

COMMENTS ON CAUSE OF DEATH OF NORTHERN ELEPHANT SEALS

From Patrick Robinson, Director, Ano Nuevo Reserve

This is a challenging thing to study and we don't have any definite answers. That said, we do have some clues (which I outline below).

-survivorship rates across the first few years of life are poor relative to later in life.

-Great white sharks and orcas are predators on of elephant seals, though we don't know how common this is.

-We have evidence to support the idea that coastal foraging is more dangerous for the seals (in terms of predation) but also more lucrative (in terms of increased prey availability).

-Weaners that have been satellite tagged go all over the place (south, coastal, even to the aleutians), and it appears that going south increases risk of mortality (though sample size was small).

-In general, we know very little about what the juveniles are doing (this is a hard group)

-Adult seals that carry instruments sometimes mysteriously blink offline and this occurs both in the open ocean and in coastal areas.

-Starvation at sea may happen, but I can't imagine it is common for adult females. A seal would lose her fetus before sacrificing her own life, yet we see very high pupping rates in returning females. (skip-breeding is more common in other species that are energetically challenged).

-The great white shark migrations are probably more closely linked to the sea lions than the elephant seals. Based on the differences between sea lion and elephant seal diving behavior and phenology, they sharks probably encounter sea lions much more frequently than elephant seals (though I'm sure they wouldn't pass up a tasty elephant seal given the opportunity!).

In summary, we don't know for sure what the most common cause of adult mortality is. It is likely a variety of factors and it will take further research to understand the relative importance of these.

From Bernard Le Boeuf, Director, UC Director of Advanced Studies Lab at UCSC

I know of no research that supports the statement "that the majority of deaths of elephant seals during their migrations are due to failure to find food and subsequent hypothermia – not predators." Indeed, it is hard to imagine the kind of data one would collect to support this statement. In general, we know that white sharks kill some elephant seals of all ages but we don't know how important this is. Same for killer whales. We know that some juveniles appear

on the beaches in poor condition but we see relatively few of these. We know that adult females, post-breeding or pregnant, have a harder time finding food in El Nino years than normal years, and they gain less weight (see attached paper). But as for the major cause of death during migrations, we don't know. Hypothermia? No data.

From Daniel Crocker, Professor of Biology, Sonoma State University

Lots of good questions in there. Short version is I don't at all agree with the docents statement, especially for adults and concur with your assessment. At a typical diving metabolic rate an adult male could fast for a year! From the large sample of tracked animals we've only seen a handful of adult animals in negative energy balance during a severe El Nino (Crocket et al. 2006) and they weren't in any danger of starvation. The lower critical temperature (LCT) for a big adult animal is way below freezing even when they've been fasting for many months with high rates of metabolism so there is really no way an adult elephant seal could die of hypothermia due to blubber depletion. We couldn't measure a LCT for a weaned pup after 9 weeks of fasting. The water would freeze before they showed an increase in metabolism. The calculated LCT for an adult male in water is -25C! We do see a decent number of shark bit animals (likely biased to large animals that survive the attacks) but those events probably occur close to the rookery and would it would be rare for a female to encounter a shark in the mid pacific. Males definitely have higher predation exposure as coastal foragers but we have no data on that sort of thing. So predation is certainly on the table but based on the number of attacks we see from the sharks at Ano (not from bites but from Pete Klimleys stomach temperature loggers in the sharks) those events are also fairly rare. When satellite tagged animals don't return those events are sometimes associated with tag failure that could represent a catastrophic event at sea but could just as easily be the tag breaking and the animal returning elsewhere. The most likely cause of adult mortality is probably closer to your area - disease. We have had females that partially aborted at sea and retained part of the fetus and went septic. We have seen fishbones perforate the small intestine and lead to sepsis. Parasite loads are high and just about any seal you sample is showing evidence of a primary immune response, especially during breeding. Parturition is associated with a strong immune response and during breeding there is evidence that body reserves influence allocation to immune responses (Peck et al. 2015). Because of colonial breeding lots of bugs are being passed around and females may reduce immune response under the constraints of fasting and lactating and then have to clear those infections while at sea. I've had a sat tagged animal move in a perfectly straight line at about 10x maximum swimming speed before disappearing who was likely on the deck of a fishing boat so fisheries bycatch is another potential source of mortality.

Young pups are more complicated. I concur that we don't see the range of body conditions you would expect if starvation was the major source of mortality. However, I'd also note the unfortunate fact that we have only seen a handful of the orange tags the MMC puts out on pups back at Ano ever, suggesting that being hand-fed during that critical window may reduce the chance of the animal figuring out how to forage successfully. Even then a yearling seal

would have to get really skinny to be subject to hypothermia. Taylor is correct that the Fall is prime time for shark predation on the juvies.

A more complicated potential viewpoint is that holding your breath for a living is incredibly physiologically stressful. Seals routinely undergo near complete blood oxygen depletion on every dive (Meir et al. 2009, 2013) well below the level of acute hypoxemia. So that consistent hypoxia/ischemia/reperfusion is a huge source of oxidative stress and the primary defense mechanism appears to be dramatic upregulation of ant-oxidant enzymes in tissues. Nutritional stress may reduce the ability of the animal to mount immune and anti-oxidant responses and compromise health.

Last bit, though Burney wouldn't agree, we now think based on the tracked animals that those natality estimates of 95% are way too high. That's based on the proportion of non-pregnant females that come back to copulate during the breeding season. We now know that most of the non-pregnant females haul out well before and after the breeding season and are only on shore for a short time. There appear to be males that specialize on those females, arriving very early or late to the party. Natality rates in the huge tracking sample are more like 84%, still pretty high and we are starting to get an understanding of the mechanisms regulating natality and have several papers in the chute on how foraging success effects stress and reproductive hormones. When females abort at sea we can see the event due to the change in buoyancy when the lean tissue fetus is ejected and it usually occurs within the first few months of the foraging trip.

From Richard Condit, Staff Scientist, Smithsonian Tropical Research Institute

I think Burney and Patrick would agree with me that there is no evidence about the majority of causes of death. Both certainly are experts and I would like to know what they think.

We occasionally see dead or moribund animals, but the vast majority of deaths are at great distance in the ocean. The tools in use now for tracking animals at sea do not offer much evidence on cause of death. So any statement about the 'majority of deaths' is just a guess.

We certainly know that animals are killed by predators. And we know that in some years with bad current conditions (ie El Nino) that animals lose weight and juveniles suffer higher than average mortality. We also see juveniles in poor condition with skin infections. You are correct, though, that animals on the beaches are nearly all in good condition. We miss the animals in really poor condition -- they don't make it back to the beaches.

Moreover, I don't know that there is any evidence about hypothermia, and I'm not convinced that hypothermia is what kills malnourished seals. It's a possibility, but malnourished seals may also suffer more predation and more infections.