EMBARGO:
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The Secret Lives of Whales

Advanced Technologies Reveal New Knowledge about the Lives and Deaths of Whales

Washington, DC. Using genetics, Navy sonar, deep-sea submersibles, and toxicology, scientists are peering into the lives of whales – past and present – in ways never before possible. At a 3:00 PM press conference on February 19th at the annual meeting of AAAS, **Steve Palumbi of Stanford's Hopkins Marine Station, Christopher W. Clark of Cornell University, Craig Smith of the University of Hawaii and Roger Payne of the Ocean Alliance** will share their latest discoveries emerging from these high tech ventures, using DNA sequences, deep-sea video and sound-clips.

Reading the Past from DNA

"Genetics is opening the door to a huge storehouse of historical information about whales," says Steve Palumbi of Stanford University. Palumbi has applied new genetic techniques to penetrate over a million years of whale history dating back to the middle of the last series of Ice Ages.

Using whale samples from the Japanese meat market, where Antarctic minke whales killed for "scientific research" are legally sold as food, Palumbi examined variations in mitochondrial DNA from individual whales. He was amazed at their genetic variation – an indicator of the past size of their population. Piecing together their ancient family trees, he has discovered that the Antarctic population of minke whales is now the longest surviving whale population on earth. It was also once the largest—many times larger than other estimates.

This information is critical to current discussions of the International Whaling Commission (IWC) because some argue that the recent surge in minke populations is unprecedented and is hampering the recovery of other whales, pointing to the need for resumed whaling. Yet the whales' varied DNA reveals a different story, a past with an ocean teeming with whales.

It also shows a steadily growing population, with drastic declines only showing up in recent history. "Whales have shown remarkable resilience to cataclysmic events - until the last one – which is us," says Palumbi. "Ice ages, sea level change and even loss of local food sources did not interrupt their lives. Living in a fluid environment they could move to new areas of productivity and find food even as the climate around them changed."

Palumbi compares the ability to read genes to counting the rings of a tree – but looking at the history of an entire population, not just an individual. "Knowing the history of populations is

critically important to managing their future," says Palumbi, "especially for populations like these whales that have figured out how to dodge the effects of climate change."

Undertakers in the Deep Sea—A New World Discovered

Earlier forensic DNA work by Palumbi and his colleagues revealed that whale populations in the North Atlantic were as much as ten times greater than today. New technologies that allow researchers to observe the deep-sea, now point to another unintended legacy of hunting whales – the elimination of entire communities of deep-sea animals.

Craig Smith, from the University of Hawaii, studies dead whales after they have sunk to the seafloor. Known as whale falls, their decomposing bodies and skeletons provide an energy source for specialized communities of animals that can last 50 to 100 years.

Smith and his colleagues first happened upon a whale skeleton in 1987 while doing a deep-sea survey using the submersible Alvin. They were amazed to find hundreds of species of animals encrusting the bones. Some of these species were remarkably similar to the sulfur loving clams, mussels and tube worms observed around hydrothermal vents. Smith immediately suspected that they might be related.

Today, Smith and others have traced the succession of events that lead to these aggregations of animals. They feed these communities like feeding pigeons in a park except that in Smith's case, they tow a dead whale out to the deep sea, place a transponder on it, and drop it to the sea floor. The transponder lets them find it later with a manned submersible or robotic vehicle.

They now know that a whale fall may host even more species than a hydrothermal vent—many unique to whale falls. Recently discovered "blind zombie worms" use an internal "bacterial garden" to break down the whale bone and feed on the fats and proteins inside. "They are an example of extreme evolutionary novelty," says Smith, "a new feeding strategy that scientists never dreamed of …" Sometimes the worms are so abundant on the whale bones, it looks like a waving lawn of grass. While the first zombie worms were described only a few months ago from one whale skeleton off California, Craig and co-workers have just found another species off Sweden and now think these zombie worms may occur worldwide.

Because of their ability to break down lipids in cold water, these animals and their bacterial garden may hold a key to better cold water washing detergents. But more importantly, study of whale worms and other whale-fall species help scientists understand how life has diversified in specialized habitats in the deep-sea. Deep-sea vent tube worms may have originated from shallow-water species, using whale falls as a food source along the way. "Whale bone worms have been around for 30 to 40 million years. It's conceivable that whale worms first appeared on whales and later adapted to deep-sea hydrothermal vents," Smith explains.

Whale fall habitats can form underwater stepping-stones—food archipelagos— for the dispersal of deep-sea species. "If you calculate the abundance of whale falls on the sea floor – say for grey whales in the northeast Pacific, the neighboring whale falls are about 5-10 kilometers away, which is a very reasonable dispersal distance for the animals that live on them," says Smith.

In the North Atlantic, where only 10% of historic populations of the great whales are estimated to still survive, Smith speculates that substantial species extinction may have occurred in the whale fall fauna. “The deep ocean appears to be a major reservoir of biodiversity on the planet. Some of the oddest animals ever discovered occur on whale falls,” says Smith. “These communities are the undertakers of the deep, assimilating huge whale carcasses and recycling their bodies back into oceanic lifecycles. If we want to understand the nature of life – what evolution can do—we must understand these habitats before extinctions occur.”

Blue Voices from the Deep

Cornell researcher Christopher W. Clark studies ocean voices. Using the U.S. Navy’s anti-submarine listening system from the cold war, and customized systems developed at Cornell, Clark is investigating how the great whales move in acoustic herds, communicating over 1000’s of square miles of ocean by using sound. “This is like using the Hubble telescope of ocean acoustics right now,” says Clark. “The Navy had heard the whales for years but hadn’t focused on the significance of their low voices. To me it was like —ohmygawd!”

Access to the U.S. Navy’s underwater listening systems took researchers from fixed-point observations such as ships, to synoptic views of the ocean. Clark can move a cursor around a screen and listen-in on different parts of the world. If he hears a whale singing, he can fix its location and position it in space and time and observe multiple animals that are 100’s of miles apart—cohorts of humpback singers moving coherently— and watch the collective migration of species over large portions of an ocean basin. “So if I am a whale off Newfoundland, I can hear a whale off Bermuda,” says Clark.

Singing whales appear to slalom from one geographic feature to the next using the echoes of their intense, infrasonic voices to navigate. They do this during long periods of complete darkness in the middle of the ocean basin where echoes take 10 to 20 minutes to return. “They must have the ability to process low-frequency sounds into images just as dolphins do with high frequency sounds, and they must have remarkable acoustic memories just as we have visual memories,” says Clark.

Clark concludes that he and other researchers have been thinking about whale herds at the wrong scales, which has been constrained by the limitations of their recording and visual observation abilities. “Suddenly you realize that the whale’s sense of scale is ocean basin sized —one song note is 20 miles long and can illuminate the entire basin,” he says.

Clark has observed that the distribution of singers is closely matched to the distribution of zooplankton, and suspects that shifts in singer distribution coincide with shifts in food distribution. Now, he is studying reactions of whales to sound pollution, tracking how whales move away or go quiet as human activities enter an area. Every decade the amount of noise is doubling. “Whales have very traditional feeding grounds and their migratory routes along coastlines have become incredibly noisy, urbanized habitats,” Clark explains. “Acoustic smog is shrinking their world.”

The Whale in the Coal Mine – Cataloging Ocean Pollution

Roger Payne and Scott McVay were the first to discover that humpback whales sing—and Payne speculated that whales might communicate across oceans. Clark and others have confirmed and expanded upon Roger Payne's early work. Today Payne is pioneering a new frontier in whale research – he is creating a map of global ocean pollution based on skin samples from whales.

"Our goal is to determine how badly contaminated oceanic fish are with persistent organic pollutants (POP's)," says Payne, "What we are working on may be the worst public health crisis that humanity has ever faced. That's because 70% of all humanity (4.2 billion people) depends on seafood as its primary source of animal protein, and if the fish are seriously polluted, they may soon be unsafe to eat."

Payne reasoned that by taking biopsy samples from whales and analyzing their contaminant loads, he could map levels of pollutants in different ocean. "The oceans act as a conveyer belt carrying contaminants across the globe and depositing them in the fats of seafood," says Payne. Now in the final year of a five-year global voyage, Payne's institute has found and collected skin samples from over 1100 sperm whales from some of the most remote ocean regions of the globe.

He chose to sample sperm whales because they ranged worldwide and are whale icons – thanks to Melville's tale of *Moby Dick*, the rare white sperm whale. Female sperm whales feed in tropical regions while males travel globally and feed near the poles. "For example, of the roughly one million sperm whales killed by whalers in the Antarctic Ocean, only one was a female," says Payne.

Ocean Alliance is testing its samples for 30 different pollutants. "Some of these are endocrine disruptors – female hormone mimics that cause serious problems. The whole world is being feminized," says Payne. Payne's greatest hope is that in the next decade, the world will have taken heed, and instituted steps to reduce the entry of contaminants to the oceans.

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MEDIA NOTE: The scientists will discuss their findings at an AAAS session on Sunday February 20th at 8:30 AM Eastern. For assistance contacting the speakers during AAAS please call Jessica Brown at #202-497-8375. *A microdocumentary DVD describing these four studies is available in the AAAS press library, on the AAAS website and from Jessica Brown.*

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