Disentanglement and multi-year survival of a free-ranging California sea lion (*Zalophus californianus*) with an upper airway stoma secondary to fishing net entanglement

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Abstract

California sea lions (*Zalophus californianus*) are susceptible to entanglement in fishing gear and marine debris. Over time, entanglement material can become deeply embedded and disrupt underlying tissue layers including skin, blubber, muscle, and regional structures. In the neck, chronic circumferential entanglement can result in airway laceration. We present a case study of an adult female California sea lion with an upper airway stoma secondary to chronic monofilament fishing net entanglement. The animal was disentangled in a remote field setting without access to surgical and rehabilitation facilities and was released without additional treatment. Satellite telemetry data from the five months following disentanglement revealed movements comparable to those of other adult female California sea lions. Subsequent visual sightings ("resights") documented a minimum two-year survival following disentanglement.

KEYWORDS

anthropogenic trauma, California sea lion, entanglement, fisheries interaction, marine debris

BACKGROUND

Marine wildlife including birds, turtles, and marine mammals are at risk of entanglement in fishing gear and marine debris.(1) Entangled California sea lions (*Zalophus californianus*; CSL) are reported throughout their range and by stranding networks and marine mammal rehabilitation facilities.(2–6) Entanglements present a severe threat to individual health and welfare, and have the potential for negative impacts at the population level.(6) Impacts of external entanglement include impaired mobility, increased energetic costs of locomotion (e.g., increased drag in water), physical injury (e.g., abrasion, laceration), and infection. Over time, the entangling material can embed deeply into the tissues with growth of granulation tissue and skin over the embedded foreign material. Chronic effects may be particularly severe in an immature individual whose growth leads to progressive constriction and tissue damage. Here, we present a case study of a CSL with an upper airway stoma secondary to chronic monofilament fishing net entanglement.

CASE PRESENTATION

An adult female CSL with a monofilament gill-net entanglement around the cranial neck was observed during land-based survey on San Miguel Island (34.034449, -120.449472) in the California Channel Islands during February 2020.

INVESTIGATIONS

DIFFERENTIAL DIAGNOSIS

TREATMENT

Anesthesia

The animal was captured on land using a hand-held cone-shaped net. Midazolam 15mg (0.17mg/kg; Akorn Pharmaceuticals, Gurnee IL USA) was administered intramuscularly (IM). Muscle relaxation was appreciated 11min after administration and the animal was manually restrained in ventral recumbency in the net. Isoflurane 5% (VetOne, Boise ID USA) in oxygen was delivered by mask from a custom-made portable anesthesia machine. Increased respiratory rate and effort were observed, and despite continuous isoflurane administration over several minutes the animal did not progress from sedation to anesthesia. The animal was removed from the net and manually restrained; examination of the entanglement wound revealed an upper airway stoma. Out of the net, the animal became

eupneic and was breathing a mixture of isoflurane in oxygen through the face mask and ambient air through the stoma. Midazolam 10mg (0.11mg/kg) and butorphanol 5mg (0.05mg/kg) were administered IM to facilitate restraint and isoflurane was continued. Moderate sedation adequate for treatment was achieved. The animal did not reach a depth sufficient for endotracheal intubation.

Upon completion of procedures, isoflurane was discontinued, and the animal received 100% oxygen by mask for 6min. Naltrexone 10mg (0.11mg/kg; ZooPharm, Swedesboro, NJ USA) was administered IM. Flumazenil was prepared for administration, but the animal was responsive to touch and lifting its head; administration would have required further manual restraint and was determined to be unnecessary. The animal was alert and fully ambulatory at 10min, voluntarily entered the ocean, and was observed swimming in the surf and exhibiting apparently normal behaviors for approximately 15min. Total handling time from capture to return to ocean was 63min and procedure time (assessment, disentanglement, biological sampling and satellite tracking device attachment) was 45 minutes.

Examination

Examination revealed a deeply embedded circumferential monofilament net entanglement of the neck (Figure 1). A 2cm aperture was present on the ventral midline just cranial to the laryngeal cartilages with palpable air flow upon inspiration and expiration. The entanglement material was also deeply embedded in the dorsal neck; sections of granulation tissue and unhaired skin had grown over the entanglement. Thoracic auscultation was unremarkable apart from mild referred upper airway sounds. No other abnormalities were found on physical examination. The animal was in adequate body condition; body weight was 88.6kg and total straight length from rostrum to tip of tail was 167cm.

Procedures

The entanglement material was carefully elevated from the tissues using a crochet hook and cut with scissors. The material was found to be a nylon monofilament gillnet with 8.5 inch stretch mesh diameter and approximately 60-pound test weight. Blood was collected from the caudal gluteal vein. A swab for wound culture was collected from the granulation tissue surrounding the stoma. A non-archival location-transmitting satellite tag (SPOT6 tag; Wildlife Computers, Redmond WA USA) was affixed on dorsal midline between the scapulae with epoxy (Devcon 5-minute epoxy resin; ITW Polymer Adhesive, Danvers, MA USA). In accordance with permitting, no additional medical treatment (e.g., antibiotic administration, wound care) was performed.

Diagnostics

In comparison to published values for adult, wild-caught CSL(7), there were no clinically significant abnormalities on serum chemistry (Axcel clinical chemistry analzyer, Alfa

Wasserman-West, Caldweel NJ USA), total nucleated cell count (Hemocue WBC system®, Brea CA USA), and manual white blood cell differential.(8) Wound culture was positive for growth of Streptococcus sp. Group C, Streptococcus sp., and Staphyloccocus sp.

OUTCOME AND FOLLOW-UP

Movement locations were tracked using data transmitted to the Argos Data Location and Collection System. Data provided by Argos were subsequently decoded and formatted using SATPAK software (Wildlife Computers). Location data were processed for outliers by removing all low quality fixes (Argos "Z" quality rating), by applying a coarse speed filter (maximum speed 7.5 m/s), and by manually removing locations that were clear outliers based on the movement capacity and range of the tagged individual. Data were visualized using the R packages sf and crawl.(9,10) Transmissions occurred from February through July, 2020. Over this period, movement patterns were qualitatively similar to other adult females over the same time period (both disentangled and non-entangled control individuals; Figure 2). The animal was visually resighted on San Miguel Island in August 2021 and February 2022. At both time points, the animal was in adequate body condition and observed behaviors were normal. Reproductive status was unknown.

DISCUSSION

The remote field setting of this work presented challenges for anesthetic management and examination. Anesthetic induction by mask, both with and without intramuscular premedication, is a frequently used protocol for otariid anesthesia in field settings.(12,13) In this case, mask induction was only partially successful due to the large volume of air passing through the stoma. Intramuscular sedation combined with light manual restraint were adequate for brief examination and disentanglement of this individual. In an ideal alternative scenario, intravenous or intramuscular induction of general anesthesia followed by intubation would have enabled airway management and increased control of anesthetic depth. This would also have facilitated a detailed wound examination with more precise determination of the location of the stoma with respect to anatomic landmarks in the pharynx. However, field conditions, drug availability, and the anatomic challenges of otariid venous access (11) precluded this approach.

The decision to disentangle and release rather than to euthanize was made based upon the animal's adequate body condition indicating successful foraging despite the chronic, severe entanglement. Satellite telemetry data over the five months following disentanglement demonstrate movements typical of adult female CSL in this region.(14,15) Visual resights confirmed a minimum two-year survival. The animal's survival in the period both before the disentanglement and after are likely attributable to the location of the wound; the stoma was cranial to the larynx, which reduced risk of water aspiration during swimming and diving.

Three other individuals with similar entanglements resulting in upper airway stoma have been previously disentangled under manual restraint on San Miguel Island by JHarris. One was resighted, alive and in adequate body condition, approximately 1 year after disentanglement. The second was recaptured 12 months after disentanglement and was found to be in adequate body condition with the upper airway stoma still patent. The third individual was not resighted after disentanglement.

In similar cases presented to a marine mammal rehabilitation facility (The Marine Mammal Center, Sausalito, CA USA), surgical wound closure has been performed with variable success (personal communications, C. Field and G. Frankfurter, January 2023). In this case, interventions such as transport to a rehabilitation hospital and surgical wound care were both beyond the scope of permitted work and logistically impossible. This individual's documented minimum two-year survival and maintenance of adequate body condition suggests that disentanglement and release may be considered in similar cases of individuals with upper airway stoma, without apparent comorbidities, and when additional therapeutic intervention is not possible.

LEARNING POINTS/TAKE HOME MESSAGES

- Chronic circumferential entanglement of the neck with monofilament fishing line resulted in a patent upper airway stoma in an adult female California sea lion. The animal was disentangled in a remote field setting and released without further medical or surgical intervention.
- Satellite telemetry and visual resights documented a minimum two-year survival after disentanglement.
- In similar cases when additional therapeutic intervention is not possible, disentanglement and immediate release may be considered for individuals with upper airway stoma, in adequate body condition and without apparent comorbidities.

AUTHOR CONTRIBUTION STATEMENT

Case management: EWhitmer, SSaunders, JHarris, AOrr. Writing, original draft: EWhitmer. Writing, review and editing: JHarris, AOrr, BSaunders, SJohnson. Project administration: SJohnson

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CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflict of interest.

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ETHICS STATEMENT

All activities were conducted under permit and/or authorization from U.S. Department of Commerce, National Marine Fisheries Service (NMFS). Research activities on San Miguel Island were conducted under IACUC protocol NWAK-19-01 and NMFS Permit 16087-02 issued to NMFS Alaska Fisheries Science Center, Marine Mammal Laboratory.

REFERENCES

1. Laist DW. Impacts of marine debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Coe JM, Rogers DB, editors. Marine Debris. New York: Springer Series on Environmental Management. Springer; 1997. p. 99–139.

2. Dau BK, Gilardi K V, Gulland FM, Higgins A, Holcomb JB, St Leger J, et al. Fishing gear-related injury in California marine wildlife. J Wildl Dis. 2009;45(2):355–62.

3. Barcenas-De la Cruz D, DeRango E, Johnson SP, Simeone CA. Evidence of anthropogenic trauma in marine mammals stranded along the central California coast, 2003–2015. Mar Mamm Sci. 2018;34(2):330–46.

4. Hanni KD, Pyle P. Entanglement of pinnipeds in synthetic materials at South-east Farallon Island, California, 1976-1998. Mar Pollut Bull. 2000;40(12):1076–81.

5. Allyn EM, Scordino JJ. Entanglement rates and haulout abundance trends of Steller (*Eumetopias jubatus*) and California (*Zalophus californianus*) sea lions on the north coast of Washington state. PLoS One. 2020;15(8):1–21.

6. Robert Harcourt, David Aurioles, Jose Sanchez. Entanglement of California sea lions at Los Islotes, Baja California Sur, Mexico. Mar Mamm Sci. 1994;10(1):122–5.

7. Williams KM. Clinical values of blood variables in wild and stranded California sea lions (*Zalophus californianus*) and blood sample storage stability [Masters]. California State University Monterey Bay and Moss Landing Marine Laboratories; 2013.

8. McClain AM, Whitmer ER, Rios C, Jensen ED, Stacy NI, Johnson SP. Evaluation of the HemoCue® WBC system as a point of care diagnostic tool for white blood cell quantification in pinnipeds. Oceans. 2022;3(1):72–83.

9. Pebesma E. Simple features for R: Standardized support for spatial vector data. R Journal. 2018;10(1):439–46.

10. Johnson D, London JM, McClintock B. NMML/crawl: Last CRAN release. Zenodo 10.5281/ZENODO.7154089. 2022.

11. Barbieri M. Health assessment of seals and sea lions. In: Frances M.D. Gulland, Leslie A. Dierauf, Karyl L. Whitman, editors. CRC Handbook of Marine Mammal Medicine. 3rd ed. Boca Raton: CRC Press; 2018. p. 856–67.

12. Martin Haulena, Todd Schmidt. Anesthesia. In: Frances M.D. Gulland, Leslie A. Dierauf, Karyl L. Whitman, editors. CRC Handbook of Marine Mammal Medicine. 3rd ed. Boca Raton: CRC Press; 2018. p. 567–606.

13. Martin Haulena. Otariid Seals. In: Gary West, Darryl Heard, Nigel Caulkett, editors. Zoo Animal and Wildlife Immobilization and Anesthesia. 2nd ed. Ames: Wiley Blackwell; 2014. p. 661–72.

14. Melin SR, DeLong RL, Siniff DB. The effects of El Niño on the foraging behavior of lactating California sea lions (*Zalophus californianus californianus*) during the nonbreeding season. Can J Zool. 2008;86(3):192–206.

15. Sharon R. Melin, Robert L. DeLong. At-sea distribution and diving behavior of California sea lion females from San Miguel Island, California. In: Proceedings of the Fifth California Islands Symposium United States Department of the Interior, MMS. 1995. p. 407–12.

FIGURE 1 Adult female California sea lion (*Zalophus californianus*) with circumferential monofilament gill-net entanglement of the neck. **Upper left panel:** Right dorsolateral view of entanglement wound with regions of active granulation tissue in the wound bed (A), skin regrowth over underlying entanglement material (B) and undisturbed skin (C). The orange material is a mask for inhalant anesthetic delivery. **Bottom left panel:** Ventral view with upper airway stoma at level of (D) and visible net material. **Right panel:** Immediately following disentanglement, with satellite tag affixed to the dorsal mid-thorax.

FIGURE 2 Movement of an adult female California sea lion (*Zalophus californianus*) after removal of a circumferential monofilament fishing net entanglement (purple tracks) in comparison with both non-entangled and other disentangled adult females over the same period (grey tracks). Movement patterns for the subject animal are similar to conspecifics.

OWNER'S PERSPECTIVE

IMAGE QUIZ

MULTIPLE CHOICE QUESTION

POSSIBLE ANSWERS TO MULTIPLE CHOICE QUESTION

CORRECT ANSWER