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Historical Perspectives
Evolution of Reinforcement and Relationships

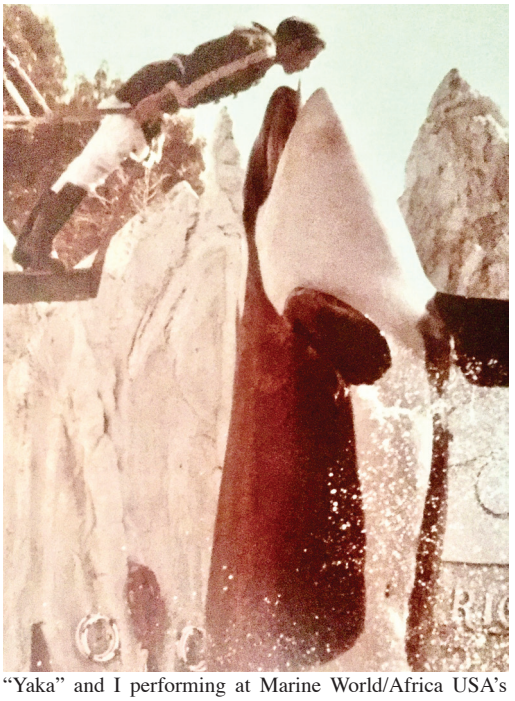
William Ralph Winhall, MSc
(born 1954)

My father and mother grew up in Bristol, England, during World War II. My mother, Violet, helped my father, Ralph, with his high school-level math homework; and afterwards, my dad would take his girl for a ride through the countryside in the sidecar of his BSA motorcycle. My father's dad assisted those who needed medical or air raid shelter assistance during World War II bombing raids. Back in World War I, my grandfather worked on biplanes as a carpenter with fiberglass and wood repair. During a test flight of a biplane after some aircraft repairs, my grandfather accidentally dropped a rifle down the surveillance opening; he experienced negative repercussions once they landed. My mother's dad worked in construction making windows; and during nighttime lights-out air raids in Bristol, he gathered his four daughters and bride and rushed them to the air raid shelter. During his youth, my grandfather played semi-pro soccer in England. He famously taught me how to properly pour warm beer into a glass.

My dad and his family sailed to the United States on the *Queen Mary* in the late 1940s, settling in the San Francisco Bay area where my father soon found a job at Bethlehem Steel as a metallurgist. Once established and living in San Mateo, California, he sent for his fiancé, who was still living in England, and soon thereafter he and my mother got married and started a family. Growing up in San Mateo as a young boy, I was interested in wildlife and nature, spending a great deal of time exploring a nearby large field with butterflies, lizards, dragonflies, birds, and rabbits. On our family vacations, we would travel to Lake Tahoe, and I would frequently go horseback riding at Emerald Bay and walk for miles along the Truckee, American, and Carson Rivers, fishing and soaking up the beauty of the Sierra Nevada mountains. My other love was sports, especially baseball. I took part in organized baseball from the ages of 8 to 20. I participated in the starting preseason lineup playing right field on the college baseball team; this soon changed once I ran into a catcher coming home and broke my rib. Once healed, I found myself on the bench and came to the realization that I should focus more on learning and apply myself to a more promising career. In the past at school, I had done only what was necessary to receive a grade of C. This included taking college courses where I only had to show up to get a grade of C. I had always loved the beach, much like my mom, and so, post baseball, I became excited about the prospect of learning more about the marine environment. The ocean seemed like such a vast relative unknown with hidden secrets, unique creatures, waves, sand, and sun, which all seemed to call to me.

In 1974, I was hospitalized with an undiagnosed disorder. I started feeling better soon after I received blood transfusions. Each morning for five days, the nurses would come into my room and withdraw eight test tubes of blood to be sent to various hospitals and universities in hopes of identifying the unique disorder. The illness was most difficult on my parents. To me, it was a bit of a surreal situation, wondering if I had a future or not. Turns out, I came down with a rare, one-in-a-million, autoimmune disorder. I went into remission and soon headed back to school, enrolling at Moss Landing Marine Laboratory in Monterey, California. I studied invertebrates, and I was especially interested in plankton.

During the next summer, I took a part-time job at the local marine park, Marine World/Africa USA, curious to discover what the marine mammals were about. I had heard stories about the dolphins and wanted to experience and learn more about them for myself. I was hired as a tour boat driver/educator of the Africa part of the park and would regularly visit the dolphin and sea lion exhibits. On one of my normally sleep-inducing tours, my pontoon boat ran out of gas, and we started drifting through the water ski show area toward Monkey Island. I radioed my boss to bring us some gasoline while we drifted closer and closer to shore until, eventually, we were shipwrecked on the island. As I beached the boat with 25 passengers aboard, the inhabitants of Monkey Island decided to board our craft, jumping on the roof with a few showing interest in some of the guests' hats. I jumped off the boat and pushed it away from shore, causing us to drift



"Yaka" and I performing at Marine World/Africa USA's killer whale show in 1978 (*Photographer:* Ralph Winhall)

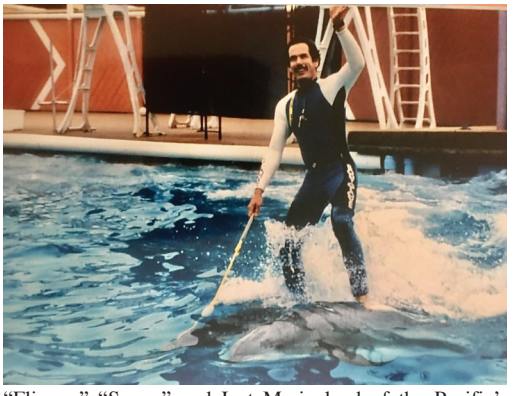
"Nepo," Yaka, and I at Marine World/Africa USA's killer whale show in 1979 (Courtesy of Marine World/Africa USA)

toward the middle of the water ski show (the show was briefly postponed due to my boat creating an obstacle blocking the main ski run). Fortunately, the spider monkeys abandoned ship as we pushed away. My boss gassed up the boat, and I couldn't help but notice the looks I received from him and the water skiers. I finished my tour with wet tennis shoes; and when we made it back to the loading dock, one couple mentioned that my tour was more entertaining than the killer whale show they viewed earlier that day (whales must not have been cooperating). I never ran out of gas on my tour again.

An opening occurred in the Marine Mammal Department for a seasonal part-time trainer, and I was selected for that position. It was not due to my "excellent" tour boat driving or education presentations I'm sure. At the end of the summer, I was offered a full-time position, and I accepted the job. To my parents' disappointment, this would mean that I would graduate in two and a half years rather than one year with a degree in Biology. My folks didn't think it was a good idea for me to be making minimum wage when I could graduate in one year and make much more money at a "real job." My father would frequently remind me that he would never do what I was doing. Then, a few gentlemen working at my dad's employment had gone to Marine World and were showing off pictures of their visit featuring me performing in the dolphin, sea lion, and killer whale shows. The office thought that was so great having one's son training and performing in the marine mammal shows, which made my dad the talk of the office. My father changed his story soon thereafter and told me if he was me in my situation (he was married and had a baby on the way at my age), he'd like to be doing something like I was doing. I fell to the ground pretending that I fainted, then got up and the three of us ate dinner together. That night as I left my parents' home, I departed as I had frequently done before with leftovers and a care package with instant potatoes, rice, bread, and canned peaches. My mother and father, having grown up in England during the war, experienced rationing. So, due to their history, my mom kept the garage cupboards full of nonperishables, which I benefited from living on a limited income.

At Marine World/Africa USA, I performed in the dolphin and pilot whale show where I learned behavioral conditioning skills from the South Philly doo wop singer of the Four Epics, one Jim Mullen. I soon discovered while training the animals that we, the trainers, do not have control over these intelligent and somewhat independent animals. I felt we were asking them to cooperate with us and that they could choose to perform a behavior or not. When a member of the dolphin group chose not to perform a certain behavior in the show (or training session), possibly testing

"Koko," the pilot whale, and I performing a jump ride at Marine World/Africa USA's dolphin show in 1979 (Courtesy of Marine World/Africa USA)



"Flipper," "Semo," and I at Marineland of the Pacific's dolphin show in 1985 (*Photographer:* Ralph Winhall)

"Raisin," "Current," and I at Marineland of the Pacific's sea lion show in 1986 (Courtesy of Marineland of the Pacific)

boundaries, I learned not to take the misbehavior personally. If the dolphin offender started cooperating at a later time in the show/session, they could eventually be rewarded for cooperating with the team and earn inclusion for their successful participation. Another experienced trainer would ignore the misbehaving dolphin, pulling their bucket for the rest of the show/session, not allowing them to earn an opportunity to participate with the group. The dolphins appeared to learn that they would not be accepted back and, therefore, would quit performing, often disrupting the show/session. I also found it most interesting that the pilot whale in the show, "Koko," never refused to do a jump ride with me on his back unless he was sick, so it left me thinking that he found that behavior somehow rewarding. Before and after training sessions and shows, we would interact, swim, and play with the dolphins and pilot whale, hopefully showing the animals we weren't just the folks that train and "make" them perform in shows. During this time, they could choose to interact with us or not, and we were in their environment more or less at their mercy. The dolphins and pilot whale chose to interact with us much more often than not. During my first year, the International Marine Animal Trainer Association's (IMATA) conference was held at Marine World Africa/USA where I was able to meet Karen Pryor and Ingrid Kang from Sea Life Park. Karen agreed to autograph my copy of her book *Lads Before the Wind: Diary of a Dolphin Trainer*, a book that had a great influence on my early training career.

So, instead of starting the graduate program doing research on plankton and primary productivity, I decided to continue to work with marine mammals a bit longer, possibly for another three years. I ended up working and eventually becoming training director for a company offering contract dolphin and sea lion shows all over the United States. I was sent to the Florida Keys to work at the Institute of Delphinid Research (later known as the Dolphin Research Center or DRC; and, yes, it was earlier known as Flipper's Sea School) for nine months where our dolphins were staying. I was responsible for the care and training of five young "green" bottlenose dolphins, and was told to put a show together for Marriott's Great America in Gurnee, Illinois. Being myself young and a bit green, I learned quite a bit from these dolphins and the challenging situation of working alone from a floating dock. I read a paper from IMATA's conference proceedings authored by Thad Lacinak (1979) titled "Making Learning Fun," which reinforced my belief and practice of making the process of training/learning interesting and enjoyable for the marine mammals.

Back in the early 1980s, I would mix things up on the dolphins at Marriott's Great America in Santa Clara (e.g., send behaviors in randomized order from different parts of the pool and use a variety of reinforcement), which took time for the veteran dolphins to adjust to because they were used to participating in a show with behaviors

done in a specific order and to being sent and reinforced from specific places around the pool. I also included a game with two dolphins, "Happy" and "Boogie," in which I would provide a specific signal and the dolphins learned they would be rewarded with enrichment devices, tactile attention, fish, and/or a fun activity for performing a "new" behavior. During the bird show, while the dolphins were in their holding pool, we would do this "innovation session" to make the holding area more stimulating while waiting for our turn to perform. The dolphins quickly learned they could perform any new/different behavior without repetition, and they would receive reinforcement for it.

I remember driving into Marineland of the Pacific's parking lot and I couldn't help but notice how breathtaking it was to see hundreds of common dolphins on the horizon porpoising with "rooster tails" flying. Happily, I was hired by Marineland in 1984 as a trainer, performing in the sea lion, dolphin, and pilot whale shows. This park was the most beautiful place I had ever worked. In 1985, we were awarded IMATA's Behavior of the Year Award for training unrestrained blood sampling, fecal collection, and gastric sampling. At that time, few if any facilities incorporated unrestrained blood collection as a part of their husbandry programs. I became more and more motivated to condition husbandry and management behavior with the marine mammals—not just to condition natural or show behaviors.

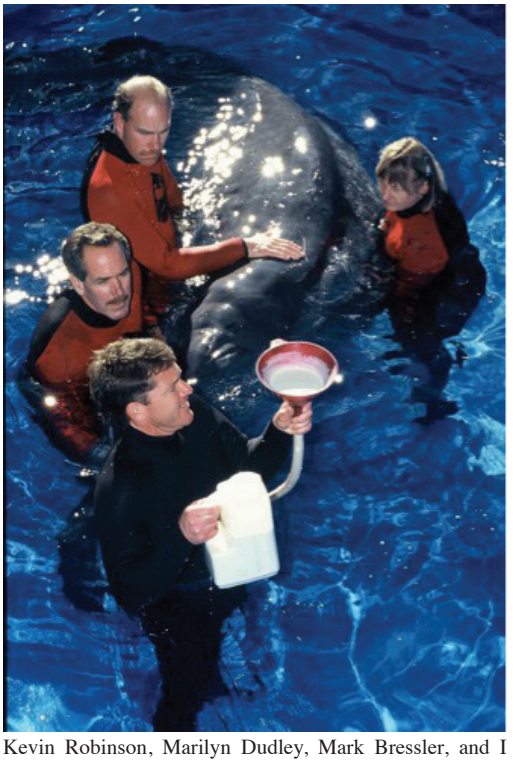
I was assigned to work with a young sea lion named "Zap" and I loved it. Along with teaching him the basic education and show behaviors, we frequently worked together without food, where I strengthened his learning with fun, attention, chase, play, and tactile reinforcement. He was allowed to come out of the holding pool into our huge fish preparation room to interact with us. On occasion, I would hide from him in the two-door refrigerator and try to surprise him after he entered the room. One of my tasks was to walk Zap from the dolphin holding area to the sea lion show. Zap did not like to go into his temporary holding pen before the show, so, after an in-water play session (e.g., swimming, running around and diving, and sliding out on the beaching platform), I went inside his pen, keeping the gate closed and not allowing him in with me. He would go back out into the pool and then come back to the holding area and check on me. Gradually, I let him place one flipper into the holding pen while he targeted on my hand, offering him a rubdown, then I sent him out and closed the gate, making this into a game. He would come back again after a brief swim, and I would open the gate and allow him to place both flippers inside and target on my hand. He'd open his mouth, and I'd reward him with some fish, again sending him out and shutting the gate behind him. Gradually, Zap was comfortable sitting next to me in the pen while I closed the gate, and I never had another problem with him gating into his pen by himself.

All the trainers swam and interacted in the water with the dolphins at Marineland. I had the privilege of working with a 4-year-old dolphin named "Misty," teaching her new behaviors. She was a fast learner and too much fun—she was a special animal. In the shallow water area of the pool, I would barely pick her up and out of the water, and then drop her. She would quickly swim around me and sit in front of me for another turn until I couldn't pick her up anymore. She seemed to enjoy this game. We had a much older dolphin, "Splash," that had vision issues that finally caused her to no longer be able to perform the baton jump or clear the long jump hurtles in the Olympic-themed show. In an effort to keep her stimulated and part of the show, I began a water ballet sequence with her. Splash performed well and seemed to enjoy the interaction. She did well enough that we used her in the show as part of the water work demonstration.

Marineland of the Pacific closed in 1987, and I was hired at SeaWorld of San Diego. I applied for an Animal Care position rather than interviewing with the Training Department. I had been a trainer for nine years and wanted to help and learn more about marine mammal rescue, rehabilitation, and husbandry. During my employment, I had some luck conditioning blood and milk sampling from the exhibit walruses, creating neonate formulas, developing hand-rearing guidelines, and estimating caloric requirements for marine mammals with great support from the veterinarians.

In 1994, I was fortunate to be part of a team rescuing nine killer whales trapped in Barn's Lake, Alaska. With the help of the local residents, we went out on Barn's Lake, which had a narrow channel leading out to the bay. We waited until it was high tide to give the channel the most depth. At low tide, it looked a little like a small water fall (tidal range 10+ feet). The group surrounded the whales, and we hit pipes with hammers hanging from the boats creating an acoustic barrier, slowly herding the animals toward the narrow channel. It was successful, and the rescue was featured on the television program *Rescue 911* with William Shatner. In 1997, SeaWorld was part of a gray whale rescue and received a stranded calf from Marina Del Rey. The whale, "JJ," was 1,670 pounds and initially required 10+ gallons of cetacean formula each day. JJ grew at a rate of roughly two pounds per hour and a ½ inch per day. It was an unusual feeling to put your arm all the way down to your shoulder into the grey whale's throat for the initial intubations.

Carrying the Olympic Torch through San Diego for the 1996 Summer Olympics (*Photographer:* Ken Bohn, SeaWorld photographer)



Kevin Robinson, Marilyn Dudley, Mark Bressler, and I performing gastric intubation of cetacean formula to "JJ," the 1-week-old gray whale, at SeaWorld San Diego in 1997 (*Photographer:* Ken Bohn, SeaWorld photographer)

She was returned to the ocean 14 months later at a weight of 19,200 pounds.

In 1996, I was lucky enough to be selected to carry the Olympic torch through San Diego for the Atlanta Olympics. I was chosen because I assisted in the rescue and care of stranded marine mammals and volunteered as a counselor's aide at a local elementary school. I found it interesting how I became a commodity at that school, being one of the very few men at this elementary school and, therefore, chosen to deal with some of the challenging 5th-grade boys. I was asked to help with the boys in one of the 5th-grade classes. If they behaved well and had a good week, then on Friday I would take them to play basketball, football, or four square. The girls in their class were envious of the boys and so, after a few weeks, I found myself rewarding the 5th-grade girls on every other Friday with basketball, four square, volleyball, or any other activity they chose. Volunteering at the elementary school was a very rewarding time for me. The kids were great, and I enjoyed the experience.

In 1997, I was selected to manage the animal components of the Wild Arctic's and, later, the Journey to Atlantis's attractions at SeaWorld. I oversaw and treated the staff as a crossfunctional, multidisciplinary, self-directed team, with me managing them as a servant leader. When appropriate, I empowered team members (bird, fish, training, and animal care departments) to communicate, discuss potential action plans, and make reasonable decisions as a group. At the Wild Arctic, I found myself establishing a polar bear training, enrichment, care, and safety/emergency response program that was all new to me. SeaWorld San Diego hadn't displayed polar bears before, so we reached out to the San Diego and other zoos as well as received input from research scientist Dr. Alison Ames and Oregon Zoo's Conservation Manager, Dr. David Shepherdson. We shifted the polar bear(s) on and off exhibit at different times, offering them a variety of natural and synthetic enrichment on exhibit and in the dens on a variable schedule, and performing learning sessions throughout each day. We were fortunate that the polar bears did not demonstrate stereotypical behavior. In fact, Dr. Shepherdson mentioned that we had the most well-adjusted polar bears in a managed care situation he'd ever witnessed.

The Wild Arctic was also fortunate to participate in the hand rearing of rescued neonate walruses from Alaska. Working closely with the veterinary

Frontiers North Tundra Buggy with Polar Bear International researchers and U.S. Fish and Wildlife Service biologists in Churchill, Manitoba, in 2005 (*Photographer:* Craig Perham, USFWS biologist)

department, we devised hand-raising guidelines and a formula that proved successful in rearing a number of neonate walruses. Once the walruses were consistent with their bottle feedings, we would routinely bring families to a behind-the-scenes tour, occasionally allowing them to bottle feed a walrus through protective contact. My daughter, at 5 years of age, would talk to and bottle feed the walrus by saying "ook ook." "Kaboodle," the neonate walrus, would vocalize back to her. Kaboodle's progress in the training program allowed us to condition her to tolerate, maybe even enjoy, being in her transport unit, and we transferred her to different pavilions throughout the park. Eventually, we felt confident about taking her to *The Tonight Show* with Jay Leno where she made a successful appearance (the video of this appearance is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147).

In the beluga exhibit, harbor seals and a ringed seal shared the beluga pool with a number of large white whales. The whales would perform in-water interactions with guests in 55°F water; and at the end of an interaction, our guests were ready to get out of the pool and into a hot shower. We learned that it was best to gate the seals before the interaction because a seal would occasionally try to steal the large herring meant for the belugas.

Two arctic foxes also made their home at the Wild Arctic attraction and were conditioned to be handled. They would spend time in the attraction with our guests as well as making appearances on television shows. On one trip to the Larry King show in New York, "Boris," the white phase fox, and I shared a room. That night, after a walk around the hotel ("What kind of dog is that?"), I filled the bath tub with ice, rolled up the shower curtain, and duct taped the hair dryer but forgot to remove the toilet paper from the bathroom before going to bed. I had to get up early the next morning to be at the studio on time. When I went into the bathroom where Boris spent the night, Boris was comfortably resting in the sink and, apparently, he'd had a busy night playing with the toilet paper. It was everywhere, not unlike when one TPs a friend's house. Needless to say, we provided a huge tip for the hotel cleaning people.

Along with hand rearing walrus calves, we raised a neonate beluga whale calf. It was entertaining to watch us take turns trying to swim down and catch the calf as she grew stronger. After catching her, we would swim with her in our arms into the medical pool where we would tube feed her formula. After feeding her, we would spend some time rubbing her down and sharing enrichment items with her in the medical pool. When she seemed calm, we would open the gate, allowing her to leave; however, we would stay in the medical pool so she could choose to return and interact with us and the enrichment objects. Gradually, she seemed to enjoy the medical pool and our rubdowns, and no longer did we have to try to catch her for a feeding with swim fins! We just opened the gate, and she swam right into the medical pool.

During this time, I was recruited to be on the Advisory Council for the NGO Polar Bear International (PBI). I spent time in Churchill, Manitoba, Canada, with researchers and, of course, the polar bears. It was quite an experience to see a polar bear walking down the street in front of the PBI condominium you're staying at or hearing cracker shells hazing polar bears out of town only a couple blocks from where you were walking home after dinner. I was also asked to participate in audits of marine mammal facilities that included assessing their water quality, food preparation, enrichment, husbandry, and training programs for the Alliance of Marine Mammal Parks and Aquariums and IMATA Facility Trainer Development Programs. Later, I also participated as an animal welfare auditor for the American Humane Conservation's assessment program. I learned so much from the

My daughter in back holding area playing with "Nanuq" and "Allua" at SeaWorld San Diego in 2009 (Personal collection)

Arctic researchers; my co-inspectors; and the various facilities' staff, management, and veterinarians. Traveling to all these different locations, states, and countries also helped open my eyes to the many different cultures and ways to meet and exceed marine mammal needs.

At the end of December 2015, I was part of a large layoff and received early retirement from SeaWorld. I still wanted to work with marine mammals and the people who took care of them, so I decided to become a marine mammal consultant. In doing so, I was able to assist in walrus transportations, walrus exhibit modifications, and marine mammal conference presentations on walrus hand-rearing procedures; polar bear exhibit design, and polar bear training and enrichment; dolphin birthing preparations, and dolphin training and enrichment; and marine mammal welfare issues. While adapting to the current global pandemic, I find myself spending most of my days riding my bike, enjoying the bay and beach, playing old-man softball, and relishing quality time with my family.

It is my pleasure to share with readers of *Aquatic Mammals* the formulas and hand-rearing guidelines I helped to develop over my lengthy career.

Formulas and Hand-Rearing Guidelines for Marine Mammals

On one of my first days volunteering for the Marine Mammal Center at Fort Cronkite (near Sausalito, California) in 1978, I found myself following the area supervisor down an old missile silo to grab some frozen herring to make a fish "milk shake" for some of the rescued mammals at the Center. This was my first exposure to making a formula and caring for some of the younger rescued marine mammals. My profession at that time was that of a marine mammal trainer performing in dolphin and sea lion shows at a nearby marine park. After 10 years of working as a trainer appearing in scripted marine mammal shows, I moved on to become an animal care specialist, focusing more closely on caring for the park's older, ill, pregnant, and neonate marine mammals, as well as participating in SeaWorld San Diego's stranded animal rescue and rehabilitation program. I became especially interested in caring for neonate marine mammals, developing specific formulas and hand-rearing guidelines for the various mammals.

When I first started in 1978, most formulas consisted of blended water, ground fish, vitamins, electrolyte solution, heavy whipping cream, and sometimes a high-calorie nutritional supplement (STAT). Depending on their age, some mammals would receive assisted feedings of whole fish. For the pinnipeds, there was a transition to a MultiMilk® and later Zoologic Milk Matrix® 30/55 powdered artificial milk formula, including an initial focus on replacement fluids. The Milk Matrix® 30/55 has trace amounts of carbohydrate and is used because many of the pinniped species' natural milk contains limited amounts of milk sugar. (Some pinnipeds may completely lack the enzyme lactase.)

In 1987, with the help of many others, I began documenting various formulas and hand-rearing guidelines for marine mammals. These guidelines became living documents in which subtle changes in the formula and hand-rearing procedures occurred after various trials. The following includes the results of many years and the efforts of many individuals working on pinniped and cetacean formula ingredients and hand-rearing guidelines.

Walrus

The walrus (*Odobenus rosmarus divergens*) formula (Winhall, 2016) contains 14.1% fat, 7.5% protein, and 2.6% carbohydrate. Assuming there are 9 kcal/g of fat, 4 kcal/g of protein, and 4 kcal/g of carbohydrate, this makes the caloric density of this formula ~1.67 kcal/mL. The daily requirement for a walrus calf is roughly 120 kcal/kg body weight. (This is a target number that works for calculating the approximate calories/volume of formula required.)

Example – For a 62.5 kg (137.5 lb) orphaned neonate walrus, the caloric/volume requirements are as follows:

62.5 kg walrus × 120 kcal/kg neonate/d = 7,500 kcal/d

7,500 kcal/d ÷ 1.67 kcal/mL = 4,491 mL/d

4,491 mL/d ÷ 6 feedings/d = 748.5 or about 750 mL/feeding

"Bocce," a walrus calf rescued by Alaska SeaLife Center from Kivalina, Alaska, in quarantine at SeaWorld San Diego in 2005 (*Photographer:* Wild Arctic team member)

The walrus formula is made as follows:

1. Blend 1,800 mL (1,822 g) of water with 1,500 ml (530 g) of MultiMilk® or Zoologic Milk Matrix® 30/55 (non-packed) powder.

2. Slowly add MultiMilk® or Zoologic Milk Matrix® 30/55 to water while blending.

3. Grind (mortar and pestle) 1 Mazuri® #5 SeaWorld marine mammal multivitamin (consists of 16,000 IU vitamin A, 250 IU vitamin E, 250 mg vitamin C, 200 mg thiamin mononitrate, 15 mg riboflavin, 15 mg pyridoxine, 15 mg pantothenic acid, 500 mcg folic acid, and 250 mcg biotin), 455 mg (7 grains) dicalcium phosphate, 9 g NaCl, and 250 mg taurine. Then, add together with an additional 500 units of vitamin E to blended formula.

4. Blend the mixture until it has a smooth and even consistency (makes approximately 2.4 L).

For the first day or two, the walrus formula is usually diluted by adding 3,000 mL of water instead of the volume of 1,800 mL. Initially, the formula is diluted in an effort to help rehydrate the animal and make the formula easier to assimilate/digest. This diluted formula has an energy content of ~0.92 kcal/mL. Thereafter, the undiluted Zoologic Milk Matrix® formula is used; however, in some cases, a more gradual change in formula concentration may be required.

At Week 4, adding a total of 50 mL of fish oil (salmon, menhaden, or Vitashine®) increases the caloric content of the now 2,450 mL formula to ~1.76 kcal/mL. At approximately Week 6, increase the amount of fish oil blended into the 2.4 L of formula from 50 to 100 mL. This 2,500 mL formula will have a caloric content of ~1.85 kcal/mL. By Week 8, add a total of 150 mL of fish oil to the 2.4 L of formula, making a formula with a caloric content of ~1.94 kcal/mL. Later, after 2 to 3 mo of bottle feedings, the formula is changed to the following walrus maintenance formula:

1. Lightly blend 4 oz (114 g) frozen clam with 250 mL of water until smooth.

2. Lightly blend 20 oz (568 g) frozen herring fillet with 550 mL of water and then add the clam gruel until smooth.

3. Slowly add 200 g MultiMilk® or Zoologic Milk Matrix® 30/55 to 1,000 mL water, and then add the herring and clam gruel while blending the mix.

4. Slowly add the rest (220 g) of Zoologic Milk Matrix® 30/55 with 250 mL fish oil and grounded vitamins/nutrients:

    a. Grind (mortar and pestle) 455 mg (7 grains) dicalcium phosphate and 250 mg taurine, then add together with an additional 500 units of vitamin E to blended formula (makes ~2,600 mL of maintenance formula with a caloric value of ~1.74 kcal/mL [formula analyzed]).

    b. Add one Mazuriâ #5 Sea World marine mammal multivitamin (consisting of 16,000 IU vitamin A, 250 IU vitamin E, 250 mg vitamin C, 200 mg thiamin mononitrate, 15 mg riboflavin, 15 mg pyridoxine, 15 mg pantothenic acid, 500 mcg folic acid, and 250 mcg biotin) just before bottle feeding.

Walrus Feeding Guidelines

1. Weigh the neonate walrus every morning before the first feed for at least the first month. Later, a weight may only be necessary once or twice a week. The calf should gain ~0.6 kg/d. This amount varies from animal to animal and with changes in the formula composition and size/age of the calf.

2. Warm the formula in 64 oz (1,824 mL) calf-nursing bottles to approximately body temperature (98°F). This appears to make the formula more palatable. Initially, the calf may more readily nurse from a lamb nipple. If this is the case, you may decide to later switch to a calf nipple (walruses readily take to bottle feedings). If the walrus is unwilling to accept

the formula from the bottle, they will sometimes welcome warm water from the bottle and nipple (try squirting a small amount of formula into the neonate's mouth, and, if necessary to initiate sucking/acceptance of formula, place a few droplets of warmed milk on one's arm, hand, or the corner of a towel and offer it to the animal). Spend time interacting with the calf to help meet the animal's initial social/physical needs.

3. Initially administer 6 or 7 feeds within roughly 12 to 16 h of each day. The number of feedings may then be reduced to 5 or 6/d starting the second or third month (increasing the volume per feed and/or caloric concentration); and finally, the number of feedings may be decreased to 4/d by about the sixth month.

4. If initial bottle feedings are not successful or adequately meeting the neonate's requirements (a weak and dehydrated calf), the veterinarians may decide the calf requires fluids and/or calories and will assist with at least the initial tube feedings and/or subcutaneous fluids.

5. At about 4 mo of age, begin introducing freshly defrosted fish and invertebrate feedings (pieces and whole organisms in a shallow pool or under an ice pile on the ground). By gradually increasing the amount of fish and invertebrates in the diet, the additional consumption of capelin, herring, clams, and squid by the pup will add to the total caloric intake for the walrus by roughly 1,500, 1,750, 800, and 700 kcal/kg of fish, respectively, therefore decreasing the number of necessary bottle feedings/amount of formula. (When increasing fish/solid food intake, be sensitive to the fact that the animal's fluid requirements must still be met.)

6. Introduce and then gradually increase the time the calf spends with other marine mammals (seals, small walruses, etc.) in a larger pool and deck area. This is often associated with an increase in exercise and more natural activity. Watch for hypothermia as the pup spends more time in the water.

7. The walrus can be weaned (often weaning itself) by approximately 8 to 12 mo.

According to Fay (1982), various artificial milk formulas have been utilized with walruses in the past using fish, clams, water, heavy whipping cream, and supplementary vitamins in proportions of 5:3:4, having 60% less fat, 30% more water, and 100 times more carbohydrate (76% water, 12% fat, 7% protein, and 2.6% sugar) than natural walrus milk. The gross energy value per unit volume was about 50% of natural walrus milk. The gross energy value of natural walrus milk is about 3.24 kcal/mL (Kleiber, 1961). Net energy available from the artificial milk diet is appreciably lower than would be available from an equivalent volume of natural walrus milk. SeaWorld and other institutions have tried to produce a more nutritionally balanced diet for appropriate neonatal growth with walrus calf formulas.

The priority for the neonates is to address their dehydration/hydration status by first replacing any fluid deficit within 24 to 48 h while simultaneously meeting the animals' daily fluid maintenance requirements. The neonates received subcutaneous fluids and/or oral electrolyte solution (Hydralyte®) and/or dilute formula initially via stomach tube (gastric intubation), gradually increasing the volume, number of feeds, and concentration of bottle-fed formula over time. After the animals' state of dehydration and daily fluid requirements are met, the focus gradually shifts to acclimation to bottle feeding and meeting the nutritional supplementation with formula while maintaining daily fluid requirements. Fish oil is incrementally added to the walrus formula to increase the caloric concentration from ~1.67 kcal/mL to ~1.94 kcal/mL of formula. This was accomplished by gradually adding up to 150 mL of fish oil to 2.4 L of formula. At roughly 2 to 3 mo of age, the formula was changed to a maintenance formula.

Three hand-reared calves at SeaWorld ate fish and fish pieces at approximately 3 to 8 mo and completely weaned off formula at approximately 7 to 10 mo. The calves gained 0.61 to 0.75 kg/d during the first 4 mo of bottle feedings and 0.46 to 0.53 kg/d at weaning (Figure 1). They initially required roughly 120 to 130 kcal/kg/d from the walrus formula. As the calves developed and consumed less of the milk replacement product and more of the natural ingredients (fish, clams, and squid) in the maintenance formula, their energy demand appeared to decrease. Collectively, the daily caloric requirements of the calves decreased to approximately 90 kcal/kg/d after 4 to 6 mo of bottle feedings due to more efficient utilization of the more natural ingredients as seen in Figure 2 (Winhall, 2016).

Kovacs & Lavigne (1992) reported walrus calf growth rate in the wild at 0.412 kg/d. According to Fay (1982), calves in the wild gained weight during the first 4 to 9 mo at rates ranging from 0.27 to 0.59 kg/d (mean of 0.42 kg/d), and their body weight doubled in approximately 6 mo. The gross energy value of walrus milk based on mean

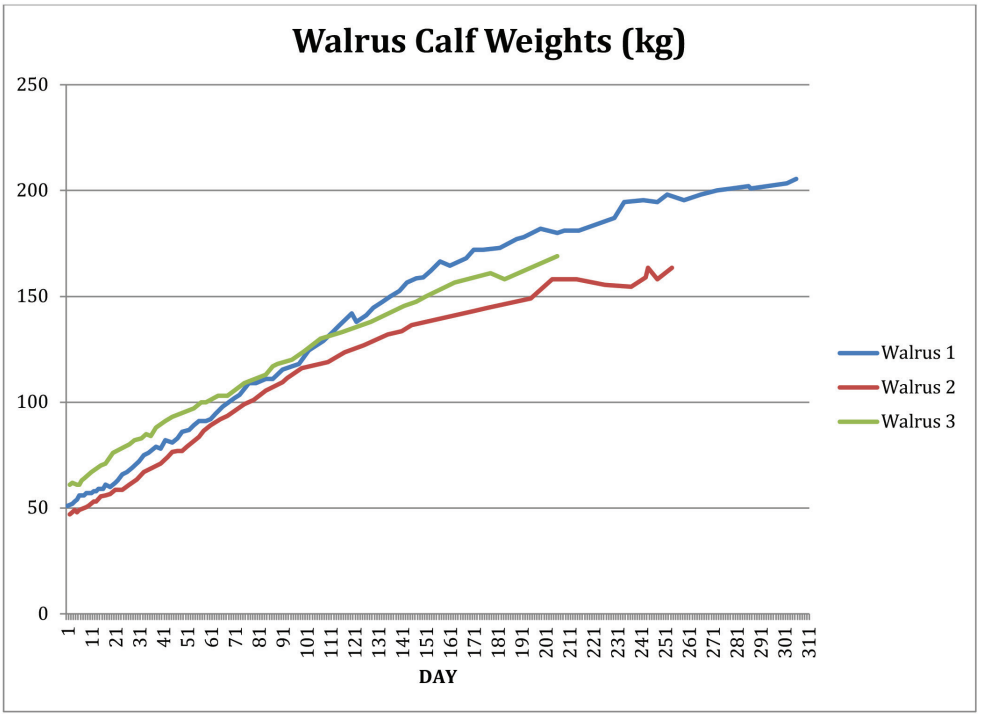


Figure 1. Walrus calves' weight during hand-rearing phase (kg) (from Winhall, 2016; reprinted with permission)

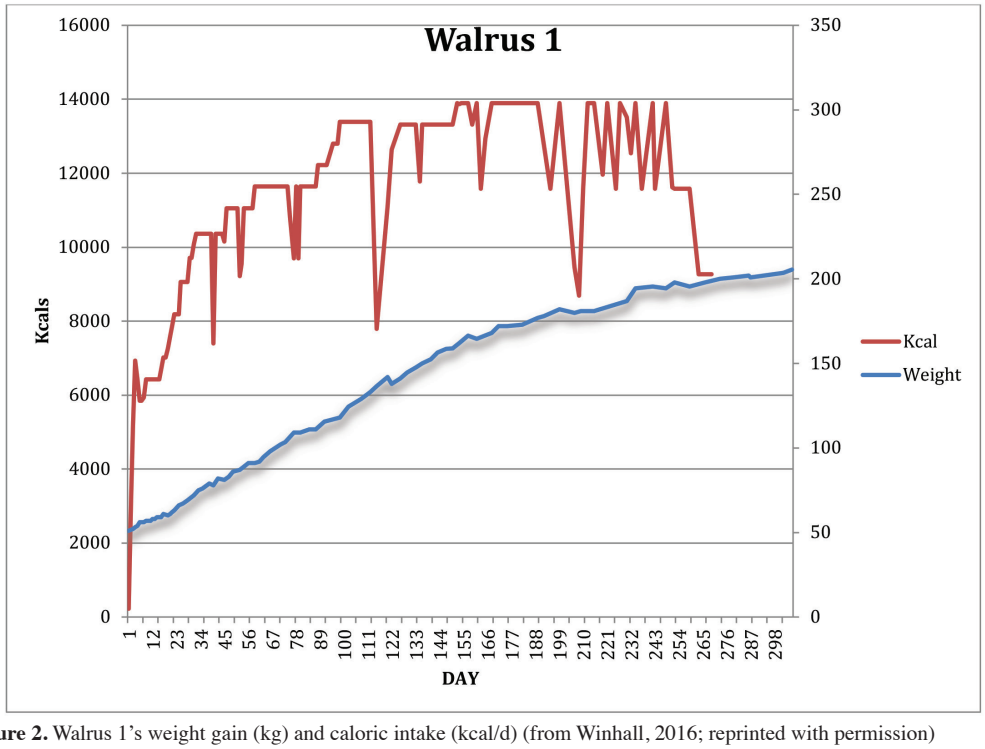


Figure 2. Walrus 1's weight gain (kg) and caloric intake (kcal/d) (from Winhall, 2016; reprinted with permission)

Feeding 1½-year-old walrus calf "Balzac" at Vancouver Aquarium in 2017 (*Photographer:* Jeannot from Quebec Aquarium)

composition of samples collected by Kleiber (1961) is about 3,240 kcal/L, consisting of 30.2% fat, 7.8% protein, and trace amounts (less than 0.025%) of carbohydrate. The formula initially given to the calves in this trial was 1,670 kcal/L containing 14.10% fat, 7.51% protein, and 2.62% carbohydrate. With the gradual addition of fish oil, this walrus formula reached an energy value of 1,940 kcal/L, containing 17.81% fat, 7.70% protein, and 0.53% carbohydrate.

Other Pinnipeds

Other pinnipeds have been reared on the walrus formula with minor modifications. For the neonate harbor seal (*Phoca vitulina*), the daily caloric requirement can be estimated to be 250 kcal/kg of body weight. As a guideline, the pup should gain ~0.12 to 0.23 kg/d. After 2 wks of dilute and concentrated formula, next add light fish gruel to the MultiMilk® (or Zoologic® 30/55) formula in place of water. After 3 wks, begin assisted feedings of whole fish, gradually increasing the amount of whole fish fed while simultaneously decreasing the volume of bottle/tube feeds. The neonate harbor seal will be completely weaned by Day 35 or sooner. The majority of neonate California sea lions (*Zalophus californianus*) rescued are often in fairly good condition. The daily requirement for the sea lion pup is estimated to be 180 kcal/kg body weight. The neonate should gain at least ~0.09 kg/d. At ~4 mo of age, if not eating on its own, begin assisted feedings with one or two small fish in addition to the regular bottle feeding. Gradually increase the number of whole fish fed each day. For neonate northern elephant seals (*Mirounga angustirostris*), the daily requirement is approximately 100 kcal/kg body weight. After approximately 4 to 6 d of tube feedings, whole fish are slowly introduced as part of the animals' diet. The neonates should receive three or four assisted feedings of whole fish by 2 wks. Gradually have the elephant seal do more of the work when it comes to swallowing the fish.

The nutritional calculations for pinnipeds (and cetaceans) do not take into account status of hydration. It is important to first satisfy the animal's fluid requirements within the first 24 to 48 h and then focus more on the animal's nutritional needs.

Beluga Whale

The beluga whale (*Delphinapterus leucas*) formula (Winhall, 2016) makes approximately 950 mL of 1.64 kcal/mL mixture. It contains 12.71% fat, 10.36% protein, and 4.09% carbohydrate, totaling approximately 164 kcal/100 g. Since fat contains 9 kcal/g, protein contains 4 kcal/g, and carbohydrate contains 4 kcal/g, this formula has an energy concentration of ~1.64 kcal/mL. It is estimated that a neonate beluga whale requires approximately 150 kcal/kg body weight/d for growth.

Postnatal Observations of Beluga Whale

Watch and record the mother and calf:

- Neonate nursing duration, left or right teat
- Neonate's defecation (color, consistency, and frequency)
- Abnormal swimming activity (listing, logging, or erratic swimming patterns)
- Respirations (frequency and effort; normal is approximately 20 respirations/5 min)
- Secretion of milk from the mother's teats
- Time when placenta is expelled
- Maternal food consumption
- Neonate weight loss (conspicuous neck region and vertebrae along peduncle)
- Maternal interest in calf (spending time with calf, keeping neonate away from the walls of the pool, and gliding and presenting her teat area to calf)

Example – For a 125-lb beluga, the caloric/volume requirements are as follows:

125 lbs × 1 kg/2.2 lbs × 150 kcal/kg neonate/d = 8,522.7 kcal/d

8,522.7 kcal/d × 1 mL formula/1.64 kcal = 5,196.8 mL/d

5,196.8 mL/d × 1 d/12 feeds = 433.1 or about 430 mL/feed

The formula is made as follows:

1. Blend 250 g of freshly defrosted 3 to 5 inch herring (no fins, head, or tail) with 325 mL of water for 3 min. Grinding the fish prior to blending has been found to yield a product with fewer chunks.

2. Add 80 g Zoologic 30/55® powder, 150 g of Zoologic 33/40® powder, 25 mL of fish oil (Vitashine® and salmon oil), 7.5 g of dextrose, 3.5 g lecithin, 1,250 mg of dicalcium phosphate (crushed with mortar and pestle), 125 mg taurine, 4.5 g salt (table salt is okay), and ½ Mazuriâ #5 SeaWorld marine mammal multivitamin (dose of 1 vitamin/5 lbs of fish or ½ vitamin/L).

3. Blend the mixture with another 375 mL of water for 1 min.

4. After blending, mix in 50 mL of heavy whipping cream (shake/mix thoroughly).

Beluga Feeding Guidelines

1. Mix formula well (total 950 mL) before using and discard leftover formula after 24 h.

2. Try to bottle feed with warm (98°F) formula using lamb or calf/different nipples (before and between tube feedings). Look for sucking response on fingers or tubing (encourage suckling/nursing). Also, try 100 mL syringe with formula attached to catheter (#18 Fr) that is secured to finger (as calf sucks on finger).

3. Weigh neonate each day at the same time for the first month (or so).

4. Check respiration rate frequently. A normal rate is ~10 to 20 respirations/5 min (higher respirations occur when calf plays at surface).

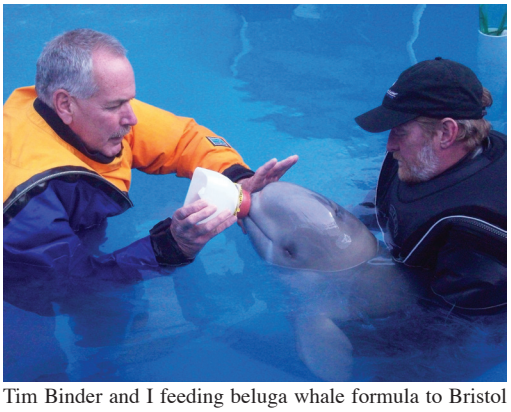
5. Clean and disinfect equipment (tubes, nipples, bottles, syringe, and blender) as soon as feeding is complete.

6. Wash hands and equipment often, and keep immediate area clean and disinfected.

7. Feed 70% calculated hourly volume with electrolyte solution for first two tubings/gastric intubations for the neonate. If that goes well, use 50% dilute simple formula (no fish or heavy whipping cream) for a couple more tubings, and then 75%. If the procedure continues to go well, begin using full-strength simple formula, gradually adding heavy whipping cream and finally fish. During this process, gradually increase the volume from 70% calculated amount to 100% of full-strength formula.

8. The feeding schedule consists of 12 feedings per 24 h for maybe the first week or two (electrolyte solution, then 50% dilute simple formula for first few tubings/feeds, and finally full-strength formula). If all goes well, gradually reduce the number of feeds (with corresponding increase in volume and/or caloric concentration per feed) to 11 feedings per 24 h (e.g., 0500 to 0100 h). By the end of the first or second month, nine feeds per 24 h should work. By Months 3 or 4, eight or seven feedings per 24 h (every 2.5 h) is all that is necessary (0600 to 2330 h or to 2100 h).

Gastric intubation of 2-week-old beluga whale calf "Pearl" with Jenifer Alongi, Rich Nunes, Mike Price, and me in 2010 (Courtesy of SeaWorld)



Tim Binder and I feeding beluga whale formula to Bristol Bay stranded beluga calf at Alaska SeaLife Center in 2012 (*Photographer:* Jaime Kincaid)

9. The caloric concentration can be increased to ~2.09 kcal/mL (analyzed) by gradually changing the amount of fish oil in the formula from 25 to 100 mL. This may be done once the calf is gaining weight and somewhat stable.

10. If possible, milk the mother every 3 to 4 h and use the birth mother's milk instead of or in addition to the prepared formula (add Immunoglobulin G [IgG] per veterinarian).

11. Begin offering the calf freshly defrosted fish and fish pieces by 2 to 3 mo of age. Soon after beginning bottle/tube feeds, work hand in mouth for eventual assisted feedings. Note that additional food equals additional calories; therefore, as the solid food intake increases, bottle and tube feedings decrease accordingly. It may be necessary to weigh the calf as often as every other day to assess the changes in the formula. A weight gain of 454 g/d (~1.0 lb/d) is a guideline for normal growth in *Delphinapterus* neonates for the first 100 d (for 180 d, 318 g/d [~0.7 lb/d]).

12. Supplemental tubings (3 to 5 times/d) have been successfully administered in situations in which a beluga calf wasn't receiving the appropriate amount of calories from its mother.

13. The caloric concentration of beluga whale milk is roughly 2.5 kcal/mL.

14. If a nurturing female beluga whale is available after an abandoned calf is treated and stable, a gradual introduction process has stimulated lactation and nursing (and a corresponding gradual reduction in tube/bottle feedings).

Example Case Study – Beluga Birth

The beluga whale pregnancy was progressing normally, and the fetus appeared typical according to veterinary evaluation (J. McBain, pers. comm., 2010). Eleven days before giving birth, the expectant female demonstrated inappetence at times, slower swimming patterns, and increased rubbing on the sides and bottom of the pool as well as on the thick ship-tie-down rope (an enrichment device) in her pool. She displayed frequent body crunching or shrimping 3 d before the calf's birth and stopped eating 11 h before the calf's delivery. Mucus was expressed, and eventually the neonate's tail flukes protruded from the mother's genital region. One hour and 37 min later, the calf was born. Due to maternal neglect and inappropriate care, veterinary staff determined that the calf should be removed from the female, and the mother was moved into the back area medical pool shortly thereafter. At 5 h and 50 min following the birth, the mother passed the placenta. The calf was closely watched 24 h/d by the trainers and veterinary staff in a beluga holding pool.

The neonate was supplemented with electrolyte solution via gastric intubation (tubing) approximately 2 h after birth and then given dilute simple formula mixed with her mom's milk for her first 4 d. Utilizing various strategies and equipment, bottle feedings were attempted throughout the day and night without much success. Complicating the matter, the mother had been conditioned to allow milking but, due to refusals to cooperate, on Day 5, the calf was fed full-strength formula via stomach tube, which included an additional 25 mL of fish oil. The caloric concentration of the formula was gradually enhanced with the addition of more fish oil to reach an energy concentration of 2.09 kcal/mL by Day 11. Due to some reflux or backward flow in the stomach tube during feedings and minor amounts of milk occasionally being expelled out of the calf's blowhole early on, it was decided to increase the number of feedings per day and add more fish oil to the formula, increasing the caloric concentration without increasing the total amount fed. Note that this was at a more frequent rate than recommended in my article, "Hand Raising and Conditioning of Neonate Beluga Whale (*Delphinapterus leucas*)" (Winhall, 2012). The number of tube feedings per day went from initially feeding the calf every 2 to 3 h to 10 feedings/d by Week 7. During this week, the calf was observed attempting to nurse on the younger female beluga that was introduced to her in the back pool (the female started producing milk, and milk samples collected from this female increased in concentration over time). From this point on, the process of decreasing the number and/or volume of formula fed was in correlation to the calf's weight gain with the result that by Week 16, the calf was fed only once a day. From Week 17 forward, no supplemental feedings were administered.

Assisted feedings began slowly with one fish to three small fish per week when the calf was 12 wks old. The team would assist the fish all the way down to the caudal portion of the mouth at the base of the tongue for the first couple of weeks. The next week, the first fish was placed all the way down the throat and, later, only three-quarters of the way to the caudal portion of the calf's mouth. Eventually, the fish was placed two-thirds of the way into the neonate's throat such that this conditioning of the calf led to her eventually swallowing the fish by herself. The team used less and less

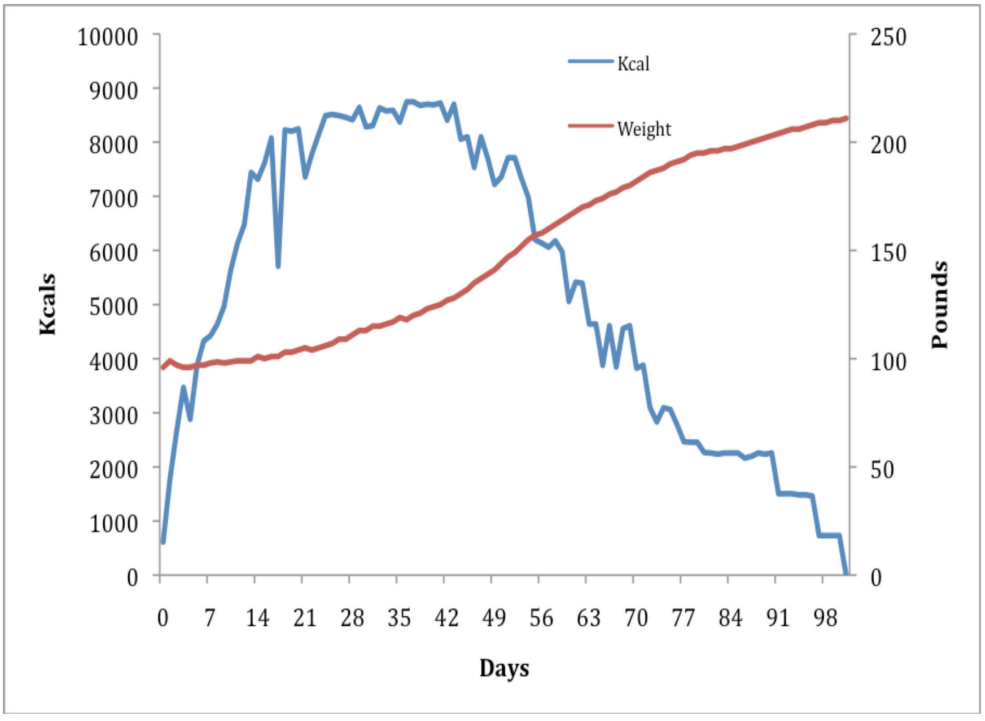


Figure 3. Beluga calf's weight and caloric intake per day (from Winhall, 2012; reprinted with permission)

restraint with the calf and made the calf do more and more of the work eating the fish, much as Ken Ramirez (2001) explains in his *IMATA Soundings* article. Ramirez talks about learned helplessness and how he and his team eventually conditioned a young beluga whale to eat on her own. The beluga whale calf was eating at poolside with minimum restraint at 24 wks. Soon thereafter, at 25 wks, the calf was hand-feeding and stationing next to two females. The calf was asked and reinforced with fish and attention for stationing either by herself or with the other adult whales during separations and other short training sessions.

This beluga calf demonstrated favorable physiological and psychological development. She had a healthy growth rate, good appetite, and normal blood parameters. The calf developed "normal" behaviors such as playing, learning, exploring, and appropriately socially interacting with other whales following a careful and gradual introduction process to the social group. She independently and freely explored the exhibit; and, on rare occasions, she interacted with harbor seals. The calf gained on average about 0.45 kg/d (1 lb/d) for the first 90 d (Figure 3), meeting the growth rate of 454 g (~1 lb/d) as interpreted from Leslie Dalton's (2007) graph of eight beluga calves' weight gain for their first 90 d of life. The above guidelines seemed to meet the needs of this calf as far as formula composition, caloric requirements, feeding guidelines, and expected growth rate.

The careful and gradual introduction of the beluga calf to the whale group went smoothly. It was important to the team for the calf to establish some sort of bond or relationship with a surrogate mother for her initial introduction to the group. This did occur and may have helped make the other calf/whale introductions successful and without incident. The calf frequently swam with the two female belugas (the surrogate and birth mother) and nursed from both. She also occasionally interacted and swam with the two male belugas. The calf's acceptance by the beluga group and her socially appropriate behavior, possibly learned from the younger surrogate mom and the other whales, was extremely important as it would be for any hand-raised neonate's development.

The beluga calf seemed to enjoy the attention from her trainers during rubdowns, play, and learning sessions. She also interacted with a variety of enrichment items. While the calf cooperated well during short training sessions, when she demonstrated undesirable behavior, team members would withdraw their attention. On occasion, they would show interest in something else, taking care not to reinforce the undesirable

behavior while trying to redirect her to a more desirable act. All the time, we assumed the calf wanted and/or found team member attention reinforcing. The calf moved from point a to point b on cue, swam back and forth between pools when asked, allowed body exams and fluke restraints, targeted on the trainer's hand (mouth closed), learned some basic cooperative management and husbandry behaviors, and made slow progress in responding to the bridge. An important goal and key to her training program was allowing the calf to be a youngster and keeping our interactions with her fun, short, mutually rewarding, and age appropriate.

Other Cetaceans

Other cetaceans have been reared on the beluga whale formula with minor modifications. The neonate bottlenose dolphin (*Tursiops truncatus*) requires approximately 150 kcal/kg body weight/d for growth. A weight gain of 0.65 lb/d is a guideline for normal growth in *Tursiops* neonates for the first 100 d. Begin offering fish pieces and, if necessary, provide assisted feedings to the calf with freshly defrosted fish by 2 to 3 mo of age. After an abandoned calf is medically and physically stable, a gradual introduction process to an available nurturing female bottlenose dolphin has frequently stimulated lactation and nursing.

A young Commerson's dolphin (*Cephalorhynchus commersonii*) requires an estimated 200 to 250 kcal/kg body weight for growth. A weight gain of 0.33 to 0.5 lb/d is a guideline for normal growth in the neonate *Cephalorhynchus*. Warmer pool water can reduce the neonate's energy loss during hand rearing. Begin offering the calf freshly defrosted fish pieces and, if necessary, provide assisted feedings to the calf by 2 mo of age. The beluga/cetacean formula was also successfully used in the rearing of a 1,670-lb neonate gray whale that resulted in a 2 lbs/h weight gain.

Acknowledgments

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