



BEHAVIORAL MANAGEMENT OF A PHYSICALLY CHALLENGED DOLPHIN

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THE STRANDING

In December 2005, Clearwater Marine Aquarium (CMA) admitted a stranded female bottlenose dolphin (*Tursiops truncatus*) calf named 'Winter' for rehabilitation. She sustained severe injuries associated with entanglement in an abandoned crab trap. Winter was approximately two months of age and presumed orphaned at the time of her stranding in the Indian River Lagoon, Florida. Assessment of her injuries revealed corneal abrasions and ulceration, deep lacerations around the pectoral fins, across the mouth, and around the entire circumference of the distal peduncle. The crab trap rope, acting like a tourniquet, had prevented blood flow to the posterior portion of the peduncle. The soft tissue of the flukes and distal peduncle surrounding several caudal vertebrae was necrotic, and the dermal layer of skin had already begun to shed away upon her arrival. Over the course of four months, Winter had lost the distal peduncle up to the original rope laceration, including several vertebrae. The last vertebra was then partially surgically removed, which aided in the growth of normal, healthy tissue, thereby eventually closing the wound.



CARE

After six months, Winter was considered rehabilitated; she had survived and, despite the loss of her tail, the wounds closed and she was otherwise a healthy animal. Our focus then became her long-term care: setting goals to manage a physically challenged dolphin. The goals set forth were for Winter to be adjusted to human care as well as to her new physical form and to be healthy. We wanted to ensure that she would have a good quality of life, one that was comparable to that of other dolphins under human care. Beyond that, we wanted to learn from the trials and tribulations of her long-term care and to utilize her presence at CMA to promote stewardship and awareness of the dangers these animals face as a result of human activities. Our approach started with the establishment of strong reinforcers, weaning, and the socialization of a young, naive animal to a companion animal.

Our first priority was the development of a structured behavior management program. This was by far the best avenue to enrich her day-to-day activities. Implementing such a program meant a gradual shift in responsibilities from the Stranding Team to the Mammal Team. Winter was cared for by over 40 Stranding Team members, each interacting and interpreting her behavior differently. Developing strong dependable relationships, achieving more behavioral consistency and establishing effective reinforcers were our first initiatives.

Initially the focus was on weaning her from formula to fish with the pressing need for her to gain weight. After attempting other methods unsuccessfully, our approach was to wean her during training sessions using a stomach tube, which was easier and less invasive than using a hand. Within two weeks, the majority of her diet was solids and she was weaned from formula shortly thereafter, at six months of age. This change greatly enhanced the training staff's ability to apply reinforcement more effectively.

Logically, the presence of a conspecific, ideally a maternal female, would provide Winter with a level of species appropriate behaviors to model that human interaction and training could not duplicate. There were concerns about how Winter would be perceived and be accepted by another dolphin. Could she socialize normally or would she be ostracized? An older, generally timid, female resident named



'Panama' was selected as an acceptable candidate with previous experience interacting with other young, orphaned animals. There was some doubt, however, as to how Panama would respond to what she might perceive as a 'funny looking dolphin'. During the introduction, Panama did display aggression, which was uncharacteristic of her but did eventually tolerate Winter's presence. Today, Panama provides good companionship but has to date shown no maternal behavior towards Winter.

As might have been expected, we observed some regression in training with Winter, due both to the introductions as well as relocations to different pools. Considering her young age and need to progress quickly in the area of medical management, it was important to limit distractions and time constraints associated with having to work in close proximity with other animals. Trainers now found themselves competing with Panama, underlining the need for our relationship with Winter to be strong. We found it beneficial to separate Winter from Panama for a few hours each day, where we could work to strengthen relationships with both animals. The process of gating and separation to different pools was established almost immediately to avoid any development of fear. We invested a few days literally swimming her through the gates.

TRAINING AND PHYSICAL THERAPY

In keeping with our original goals for Winter, we placed great importance on challenging her while maintaining the 'fun' in training that we felt was so important to enriching her life. To achieve this, behaviors were selected based on observations of what she was physically capable of and comfortable doing in her free time, such as somersaults, porpoising, barrel rolls, and positioning vertically in the water.

Winter presented some unique challenges in the area of medical management. In learning to compensate for the lack of tail flukes, Winter had

developed a method of sculling and a side-to-side, head to peduncle, wave-like movement similar to the undulations of a snake but to a much lesser degree. Daily physical therapy (PT) sessions were conducted to address some of the medical concerns associated with this learned movement, such as the abnormal development of the lateral muscles and the under-utilization of those muscles normally used for propulsion. Over-utilization of the former muscle groups began to produce a slight deviation in the peduncle similar to what is seen in beached animals that develop vertebral deviation. During PT the dorsal and ventral muscles and tendons of Winter's peduncle are stretched by the trainers to counteract the natural flexion or curling under of the peduncle that could result in a limited range of motion and contraction if left to its own. PT sessions were held two to three times daily and required one to three trainers working poolside. The objective is to align the calf's body parallel to the platform and stretch or bend at specific points along her peduncle. A few other approaches were considered, such as removing Winter from the pool, since it allowed for more stability and control. Winter would enter a stretcher voluntarily; it was not a practical approach for staff, as Winter was unusually tense during this process. Future plans include the utilization of an underwater platform during physical therapy sessions.

To track Winter's growth as it pertains to the development of her spine and muscles, as well as the progress of physical therapy, routine digital x-rays are scheduled on an on-going basis. Of particular interest is whether the x-rays show any evidence of scoliosis or individual vertebral change. The results of the initial x-rays taken in March of 2007 yielded no remarkable findings. At the time, Winter displayed a fairly significant s-shaped curve along her peduncle, which was equated more to the abnormal muscle development than the curvature of the spine. This s-shape significantly reduced over time through her daily physical therapy. X-rays taken in September of 2007 showed a fusion of the last two vertebrae, which we do not believe will affect her mobility and is generally not of concern.

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AN UNUSUAL GOAL

The development of prosthetic flukes was one of the initiatives taken for improved care of Winter. Our belief was that a prosthetic would have a positive effect on the areas of medical management and physical maintenance of spinal architecture, as well as quality of life. While originally intended to give partially back what she had lost, medically it could also address several of the concerns regarding her physical development by simply enabling her to utilize a more normal method of propulsion, if only for a few hours each day. The concept was well received by staff and the public, but was it feasible? The obvious question was how to attach the prosthetic to her body. Attempting to replicate what nature designed was an ambitious project led by Kevin Carroll of Hanger Prosthetics Inc., a leading human prosthetics company. It involved a team of highly respected individuals including Dr. Mike Walsh, CMA veterinarian, as well as Dr. Juli Goldstein and Steve McCullough, from Harbor Branch, among others.

At a preliminary gathering to generate ideas, Mr. Carroll presented us with his initial model of the tail flukes and his proposed method of attachment. This model incorporated a silicone sleeve commonly used in human prosthetics, which is held in place by the powerful suction created against the skin. A metal disc at the end of the sleeve is the attachment point

the skin is partially protected by a silicone sleeve, the pressure from the up and down motion of the tail could transfer to the more solid portions of the mechanism and might cause skin damage. In order to avoid these problems, a crucial component to the prosthetic would be a breaking point or joint necessary to absorb pressure and to mimic the normal connection and movement of the fluke in relation to the peduncle. Other factors needed to be addressed as well, including the weight and buoyancy of the material. Behaviorally, any abrasions might decrease acceptance by Winter slowing future progress. Thus, both training and vet staff had to carefully monitor skin changes and review developments before they were applied. Skin changes included abrasions, bruising, and pressure points. Then we had to consider possible changes in buoyancy of the device, distance of her flukes in relation to the solid brace, size and thickness of the peduncle socket, the joint material and flexibility, and the actual brace itself as it relates to adherence to her skin. All of these considerations are constantly changing as we learn more and she continues to grow.

INNOVATION

The design process soon became one of idea development and application, then evaluation of progress and fit. Several prototypes were developed as new ideas were formulated, and as we discovered the need for changes both from the technical as well as medical aspects of the project. A critical point in this process occurred when the decision was made to go with a custom fitted sleeve as opposed to the generic one utilized initially. These modifications included using a different material for the new sleeve-- a thicker, silicone gel-based material that had never before been applied in this manner. It provided increased protection, addressing some of the medical concerns related to Winter's skin sensitivity, as well as better adherence to the peduncle. To provide a custom fit, we created a cast mold of her peduncle, a process that will be repeated routinely

for the prosthetic flukes. This original model became a platform for discussion to familiarize all members of the team with various options and constraints from both technical and medical standpoints. Medical concerns of Dr. Walsh included the delicate nature of a dolphin's skin and the risks associated with the friction of the prosthetic against the skin. Although

as she grows. In addition, instead of the prosthetic flukes attaching by the metal disc at the end of the sleeve a separate sleeve was constructed to fit over the primary one. This latter sleeve incorporates a brace to which the tail flukes attach.

TRAINING FOR THE FUTURE

From a training perspective, we had two major objectives using the prosthetic. The first was basic desensitization to the entire process and the various prototypes. The intervals between each new version of the sleeve allowed sufficient time for effective counter-conditioning to occur before the training for each prosthetic component. This also proved helpful as we progressed to a more advanced, multi-step process incorporating the secondary sleeve and brace, as the need for desensitization at this level was greatly reduced. Our second major objective was to emit the proper range of motion of the peduncle upon placement of the prosthetic tail. This goal is much more involved and is still on-going.

The first step in the application of the prosthetic sleeve was to establish the optimal layout. Ideally, the sleeve should be applied to dry skin as this allows for better adherence to the peduncle. Therefore, a vertical position would be the logical choice. This was an established behavior but was not preferable, as it would complicate many other aspects of the training process.

A layout allowing us closer proximity to provide intermittent reinforcement and greater physical and stimulus control through eye contact and physical support was necessary. Moreover, it was important to provide the necessary support and stability to properly apply the sleeve, and so it was decided to incorporate two trainers working her parallel to a platform to begin training.

To approximate the length of time that she would need to wear the primary sleeve, less cumbersome and restrictive bands were made of the same material. Although snug against the skin, these bands did not create the suction needed to keep them in place with certain movements of her peduncle. Unfortunately, this resulted in a considerable regression in the behavior since she had learned that it was possible to remove them! In retrospect, if these smaller bands had not been introduced, the

opportunity for this self-reinforcing behavior would not have presented itself, as the primary sleeve is difficult to remove without a concerted effort on Winter's part. To correct this, the majority of Winter's primary reinforcement was applied during the actual layout, while the sleeve was on, as opposed to reinforcing the completion of the behavior, i.e. once the prosthetic was removed. This was facilitated by our chosen layout position for her. Additionally, we anticipated the length of time we could successfully keep the sleeve on and used physical support to discourage her from breaking from her station.

Our first attempt at shaping the proper movement of the peduncle was to emit an 'up' motion, using a target or slap on the surface of the water paired with a continuous S^d. In doing this, several issues became apparent. Abnormal development of the peduncle caused a curvature or a downward, shrimp-like, curve to the tailstock, resulting in a motion that was more of a flail than an actual down/up stroke. Furthermore, the existence of bends in the peduncle due to abnormal development of the lateral muscles caused her peduncle to curve to either side on the upstroke. It became necessary to re-train the proper range of motion needed to utilize the prosthetic tail effectively, thereby avoiding injury such as muscle strain and skin damage. The behavior was done under greater stimulus control. To achieve this, a tactile cue was instituted to signify the timing and speed of the required up and down motion. The trainer glides a hand up the peduncle toward the dorsal fin, cuing Winter to drop the tailstock. Then the hand is moved down to the tip of the peduncle, cuing her to bring it back up. The speed at which the trainer moves the hand dictates Winter's speed in raising and lowering the peduncle. In addition to establishing these subtle cues, we also incorporated an arch behavior to strengthen the muscles associated with her upstroke. In doing this, we could limit the down stroke or shrimping of the peduncle and increase the range of the upstroke.

Once we decided that the desensitization process as well as the shaping of the proper motion of the peduncle had been established, it was time to combine the two. Up until this point, the trainers had physically supported the peduncle with the prosthetic sleeve in place. The next step would necessitate letting go of her body. We were concerned with giving her the opportunity to drift and/or to remove the prosthetic sleeve, an activity she found reinforcing in earlier stages of training. However, because both behaviors were trained using the identical layout as well as being worked consecutively, there was no confusion on Winter's part. She was preoccupied with the task at hand and was not presented with any opportunities to drift. However, some slight regression in range of motion was observed. Due to the thickness of the material, it was difficult for Winter to feel the trainer's cues on her peduncle. The large area utilized for the S^d



was faded to a smaller section just above the sleeve, which helped to alleviate this problem. Later, the cue was given on her dorsal fin and than her rostrum in an effort to fade out the trainer's hands. We were then able to proceed with the approximations necessary to incorporate the actual flukes while systematically introducing the various components. The approximation flukes varied in size, thickness, and flexibility as part as the training process.

WHAT IS AHEAD?

As we progress in teaching Winter to use her prosthetic, this entire process continues to be reevaluated in all arenas: medical, technical, and behavioral. Major milestones still to come include her conceptualization of the prosthetic as her primary means of propulsion. To this end, our training goals will focus on ways to limit her propulsion by means of her standard lateral movements and/or sculling by using for example, alternate response training or differential reinforcement. Progress in the use of the artificial flukes by Winter will be partially evaluated by attempting to incorporate the use of movement analysis in comparing normal parameters such as range of motion of a tailed individual with those of Winter as the design and application process progresses.

The complexity and challenges of teaching an infant marine mammal to swim with prototype prosthetic tail flukes are still unfolding. We expect some setbacks. However, we also expect this learning process to be a counterbalanced by new information on prosthetic development, material application, and spin-offs that will benefit not only Winter, but also other individuals and species. Bandaging techniques for cetaceans

will improve and others will be inspired to try more. Already, human amputees have benefited from the knowledge gained by these approaches, which take into account the unique qualities of cetacean skin. Winter will not wear her prosthetic continually, but if it can help to maintain the normal architecture of her vertebrae and improve her mobility and function even for a time it will be well worth the efforts.

Winter has been broadcast worldwide and her story has reached millions of people. Her tale puts a face to the concerns we all share about our ocean environment and the need to educate others about the harmful effects some human activities have on the planet. We encourage our visitors to be inspired and to join us in the preservation of our environment and the conservation of marine mammals.

EDITORS NOTE:



This paper received the following awards during the 35th IMATA conference at Indianapolis, IN: the 1st place Outernet Technology Awards and the 2nd place Husbandry Training Award.