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Satellite tracking a rehabilitated Guadalupe fur seal (*Arctocephalus townsendi*)

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Abstract

A female Guadalupe fur seal (*Arctocephalus townsendi*), which stranded on 4 January 1998 at Point Lobos State Reserve, Carmel, California, was the first adult Guadalupe fur seal rehabilitated by The Marine Mammal Center, since establishment during 1975. Hematology and serum biochemistry data collected during rehabilitation indicated values were within ranges reported for northern fur seals (*Callorhinus ursinus*), and are the first published for this species. To monitor this rare individual after release, a Satellite-Linked Time-Depth recorder, which was optimized to record locations and depths and durations of dives using the Service ARGOS satellite system, was glued to the dorsum using 5-min epoxy. The fur seal was released 5 March 1998 at Point Piedras Blancas, California. After release, 25 positions were received, indicating the fur seal travelled south to eastern Guadalupe Island before travelling approximately 1430 km north (39°30.6′N, 127°18.0′W) along a similar track. Minimum distance travelled from time of release was approximately 2890 km and mean rate of travel was 3.2 ± 1.4 km/hr. Transmissions ceased seven weeks after release on 22 April 1998 when the animal was ~315 km off-shore of Mendocino County, California. During transit, the majority of dives were shallow (<20.2 m) and most dives ranged from 2–4 min. Oceanographic conditions, as a result of El Niño, probably attributed to initial stranding of the fur seal and also could have affected the movements and behaviour of this animal after release. This is the first documentation of the post-release survival for a rehabilitated Guadalupe fur seal.

Key words: Guadalupe fur seal, *Arctocephalus townsendi*, rehabilitation, post-release survival.

Introduction

The population of Guadalupe fur seals (*Arctocephalus townsendi*) has increased since near extinction during the 19th century (Gallo, 1994), as have strandings and observations of Guadalupe fur seals off California (Bartholomew, 1950; Stewart & Yochem, 1984; Stewart *et al*., 1987; Hanni *et al*., 1997; Melin & DeLong, 1999). Although some free-ranging adults of normal weight and health have been sighted on islands off California, only stranded juveniles have been admitted to The Marine Mammal Center (TMMC), Sausalito, California, for rehabilitation. This allowed staff the opportunity to study this rare species in captivity (Webber & Roletto, 1987; Gerber *et al*., 1993; Feldman, 1996; Hanni *et al*., 1997).

An adult female Guadalupe fur seal (GFS#12) that stranded on 4 January 1998 at Point Lobos State Reserve, Carmel, California, was the first adult Guadalupe fur seal admitted to TMMC, since establishment in 1975. Little is known of behaviour or demography of Guadalupe fur seals, which breed along the eastern coast of the Isla de Guadalupe, approximately 260 km west of Baja, California, Mexico. Furthermore, *A. townsendi*, listed in the IUCN Red list as 'vulnerable', is the smallest fur seal population, estimated to comprise less than 10,000 individuals (Gallo, 1994; Wickens & York, 1997). Thus, in addition to reporting health profiles of the animal while captive, we decided to monitor the post-release survival of the fur seal to determine if rehabilitation efforts were successful.

Materials and Methods

On arrival and before release, the fur seal was weighed, and blood collected from the caudal gluteal vein and analyzed using a Sysmex automated hemocytometer (F-800; Toa Medical Electronics Co.) and an Olympus model (AU5200: Unilab, Sacramento). Prior to release at Point Piedras Blancas, San Simeon, California on 5 March 1998, a Satellite-Linked Time-Depth recoder (SLTDR (quarter-watt model SDR-T10); Wildlife Computers, Redmond, WA) was glued directly

to the dorsum using 5-min epoxy (Baker pers. comm.).

The SLTDR was optimized to record time at depth (TAD), depths and durations of dives, and to provide 'at-sea' and 'on-land' locations using the Service ARGOS satellite system. The SLTDR was duty-cycled to transmit data every other day and was programmed to store, summarize, and encode data into histograms, consisting of bins that contained counts of dives for a given range of depths or times. Counts were accumulated for four, 6 h periods: 0=2100-0259 h, 1=0300-0859 h, 2=0900-1459 h, and 3=1500-2059 h. For TAD histograms, the count in each bin, as a fraction of total counts in all bins, represented the fraction of the 6 h period that the animal spent at each depth range. Upper limits of maximum-depth and TAD histogram bins included 20, 40, 80, 160, 320, and >320 m, and upper limits of dive-duration histogram bins included 1, 2, 4, 8, 10, and >10 min. Data were analyzed by summing counts of dives from histograms. Mean ($\pm$ 1 SD) and median depth and duration of dives were calculated using the range midpoint of a bin as the depth or duration for all dives in a bin (Merrick & Loughlin, 1997). Path of travel was plotted, and total distance travelled was calculated using Arcview 3.0 and Animal Movement (an ArcView extension; Hooge & Eichenlaub, 1997). Mean rate of travel was calculated by dividing the distance (km) between sequential daily positions by the hours that elapsed between those positions (Westgate *et al.*, 1998). Data were examined for erroneous positions (i.e., positions of z location class (LC) and position estimates that placed the seal inland or outside the study area; Loughlin *et al.*, 1987; Merrick & Loughlin, 1997) and to ensure that distances between locations were possible given the elapsed time between the fixes and an estimated swim speed of 7 km/hr found for a wild, adult female Guadalupe fur seal tagged with a time-depth recorder (TDR) during 1993 at Isla de Guadalupe (Gallo, 1994).

Results

As with previously stranded Guadalupe fur seals (Hanni *et al.*, 1997), GFS#12 was emaciated (39 kg body weight) and physically inactive when admitted. Blood results indicated hematology and serum biochemical values were within ranges reported for northern fur seals, *Callorhinus ursinus*, (Bossart & Dierauf 1990; Table 1). Over the eight weeks of rehabilitation, neutrophil counts decreased, whereas lymphocyte and eosinophil counts increased, suggesting the seal had a stress-related leukogram on stranding (Table 1). Plasma progesterone level at release was 0.1 ng/ml and estradiol was 44.0 pg/ml. Although plasma reproductive hormone levels are unpublished for this species, these values were consistent with anestrus and non-pregnancy in other pinnipeds (Daniel, 1975; Kirby, 1990). Abdominal ultrasound examinations also indicated the animal was not pregnant. After rehabilitation, the fur seal weighed 51 kg, which was comparable to a mean body mass of 49 kg reported for free-ranging adult females (Gallo & Figueroa, 1996).

After release, 25 positions were received over a seven week period. With the exception of two positions, all LCs (0-3, A, and B) were plotted (Fig. 1). The fur seal travelled south from Piedras Blancas to eastern Guadalupe Island (29°1.1′N, 118°12.9′W) in 14 to 15 days. Because the SLTDR was programmed to suspend transmissions after being hauled-out for 23 h, it was assumed the fur seal hauled-out on the island when transmissions ceased for seven days. From time of release until 20 March, when the seal presumably reached Isla de Guadalupe, minimal dive data were collected. Mean depth ($\bar{x}$=15.7 $\pm$ 11.8, median=12.0 m, n=18) and duration ($\bar{x}$=1.7 $\pm$ 1.0, median=1.5 min, n=16) of dives were calculated for data collected for three days during the seal's southbound trip. Fourteen of 18 depth readings and 14 of 16 duration readings were collected during period 3. Remaining dives (n=6) were collected during period 1. Messages received during this time indicated the repetition rate of the PTT was at an 'on land' rate, indicating the animal was either hauled-out or the instrument was 'dry'. Because the shallowest depth considered a dive was 4 m and location data indicated the seal was travelling offshore, we assumed the animal was swimming at the surface or within 4 m of the surface during the majority of its trip down to the island. Furthermore, with the exception of one TAD histogram that indicated the fur seal spent 4.5 min within a 20–40 m depth range, all TAD histograms (n=5) indicated the animal spent all hours of each period between the surface and 20 m.

The fur seal remained around the island for at least nine days before travelling approximately 1430 km back north (39°30.6′N, 127°18.0′W), over a three week period. The seal travelled north along a track that was almost identical to that of her initial southern track. A total of 520 dive depth readings and 606 dive duration readings were received from 2 to 22 April 1998. The majority of depth readings occurred during nocturnal hours (period 0), and the remainder of dives occurred during crepuscular periods (periods 1 & 3), whereas duration readings were distributed more evenly among periods (Table 2). No dive data were collected during diurnal hours (period 2). Mean depth and duration of dives did not differ significantly

Table 1. Haematology and serum biochemistry values at stranding and prior to release in a Guadalupe fur seal (*Arctocephalus townsendi*) rehabilitated at TMMC. Dates of collection are indicated in parentheses.

Parameter	Stranding (1/7/98)	Pre-release (2/23/98)
White blood cell count (10^3/μl)	6.10	4.60
Red blood cell count (10^6/μl)	5.18	4.31
Haemoglobin (g/dl)	18.70	15.50
Haematocrit (%)	54.50	52.50
Mean cell volume (fl)	105.20	121.80
Mean cell haemoglobin (pg)	36.10	36.00
Mean cell haemoglobin conc. (g/dl)	34.30	29.50
Neutrophils (10^3/μl)	5.06	3.20
Lymphocytes (10^3/μl)	0.42	0.78
Monocytes (10^3/μl)	0.42	0.36
Eosinophils (10^3/μl)	0.00	0.18
Platelets (10^6/μl)	528.00	447.00
Sodium (mEq/l)	158.00	154.00
Potassium (mEq/l)	5.10	4.50
Chloride (mEq/l)	110.00	109.00
Glucose (mg/dl)	135.00	153.00
Blood urea nitrogen (mg/dl)	43.00	64.00
Creatinine (mg/dl)	1.20	1.10
Total protein (g/dl)	8.30	7.80
Albumin (g/dl)	3.50	4.10
Globulin (g/dl)	4.80	3.70
Uric acid (mg/dl)	1.00	1.00
Calcium (mg/dl)	9.60	8.90
Phosphorous (mg/dl)	6.50	7.70
Total bilirubin (mg/dl)	0.50	0.50
Direct bilirubin (mg/dl)	0.20	0.10
Gamma glutamyl transferase (IU/l)	121.00	123.00
Alkaline phosphatase (IU/l)	43.00	45.00
Aspartate transferase (IU/l)	27.00	63.00
Alanine transferase (IU/l)	29.00	89.00
Lactate dehydrogenase (IU/l)	550.00	630.00
Iron (μg/l)	46.00	88.00
Cholesterol (mg/dl)	250.00	207.00
Triglycerides (mg/dl)	44.00	83.00

among periods 0, 1, and 3 (H=4.645, F=2.590; P=0.098, 0.077, respectively; Table 2). The majority of dives were shallow (<20.0 m), and most dives ranged between 2–4 min (Fig. 2). Total mean depth ($\bar{x}$=13.9 ± 7.8, median=12.0, range=12.0–130.0 m, n=520) and duration ($\bar{x}$=2.5 ± 1.3, median=3.0, range=0.5–5.0 min, n=309) of dives during April were slightly less than mean depth ($\bar{x}$=16.9 ± 10.3, range=3.0–82.0 m, n=1465) and duration ($\bar{x}$=2.6 ± 1.4, range=0.5–18.0 min, n=761) of dives reported for the wild, adult female Guadalupe fur seal tagged by Gallo (1994). That female also dove during the night and transited during the day.

The last transmission was received on 22 April 1998. Minimum distance travelled from time of release was approximately 2890 km and mean rate of travel was 3.2 ± 1.4 km/hr. Transmissions ceased when the animal was ~315 km off-shore Mendocino County, California (Fig. 1). The end-point of the seal's trip is the northern-most location documented for Guadalupe fur seals. The fate of the animal remains unknown.

Discussion

It was difficult to determine whether behaviour exhibited by this rehabilitated individual was typical because *A. townsendi* is one of the least studied of all fur seal species (Wickens & York, 1997). Furthermore, most research of the Guadalupe fur seal occurred during the breeding season (Pierson, 1987; Figueroa, 1994; Gallo, 1994). Although GFS#12 travelled to Isla de Guadalupe during late March, free-ranging females typically arrive at the island during June (Pierson, 1987), and it is believed that nonparous females live at sea for all or part of

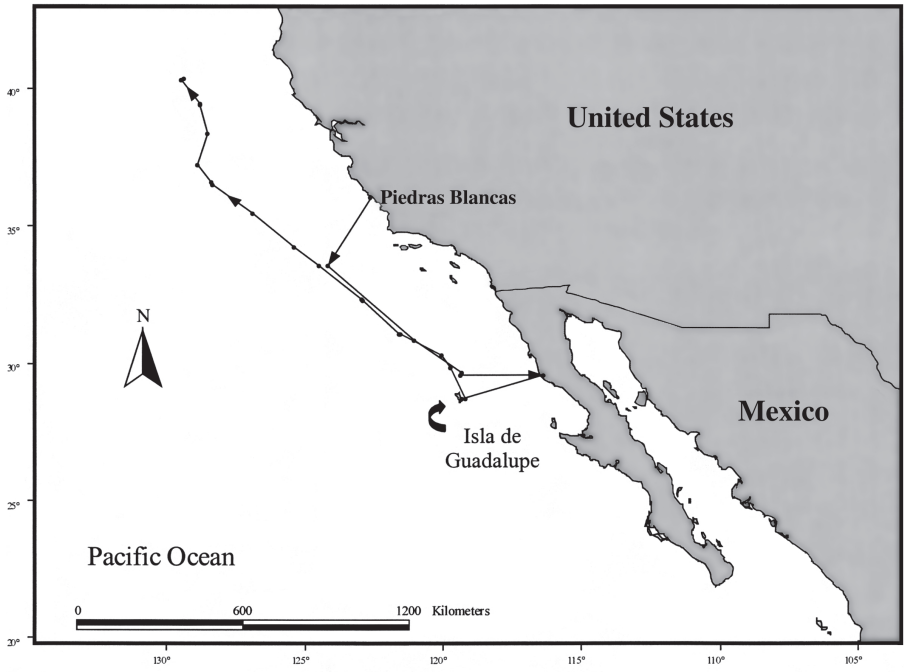

Figure 1. Movements of a rehabilitated Guadalupe fur seal (*Arctocephalus townsendi*) released at Point Piedras Blancas, San Simeon, California on 5 March 1998.

Table 2. Mean ($\bar{x} \pm$ standard deviation), range, and sample sizes (n) of depths and durations of dives during periods 0 to 3 from 2 to 22 April, 1998 for an adult, female Guadalupe fur seal (*Arctocephalus townsendi*) released from TMMC. No data were collected during period 2.

	Depth (m)			Duration (min)		
Period	$\bar{x} \pm$ SD	range	n	$\bar{x} \pm$ SD	range	n
0	13.5 ± 5.9	12.0 ± 60.0	330	2.3 ± 1.6	0.5–6.0	127
1	13.2 ± 5.9	12.0 ± 60.0	100	2.7 ± 1.5	0.5–6.0	100
2	—	—	0	—	—	0
3	15.5 ± 13.6	12.0 ± 130.0	90	2.8 ± 1.4	0.5–6.0	82

some seasons, but their distribution at sea is unknown (Reeves *et al*., 1992). It is possible that GFS#12 returned to Guadalupe Island as a result of being maintained in captivity for two months, or perhaps was returning to a pup. The lactation period of Guadalupe fur seals ranges from 9 to 11 months (Wickens & York, 1997) and females nurse their pups as late as April (Pierson, 1987; Melin & DeLong, 1999). Although GFS#12 was not lactating when admitted to TMMC, lactation could have discontinued as a result of stress and malnourishment. In addition, she probably was not pregnant due to her physiological state. Other otariids show a marked reduction in fertility during El Niño years (Trillmich *et al*., 1991).

Oceanographic conditions, as a result of El Niño, probably attributed to initial stranding of GFS#12 and also could have affected the movements and behaviour of this animal after release. In the past, the majority of stranded Guadalupe fur seals admitted to TMMC occurred during the 1991–1993 El Niño (Hanni *et al*., 1997). The correspondence of strandings and sightings of Guadalupe fur seals with warm-water years in California indicated that distribution of this species could be limited by water temperature (Hanni *et al*., 1997). Aurioles-Gamboa & Hernández-Camacho, (1999) suggested that Guadalupe fur seals disperse north when El Niño conditions affect Guadalupe Island, probably the result of decreased food availability due to

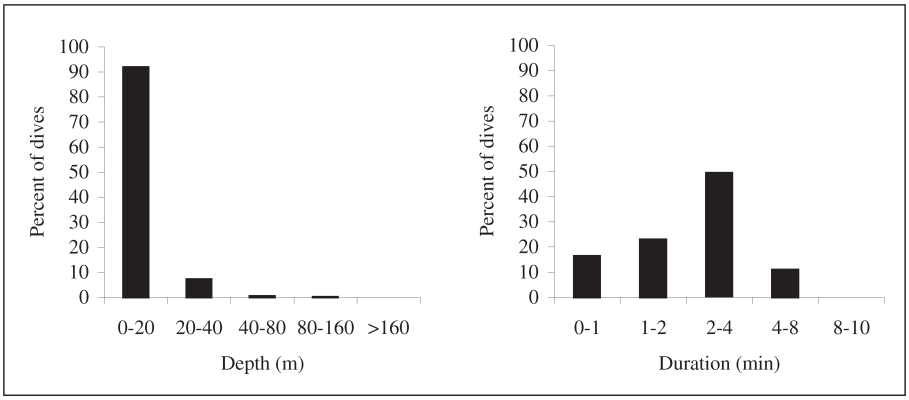

Figure 2. Frequency distributions for depths of dives (n=520) and duration of dives (n=309), according to bin ranges, from 2 to 22 April 1998, for a rehabilitated Guadalupe fur seal (*Arctocephalus townsendi*) released from TMMC.

northward movement of prey. The island normally is favoured by upwellings and the cold waters of the California Current, which presumably provide sustained food resources (Hubbs, 1948; 1960; Fleischer, 1987). During El Niño, however, the westward flowing North and South Equatorial Currents reverse direction and flow eastward, enabling warm, nutrient-depleted water from the tropical Pacific to flow southward along the South American coast and northward along the North American coast. Furthermore, southward flow of the California Current along the west coast of North America weakens, decreasing nutrient enrichment in southern California and Mexico. Consequently, fish and invertebrates normally found in Mexico extend their ranges northward along the west coast of North America (Arntz *et al*., 1991). It is unknown whether northward dispersal of GFS#12 from Guadalupe Island was a result of normal behaviour or a northern redistribution of prey normally found off Mexico and southern California.

Trillmich *et al*. (1991) found that mortality of other *Arctocephalus* adult females increased during the 1982-83 El Niño. Because El Niño conditions were still present in the Southern California Bight when the fur seal was released during March, the animal could have been a victim of El Niño a second time. However, GFS#12 could have been resistant to El Niño-related conditions if she was an efficient forager once travelling back into northern waters. Trillmich *et al*. (1991) found that during El Niño, some adult otariids reacted to changes in the marine environment by emigrating or diving deeper. Diving activity of GFS#12 was much more prominent during her northern transit than during her southern transit, and as with most species of fur seals (Gentry & Kooyman, 1986), diving activity occurred predominantly at night. Most dives were shallow though, possibly indicating that foraging occurred within the deep scattering layer. Unfortunately, time of individual dives or diving bouts can not be examined using SLTDRs. Potential foraging behaviour, therefore, could not be discerned.

It is unknown where Guadalupe fur seals forage, and currently there is limited information on the food habits of this species (Fleischer, 1987). Hanni *et al*. (1997) recovered hard parts from the feces and gastrointestinal tracts of stranded Guadalupe fur seals and concluded that the diet was similar to that of other *Arctocephalus spp*., consisting of different squid and teleost species. Additionally, Gallo (1994) found that *A. townsendi* fed on species of Scombridae, Clupeidae, and vertically migrating squid in shallow depths. Thus, it is possible that GFS#12 was foraging on similar prey items.

This is the first documentation of the post-release survival for a rehabilitated Guadalupe fur seal. Although the behaviour of this rehabilitated individual may not be an indicator of trends that were occurring in the wild population, these data indicate this species' capabilities. These data also are useful for management and establishing release criteria in California waters for rehabilitated Guadalupe fur seals.

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