Aquatic Mammals 2001, **27.3,** 215–221

Medical and nutritional aspects of a rehabilitating California gray whale calf

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Abstract

A week-old, 760 kg, 4.2 m neonatal gray whale calf (*Eschrichtius robustus*) was transported on 11 January 1997 to SeaWorld of California in San Diego for rehabilitation. Initial emergency therapy consisted of intramuscular corticosteroids and warm water and dextrose administered via stomach tube. Within 2 hrs the whale was alert, at which time an artificial milk formula was fed via gastric intubation. Within 8 days, the whale was nursing from an artificial nurser, finally weaning by 7–8 mo of age onto solid food consisting of a mix of krill, herring, squid, and smelt. During the 436 days of rehabilitation, the whale gained 7968 kg and grew 4.87 m. Overall daily weight gains averaged 18 kg/day, average lengthening was 1.2 cm/day, and caloric intake required to maintain these gains averaged 30 kcal/kg. These numbers currently stand alone as there is no similar gray whale data for comparison.

Key words: gray whale, whale lice, hypoglycemia, milk formula, electrophoresis.

Introduction

In the evening of 11 January 1997, an emaciated and comatose, newborn California gray whale (*Eschrichtius robustus*) arrived at the Animal Care Facility at SeaWorld of California, San Diego, after rescue at a beach near Los Angeles and subsequent 2-hr transport by truck. The female calf, later named 'JJ', weighed 760 kg and was 4.2 m long on arrival. The initial physical examination showed no palpebral response, lax jaw tone, extremely shallow and depressed respiration (*ca.* 2–3/min), and a faintly palpable heartbeat. There were many non-healing lacerations on the ventral and lateral surfaces, sustained from rubbing on sharp rocks. Whale lice (*Cyamus scammoni*) inhabited all mucocutaneous junctions. Within minutes of her arrival, we began emergency medical treatment to revive and stabilize the calf. Here, we describe those initial steps and also the general procedures and medical results from the next 13 mo of rehabilitation.

Materials and Methods

Medical aspects

Our first step was to obtain and quickly evaluate a sample of blood to direct subsequent emergency care. The whale remained still when a 19 ga, 3.8-cm needle was inserted dorsally into the fluke vein to draw a 12-cc blood sample. While blood sugar and electrolytes were analyzed in the laboratory, JJ was lifted-out of the truck by a crane and lowered into a 12 m × 12 m × 1 m (depth) pool. The initial blood work indicated severe hypoglycemia (glucose= 27 mg/dl), normal electrolytes, and moderate inflammation. Consequently, to resolve the low blood sugar condition, we immediately gave her 6 l of warm water and 3 l of 50% dextrose via gastric tube and 60 mg of dexamethasone sodium phosphate by intramuscular injection into the epaxial musculature, approximately 10-cm lateral to the dorsal ridge. We then floated JJ out of the stretcher, and within 15 min she began to swim slowly. She opened her eyes 5 min later, and within 30 min began moving about the pool unassisted. Forced feeding of an artificial milk formula (Table 1) with a gastric tube began about an hour later. We used half-strength formula for the first five feedings during the next 10 hrs in the event that JJ was unable to digest a more concentrated formula. Then, we fed her full-strength formula every 2 hrs.

To counter the diagnosed inflammation, we gave oral doses of enrofloxacin (2.5 mg/kg) twice a day and nystatin (13 000 IU/kg) three times a day starting 2 hrs after her arrival. We found no antibodies to any marine morbillivirus or canine distemper in serum samples using virus neutralization techniques (Duignan *et al.*, 1994).

Table 1. Ingredients for 1 l of milk formula used to raise JJ, a California gray whale calf

Ingredient	Amount
Ground herring (heads removed)	230 g
Zoologic[1]	45 g Zoologic 33/40 25 g Zoologic 30/55
Heavy whipping cream	50 ml
Dextrose	7.5 g
NaCl	4.5 g
Lecithin[2]	3.5 g
Taurine[2]	125 mg
Dicalcium phosphate	18.75 g

[1]Zoologic Milk Matrix, Pet Ag, 201 Keyes Ave., Hampshire, Illinois 60140.
[2]Natures life, Garden Grove, California 92841.

Electrophoresis of selected blood proteins revealed apparently normal patterns for albumin (3.6 mg/dL), alpha globulin (0.2 mg/dL), beta globulin (0.5 mg/dL), and gamma globulin (2.2 mg/dL; Table 2, Fig. 1). In contrast, no gamma globulin was found in blood serum of another neonatal gray whale that also stranded on 11 January in northern California, but soon died. These comparative data suggested that gamma globulin is not a component of the blood of newborn gray whales, but that they may soon be acquired through suckling. Moreover, the presence of gamma globulin in JJ's blood and the presence of large numbers of whale lice is strong evidence that JJ had intimate contact with her mother for at least a brief time prior to separation.

By 11 February 1997, JJ's blood chemistry improved and the signs of infection virtually disappeared. Consequently, we discontinued the anti-inflammatory medication. We think that the acquisition of gamma globulin during brief suckling bouts was a key factor in JJ's rather quick recovery from the severe infection indicated by blood plasma analyses.

The hematological and biochemical parameters during the first 32 days were similar to most neonatal cetaceans with inflammatory disease; a mild normocytic, non-responsive anemia, leukocytosis, neutrophilia, hyperfibrinogenemia, elevated ESR, and hypoferremia (McBain, 1996). The drop in globulin levels was similar to those observed in animals with passive transfer of colostral antibodies (Table 3). The rest of the blood chemistry analyses were similar to patterns reported for other young, growing cetaceans (i.e., elevated serum alkaline phosphatase, ALP), except for cholesterol and triglycerides (*cf.* Table 3; Gilmartin *et al.*, 1974; Lambertsen *et al.*, 1998; Lenfant, 1969; Priddel & Wheeler, 1998; Smith *et al.*, 1987; Zettner, 1974). While JJ was fed formula, serum triglycerides were higher relative to cholesterol levels, but this pattern reversed after she shifted to solid food. Cholesterol peaked at high levels similar to those reported for another juvenile gray whale (Gigi II) monitored in 1971 (Medway & Cornell, 1989) and other hand-raised odontocete neonates (A. Johnson & M. Walsh, pers. comm.). We believe this change simply reflected the change in diet to one richer in krill, which is known to have high cholesterol levels.

Circulating levels of creatinine increased slightly (to 2.6 mg/dL on 6 January) in early January 1998, shortly after JJ started a spontaneous, voluntary fast, and were even higher (3.4 mg/dL) by 20 January. But no other signs of distress, dehydration, or kidney failure (i.e., elevated blood urea nitrogen, plasma proteins, phosphorus, or electrolytes) were apparent. She spontaneously resumed eating around 28 January and creatinine then returned to normal (1.9 mg/dL). A similar, but less substantial, increase in circulating creatinine occurred when JJ shifted to solid food in early June 1997. Levels rose from 2.4 mg/dL, then dropped to normal levels (1.9 to 2.1 mg/dL) within several months. We believe that these fluctuations were related to food intake.

Nutritional aspects

On 14 January, JJ wrapped her tongue around the feeder's arm and lightly suckled. She was encouraged to continue this behavior and on 19 January we were able to stop feeding her with the gastric tube, replacing it with an artificial nursing device from which she could voluntarily suckle (see Bruehler *et al.*, 2001). Feedings of formula continued for several months and then the feeding schedule was adapted to JJ's developing behavior and acceptance of solid food (see Bruehler *et al.*, 2001).

We also collected blood samples and made measurements of body size and mass periodically to assess her health and nutritional condition. During her first month of rehabilitation, JJ's body mass (Fig. 2) and length (Fig. 3) increased steadily, though the ratio of her girth-to-length decreased (Fig 4; see also Sumich *et al.*, 2001). Consequently, we increased the composition of milk matrix in the formula by 10%, increasing the caloric content of the formula by about the same amount. She then gained weight more rapidly and her girth-to-length ratio also increased (Fig. 4).

Although the composition of gray whale milk is not known, we estimated that it might be around 52% moisture, 35% fat, 12% protein, and 1% carbohydrate, accounting for 3.67 kcal/ml (*cf.* Jenness & Sloan, 1970 for comparative composition of milk of other baleen whales). We increased the caloric density of the formula to match this estimate, but

Table 2. Selected biochemical parameters from JJ, a California gray whale calf, during rehabilitation.

Hematological parameter	Date													
	11/01/97	13/01/97	17/01/97	28/01/97	11/02/97	11/03/97	22/04/97	20/05/97	17/06/97	22/07/97	09/09/97	11/11/97	28/01/98	25/02/98
Glucose (mg/dL)	27	147	141	116	120	114	95	99	94	94	92	101	97	97
BUN (mg/dL)	75	48	21	24	29	52	62	60	50	59	71	73	68	61
Creatinine (mg/dL)	0.6	0.5	0.5	0.8	0.8	1.3	1.8	1.7	2.4	2.4	2.2	1.1	1.9	2.1
Cholesterol (mg/dL)	152	136	228	260	310	400	525	675	800	1060	1110	1160	1450	1470
Triglycerides (mg/dL)	42	49	267	640	410	330	210	176	120	84	144	175	159	173
Total Protein (g/dL)	6.2	6.5	6.1	4.3	4.2	4.8	5.6	5.4	5.8	5.9	6.0	6.0	6.2	6.2
Albumin (g/dL)	3.4	3.6	3.5	3.1	3.2	3.0	4.1	4.1	4.3	4.3	4.0	4.0	3.9	4.0
Alpha Globulin (g/dL)	0.4	0.2	0.2	0.2	0.5	0.5	0.4	0.6	0.7	0.7	0.6	0.8	0.9	1.8
Beta Globulin (g/dL)	0.3	0.7	0.6	0.5	0.8	0.7	0.6	0.4	0.5	0.7	1.1	1.0	1.1	0.1
Gamma Globulin (g/dL)	2.2	1.9	1.8	0.6	0.9	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.3
ALP (U/L)	3120	2648	2039	2522	2054	2212	1795	1483	1546	1597	1355	1615	1263	1360
ALT (U/L)	6	3	3	7	6	5	5	3	3	4	9	13	5	9
AST (U/L)	117	101	103	62	52	49	50	41	47	42	58	59	44	43
GGT (U/L)	52	52	40	19	23	11	10	3	4	7	7	2	5	7
CK (U/L)	287	174	107	125	175	218	175	142	145	164	121	115	159	152
LDH (U/L)	714	457	396	258	260	155	120	146	198	153	216	193	209	172
Calcium (mg/dL)	9.1	7.9	8.8	8.2	10.1	9.7	11.0	10.5	10.8	10.9	10.5	10.2	10.6	11.3
Phosphorus (mg/dL)	3.3	7.0	4.7	7.6	7.3	7.3	8.8	9.3	8.2	8.2	5.1	7.0	6.8	7.4
Sodium (mEq/L)	151	149	149	147	146	150	150	150	150	151	154	154	153	150
Potassium (mEq/L)	4.3	3.8	4.5	4.7	5.0	4.7	4.7	4.2	4.2	4.8	4.3	3.9	3.9	3.6
Chloride (mEq/L)	115	110	106	110	111	113	112	109	109	110	112	112	114	113
CO2 (mEq/L)	30	34	39	37	35	31	34	35	34	30	29	32	24	27
Iron (µg/dL)	207	54	141	112	163	328	181	224	177	181	201	322	237	237

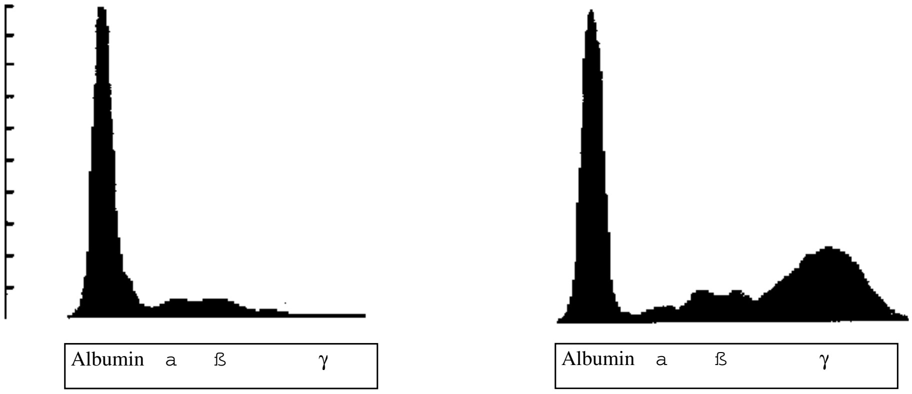

Figure 1. Serum protein electrophoresis from two stranded California gray whales. The one on the left was drawn from a newborn calf that had not suckled. Note the absence of gamma globulin in contrast to its presence in JJ's profile to the right.

this produced a formula that was too viscous to pass through the feeding tube. Therefore, we doubled or tripled the daily volume fed to JJ to reach our theoretical estimates required for growth (*ca*. 60 to 65 kcal/kg body mass).

On 17 April, JJ first ate her solid food and by 22 May she was actively soliciting solids and sucking-up food from the bottom of the pool, behavior similar to free-ranging gray whales (e.g., Darling *et al*., 1998). We retrieved uneaten food from the bottom of the pool, weighed and compared it with the amount offered to determine her daily consumption of solid food. By 13 August, JJ's diet was only 1–2% solid food and she was still principally interested in formula. To encourage weaning, we gradually reduced the powdered milk content of the formula by 20% every other day for ten days. As the caloric content decreased, JJ satisfied more of her hunger by eating more solid food. Her body mass then stabilized (Fig. 2) and girth-to-length ratio decreased (Fig. 4). Within three weeks, she was entirely weaned from the formula and eating 180 to 230 kg of solid food daily, mostly capelin and sardines (25% of diet), squid (60% of diet), and krill (15% of diet). Frozen clams, and live tubeworms, red crabs, sea cucumbers, and snails (*ca*. 1% of diet) also were placed on the bottom of the pool as novel prey items. Our ultimate goal was to encourage and allow JJ to gain sufficient mass and blubber resources to support her energetic requirements while migrating to northern feeding grounds in the Gulf of Alaska and Bering Sea once released.

Results

Between her arrival at SeaWorld on 11 January 1997 and her reintroduction to the Pacific Ocean on 31 March 1998, JJ gained 7968 kg (Fig. 2) and grew 4.87 m in length (Fig. 3). She gained around 18 kg/day, on average (greatest 31 kg/day) and her length increased by 1.2 cm/day. The caloric intake required to support that growth averaged 20 kcal/kg. Her body mass nearly doubled and her length increased by 2 m in the 6 mo prior to release. With medical treatment and intensive husbandry care during her 14-mo rehabilitation, JJ overcame life threatening hypoglycemia, numerous skin lacerations and infections, and malnutrition, while physiologically adapting to an artificial milk diet, learning to suckle from an artificial teat, and finally weaning onto a variety of fish and invertebrates.

Discussion

The past successful hand-rearing of several bottlenose dolphins (*Tursiops truncatus*), common dolphins (*Delpinus delphis*), and harbor porpoise (*Phocoena phocoena*), and another gray whale calf provided some guidelines for estimating the caloric requirements for growth and vitality (e.g., SeaWorld Animal Care, unpubl. data; Townsend, 1999; Wahrenbrock *et al*., 1974). Those data were perhaps key to our ability to quickly respond to JJ's needs to stabilize her and promote her growth. From those data we estimated that JJ would need between 30 to 70 kcal/kg and then determined daily volumetric requirements as follows:

1. total daily caloric needs = estimated kcal/kg × body weight (kg)
2. daily volumetric needs = total daily caloric needs ÷ caloric density (milk)
3. number of daily feedings = daily volumetric needs ÷ estimated volume/feeding
4. volume/feeding = daily volumetric needs ÷ number of feedings

Table 3. Selected hematology parameters from JJ, a California gray whale calf, during rehabilitation.

Hematology parameter	Date													
	11/01/97	13/01/97	17/01/97	28/01/97	11/02/97	11/03/97	22/04/97	20/05/97	17/06/97	22/07/97	09/09/97	11/11/97	28/01/98	25/02/98
Hemoglobin (g/dL)	14.4	14.2	13.8	13.3	13.4	13.7	13.9	13.9	14.2	14.9	15.8	15.0	15.4	15.5
Hematocrit (%)	44	43	42	39	40	42	41	42	41	44	46	45	47	46
RBC (M/μL)	3.10	3.00	3.00	2.80	3.00	3.10	3.10	3.20	3.20	3.40	3.50	3.30	3.50	3.50
MCV (fL)	142	142	140	138	135	134	133	132	129	130	131	135	134	132
MCH (pg)	47	47	46	48	45	44	45	43	44	44	45	46	44	44
MCHC (g/dL)	33	33	33	34	33	33	34	33	34	34	34	34	33	34
RDW (%)	N.T.*	22.4	21.4	20.4	19.4	19.9	20.2	19.1	18.4	17.6	18.1	20.5	19.5	19.8
Platelets (K/μL)	clumped	60	130	220	310	220	220	210	200	170	140	160	100	140
MPV (fL)	N.T.	15.5	15.2	12.3	11.9	11.5	11.8	12.1	11.6	12.4	13.8	14.2	13.4	15.4
NRBC/100 WBC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reticulocytes (%)	0.1	0.1	0.5	1.6	1.6	1.5	1.8	1.4	1.2	1.3	0.5	0.5	1.0	1.2
WBC (K/μL)	6400	8700	12 700	7100	4100	3000	3300	2700	2900	3600	3100	4700	4600	4000
Bands (%)	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Neutrophils (%)	80	85	87	87	84	83	75	69	81	69	54	77	70	67
Lymphocytes (%)	9	8	5	5	9	10	21	20	15	23	36	18	22	20
Monocytes (%)	11	7	8	8	7	7	3	9	3	7	10	5	8	1
Eosinophils (%)	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Basophils (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ESR (mm/hr)	63	77	86	107	73	60	60	58	55	77	78	48	60	66
Fibrinogen (mg/dL)	384	451	455	526	357	422	331	355	297	312	N.T.	277	352	345

*N.T., not tested

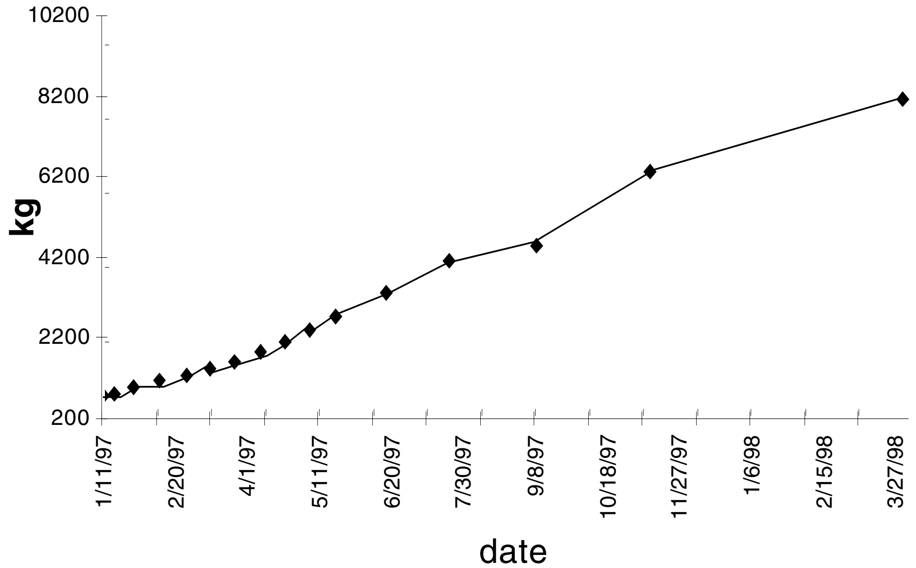

Figure 2. Increase in body mass of JJ, a rehabilitating California gray whale calf.

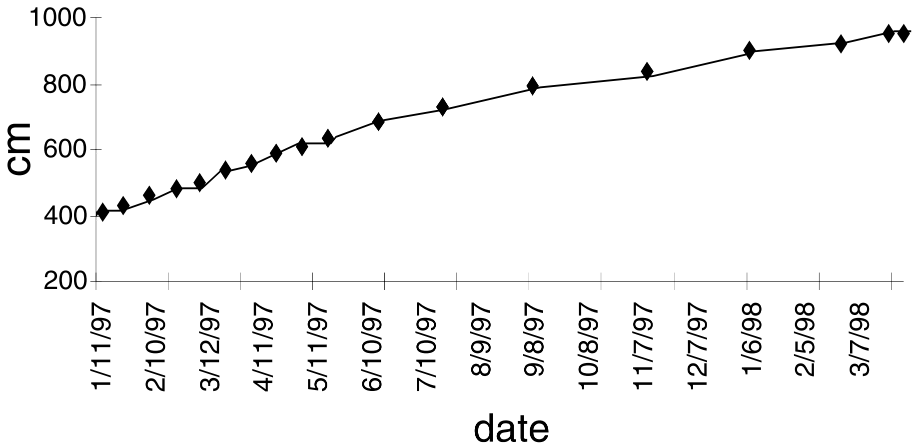

Figure 3. Increase in body length of JJ, a rehabilitating California gray whale calf.

Those relationships allowed us to adjust the ration volume as the caloric density of the milk or metabolic requirements of the whale changed. Initially, JJ required nearly 70 kcal/kg to grow, tapering to around 20 kcal/kg at the time of release.

The challenges in logistic management of the care and feeding of JJ were truly exceptional considering her size. However, we found that otherwise the general medical and nutritional challenges were similar to those faced during the care and treatment of small cetacean neonates. Our primary challenges in rehabilitating this gray whale neonate were meeting her grossly greater energetic needs versus the constraints of substantially lower levels of fat and total calories possible in the synthetic milk formula. We found that this constraint could be overcome by greatly increasing, by two or three times, the daily estimated intake volume. We also found that it was very important to maintain volumes that were similar each day, while decreasing the total daily caloric intake to stimulate appetite for solid food. Finally, building sufficient blubber reserves to sustain a northward migration of several weeks required preparatory daily intakes of around 200 kg or more of solid food to account for average daily weight gains of around 50 kg in this rather sedentary, but otherwise growing gray whale calf.

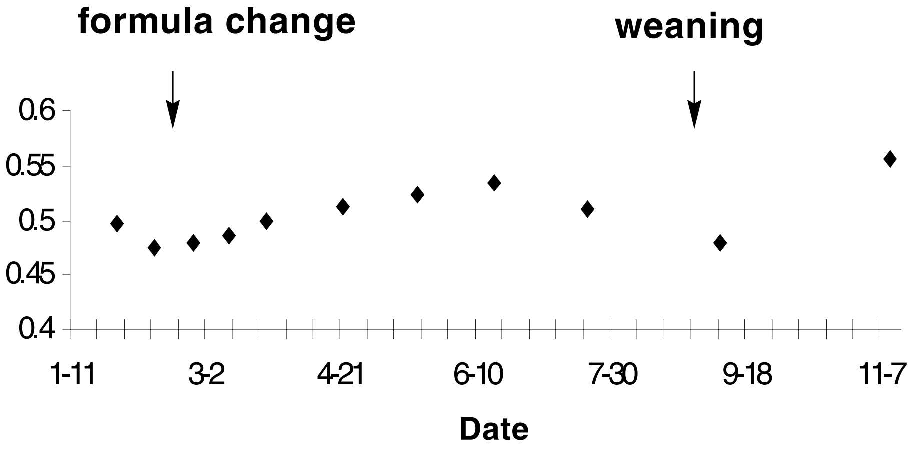

Figure 4. Change in the ratio of girth-to-length of a California gray whale during the first eleven months of rehabilitation. Note the drop in ratio of girth-to-length during a early nursing period, followed by a rise when the caloric content of the artificial milk was increased. At weaning, the girth-to-length ratio dropped as the whale's diet was switched from artificial milk to solid food.

Acknowledgments

We thank the Animal Care and Laboratory staffs of SeaWorld of California for their outstanding efforts and passion during one of the most unique rehabilitation efforts of the 20th Century.

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