



Clinical Communications: Adult

SEVERE SEA LION BITES IN URBAN COLD-WATER SWIMMERS

Aaron E. Kornblith, MD,* Jehan Z. Budak, MD,† Claire A. Simeone, DVM,‡ and Thomas J. Nuckton, MD, MS§||

*Departments of Emergency Medicine & Pediatrics, University of California, San Francisco, San Francisco, California, †Division of Infectious Diseases, University of California, San Francisco, San Francisco, California, ‡Department of Veterinary Science, The Marine Mammal Center, Sausalito, California, §Department of Medicine, Sutter Eden Medical Center, Castro Valley, California, and ||Department of Medicine, University of California, San Francisco, San Francisco, California

Reprint Address: Aaron E. Kornblith, MD, Division of Pediatric Emergency Medicine, UCSF Benioff Children's Hospital, 550 16th Street, Box 0632, San Francisco, CA, 94143

Abstract—Background: A series of sea lion bites in open-water swimmers recently gained the attention of the national and international media. Pinniped (the clade including seals and sea lions) bites historically have been in people who hunt or handle marine mammals. As populations of humans and pinnipeds continue to grow, interactions with animals by those participating in recreational activities are likely to become more frequent. **Case Reports:** In December of 2017 and January of 2018, four sea lion (*Zalophus californianus*) bites in humans occurred at a popular open-water recreational swimming area in San Francisco, California. Three swimmers required treatment at a local trauma center and two required surgery. Two of the wounds were potentially life threatening; one swimmer required a field tourniquet to stop bleeding from the ante-cubital fossa, and the bite in another narrowly missed the femoral artery. The purpose of this report is to offer an in-depth discussion of antimicrobial use and rabies postexposure prophylaxis in patients with severe pinniped bites. **Why Should an Emergency Physician Be Aware of This?:** Information from this report can be used in conjunction with input from local experts to develop a thoughtful therapeutic plan for patients with severe pinniped bites. Doxycycline is the first-line antibiotic therapy, but broader coverage may be needed for severe wounds with the potential for contamination. The likelihood of rabies is low, and rabies postexposure prophylaxis should be reserved for cases that involve unusually aggressive animal behavior or other factors suggestive of rabies. © 2019 Elsevier Inc. All rights reserved.

Keywords—animal bites; marine mammals; pinnipedia; California sea lions; swimming

INTRODUCTION

California sea lions (*Zalophus californianus*) are a pinniped (clade that includes seals, sea lions, and walruses) species that often live in waters adjacent to urban environments. The population of California sea lions is increasing along the U.S. West Coast (1). Cold-water swimming is also increasing in popularity, raising the potential for contact between humans and sea lions (2–4).

In this series, we report four cases of sea lion bites in persons swimming without wetsuits in a popular recreational area in San Francisco, California. These bites received both national and international media attention, likely due to the emotional response generated from bites of wild animals in humans and curiosity about the sport of recreational cold-water swimming (5,6). As outlined below, two of the bites were potentially life threatening.

This report offers information on possible reasons for erratic sea lion behavior, wound care, antibiotic treatment, and rabies postexposure prophylaxis. Information from this report can be used in conjunction with input from local experts to develop a thoughtful therapeutic plan for patients who sustain pinniped bites.

CASE REPORTS

In December of 2017 and January of 2018, a series of pinniped bites in humans occurred at a popular recreational swimming area, Aquatic Park Cove (Figure 1), in San Francisco, California. Aquatic Park Cove is a protected recreational area confluent with the San Francisco Bay and is used for water sports, anchoring vessels, and observing wildlife. For this report, data were collected retrospectively from medical records and patient interviews. Written consents for the use of medical data and photography were obtained from each swimmer.

All of the bites were unprovoked. In one of the encounters, Case 2, the swimmer was confident that the animal in question was a sea lion, rather than a harbor seal (*Phoca vitulina richiardii*—also common in the waters of the San Francisco Bay). Encounters with sea lions are relatively rare, and because all bites occurred in the same region of Aquatic Park Cove (400 meters offshore near a breakwater), a single sea lion was suspected for all cases. However, the animal was never definitively identified or captured. The water temperature on the days of the encounters was between 11–13°C (51.8–55.4°F) (7). All of the swimmers were cold-water swimming enthusiasts and were swimming without wetsuits.

Case 1

On December 12, 2017, at approximately 5:00 PM, in Aquatic Park Cove (approximately 400 meters offshore near a breakwater), a cold-water swimmer sustained a pinniped bite without warning that resulted in only superficial wounds to the dorsum of the right foot. The swimmer was uncertain about the species of the animal. The swimmer washed the area with soap and warm water and did not seek medical attention. Wound healing was complete and without complications.



Figure 1. Aerial photograph of Aquatic Park Cove, San Francisco, CA. (Photo: Courtesy San Francisco Maritime National Historical Park).

Case 2

On December 14, 2017, a cold-water swimmer presented via ambulance to the local Level I trauma center at 2:07 PM, after sustaining a sea lion bite in Aquatic Park Cove approximately 1 h prior to arrival. The swimmer was swimming approximately 400 meters from shore near a breakwater when he noticed a sea lion swimming closely behind him; the swimmer felt confident that the animal was a sea lion. The sea lion closed in rapidly and the swimmer turned to face the animal. The bite occurred as the swimmer raised his arm defensively as the animal lunged toward him. He sustained a single injury to his right arm that resulted in a deep penetrating wound of the right antecubital fossa with skin tearing and profuse bleeding. A passing sailboat extracted the swimmer from the water. Soon after, emergency medical services personnel arrived and applied a tourniquet proximal to the swimmer's injury. The swimmer was transported emergently to a local trauma center. The wound was explored in the Emergency Department (ED) and noted to be 7 cm in its largest dimension. The wound had a large skin flap and was hemorrhaging from the antecubital vein (Figure 2) as the tourniquet was taken down. Hemostasis was obtained with direct pressure and the wound was lavaged with normal saline. The patient was taken to the operating room, where the median antecubital vein was ligated secondary to injury, a 1/4-inch Penrose drain was left in place, and the wound was closed. He received tetanus, diphtheria, and pertussis (Tdap) vaccination, ceftriaxone (1 g intravenously, every 24 h) and doxycycline (100 mg orally, twice a day) on hospital days 1 and 2. He also received rabies vaccine and rabies immune globulin. He was discharged on hospital day 2 with levofloxacin (750 mg orally, once a day) to complete a 10-day antibiotic course. The swimmer subsequently reported



Figure 2. Bite wound in Case 2; injury to the right upper extremity with extensive involvement of the antecubital fossa (Photo: R. Plevin).

persistent erythema after removal of the drain and sutures and completion of levofloxacin. He was not taking medications that would have interfered with levofloxacin efficacy. Upon re-initiation of oral doxycycline, the erythema improved rapidly. Wound healing was complete after 10 days of doxycycline therapy.

Case 3

The third encounter occurred on December 15, 2017, at approximately 8:00 AM, in Aquatic Park Cove (approximately 400 meters offshore near a breakwater), when a swimmer sustained an unexpected pinniped bite to his right iliac fossa. The swimmer was uncertain about the species of the animal. The swimmer was able to swim to shore without assistance, but was transported emergently via ambulance to the local trauma center. High-pressure irrigation was applied in the ED. He subsequently received surgical exploration, debridement, and wound closure. Wound closure was completed with interrupted vertical mattress nylon sutures, and a 1/4 -inch Penrose drain was left in place in the deepest wound to allow further drainage. Examination of the wounds indicated that the bite narrowly missed his femoral artery (Figure 3). This patient also received Tdap vaccination, ceftriaxone (1 g intravenously, once) and doxycycline (100 mg orally, once), rabies vaccine, and rabies immune globulin. He was discharged on the same day of admission and prescribed levofloxacin (750 mg orally, once a day) to complete a 10-day course of antibiotics. Wound healing was complete and without complications.



Figure 3. Bite wounds in Case 3; injury to right inguinal region with close proximity to the femoral vasculature (Photo: R. Plevin).

Case 4

On January 11, 2018, at approximately 7:00 AM, a fourth swimmer was bitten by a pinniped without warning while swimming in Aquatic Park Cove (approximately 400 meters offshore near a breakwater). The swimmer was uncertain about the species of the animal. She received puncture wounds to the anteromedial left thigh and a 3-cm superficial laceration adjacent to the left posterolateral knee; the joint space was not involved. After being helped to shore by other swimmers, she was transported emergently to the local trauma center. In the ED the wounds (Figure 4) was assessed and high-pressure irrigation was applied. The wounds were covered with a simple gauze dressing; sutures were not applied to the laceration. Prior to discharge from the ED, she received Tdap vaccination and was prescribed doxycycline (100 mg orally, twice a day) for 7 days. Wound healing was complete and without complications.

MANAGEMENT AND OUTCOME

Local authorities closed Aquatic Park Cove to swimmers between December 15, 2017 and December 20, 2017. During the months of the encounters (December 2017 and January 2018), the Marine Mammal Center of Sausalito, California monitored for erratic behavior and illness in marine mammals. Other than the cases we report, there were no reports of erratic sea lion behavior or unusual illnesses in sea lions.

Management and outcome from the above cases can be summarized as follows: 3 of the 4 patients who sustained a bite were treated at a local trauma center. Each of these patients (Cases 2–4) received local wound care, including high-pressure irrigation, in the ED. Two



Figure 4. Bite wounds in Case 4; injury to the anteromedial left thigh; additional 3-cm laceration adjacent to the left posterolateral knee (not visible in photo); the joint space was not involved (Photo: I. Chan).

patients (Cases 2 and 3) were admitted to the hospital from the ED for surgical debridement on the same day of admission. After initial inpatient treatment with intravenous ceftriaxone and oral doxycycline, the patients were prescribed oral levofloxacin to complete a 10-day outpatient course of antibiotics. The patient in Case 2 reported persistent erythema after completion of oral levofloxacin that improved rapidly after re-initiation of oral doxycycline. Rabies postexposure prophylaxis was initiated in Cases 2 and 3. The patient in Case 4 was not admitted and was prescribed oral doxycycline on discharge from the ED. No wound cultures or microbiologic data were obtained from any patient. All patients who received medical care at the hospital (Case 2–4) received Tdap vaccination. All wounds eventually healed completely.

DISCUSSION

Possible Reasons for Aggressive Sea Lion Behavior

Possible reasons for aggressive behavior by a sea lion include illnesses (including meningitis or domoic acid toxicity), hormonal changes during breeding season, and human desensitization. Outbreaks of meningitis or other illnesses in pinnipeds were not seen by the Marine Mammal Center during the months of the encounters. As outlined below, rabies is rare in pinnipeds (8,9). Domoic acid is a biotoxin naturally produced by marine algae (*Pseudo-nitzschia* spp.) that binds to glutamate receptors in the brain, causing seizures, brain damage, and erratic behavior (10). Domoic acid toxicity in sea lions can be either acute or chronic. In the months leading up to the encounters, domoic acid levels in California water and shellfish were not substantially elevated (11), and no cases of acute domoic acid toxicosis were reported by the Marine Mammal Center, which tracks diseases in regional pinnipeds. Thus, acute domoic acid toxicity seems unlikely. However, because chronic domoic acid exposure occurs across an extended time period, animals with brain damage can be observed at any time of year, regardless of whether an active bloom is occurring (10). Brain damage from chronic domoic acid exposure remains a potential cause of erratic behavior, although follow-up of the suspected animal was not possible.

Sea lion breeding typically occurs between May and August in Mexico and Southern California (12). Because the attacks in this series occurred in winter in San Francisco, hormonal changes related to breeding are an unlikely etiology of aggression. None of the cases in this series involved human behavior that would have provoked an aggressive response from the animal (4). It is possible that the animal in question had prior encounters with humans, which might have resulted in desensitiza-

tion and bolder or more aggressive behavior (13). However, the Marine Mammal Center received no reports of a sea lion interacting with humans in the days prior to the encounters.

Thus, with a limited amount of information, we believe that the bites were most likely related to erratic behavior from a single animal, with no clear triggering factor or underlying cause. Of the medical causes of erratic behavior in pinnipeds, chronic domoic acid toxicity seems most likely, but could not be confirmed. Due to the potential for multiple bites, swimmers should leave the water as soon as possible after an encounter with an aggressive sea lion (4).

WHY SHOULD AN EMERGENCY PHYSICIAN BE AWARE OF THIS?

Antibiotic Use and Wound Care

Historically, a tetracycline (e.g., doxycycline) has been used to treat pinniped bites (4,14–19). Novel *Mycoplasma* species (e.g., *Mycoplasma phocacerebrale*) have been isolated from pinnipeds and from pinniped bite wounds to the dermal layers and joints in humans (18,20–23). *M. phocacerebrale* has been found to be susceptible to tetracycline (18). Thus, coverage for *Mycoplasma* species (spp.) is an important consideration when treating pinniped bite wounds, and doxycycline is frequently recommended as first-line therapy (16,17,19,24).

However, there are several reasons to consider expanded antibiotic coverage beyond that provided by doxycycline, particularly in large open wounds. Although only a small number of bacteria species (*Mycoplasma* spp., *Pasteurella* spp., and *Erysipelothrix* spp.) have been isolated from pinniped bite wounds in humans, studies with microbiologic data from humans after pinniped bites have been few and limited (18,25,26). Additionally, in several animal studies, a wide variety of potentially harmful bacteria have been isolated from the mouths of pinnipeds, including beta-hemolytic *Streptococcus* spp., *Mannheimia* spp., *Vibrio* spp., and *Staphylococcus* spp. (27–29). Although many of these organisms are susceptible to doxycycline, infections involving more than a single organism are frequent in bites in humans from other animal species (30–32). Lastly, after exposure to sea water, wounds may be at risk for contamination with organisms requiring broader antibiotic coverage (33–36).

Levofloxacin, a fluoroquinolone, offers broader antibiotic coverage than doxycycline, particularly for Gram-negative organisms. After first receiving intravenous ceftriaxone and oral doxycycline, 2 patients in our series were subsequently discharged with oral

levofloxacin. Fluoroquinolones are typically active against *Mycoplasma* spp. and have been shown to be active against *M. phocacerebrale* found in pinnipeds (18). Additionally, levofloxacin should provide adequate coverage against *Streptococcal* spp., most Gram-negative organisms, methicillin-sensitive *Staphylococcus aureus*, *Pasteurella* spp., and *Erysipelothrix* spp. However, in Case 2, the patient reported persistent wound erythema despite completing an oral levofloxacin course, with subsequent improvement after re-initiation of oral doxycycline. It is possible that the patient had an infection with an organism (e.g., a unique *Mycoplasma* species or other) that was resistant to levofloxacin—but without culture and sensitivity data, we have no way of knowing if this case represents true levofloxacin treatment failure.

Based on our review of the literature, our prior experience, and this case series, we agree with others who recommend a tetracycline as first-line therapy after pinniped bites with skin penetration (4,14–19,24). Although levofloxacin offers broader coverage and could be viewed as an acceptable alternative, a possible treatment failure with levofloxacin in this series and a long history of empiric tetracycline success sways us toward continued use of doxycycline. We recommend a standard dose of doxycycline (100 mg orally, twice a day), typically for 2 to 6 weeks, with the specific length of therapy based on the extent and location of the infection. However, due to the possibility of infections that are not covered by doxycycline, all patients should be followed closely, and antibiotic therapy modified based on microbiologic results and the clinical course of wound healing. We recommend wound cultures and molecular-based testing (such as polymerase chain reaction or other culture-independent methods to identify *Mycoplasma* spp.) after all serious pinniped bites (18,19,23)—the lack of culture and other microbiologic data is a weakness of this report. Although *Mycoplasma* spp. are difficult organisms to culture, microbiologic data may be useful in guiding antibiotic therapy in specific cases, and future studies with microbiologic data may better determine the antibiotic sensitivities of *Mycoplasma* spp. or other organisms associated with pinniped bites.

In addition to antibiotic therapy, patients with severe bites should receive local wound care, such as washing with soapy water or normal saline; the benefits of high-pressure irrigation and closure of bite wounds are debatable and should be considered on a case-by-case basis (37–39). Based on the extent of the wound, surgical consultation with subsequent surgical exploration and repair may be needed. Given the ubiquitous nature of *Clostridium tetani*, tetanus vaccination should be given if not up to date.

Finally, we stress that there is no “one size fits all” treatment regimen for pinniped bite wounds. Indeed, a

wide variety of presentations and wounds were seen in this small series alone. In Case 1, the swimmer had only a superficial wound, and wound healing was complete with local wound care only, without oral or intravenous antibiotics. Previous cases of superficial pinniped bites have also been treated successfully with local wound care only (4). Case 4 involved a classic bite to the skin and soft tissue that was successfully treated with 7 days of oral doxycycline monotherapy. The bite in Case 4 was adjacent to the knee but did not involve the joint space; had the joint itself been infected, a longer course of antibiotic therapy (e.g., 3 to 6 weeks or longer) likely would have been indicated (23). Cases 2 and 3 involved large tearing wounds that were subject to contamination; both of these cases received intravenous ceftriaxone and oral doxycycline initially, followed by outpatient treatment with oral levofloxacin. Given a possible treatment failure with oral levofloxacin, we cautiously recommend subsequent outpatient treatment with oral doxycycline rather than oral levofloxacin in similar cases in the future—but stress that the choice of antibiotic depends on many factors, including the character and depth of the wound and the potential for contamination from the environment. We recommend wound cultures and molecular-based systems to identify *Mycoplasma* spp. and close follow-up of all wounds, regardless of the initial antibiotic choice.

Rabies and Pinnipeds

The California Department of Public Health advises that pinnipeds pose a negligible risk for rabies and therefore does not recommend routine rabies postexposure prophylaxis after pinniped bites (40). Rabies in pinnipeds is rare. The only reported cases of rabies in marine mammals were in a ringed seal in Svalbard, Norway during a concomitant outbreak of rabies in arctic foxes and an isolated case of a seropositive gray seal on an Estonian island (8,9). Rabies has never been described in a California sea lion or harbor seal.

However, untreated rabies is often a fatal disease, and complications from modern postexposure rabies prophylaxis are uncommon (41,42). This case series was unusual in that multiple encounters occurred within a relatively short time and the presumed animal was highly aggressive. For these reasons, and because no animal was available for examination, 2 patients received rabies postexposure prophylaxis. Because rabies is rare in marine mammals and has never been described in pinnipeds in California, we recommend that providers consider rabies postexposure prophylaxis only in severe cases that involve multiple attacks, unusually aggressive animal behavior, recent rabies outbreaks in other local animals, or other factors suggestive of rabies.

Final Recommendations

In the field, patients with severe pinniped bites should be stabilized and bleeding controlled. After transfer to a medical facility, wounds should be examined carefully for potential deep-tissue or vascular damage. Based on the extent of the wound, surgical consultation with subsequent surgical repair may be needed. Antibiotic therapy should be given after a severe pinniped bite. Doxycycline should be used as first-line therapy, although broader coverage may be indicated based on the characteristics of the wound and the potential for contamination. All patients should be followed carefully for signs of treatment failure. We recommend wound cultures and molecular-based testing to identify *Mycoplasma* spp. after all serious bites. In addition to antibiotics, patients should receive local wound care; use of high-pressure irrigation and closure of bite wounds should depend on the extent and location of the wound. Tetanus vaccination should be given if not up to date. Lastly, the likelihood of rabies in pinnipeds is low, and rabies postexposure prophylaxis should be reserved for cases that involve multiple attacks, unusually aggressive animal behavior, or other factors suggestive of rabies.

Acknowledgments—Thank you to Dr. Rebecca Plevin for photography and to Jennifer Elhawary for assistance in manuscript preparation. Thank you to the swimmers for sharing their encounters.

REFERENCES

- Auriolos-Gamboa D, Hernandez-Camacho CJ. *Zalophus californianus*. 2015. The IUCN red list of threatened species. Available at: <https://www.iucnredlist.org/species/41666/45230310>. Accessed January 19, 2019.
- Ducharme J. Why people are swimming in freezing water. Time. 2018. Available at: <http://time.com/5159851/why-people-are-swimming-in-freezing-water/>. Accessed January 19, 2019.
- Nuckton TJ, Koehler EA, Schatz SP. Characteristics of San Francisco Bay cold-water swimmers: biophysical parameters and demographic data, with analysis of exercise patterns, weight changes, safety concerns, and perceptions of cold tolerance. *Open Sports Med J* 2014;8:1–10.
- Nuckton TJ, Simeone CA, Phelps RT. California sea lion (*Zalophus californianus*) and harbor seal (*Phoca vitulina richardii*) bites and contact abrasions in open-water swimmers: a series of 11 cases. *Wilderness Environ Med* 2015;26:497–508.
- Fimrite P, Rubenstein S. SF aquatic park closed to swimmers after third sea lion attack in a week. *San Francisco Chronicle*. 2017. Available at: <https://www.sfchronicle.com/bayarea/article/Second-swimmer-attacked-by-sea-lion-at-SF-s-12433775.php>. Accessed January 19, 2019.
- Sea lion attacks swimmer in San Francisco Bay. *BBC News*; 2017. Available at: <https://www.bbc.com/news/world-us-canada-42366891>. Accessed January 19, 2019.
- National Oceanic and Atmospheric Administration (NOAA), NOAA's National Data Buoy Center. Station FTPCI, San Francisco, CA (water and air temperatures, San Francisco), 2017 and 2018. Available at: <http://www.ndbc.noaa.gov/>. Accessed January 19, 2019.
- Mork T, Prestrud P. Arctic rabies—a review. *Acta Vet Scand* 2004;45:1–9.
- Odegaard OA, Krogsrud J. Rabies in Svalbard: infection diagnosed in arctic fox, reindeer and seal. *Vet Rec* 1981;109:141–2.
- Goldstein T, Mazet JA, Zabka TS, et al. Novel symptomatology and changing epidemiology of domoic acid toxicosis in California sea lions (*Zalophus californianus*): an increasing risk to marine mammal health. *Proc Biol Sci* 2008;275:267–76.
- California Department of Public Health. Health information; marine biotoxin monitoring reports, 2017 and 2018. Available at: <https://www.cdph.ca.gov/Programs/CEH/DRSEM/Pages/EMB/Shellfish/Marine-Biotoxin-Monitoring-Reports.aspx>. Accessed January 19, 2019.
- Flatz R, Gonzalez-Suarez M, Young JK, et al. Weak polygyny in California sea lions and the potential for alternative mating tactics. *PLoS One* 2012;7:e33654.
- National Oceanic and Atmospheric Administration (NOAA)/NOAA Fisheries (National Marine Fisheries Service). Frequent questions - feeding or harassing marine mammals in the wild. 2017. Available at: <https://www.fisheries.noaa.gov/insight/frequent-questions-feeding-or-harassing-marine-mammals-wild>. Accessed January 19, 2019.
- White CP, Jewer DD. Seal finger: a case report and review of the literature. *Can J Plast Surg* 2009;17:133–5.
- Mass DP, Newmeyer WL, Kilgore ES Jr. "Seal finger". *J Hand Surg Am* 1981;6:610–2.
- Hartley JW, Pitcher D. Seal finger—tetracycline is first line. *J Infect* 2002;45:71–5.
- Cowan DF, House C, House JA. Public health. In: Dierauf L, Gulland FMD, eds. *CRC handbook of marine mammal medicine*. 2nd edn. Boca Raton, FL: CRC Press; 2001:767–78.
- Baker AS, Ruoff KL, Madoff S. Isolation of *Mycoplasma* species from a patient with seal finger. *Clin Infect Dis* 1998;27:1168–70.
- Maeyens E. Aquatic skin disorders. In: Auerbach PS, ed. *Wilderness medicine*. 6th ed. Philadelphia, PA: Elsevier/Mosby; 2012:1646–66.
- Giebel J, Meier J, Binder A, et al. *Mycoplasma phocarhinis* sp. nov. and *Mycoplasma phocacerebrale* sp. nov., two new species from harbor seals (*Phoca vitulina* L.). *Int J Syst Bacteriol* 1991;41:39–44.
- Haulena M, Gulland FM, Lawrence JA, et al. Lesions associated with a novel *Mycoplasma* sp. in California sea lions (*Zalophus californianus*) undergoing rehabilitation. *J Wildl Dis* 2006;42:40–5.
- Ruhnke HL, Madoff S. *Mycoplasma phocidae* sp. nov., isolated from harbor seals (*Phoca vitulina* L.). *Int J Syst Bacteriol* 1992;42:211–4.
- Westley BP, Horazdovsky RD, Michaels DL, et al. Identification of a novel *Mycoplasma* species in a patient with septic arthritis of the hip and seal finger. *Clin Infect Dis* 2016;62:491–3.
- Barnett J, Knight A, Stevens M. *Marine mammal medic handbook*. 7th ed. Uckfield, East Sussex: British Divers Marine Life Rescue; 2013.
- Sundee P, Cleeve V. Isolation of *Bisgaardia hudsonensis* from a seal bite. Case report and review of the literature on seal finger. *J Infect* 2011;63:86–8.
- Suer LD, Vedros NA. *Erysipelothrix rhusiopathiae*. I. Isolation and characterization from pinnipeds and bite/abrasion wounds in humans. *Dis Aquat Org* 1988;5:1–5.
- Bik EM, Costello EK, Switzer AD, et al. Marine mammals harbor unique microbiotas shaped by and yet distinct from the sea. *Nat Commun* 2016;7:10516.
- Carrasco SE, Burek KA, Beckmen KB, et al. Aerobic oral and rectal bacteria of free-ranging Steller sea lion pups and juveniles (*Eumetopias jubatus*) in Alaska. *J Wildl Dis* 2011;47:807–20.
- Hansen MJ, Bertelsen MF, Christensen H, et al. Occurrence of *Pasteurellaceae* bacteria in the oral cavity of selected marine mammal species. *J Zoo Wildl Med* 2012;43:828–35.
- Abrahamian FM, Goldstein EJ. Microbiology of animal bite wound infections. *Clin Microbiol Rev* 2011;24:231–46.
- Brook I. Microbiology of human and animal bite wounds in children. *Pediatr Infect Dis J* 1987;6:29–32.
- Griego RD, Rosen T, Orengo IF, et al. Dog, cat, and human bites: a review. *J Am Acad Dermatol* 1995;33:1019–29.

33. Center for Disease Control and Prevention. Emergency wound management for healthcare professionals - special considerations related to contamination of wounds by water. Available at: <https://www.cdc.gov/disasters/emergwoundhcp.html> - guidance. Accessed January 19, 2019.
34. San Francisco Bay Regional Water Quality Control Board. San Francisco beaches pathogens TMDL, project definition. 2013 September. Available at: https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaybeachesbacteria/Project_Definition.pdf. Accessed January 19, 2019.
35. Kueh CS, Kutarski P, Brunton M. Contaminated marine wounds—the risk of acquiring acute bacterial infection from marine recreational beaches. *J Appl Bacteriol* 1992;73:412–20.
36. Zhu H, Li X, Zheng X. A descriptive study of open fractures contaminated by seawater: infection, pathogens, and antibiotic resistance. *Biomed Res Int* 2017;2017:2796054.
37. Aziz H, Rhee P, Pandit V, et al. The current concepts in management of animal (dog, cat, snake, scorpion) and human bite wounds. *J Trauma Acute Care Surg* 2015;78:641–8.
38. Cheng HT, Hsu YC, Wu CI. Does primary closure for dog bite wounds increase the incidence of wound infection? A meta-analysis of randomized controlled trials. *J Plast Reconstr Aesthet Surg* 2014;67:1448–50.
39. Hassinger SM, Harding G, Wongworawat MD. High-pressure pulsatile lavage propagates bacteria into soft tissue. *Clin Orthop Relat Res* 2005;439:27–31.
40. Animal bite investigation: rabies assessment. In: Veterinary Public Health Section, Infectious Disease Branch, Division of Communicable Disease Control, Center for Infectious Diseases, California Department of Public Health. 3rd edn. Sacramento, CA: Investigation, management, and prevention of animal bites in California; 2014. 10–9. Available at: <https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/InvestigationManagementandPreventionofAnimalBitesinCA.pdf>. Accessed January 19, 2019.
41. Manning SE, Rupprecht CE, Fishbein D, et al. Human rabies prevention—United States, 2008: recommendations of the Advisory Committee on Immunization Practices. *MMWR Recomm Rep* 2008;57:1–28.
42. Sabchareon A, Lang J, Attanath P, et al. A new Vero cell rabies vaccine: results of a comparative trial with human diploid cell rabies vaccine in children. *Clin Infect Dis* 1999;29:141–9.