AMONG FRIENDS

Friends of the Elephant Seal Member Newsletter

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Summer 2018

Water Conservation in Elephant Seals

Elephant seals have powerful mechanisms to conserve water and regulate hydration in the environments in which they live, both on land and in the ocean. While at sea, their water needs are met from the food that they consume. Their kidneys are able to efficiently absorb water from their food and eliminate excess salt by producing urine that has a concentration equal to or greater than seawater, thus resulting in a net gain of water. Energy in excess of their needs, stored as fat, forms their blubber layer and serves as a source of energy and water during prolonged periods of fasting.

It is well documented that while elephant seals are on land, they are able to fast, going without food or water for up to three months at the breeding rookery. Females fast for a month while expending their energy stores to nurse their pups. Weaners stay on the beach for weeks after their mothers leave. How do they survive without an external source of water? How do they conserve water needed for their body functions during these prolonged periods of fasting?

Fasting elephant seals largely depend on metabolism of their fat stores for water. Water is one of the by-products of using fats for energy; this process is called metabolic water production. In fact, researchers have detected a net positive water balance in fasting weaners, because, in addition to gaining water by metabolizing fat, they also minimize water loss by producing increasingly small amounts of highly concentrated urine. Weaner urine production during the post-weaning fast has been documented to decrease from 430 ml (almost 2 cups) per day early in the

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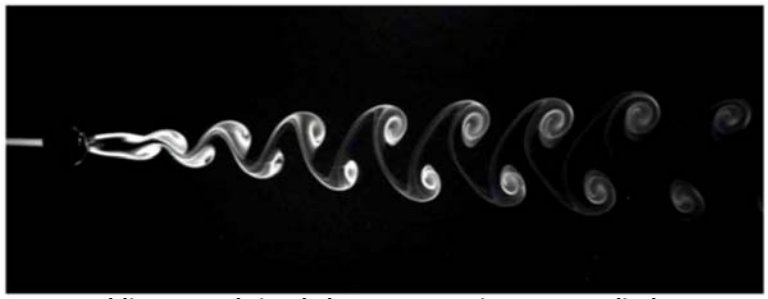
Whiskers

In the deep northeastern pacific, an elephant seal senses something; it's the right size to be food and not moving fast. As the seal turns to follow, it senses that the prey may be 3 minutes ahead – chances of a meal are very good. Research has shown that seals generally have whiskers (technically vibrissae) that make this scenario routine.

A fish moving through water creates a disturbance. As the tail of a fish moves back and forth propelling the fish, eddies are left behind with each stroke. It turns out they are long lasting; fish leave "tracks".



Eddies caused simply by water moving past a cylinder.

Seals have developed the ability to sense these tracks with their whiskers. Cats and rats are two terrestrial animals that conspicuously use their whiskers, especially to get around in the dark. The abilities of seals are much more impressive. It's not surprising, since pinnipeds (seals, sea lions and walruses) have the largest and most highly developed vibrissae of all mammals.

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Water Conservation *(Continued from page 1)*

fast, to 70 ml (1/4 cup) of highly concentrated urine per day towards the end of the fasting period.

Lactating females use their fat stores for water production and conserve water by producing milk high in protein and fat, with water content decreasing markedly during the course of their 4 week lactation period. The high fat content of elephant seal milk causes little water expenditure in the mother.

However, metabolic water production from using fat stores and water conservation through concentrating urine is only part of the story. Elephant seals also have other mechanisms to minimize water loss. Loss of water in exhaled air during respiration is minimized by holding their breath for several minutes at a time while resting on land. Their well-developed ability to tolerate low blood oxygen levels, during periods of apnea, both reduces the energy costs of respiration and markedly reduces water loss through respiratory evaporation.

Evaporation is further reduced through countercurrent heat exchange as the moisture in warmer exhaled air condenses as it passes through the cooler membranes lining the complex turbinate structures of their nasal passages. Lastly, elephant seals do not have prominent sweat glands, so they cannot lose water though perspiration, as we humans do.

Adams, S. H. and Costa, D. P. (1993). Water conservation and protein metabolism in northern elephant seal pups during the post-weaning fast. *J. Comp. Physiol. B.* 163:367 - 373.

Lester CW, Costa DP. (2006) Water conservation in fasting northern elephant seals (*Mirounga angustirostris*) *Journal of Experimental Biology*. 209: 4283-4294

The northern "Mesa" with workmen looking into the catchment basin. The original road is in the upper left where the red vehicle is parked downhill from the tree. The excavator in the foreground is loading the truck with slide debris from Mud Creek. There are ten men throughout the site whose only job is to watch the mountain and monitor seismic instruments to warn other workers if they detect movement.

Scenic Highway 1 Is Open

Caltrans reopened California State Highway 1 between Cambria and Big Sur on July 20. The world-class scenic route had been closed since December 2016 when winter storms destroyed the Pfeiffer Bridge near Big Sur and triggered a series of landslides in San Luis Obispo and Monterey Counties.

The only highway along California's central coast, this stretch of Highway 1 was opened in 1938. Because it was built across steep cliffs of sandstone and shale, landslides have closed portions of the road more than sixty times. The largest of these was at Mud Creek on May 20, 2017. More than 5 ½ million cubic yards of dirt and rocks thundered down the mountain burying ¼ mile of Highway 1. When the unstoppable avalanche reached the Pacific Ocean, it pushed 550 feet past the existing shore creating a 15-acre peninsula with 2,400 feet of new shoreline.

Acknowledging that the shale mountain above the road bed would be unstable in perpetuity, the engineers designed a way to manage future slides rather than attempting to hold the mountain in place.

Utilizing the new peninsula, engineers moved the road as close to the ocean as possible. To stabilize the 2,400 feet of new shoreline, 8 to 10-ton boulders were brought in by a fleet of trucks operating from sun-up to sun-down for months. The maximum load was three boulders per truck.

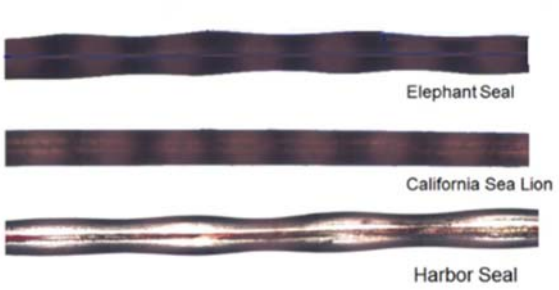
By moving the road away from the unstable mountain, enough space was created between the new roadbed and the mountain to build two massive mesas (berms) with catchment basins designed to contain and hold future slide debris. This debris will be removed by giant excavators and trucked off-site for disposal.

A filtered channel between the mesas was created to tame Mud Creek. A series of boulders positioned perpendicular to the flow of the creek retains mud and rocks but passes water to the ocean through a massive culvert beneath the new road.

To replace the ¼ mile of road, more than 2 miles of roads were built to give Caltrans crews maintenance access from the top of the mesas to the toe of the peninsula.

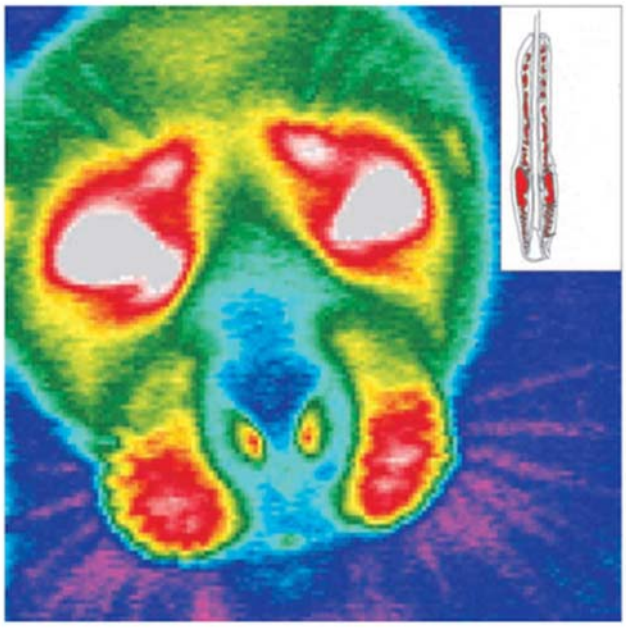
On your next visit to the Elephant Seal Rookery, travel California State Highway 1. Caltrans has added a spectacular new feature to the scenic glories you remember.

The whiskers of seals are slightly oval as they leave the face, but that oval becomes progressively flatter as you near the tip. This shape moves through the water smoothly so as to interfere as little as possible with the sensing of the delicate trails of fish. Many of the true seals, including harbor and elephant seals, have whiskers with an undulating or bead like shape rather that the smooth oval shape of sea lions. They cause even less disturbance moving through the water. The whiskers are stiff enough to be held out away from the face, but thin enough near their ends to sense very delicate vibrations.



The shapes of the vibrissae of three seals.

Whiskers are hairs, but much coarser than normal pelage. Elephant seal whiskers may be 5 " long or more in one year olds, but there is limited data available. The longest whisker reported for southern elephant seal males was 6.3". They probably they don't get much longer. The whiskers may be a millimeter across (roughly 10 times the width of human hair) near the face, and, as befits the greater width, the follicles from which they arise may be ¾ " long, much different than the follicles we observe in samples of molted hair. They have 5 to 10 times as many nerve endings as terrestrial mammal whisker follicles. As seen in the photo at the beginning of this article, there are in addition to the roughly 50 facial (mystacial) whiskers on each side whose purpose is known, there are one or two on either side of the nose, (rhinal), and 5 to 9 above each eye (supraorbital) whose function is not understood.



A thermogram of a young elephant seal. The inset shows the blood supply to the follicle of a single whisker.

To avoid the numbing effect of cold waters and to furnish the many nerves with needed oxygen, the whisker follicles are supplied with enough blood that even the skin around them is a few degrees warmer than the face generally.

Many species of seals have been studied to understand how their vibrissae function. While the harbor seals have been studied more than elephant seals, nothing has shown up pointing to differences between the abilities of the two species to use their vibrissae. Studies with blindfolded harbor seals and simulated fish have found that the seals can follow the trail of the object whether it is "swimming" or gliding. Also, if the seal comes across a trail it will follow the trail toward the source. Captive pinnipeds have shown they can use their whiskers to discriminate between objects based on size and shape as well as land-based animals that can grasp objects. Blind seals of several species have been observed surviving in the wild, some even raising pups.

As mentioned above, the undulating surfaces of vibrissae reduce turbulence as they pass through water. Researchers at the NASA Glenn Research Center are testing turbine blades designed with wavy surfaces inspired by seal vibrissae. They report a reduction in drag of 50%, and evidence that the noise of an engine with those blades would be reduced as well.

And what article would be complete without a picture of an elephant seal bull – in this case to see the positioning of the whiskers. Leaving us to wonder whether that nose might be a help or hindrance in the capture of prey.

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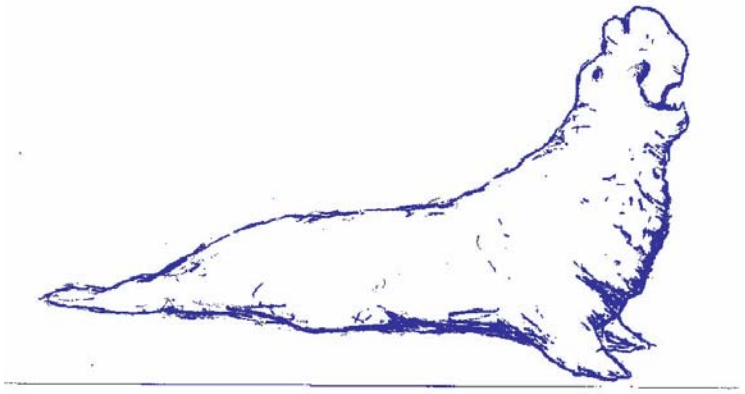

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- Interesting visitors on the boardwalk
- In-depth training and continuing education
- Satisfaction in protection of the seals and in helping visitors to appreciate their wonders

Visit our website for information and application:

www.elephantseal.org

Volunteer Training Dates

Basic Training in San Simeon:

Saturday , September 22, 2018

Advanced Training in San Simeon:

Saturday, October 6, 2018

Saturday, October 20, 2018

Calendar

January **-** Females continue to arrive. Peak of births usually occurs during the last half of month.

February **-** Births end early in the month. The peak of mating is around Valentine's Day. Females begin leaving.

March - Last adults leave. Weaned pups teach themselves how to swim.

April **-** Females and juveniles return to molt.

May **-** Females and juveniles molt.

June - Subadult males return to molt.

July - Subadult and adult males molt.

August - Last of males molt.

September and October **-** Young-of-the-year and juveniles haul out to rest.

November - Juveniles joined by subadult males. Mature males begin arriving at the end of the month.

December - Bulls continue to return. Females arrive. The first birth is usually mid-month.

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