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Post-release monitoring and tracking of a rehabilitated California gray whale

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Abstract

We developed surface-mounted, buoyant housings for VHF and UHF (satellite-linked) radio-transmitters for attachment to a rehabilitated gray whale calf (JJ). We then used those devices to track her for several days after her return to the Pacific Ocean on 31 March 1998. The instruments came off within three days, evidently owing to shallow and incomplete seating of the barb and toggle anchors placed in the blubber layer and from JJ rubbing against the sea bottom when attempting to feed. Nonetheless, the instruments performed exceptionally well during the brief tracking period and the buoyant design allowed us to recover them using radio signals detected by boat-based observers, and shore-based crews, and by earth-orbiting satellites. Secure, reliable attachment methods that will not compromise the health and vitality of cetaceans remain the key substantive issue for advancing studies of long-term movements and behavior baleen whales.

Key words: gray whale, satellite tracking, migration, dive patterns, cetaceans.

Introduction

It has long been known that California gray whales feed in the Bering, Chukchi, and Beaufort Seas during summer and breed in the lagoons of Baja California in winter (e.g., Scammon, 1874; Wyrick, 1954; Rice & Wolman, 1971). Yet, little is still known about the migratory routes of individuals (*cf.* Mate & Harvey 1984) or whether all gray whales make complete migrations between these areas every year. The development of methods to track whale movements has been slow during the past several decades owing to limit amounts and distribution of funding, few opportunities to experiment with an attachment of radio-telemetry devices to whales, and even rarer opportunities and efforts to inspect whales and instruments after attachment to determine reasons for poor radio-tracking performance. The successful rehabilitation of a California gray whale calf (JJ) at SeaWorld of California offered an opportunity to attach tracking instruments to her in relatively controlled conditions and monitor her movements and diving patterns once returned to the Pacific Ocean. Here, we describe the results of those efforts.

Materials and Methods

We developed custom-fitted plastic polymer housings (Fig. 1) to hold several short-range (VHF) and long-range (UHF satellite-linked) radio-transmitters, which could be mounted to JJ's body surface. The housings were filled with buoyant foam, after the transmitters were inserted, to insure that they would float upright if they detached and so allow us to recover them, inspect their condition to determine cause of detachment, and retrieve stored dive data from the satellite-linked transmitters.

We decided early on, in consultation and agreement with SeaWorld veterinarians and animal care staff, to not implant the transmitters or use deeply implanted sub-dermal anchors to attach them because of the risks for infection that could occur if the muscle fascia or muscle were penetrated. Consequently, we used small barbs and toggles placed within JJ's blubber to anchor the transmitters to the skin surface. We coated all sub-dermal anchor components with an inert, biostable and biocompatible material (Parylene) that is routinely used for medical applications to prevent immune system responses. A short length of stainless steel cable encased in vinyl tube ('shark leader') was attached to each sub-dermal anchor, emerged from a small incision in the skin, passed through the transmitter housing and then was fastened against stainless steel grommets with stainless steel crimps. Those anchors and cables were inserted into the blubber several days before JJ was released. We then secured the transmitter housings to the cables on 31 March 1998, several hours before JJ was

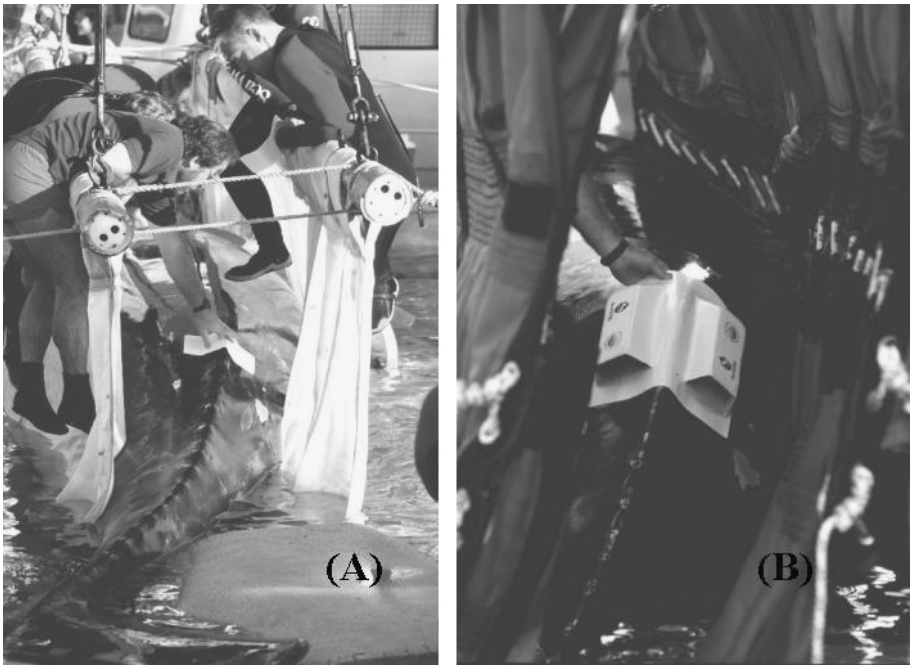

Figure 1. Custom-fitting housing for attachment of radio transmitters to a rehabilitating gray whale calf (JJ); A. creating the base mold shape; B. testing fit of final housing design.

driven to meet the transport and release vessel (USCG buoy tender *Conifer*).

We outfitted JJ with 5 radio-transmitters incased in two housings (Fig. 2). One housing was attached to her skin surface about 1.3 m behind her blowhole (Fig. 2A, Fig. 3). It contained one satellite-linked radio-transmitter (operating in the ultra high frequency radioband, UHF) and one short-range radio transmitter (operating in the very high frequency radioband, VHF). Another saddle-shaped housing was attached to her skin surface over the first bump of her dorsal ridge, about 2/3 of the way back from her head. That housing contained two UHF transmitters and one VHF transmitter and was custom-shaped to fit over the dorsal ridge (Fig. 2B, Fig. 3). Our goals in attaching several transmitters was to enhance the possibilities for tracking and possible recovery of dislodged or shed housings with redundancy of instruments and diversity in manufacture.

The satellite-linked radio-transmitters permitted tracking through the ARGOS Data Collection and Location Service (DCLS) to locate her and acquire data. The ARGOS DCLS has been described in detail elsewhere (e.g., ARGOS, 1984; Fancy *et al.* 1988; Stewart *et al*., 1989) and is now routinely used for tracking a variety of marine and terrestrial wildlife. Briefly, there are two satellites operating in the ARGOS system, both in near-polar orbits around Earth. The characteristics of those orbits allowed about five good opportunities each day for JJ to be located. On each of those five orbits, JJ could have been detected during a ten-min window if she was at the surface. We were able to locate her this way about 2–3 h after a satellite passed over and detected signals from the transmitters.

The short-range VHF transmitters allowed tracking JJ by boat (M/V *Megalodon*), as long as we remained within about 1–2 km, or from land from a greater distance if the ground crew was on a bluff or peak along the mainland. This tracking allowed us to collect detailed observations on JJ's swimming, diving, and feeding behavior. Because radio signals could only be heard when the transmitter's antenna broke the sea surface and because we might detect only one or two of these signals each time JJ surfaced, we used an automatic direction finding (ADF) system to help us navigate and follow her signals. That system consisted of four antennas mounted at right angles to each other on a tracking boat on a mast about 10 m above the sea-surface. The antennae were wired directly to a radio-receiver, which was tuned to the transmitter's frequency, and an ADF circuit board that determined which antenna detected the signal best. A series of

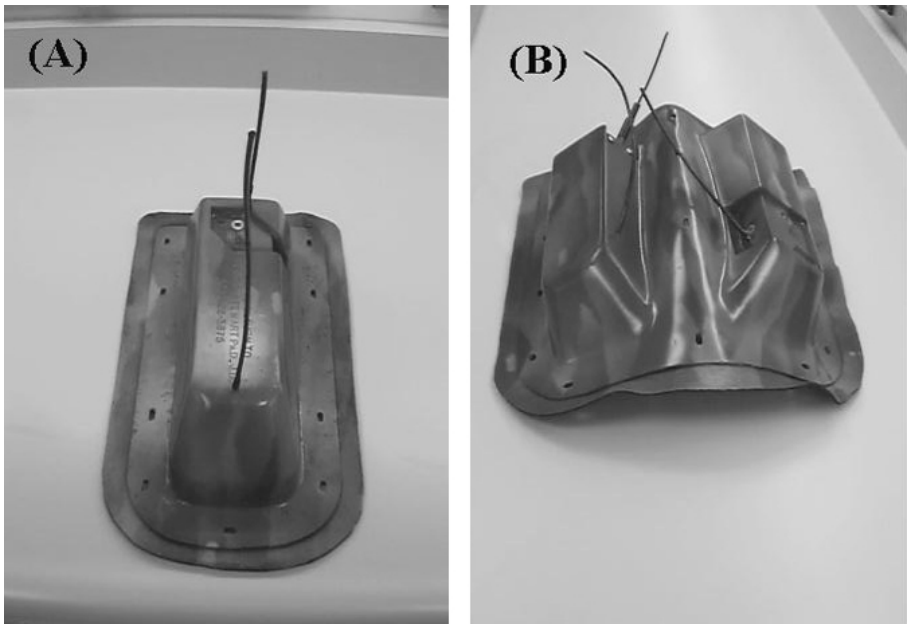

Figure 2. Final radio-transmitter housings for attachment to a rehabilitated gray whale calf (JJ); A, forward-mounted housing and B, dorsal-ridge mounted housing.

lights responded to that signal which indicated which direction to turn to stay on JJ's track.

To log boat movements, we used a Global Positioning System (GPS) receiver hooked-up to a small laptop computer, which automatically recorded our location accurately every 30 s.

Results and Discussion

JJ was released several km off Pt. Loma, San Diego (Fig. 4), at about 1018 hr on 31 March 1998. That location was determined by consensus to be the best for release based on considerations of logistics of moving and release, JJ's health and welfare, and free-ranging population movements and biology of gray whales generally. JJ dove immediately under the release boat (U.S. Coast Guard Buoy Tender, *Conifer*) and then evidently remained submerged for several minutes. Indeed, she was not sighted again until we located her by satellite telemetry about 4 hr later several km to the east. Her disappearance was rather remarkable considering that several hundred enthusiastic people, including television and radio reporters, support boats and helicopters were searching after her release. Similar behavior was observed during release of another gray whale, Gigi II, in 1972. Gigi II was not seen again until two days later (Evans, 1974).

Soon after JJ's release, we began an outward spiraling search pattern by boat (Fig. 4) scanning visually and also acoustically for signals from the short-range VHF transmitters. Nonetheless, we could not find her until the first satellite-determined locations just after 1400 hr suggested she was several km east of the release site at around 1230 hr, near the beach at Coronado (near San Diego Bay). Consequently, we terminated our search pattern and headed directly there. Despite building wind, rain, and sea conditions, we detected a signal from one of the VHF transmitters with our ADF system at around 1425 hr. Subsequent signals allowed us to quickly home-in on JJ and we made visual contact around 1445 hr. At that time, she was swimming southward at about 2 kts and about 100 m offshore, just beyond the surf. We tracked her south to the Imperial Beach Pier, just north of the U.S.-Mexico border, by 1800 hr where she lingered briefly. She then headed north a couple of miles, then south, and then back north to near the rock jetty at the entrance to San Diego Bay where we last saw her just before sunset. JJ remained in that area until at least 2200 hr when we lost radio contact owing to a substantial amount of radio noise coming from the North Island Naval Base, the commercial airport at Lindbergh Field, and a variety of other sources. Our ground-based tracking crew also had been traveling along the coast from Imperial Beach Pier to Pt. Loma and detected weak signals near the San Diego Bay jetty until late evening. Throughout our close tracking by boat, JJ was swimming strongly

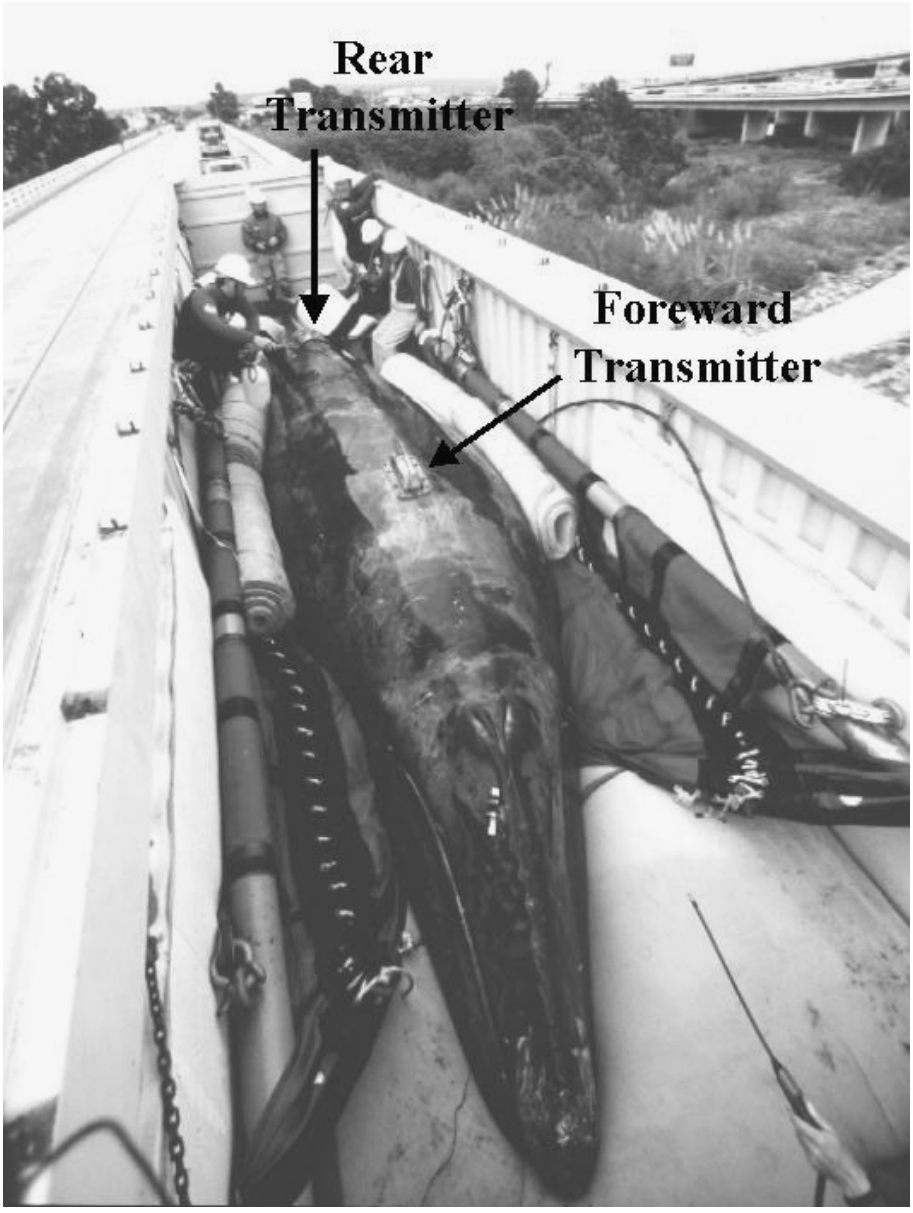

Figure 3. A rehabilitated gray whale calf (JJ) enroute to being returned to the Pacific Ocean on 31 March 1998 showing attached radio transmitters.

and never appeared to be in distress. Indeed, at first contact she was already raising her rostrum clear of the water when surfacing to keep her blowhole well above the sea surface when breathing to prevent entry of water in the heavy, choppy seas. She stayed clear of the surf zone and appeared to navigate well around the long pier structure at Imperial Beach when encountering it on her southbound and then northbound movements.

We had no further satellite fixes to help find JJ until the afternoon on 1 April. In the meantime, we made additional searches of the coastline by boat and by land, first south and then north to La Jolla, while awaiting additional satellite fixes. Our search distances were based on estimates of the distance that JJ could have traveled either south (although we were limited to searches in U.S. territorial waters) or north calculated from her swim speeds

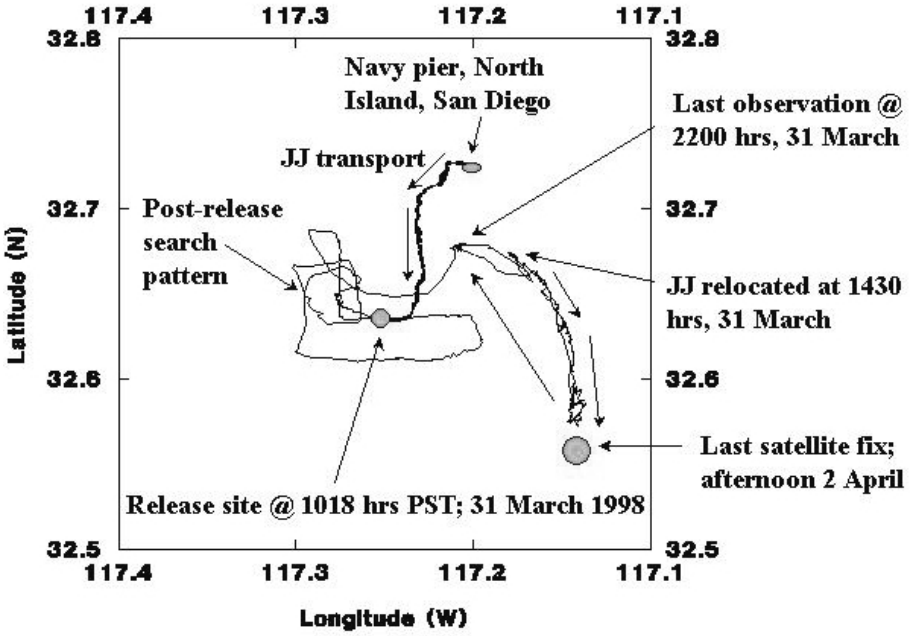

Figure 4. Pre-release transport, release location and subsequent search pattern for and movements of a rehabilitated gray whale calf (JJ) from 31 March through 2 April 1998.

that we measured on 31 March. In late afternoon on 1 April, we acquired additional satellite fixes suggesting that JJ had perhaps been in the south part of San Diego Bay earlier in the day. We then headed there by boat while dispatching the shore-tracking crew to the Imperial Beach Pier. We were unable to relocate her during these searches, but we spotted three gray whales just outside the entrance to San Diego Bay just around sunset. We made intensive visual and radio observations for several hrs at that site, but JJ was not among those whales.

Early on 2 April, we acquired additional satellite fixes from the transmitter mounted in the dorsal-ridge housing, suggesting JJ had been in the area we searched the night before. Based on the sensor data and timing pattern of transmissions we suspected, however, that the instruments could have dislodged and might be ashore. Consequently, we did radio surveys along the beach just after sunset, homed in on some weak signals, and retrieved the housing from the beach. The toggle attachments appeared to have been set too shallow in JJ's blubber to hold it fast given the flex in her body near the dorsal ridge when she was swimming.

Our next satellite fix from the remaining transmitter was acquired in early afternoon of 3 April, indicating that JJ had been further south near the U.S.-Mexico border just a few hrs earlier. According to the data and timing of transmissions, the transmitter was still attached to JJ. Consequently, we headed for that location and when within about 1 km of the satellite fix location we detected radio signals from the short-range transmitter. We homed-in on that and retrieved the housing from the beach. We think that it became dislodged from JJ sometime in early afternoon on 2 April. Scrape marks on the housing suggested that JJ had been rubbing it on the seafloor, typical behavior of foraging gray whales.

All dives that JJ made during the several day tracking period were <20 m deep and most (85%) were <10 m. We obtained the most detailed information on dive patterns when we tracked JJ directly by boat and recorded all surfacing events during continuous surveillance of radio-signals. Most submergences lasted 0.5 to 1.25 min, though a few lasted between 8 and 13.25 min (Fig. 5).

Between 3 and 15 April, we received nearly 40 telephone calls reporting very nearshore sightings of gray whales, including small whales, from the Mexican coast near Tijuana northward to Malibu and Santa Barbara. We directly investigated as many of those as possible and talked with the observers of the other sightings. None were confirmed to be JJ.

From our direct observations while tracking JJ by boat and from the short-lived satellite tracking data, we think that JJ quickly adapted to the new, unbounded marine environment after her 14-mo rehabilitation in a more confined setting where her

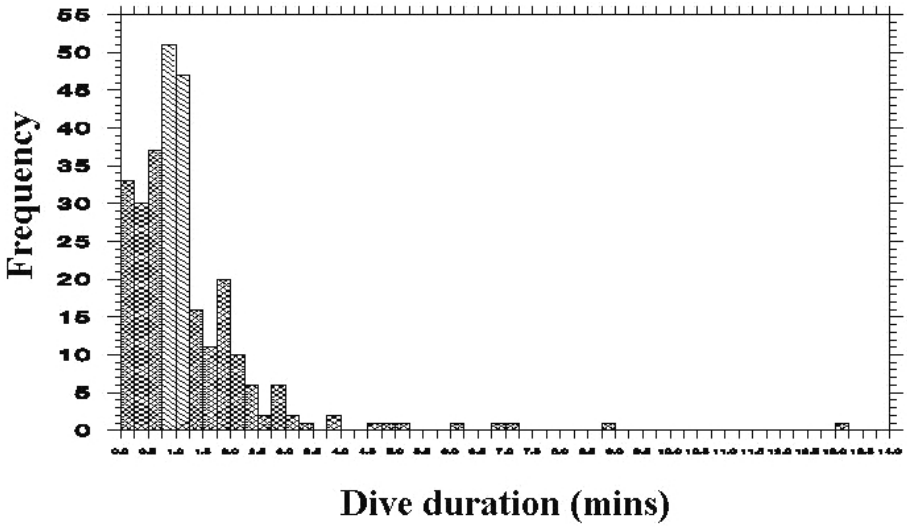

Figure 5. Dive durations of a rehabilitated gray whale calf (JJ) from 1449 hr through 2159 hr after return to the Pacific Ocean on 31 March 1998.

mobility was greatly limited. Her breathing patterns, strong intentional swimming and success in navigating along the coast to avoid breaking surf and human made structures (e.g., the jetty at the entrance to San Diego Bay and the pier at Imperial Beach) were all promising signs for her long-term survival. The expression of innate bottom-feeding behavior (*cf*. Bruehler *et al*., 2001; Ray & Schevill, 1974) and timely weaning from formula to fish and invertebrates at SeaWorld in summer 1997 were also promising indications for success in quickly learning how to adapt to natural ocean habitats and conditions.

Although the brief satellite-tracking period, owing to instrument detachment within three days of release, was disappointing it was not entirely unexpected. Prior to our studies most tracking of large cetaceans lasted only several hrs to several days, owing to instrument failure (e.g., antenna damage, physical damage to transmitters when attached, electronic failure), quick shedding of transmitters, and other factors. More recently, long-term tracking was reported for several species (e.g., Mate *et al*., 1997; Mate *et al*., 1999; Mate *et al*., 2000), largely related to deep penetration (*ca*. 14–15 cm) of anchoring barbs which clearly penetrated and anchored within the muscle. When released, the thickness of JJ's blubber (determined from ultrasound measurements) was around 6 cm at the site of the forward-transmitter housing and around 3–4 cm at the dorsal-ridge housing attachment site. Consequently, the anchoring barbs and toggles could be safely inserted only to ¾ that depth to avoid penetrating the fatty and muscle layers beneath. We believe there was not enough reach on the inserted anchors for the barbs and toggles to effectively flatten-out at a suitable blubber depth to hold the housings securely to the skin. Moreover, the anchors could also have pulled straight-out of the insertion slits without flattening at all. This was likely exacerbated by JJ's apparent rubbing her side and back along the sea bottom (perhaps while foraging), as evident from marks on the recovered forward-transmitter housing. In any event, the instruments performed exceptionally well during the short tracking period as did the buoyant housings which allowed us to recover the transmitters after they came off. Indeed, the satellite-linked transmitters continued to function for several months during subsequent deployments on southern elephant seals (*Mirounga leonine*) (Stewart, unpubl. data). The ADF tracking and computer-based GPS automatic track-logging systems also functioned well allowing us to monitor JJ's movements and breathing patterns, closely and rather effortlessly, especially near and after sunset.

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