AMONG FRIENDS

Friends of the Elephant Seal Member Newsletter

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Spring 2018

What Is She Eating?

Over the years, efforts have been made to determine the diet of the northern elephant seal. Thirty years ago the stomach contents of 57 male and female seals in the rookery on San Miguel were examined.[1] There was evidence of squid and crabs in more than 80% of stomachs, fish in 20% of males and 40% of females. Other creatures were present with lower frequency. Limitations of this study include the fact that some creatures leave less trace and what was found was eaten recently, not near the primary feeding areas. What it did show was that the seals will eat almost any creature they can swallow.

A more recent study[2] was based upon a jaw motion recorder attached to 15 female elephant seals. This study gives insight into the diet by noting where eating occurs and estimates prey size given the number of feeding events and knowledge of food available. No actual observation of eating was made. It is clear from these two studies that female seals are feeding primarily in the deep scattering layer, a layer in the ocean first detected by sonar during WWII, that is sufficiently dense in biomass to simulate the ocean floor.

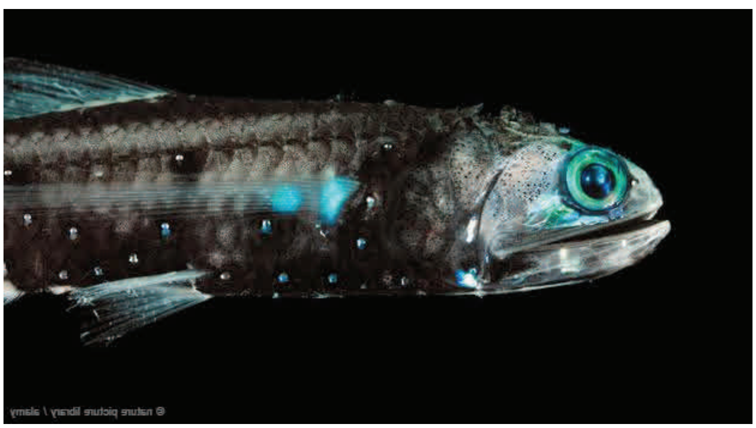

Figure 1: Lanternfish, showing bioluminescence

Within the deep scattering layer are many small bioluminescent creatures (see accompanying article). Elephant seal's eyes are particularly sensitive to the blue bioluminescent colors. From what is known of the population of the layer, it is believed that fish of a family known as lantern fish, including 246 species, comprise a large portion of the biomass at that depth. They are believed to have a global mass of over 500 million tons, possibly several times that amount. Since no actual consumption is observed, the importance of lanternfish to the diet is only inferred.

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Bioluminesence

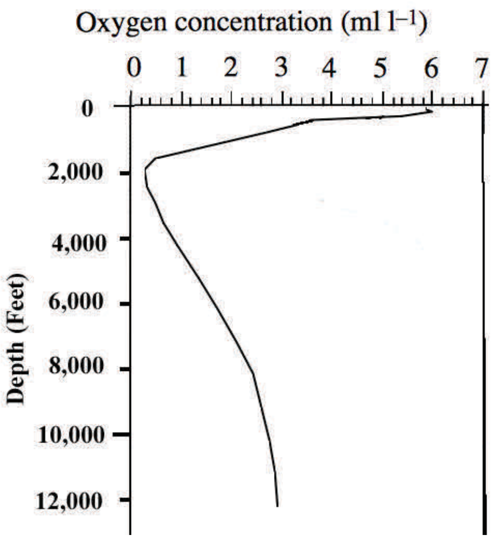
The ocean has a wide range of organisms producing and emitting light and thus creating a world of pale glows, dancing lights, ghostly shadows and beautiful sparkles. The colors they emit vary from light green or deep blue to red or, most frequently, blue-green. The ability to create and emit light is called bioluminescence and it can be found in sea creatures from near the surface to great depths. Most emit light in flashes but some are able to do so continuously. Four fifths of the organisms capable of bioluminescence live in the ocean. They include a wide range of creatures including fish, octopus, shrimp, marine worms and plankton. All use chemical reactions in specific light-producing molecules to do this but the actual process varies. Scientists believe the ability to create light evolved more than 40 different times. It's evolutionary roots go back millions of years and predate the rise of the dinosaurs.

Starting in 1999, researchers from Monterey Bay Aquarium Research Institute (MBARI) have investigated the prevalence of bioluminescence in the ocean. Previous studies suggested that bioluminescence was fairly common but its overall frequency had never been measured. Using high definition cameras and remotely operated vehicles, MBARI, over a 17-year period, undertook 240 research dives, video recorded 350,000 observations of sea creatures, and documented information on 553 types of organisms from the surface to a depth of around 12,800 feet. Using this data they gauged the presence, abundance and distribution of bioluminescent and non-bioluminescent creatures throughout the water column. They found that within the ocean's waters 76% of observed marine organisms are capable of making their own light. The predominant source of light in the deep ocean is bioluminescence. Animals with this trait dominate the entire water column.

(Continued on page 2)

OXYGEN MINIMUM ZONES

Zones of minimum oxygen level are found at intermediate depths in most of the world's oceans, and the Northeast Pacific is no exception. Oxygen produced by photosynthesis near the surface is progressively used by animals and processes further down the water column, usually reaching a minimum between 1500 and 3000 feet. Below this, the oxygen level begins to rise again due to mixing from deep, cold, oxygen-carrying currents that originate near the poles.



The oxygen minimum layers harbor many forms of life, but all must adapt to the low oxygen levels. Some adapt with more efficient gills, making them better able to take oxygen from the water. Most are also animals of low metabolism – there is just not enough oxygen for the rapid darting motions of fish near the surface. Since most elephant seal foraging is done at depths of 500 to 2500 feet, they are taking advantage of the slower moving prey at these levels.

There are other periodic or circumstantial oxygen minimum zones formed when high levels of nutrients are available due to run-off or upwelling. The high production in these areas yields more consumers of oxygen than producers, and the amount of oxygen available may drop almost to zero producing "dead zones". These are usually surface phenomena and may affect many marine animals. Elephant seals are usually not affected, even if the zone is toxic, because they feed far below and in colder waters than is common for oxygen minimum zones.

*(**Bioluminescence** Continued from page 1)*

Why is bioluminescence so prevalent? Sea creatures use light as land animals use sound. They use it to hide, intimidate, stun, mislead, hunt and find mates. Dinoflagellates, a marine plankton, emit a blue-green light that makes the sea sparkle at night. When threatened these flashing lights can be used to startle and scare predators. The flashing lights also illuminate the predator making that predator vulnerable to things that eat it. A species of free-swimming worms, nicknamed the green bombers, has an unusual defense. Down more than 6,000 feet in the ocean, they are armed with eight small fluid filled sacs that look like small balloons. The worms heave these sacs at predators when threatened. Once thrown, the sacs burst emitting a brilliant green display that distracts predators and allows the worms to escape.

It's hard to hide in the ocean. Between 660 feet and 3300 feet, the limited light filtering down creates a twilight effect. Unless creatures can blend with the water, they become a dark shape against a lighter background and are easily visible to predators looking up. To defend against this, many sea creatures use bioluminescence to counter-illuminate as a method of camouflage. The light they produce on their bellies matches the light coming from above. This reduces the contrast between their bodies and the ocean making them virtually invisible.

Lastly, some sea creatures use bioluminescence to prey on other creatures. A famous predator is the anglerfish that uses bioluminescence to lure prey. It has a huge head, sharp teeth and a long, thin growth on the top of its head. On the end of this growth hangs a ball that the anglerfish lights. Smaller fish, curious about this spot of light, swim in for a closer look. By the time the prey sees the dark jaws behind the bright ball, it's usually too late. And then there is the cookie-cutter shark that may have taken predation to a new level. It counter-illuminates and has a chocolate brown body with an underside that emits a green glow. Thus practically all of its body blends into the downward light except for a dark collar around its gills. When viewed from below, this area mimics the shape of a small fish and appears to act as a lure. Cookie-cutters travel in schools, so seeing an apparent school of small fish would heighten the appeal for a predator. Once the predator gets close, the shark attacks taking a small round chunk of flesh. The effect of such attacks can frequently be seen on elephant seals. Visitors at our Rookery often ask what caused the small round scars about the size of an Oreo cookie on the eseal bellies. Usually it is the result of the seal's encounter with cookie cutter sharks.

Martini, Severine & Haddock, Steven H.D. Quantification of bioluminescence from the surface to the deep sea *Scientific Reports* 7:45750 April, 2017

http://biolum.eemb.ucsb.edu

http://annualreviews.org.bioluminescence

What is She Eating (Continued from page 1)

There are certainly other small creatures, most of them bioluminescent, in the deep scattering layer although in smaller quantity. Given the evidence from the first paper that the elephant seals are not picky eaters, the assumption that the lantern fish is of major dietary importance is reasonable. It should be noted that these fish are very small, averaging around one-half ounce---a small taste for a 1000-pound creature. However, 24 females equipped with the jaw motion detectors, on an average 70 day voyage after weaning their pup, averaged 112,000 feeding events. Among them were seals with many fewer feeding events that had greater than average weight gain. This suggests that they sought different prey during portions of the voyage.

Evidence of that can be seen in the dive figure below. It is complex but informative so some patience is encouraged.

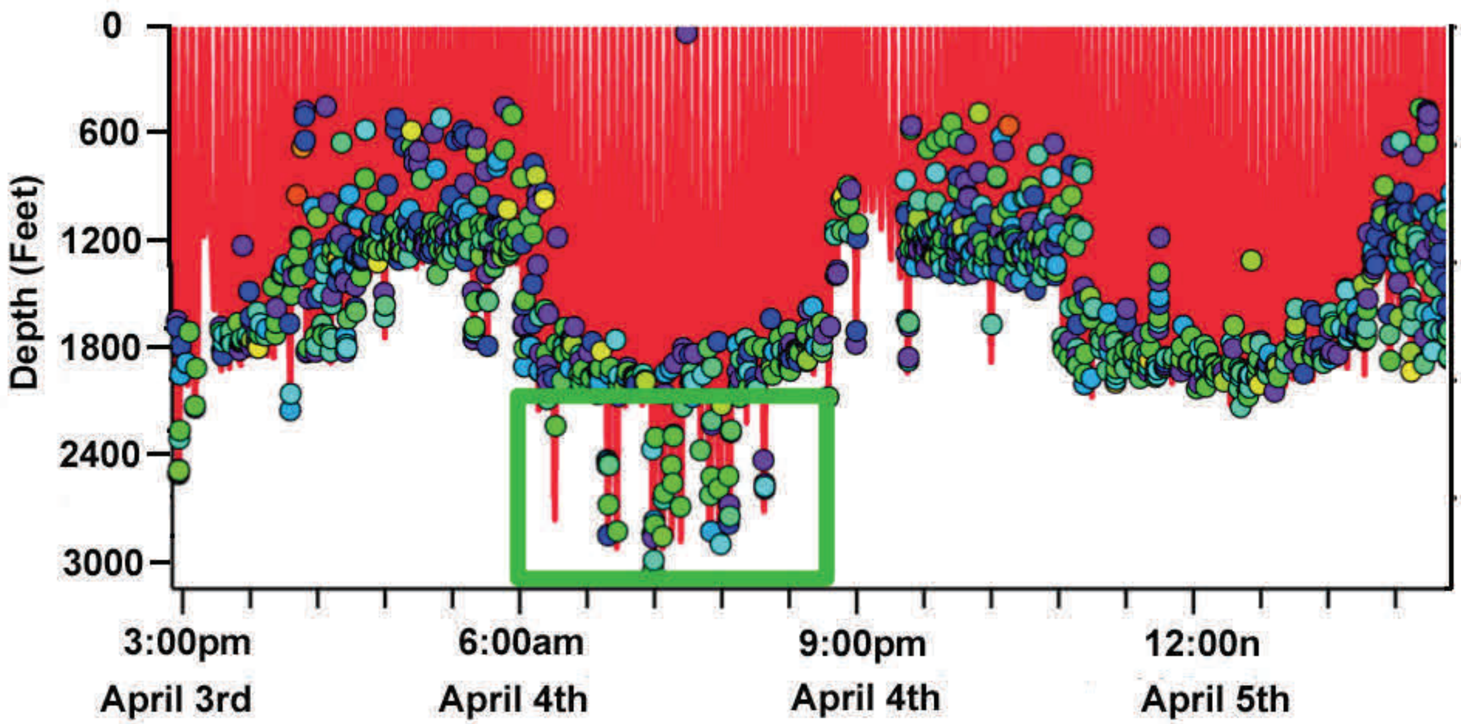


Figure 2: Figure showing diving and feeding events over a two and one-half day period.

The vertical red lines show the depth of each dive. The color-coded circles indicate the number of feeding events during each dive. During the night, the dives are relatively shallow, typically around 1300 feet. During the day, the great majority of dives go to around 1800 feet. The green rectangle draws our attention to dives that go well beyond the 1800 foot depth, approaching 3000 feet. These dives are into the oxygen minimum zone (OMZ).

A study[3] of female elephant seals in the OMZ included a seal equipped with a camera that recorded the encounter with a ragfish. The ragfish appeared to make no movement to escape, possibly reflecting the very low oxygen content of the water. The ragfish, unlike the lanternfish, is not small, having been found at over 2 meters long.

Except for the first study, all these results are about female seals swimming in the open ocean. The food supply on the slope of the continental shelf, the primary feeding ground of the male, has been less studied. It is clear, from the greater size and shorter time at sea of the older males, that a very different diet can be expected.

For one of the very few pictures of an elephant seal eating, go to www.youtube.com/watch?v=nzMB8jqioV0

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[1] G. A. Antonelis, Jr., *et al*. (1987), Assessing northern elephant seal feeding habits by stomach lavage. *Marine Mammal Science,* **3(4)**: 308-322.

[2] Y. Naito, *et al*. (2013), Unravelling the mysteries of a mesopelagic diet: a large apex predator specializes on small prey. *Functional Ecology,* **27:** 710-717.

[3] Y. Naito, *et al*. (2016), Oxygen minimum zone: An important oceanographic habitat for deep-diving northern elephant seals, *Mirounga angustirostris. Ecol Evol* 2017;00:1-12.

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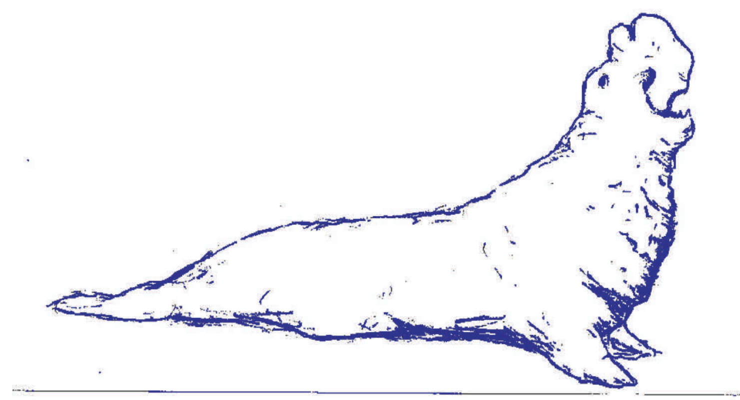

Calendar

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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