, all these findings suggest that EE influences the behaviour of sea turtles in a positive way; they become much more active, they want to investigate the EE items, be in contact with them and try to manipulate them. All the above led to the display of natural behaviours of sea turtles. Similar results are found in the limited published research studies on EE on sea turtles so far (Therrien et al. 2007; Lloyd et al. 2012). The main findings in this study were that resting and stereotyped 'pattern' swimming decreased, while random swimming as well as behaviour directed at

the EE objects and other features of the tank increased. Further research is required though to thoroughly understand the effect of EE on sea turtle behaviour.

In addition, the duration of repetitive behaviour in the current study should not be overlooked even though it may seem like the turtles engaged in this behaviour for only small amount of time. It is not possible to estimate how often repetitive behaviour actually occurred due to the limited duration of data collection per day. Repetitive and invariant behavioural patterns, with no obvious function or goal, are often defined as stereotypical (Mason 1991). At a population level, such behaviours are commonly thought to indicate poor welfare, since they are developed in situations where an animal may be frustrated, stressed, fearful, restrained or lacking stimulation and higher incidence is usually seen in environments where other indicators of poor welfare co-occur (Mason 1991). However, at an individual level, within a given environment, stereotypies often occur in individuals that show fewer concurrent symptoms of poor welfare than their non-stereotyping counterparts, as their performance may help animals to cope (Mason & Lanthan 2004).

Assessment of the level of interest when presenting the same EED: EEDs directed behaviour changed over consecutive days of presentation. The wooden platform was subject to increased focused behaviour over time. The turtles were mainly displaying comfort behaviour, especially self-cleaning through repetitive scratching and rubbing of their heads, flippers and carapace against the platform. This behaviour has been observed and detected in the wild, where sea turtles are actively removing epibiota, such as barnacles and algae, by scratching themselves against submerged rocks or anchors (Schofield et al. 2006). Therefore, the use of the wooden platform as an EED encouraged the display of apparently natural behaviours, and consequently it may have contributed to the improvement of the turtles' overall welfare. The current study suggests there was no significant decrease in the level of interest or habituation towards each EED. There are no previous studies focusing on these aspects, which is understandable given there is limited knowledge on many behavioural aspects of sea turtles. Further research is required on the long-term use of EE in sea turtles in a larger number of individuals.

Assessment of the use of EE as a potential motive for diving attempts: The majority of the sea turtle patients at the STRC are recovering from deliberately inflicted head traumas. Observations indicate that they experience different levels of difficulty in diving due to neurological damage. This phenomenon led to the idea of using EEDs as a potential motive for these individuals to dive. The results included in this article suggest that EE can be used as a motive for the sea turtles to dive. The number of diving attempts when the EE was present was more than double compared to when EE was absent. Similarly, the duration of the diving attempts was almost double in the sessions with the EEDs compared to the sessions without them. Apart from diving, the EEDs used in this study provided the sea turtles with opportunities to exercise their motor patterns and muscle tone, as has been observed in previous studies (Therrien et al. 2007; Monreal-Pawlowsky et al. 2017). Furthermore, the detailed information about the individuals and their diving condition, obtained through the recordings, was incorporated into decisions regarding their release. There is no prior study on the use of EE as a potential motive for diving attempts in sea turtles and therefore further research is required.

Incorporation of EE into rehabilitation routine and future directions: Throughout the period of EE observations in 2016 and 2017 at ARCHELON's STRC, detailed information was obtained about 17 sea turtles and their diving condition. This proved useful, and behavioural observations were incorporated into decisions regarding an individual's

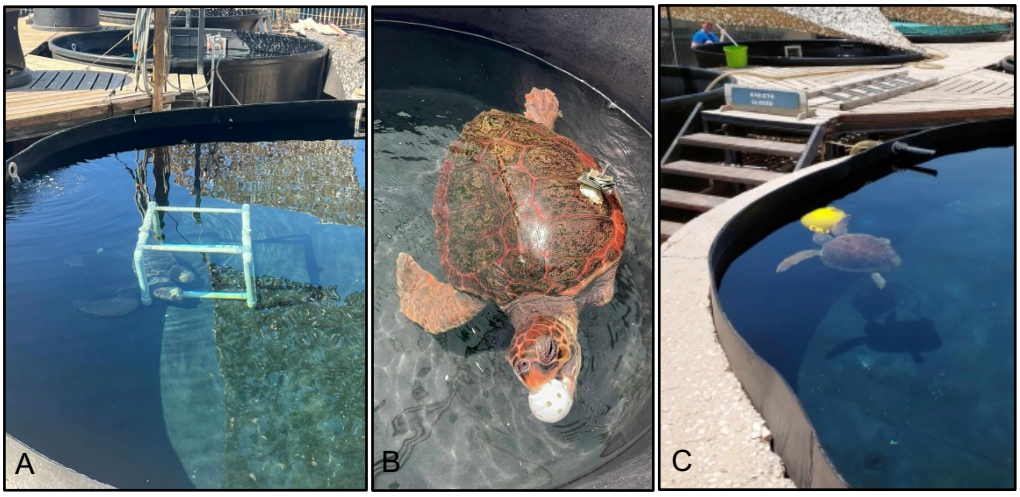

Figure 4. Additional EEDs that have been used over the years at the STRC. A: Formation of PVC pipes, B: Small feeding balls, C: Bigger feeding balls.

release. Furthermore, the conclusions drawn from the study led to EED being integrated into the daily routine of rehabilitation. Rehabilitation staff and volunteers at the STRC have subsequently been continuously utilising EE, but also designing and implementing additional EEDs depending on the needs of the sea turtle patients. PVC frames and difference sized feeding balls are some examples of EEDs that have been used (Fig. 4). Consequently, EE contributes to the promotion of sea turtle welfare as well as to their management at the STRC.

Conclusion

In summary, EE is not an extra benefit that we may choose to provide as a luxury; it is essential for proper management, even for reptiles (Burghardt 2013). Although most research regarding EE is focused on mammals and birds, EE programmes are vital for reptiles too. Their need for stimulation, their individual and species level temperament and personality differences, as well as their cognitive and learning capacities should not be underestimated (Burghardt 2013). Through the systematic observation and experimentation in EE studies like this one, the best ways to enhance the lives of reptiles can be examined. This knowledge can be beneficial not only for animals in captivity but also for animals in conservation efforts (Alberts 2007). The authors hope that the information derived from the use of EE as a potential motive for diving can be helpful for other rehabilitation centres worldwide, where sea turtles may experience diving problems, particularly due to neurological damage that is caused by head traumas.

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