



TRANSPORTATION, HUSBANDARY, AND RELEASE OF A WHALE SHARK (RHINCODON TYPUS)

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Acknowledgements

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TRANSPORTATION, HUSBANDARY, AND RELEASE OF A WHALE SHARK (*RHINCODON TYPUS*)

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Key words: animal release, aquarium, behavior, husbandry, whale shark.

ABSTRACT

The National Museum of Marine Biology and Aquarium of Taiwan housed a whale shark in a 3.7 million liter indoor oval tank from June 2005 until July 2013, at which point it was released. This study reports the transport of the whale shark into and out of the Museum, its husbandry conditions, feeding regime, growth during captivity, and details on the release of the animal. During the eight years in captivity, the animal grew from 2.3 to 7.8 m in length and from 200 to 3,600 kg in weight when released, with estimated overall growth rates of 0.67 m yr⁻¹ and 412 kg yr⁻¹ in length and mass, respectively. The animal beached shortly after release, possibly due to having acclimated to life in captivity. Therefore, detailed behavioral knowledge is needed for future releases of animals that have been maintained in captivity for extended periods.

I. INTRODUCTION

The display of large animals has been a focal point of modern aquaria worldwide. The Okinawa Churaumi Aquarium (formerly the Okinawa Expo Aquarium) first exhibited whale sharks (*Rhincodon typus*) to visitors in 1982, and other aquaria followed suit, including the Osaka Aquarium Kayukan, Taiwan's National Museum of Marine Biology and Aquarium (NMMBA), and the Georgia Aquarium (USA), among others. An impressive school of giant manta rays (*Manta birostris*)

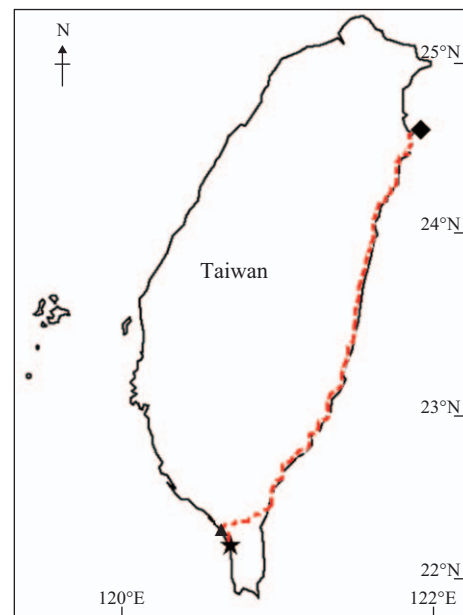


Fig. 1. Transportation of the whale shark from northeastern to southwestern Taiwan by truck (dashed line, representing a 380-km distance). ◆: Set-net location. ★: National Museum of Marine Biology and Aquarium. ▲: Release location.

was displayed in the Okinawa Churaumi Aquarium in November 2002, followed by the Oceanário de Lisboa in Portugal. Great white sharks (*Carcharodon carcharias*) were even put on exhibit in the Monterey Bay Aquarium (USA) in 2004. The largest bony fish, the ocean sunfish (*Mola mola*), is currently displayed in aquaria such as the Oceanário de Lisboa and the North Sea Oceanarium in Denmark. Transportation of these animals from where they were caught to the aquaria at which they were housed and reared/exhibited often requires careful planning and special equipment and techniques (Uchida, 1982; Correia, 2001; Correia et al., 2008; Correia et al., 2011; Rodrigues et al., 2013) because some of these animals commonly perish during transportation or shortly thereafter (Smith et al., 2004).

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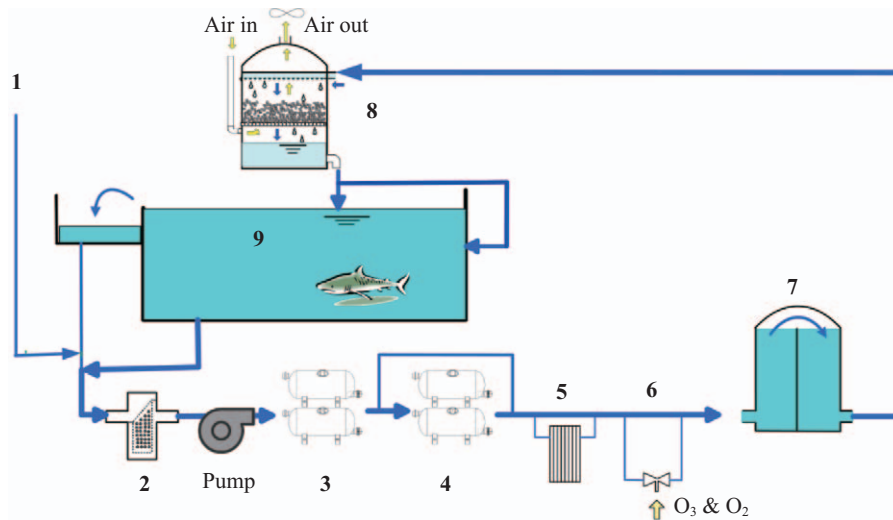


Fig. 2. General design of the life support system used for the “Open Ocean” animals’ exhibition of Taiwan’s National Museum of Marine Biology and Aquarium. 1. Makeup water from pump station. On average, 30% of the tank water is turned over daily. 2. “Pro-Filter” to filter large particles. 3. High-pressure sand filter to filter small particles. 4. Active carbon filter to absorb excess oxidants after ozone treatment. 5. Heat exchanger to control water temperature. 6. “Ventri” unit where oxygen and ozone are added. 7. Tank for mixing ozone and seawater. 8. De-gassing tank to eliminate excess CO₂ and increase oxygen saturation. 9. “Open Ocean” Tank (volume = 3.7 million liters).

Taiwan’s NMMBA was built and operated by the government in February 2000, but the exhibition halls were soon leased to a private company (Hi-Scene Co.). On 26 June, 2005, a male whale shark was caught in a set-net located at Nan-Fang-Ao of Yilan county, northeast Taiwan (Fig. 1). After careful consideration, Hi-Scene Co. purchased and exhibited the animal in the “Open Ocean” Tank, a 3.7 million liter indoor cylindrical tank housed at the NMMBA (Fig. 2).

In July 2001, The Fishery Agency of Taiwan requested that all fishermen report the catch of whale sharks around Taiwanese waters. After the animal was listed in Appendix II by CITES in 2002 (Appendix II includes species not necessarily threatened by extinction, but in which trade must be controlled), the Fishery Agency began a restriction on the total annual number of whale sharks caught in July 2002. In 2008, the catch, possession, and trade of whale sharks were completely prohibited in Taiwan. Since then, the NMMBA was under constant pressure, both from politicians and animal welfare organizations, to release the captive whale shark back into the ocean.

Between March and July 2013, thirteen meetings were held at the NMMBA, plus one meeting organized by politicians and animal welfare organizations, concerning the release of the whale shark. The personnel participated, equipment, training, simulation of the release, as well as the tentative schedule of release were arranged and determined during these meetings. The final release spot (Fig. 1) was determined because it has been a common site where whale sharks were seen or caught in the past. On 10 July, 2013, after eight years in captivity, the whale shark was finally released into the wild.

Whale sharks have been exhibited in some large aquaria worldwide, such as the Georgia Aquarium, the Okinawa

Churaumi Aquarium, and the Yantai Aquarium in China, to name a few. However, no scientific reports on their husbandry conditions have been published. Since it is considered a vulnerable species by the International Union for Conservation of Nature (IUCN), we believe that providing information on its husbandry condition will enhance the animal’s survival in captivity in other aquaria. Thus, the current report documents the transport of the whale shark from capture to the Museum, its environmental conditions while in captivity, its feeding regime and growth during captivity, and, finally, its ultimate release into the wild.

II. TRANSPORTATION

The 2.3-m long male whale shark described above was moved from the set-net in northeastern Taiwan to a nearby circular cage where it could feed on naturally occurring zooplankton. After positioning the required equipment in place, transportation of the animal from the set-net to the Museum began. Since sharks can easily perish during transportation or shortly thereafter (Smith et al., 2004), the equipment needed for the transportation was carefully prepared. In the evening of 27 June, 2005, the animal was removed from the cage using a non-abrasive vinyl stretcher and transported ashore in a fiberglass reinforced plastics (FRP) container (5 × 2.5 × 1 m) fully filled with seawater. The trip to shore took approximately 30 min. The FRP container was then loaded onto a truck and moved to the Museum by road. The trip from the port to the Museum was 380 km and lasted 10 hrs, during which fresh seawater was pumped three times directly from the nearby seashore. This exchange of fresh seawater minimized the risk of ammonia build-up and decreased pH value

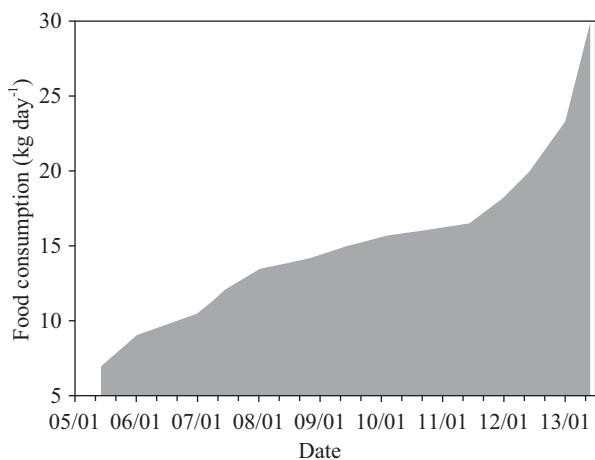


Fig. 3. Daily food consumption of the whale shark in captivity between June 2005 and June 2013.

during transportation, which could have resulted from the release of nitrogenous wastes and carbon dioxide, respectively (Correia et al., 2008; Rodrigues et al., 2013). Since the access to fresh seawater was available, we did not add buffering agents such as baking soda (i.e., sodium bicarbonate- NaHCO_3) and/or soda ash (i.e., sodium carbonate- Na_2CO_3) to control pH, nor did we add quenching agents to remove ammonia, as suggested by Rodrigues et al. (2013).

While in transportation, the animal, equipment, and water quality (i.e. dissolved oxygen, pH value, and temperature) were checked approximately every 2-3 hrs. During the whole transportation period, oxygen was pumped to the water from a compressed oxygen cylinder via an airstone, and the dissolved oxygen was maintained above 100% saturation. When the whale shark arrived at the Museum, the container was moved directly into the Open Ocean Tank. The container was slowly pushed on one side by divers to submerge it into the water, and the whale shark was allowed to swim out into the tank. The tank (32 m long \times 22 m wide \times 9 m high) was connected in parallel to a recirculation system composed of a pro-filter equipped with high pressure sand filters, active carbon filters, a heat exchanger, an ozone content tank and a de-gassing tank (Fig. 2).

III. HUSBANDARY

During captivity, the whale shark was primarily fed with small, frozen Antarctic krill (*Euphausia superba*, 40%) and sergestid shrimp (*Acetes intermedius*, 30%), as well as processed fish and shrimp; sardines (*Sardinella* spp., 10%), mackerels (*Scomber* spp., 10%), and spear shrimp (*Parapenaeus hardwickii*, 10%) were amongst these processed fish and shrimp. During each meal, water was gently splashed onto the surface of the tank with a metal scoop to alert the animal (Leu et al., 1996). When the animal was in position, food was dumped into the water close to its mouth. The animal was fed twice daily (1000 hr and 1500 hr), and the daily amount

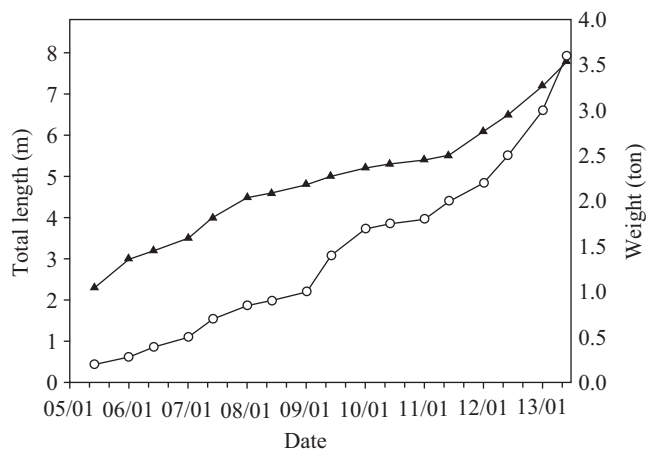


Fig. 4. Total length (closed triangle) and weight (open circle) of the whale shark in captivity between June 2005 and June 2013.

of food consumed over the eight-year period is shown in Fig. 3.

The whale shark when arrived at the Museum was 2.3 m long and weighed 200 kg. After spending more than eight years in captivity, it grew to a total length of 7.8 m and weighed 3,600 kg (Fig. 4) when released. There was an estimated overall growth rate of 0.67 m yr^{-1} and 412 kg yr^{-1} in length and weight, respectively. Though these data are from only one individual, the growth rate was ~ 2 -fold higher than that of whale sharks reared in the Okinawa Churaumi Aquarium (average growth of 0.34 m yr^{-1} , $N = 33$ whale shark, Dr. Senzo Uchida, personal communication).

The water temperature in the tank was maintained between 22.79 and 29.07°C , with an average of 26.21°C (± 0.95 S.D., Fig. 5). Salinity fluctuated between 29.53 and 34.99 psu, with an average of 33.51 psu (± 0.70 S.D.). The pH level was lower than that of the ambient seawater, averaging only 7.71 (± 0.12 S.D.), whereas the percent dissolved oxygen was maintained normally 100% (average $101.47\% \pm 4.45$ S.D.) during the entire period (Fig. 5). These physical parameters were measured daily between 10:00 and 11:00 hr.

A more detail analysis of the seawater in the whale shark's tank was conducted biweekly. Ammonia concentration [NH_3] was below $0.1 \mu\text{g L}^{-1}$ (average 0.04 ± 0.05 S.D. $\mu\text{g L}^{-1}$) most of the time, but rose as high as $0.4 \mu\text{g L}^{-1}$ on two occasions during the typhoon season (Fig. 6) when the exchange of seawater was shut down due to very high turbidity in the ambient seawater. Nitrite concentration [NO_2] averaged 0.004 ± 0.006 S.D. $\mu\text{g L}^{-1}$ and was below $0.01 \mu\text{g L}^{-1}$ for the majority of the sampling time. The concentrations of nitrate [NO_3] and phosphate [PO_4] fluctuated over wider ranges (Fig. 6): 0.12 - $1.59 \mu\text{g L}^{-1}$ (average 0.65 ± 0.27 S.D. $\mu\text{g L}^{-1}$) and 0.01 - $0.84 \mu\text{g L}^{-1}$ (average 0.27 ± 0.14 S.D. $\mu\text{g L}^{-1}$), respectively.

IV. ANIMAL RELEASE

At 01:00 hr local time on 10 July, 2013, the whale shark

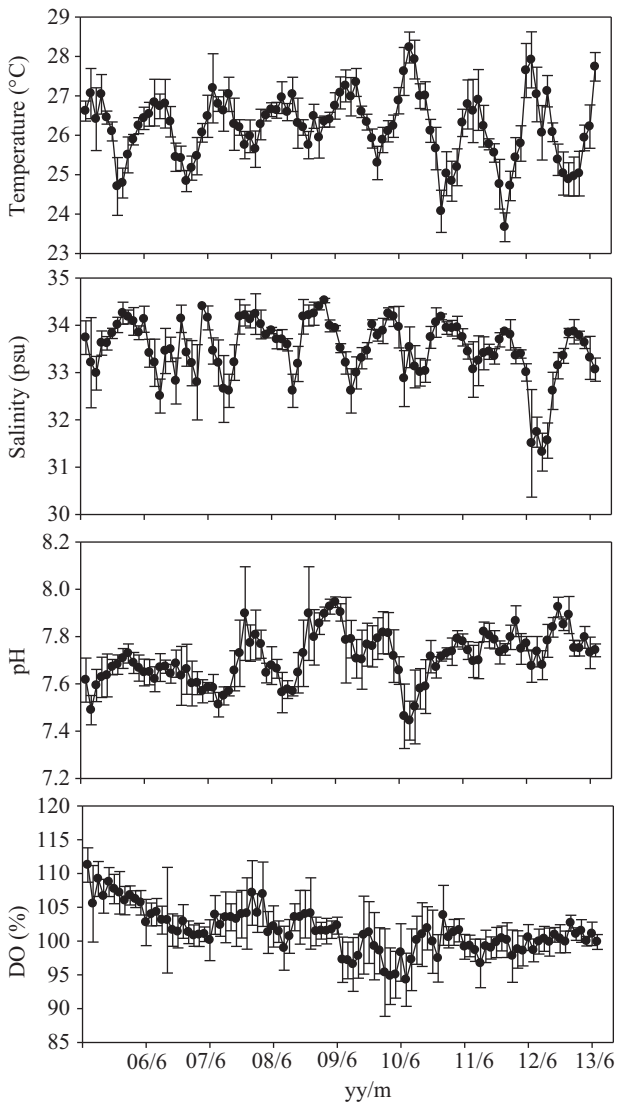


Fig. 5. Monthly mean (\pm SD) of the seawater quality parameters of the whale shark husbandry tank between June 2005 and June 2013.

was removed from the tank using a nonabrasive vinyl stretcher and transported to a FRP container ($8 \times 2.5 \times 1$ m) fully filled with seawater for release. The container was then loaded onto a truck and moved to a nearby fishing port 40 min from the Museum (Fig. 1). Oxygen was pumped into the water and maintained above 100% saturation using a compressed oxygen cylinder and airstone during the journey. The animal was transferred into an outdoor cage upon arrival at the port, and a boat slowly moved the cage into the ocean two nautical miles from the shore. The cage was then lacerated by divers and the whale shark swam out of the cage and into the open ocean at 05:05 hr. However, 30 min later, the animal was spotted swimming in circles less than 100 m from the coast. Helped by a raft, the animal was moved to three nautical miles from the coast. During the second release, the animal was lively and dove into the deep after some degree of circling on the surface. However, five hours after the second release, the

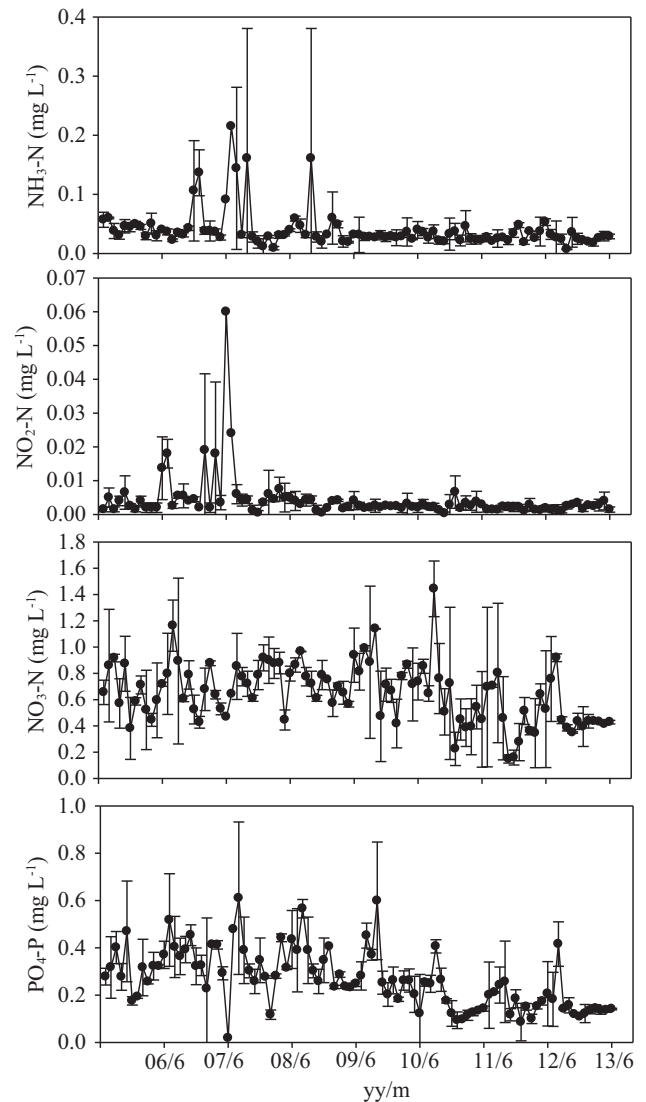


Fig. 6. Monthly mean (\pm SD) of the nutrient levels in the whale shark husbandry tank between June 2005 and June 2013.

coast guard informed us that the whale shark had stranded a few kilometers from the Museum. Although there were multiple abrasions on the body and the shark appeared weak, the veterinarians in the field concluded that the shark had a better chance of surviving if it was sent back to the ocean rather than to the aquarium. The animal was kept wet by continuously pouring water on its body and into its mouth during the beaching period. Aided by a raft, the animal was pulled back into the water during high tide. At 15:20 hr, the animal was once again released, this time at four nautical miles from the shore.

V. CONCLUSIONS

Of all the whale sharks in captivity worldwide, we are the first to report the seawater quality and feeding regime parameters that, in part, allowed for its continued growth over a

multi-year time period. Temperature and salinity in the tank fluctuated concurrently with the incoming coastal water, while the pH was lower than the natural seawater, possibly due to the slow accumulation of organic matter over the years. The growth of the animal under our feeding regime was greater than those kept in the Okinawa Churaumi Aquarium, possibly suggesting that the fish+shrimp diet may also be suitable for whale sharks in other aquaria.

The release of the animal was ultimately unsuccessful. The technical and mechanical steps proceeded satisfactorily, but the behavior of the animal was not considered thoroughly before its release. Although whale sharks have been spotted about two nautical miles from the coast in this area, and reportedly close to shallow coastal waters (de la Parra Venegas et al., 2011; Ketchum et al., 2013), releasing it further away from the shore might have prevented it from swimming towards the beach. We also suspect that the whale shark may have been attracted to the noise from the engine of the boat since it resembles the engine above the aquarium tank that signaled its feeding time during captivity.

Beach strandings of whale sharks have been recorded in South Africa (Beckley et al., 1997) and Australia (Speed et al., 2009). There were no obvious reasons for these strandings; however, some hypotheses have been proposed: (1) sudden changes in water temperature could reduce their metabolic rate and/or (2) the combination of heavy wave action and a steeply sloping continental shelf could push the sharks shoreward (Beckley et al., 1997). In the present study, the animal seemed to have acquired the habit of swimming in circles even when in the ocean. This is a very important observation that needs consideration in the future, not only for this species, but also for any captive animals that are to be released into the wild. Indeed, Swaisgood (2007) stated that captive-release and translocation programs require detailed behavioral knowledge to predict responses to novel environments and ensure that animals are adequately prepared for environmental changes.

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