

OCEA 101 Extra Credit #1 (Due February 21, 2007)

Read the two recent newspaper articles discussing global warming. Based on the articles, your own knowledge, and what you have learned in class, answer the following (similar to an essay on an exam):

The IPPC recently announced that humans are almost certainly the cause of recent global warming. As a result, President Bush has decided that “global warming” may be something that his administration should look at, and he has proposed to increase funding for oceanography and other related sciences. However, Cheney keeps telling Bush that global warming isn’t real, and even if it were, does it really matter if it’s a degree or two warmer? After all, who cares if it’s 72° or 73°?

So Bush’s question to you, as his appointed expert on Marine Biology and, is the following.

- 1) Can we really say that it’s warmer?
- 2) And if so, is that really likely to be a bad thing for the oceans?

You may argue either side (for or against global warming), as long as you justify your opinion. You must turn in your (typed) extra credit no later than Weds., February 21, 2007.

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[A WARMING WORLD: THE DIFFERENCE A DEGREE MAKES SEASHORE SEA CHANGE](#)

- [Jane Kay, Chronicle Environment Writer](#)

Monday, January 16, 2006




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Pacific Grove, Monterey County -- On the edge of the California coast, in the tide pools that tourists can see from Cannery Row, delicate anemones and sea stars are helping to tell the story of a warming world.

At low tide in the dawn light, John Pearse, a retired professor of biology at UC Santa Cruz, kneeled in the water in hip-high waders examining sunburst anemones. He found pink barnacles encrusting rocks, and the hard white shells of worm snails.

Those invertebrates normally are more common in warmer southern waters. But over decades, they have increased in numbers here. Invertebrates that do well in colder water, such as giant green sea anemones and porcelain crabs, have declined. Central California has become more like Southern California.

"Animals are responding to changes in temperature, and the change in temperature is very rapid," said Pearse, who began studying the low-tide zone as a graduate student nearly 50 years ago.

Unlike in the Arctic, where floating sea ice and land glaciers dramatically melt before Alaskans' eyes, along the California coast the signs of a changing environment are more subtle.

Those who know where to look can see that a few degrees increase in the temperature of the Pacific and a couple of inches rise in sea level have already changed life in Monterey Bay's fragile tide pools.

While some species will prosper, others may die. The question scientists up and down the coast are pursuing is just how the continued warming of the atmosphere and water may disrupt the

ocean's intricate web of life.

In the ocean, the whales, seabirds and fish at the top of the hierarchy depend on lower organisms for food. In the last six decades, as sea water temperatures on the Monterey coast increased about 3 degrees Fahrenheit, scientists measured a 70 percent decline in zooplankton, the tiny animals at the base of the food chain.

What does it matter if a warmer world loses some inedible crabs or sea stars?

"It's hard to predict," said George Somero, director of the Hopkins Marine Station, the state's oldest marine laboratory, which looks down on the rocky shore here. "If you remove one species from the ecosystem, there could very well be severe perturbations in the system. In many cases, we can't predict what that means."

Somero is the latest in a line of Hopkins directors who have peered into tide pools to gauge the ocean's health. He's seen that many animals can't mutate fast enough to adapt to higher temperatures.

"A 1-degree or 2-degree change has a very pervasive effect," he said. "These animals for hundreds of thousands of years didn't have to adjust to temperature. So now the climatic change is asking them to do things that they're not prepared to do."

"When species evolve, they don't build in extra protection for survival."

Scientists have documented that plants and animals evolve in a web of synchronicity, the normal workings of seasons, light and temperature and the interdependence of species for food and reproduction.

Nut trees need bees to pollinate the fruit. Bees need the right temperatures to survive and certain types of plants on which to feed. The plants need certain moistures, and perhaps birds to help them reproduce.

Now, what humans know as normal natural systems will be thrown into disarray, scientists say. Homo sapiens hasn't lived through these kinds of changes during the 200,000 years of its existence. No one can predict where it will lead.

Changing ocean

In the Arctic, glaciers and ice sheets melt, raising sea levels and flooding low-lying shorelines. Shrinking sea ice disrupts wind patterns and sea conditions and destroys habitat for the polar bear, ice seals and seabirds.

Alaska's average temperature has increased 4 to 5 degrees in the last 50 years, compared with about 1 degree worldwide in the last century. In winter, it sometimes rains instead of snows. The Portage Glacier, 45 minutes from Anchorage, is losing 20 feet a year.

On the Kenai Peninsula, wildfires have destroyed forests weakened by bark beetles that survive the warmer winters, and salmon streams run at temperatures unsafe for spawning.

In Newport, Ore., Bill Peterson is an oceanographer who began studying the Pacific nearly 35 years ago. He focuses on fish research for the National Oceanic and Atmospheric Administration from a laboratory looking out at the Yaquina Bay bridge.

He is seeing new species moving north, following prey fleeing warmer ocean conditions that are now occurring more frequently, lasting longer, and appearing more unpredictably than in the past 60 years.

Thirty-pound jumbo squid, 3 feet to 4 feet long, that used to come north from Central and South America only in warm El Niño years, are now schooling in the Pacific Northwest -- to the delight of diners and a burgeoning squid fishery.

But there is a matching decline of cold-water coho and Chinook salmon, anchovies, smelts and tiny copepods, or plankton.

Peterson has come to a basic conclusion important to commercial and sports fisheries as well as to the fish-loving public: "The salmon returns are very, very low in warm-water years, and very high in cold-water years."

He has some ideas why that is so, as his team works to understand the link between a warm or a cold ocean and salmon survival.

"A fish like a salmon," he said, "will grow and survive better when feeding on a food chain that has been fueled by krill, shrimp-like creatures, and fatty northern copepods, tiny crustaceans. In warmer waters, the krill aren't as plentiful and the copepods aren't as fatty, and so fish can't get as fat."

The ocean is warming because the equilibrium between the energy the Earth receives from sunlight and the heat the Earth radiates back into space has changed.

As carbon dioxide and other gases produced by burning fossil fuels accumulate in the atmosphere, they trap more heat. Over decades, scientists say, that has warmed the ocean.

Ocean waters normally have a layer of warmer surface water on top of colder, deeper water. The layers stir and mix vertically, forcing an upwelling of phosphates, nitrates and other nutrients from the cold bottom up to the sunlit surface. There phytoplankton, tiny plant life, grows and feeds the whole food chain, starting with the krill and the copepods.

But the warming has created a deeper layer of warm water at the surface that blocks the mixing and the rise of nutrients. So there has been a decline in productivity -- fewer zooplankton, fewer birds, fewer commercial fish.

Frank Schwing, an oceanographer with the National Oceanic and Atmospheric Administration in Pacific Grove, noted the importance of the deeper layer of warm water:

"It's the equivalent of a blacktop over the surface of the ocean."

Farallon Islands

Twenty-seven miles off the Golden Gate, hundreds of thousands of seabirds nest on the rocks of the Farallon Islands.

White sharks, humpback and blue whales, elephant and northern fur seals and California sea lions feed on the fish, crustaceans, plankton and mollusks that live in the crashing waters.

On the protected wild islands, Point Reyes Bird Observatory scientists have observed and recorded the behavior and reproduction of a dozen seabird species for 35 years for the U.S. Fish and Wildlife Service.

Just as scientists have noted a decline in ocean plankton since the mid-1970s that is correlated with warmer temperatures, the Farallones biologists have found that seabirds reproduced poorly over the same period.

The driving force is the California Current, a band of water coursing along the coast from Vancouver to Baja California.

The temperature of the current goes up and down like the stock market, influenced by the powerful short-term effects of El Niños, the fluxes of warm water that are precipitated by a failure of trade winds at the equator.

In cold years, the upwelling of nutrients is strong, boding well for sea animals from plankton on up to marine mammals and seabirds. When the temperature goes up -- like this year -- the sea life generally fares poorly.

Only recently, scientists determined that the warm and cold periods have alternated for thousands of years according to 15- to 20-year cycles called climate regimes, driven by currents from the North Pacific Ocean and changes in the direction of winter winds.

Oceanographers think the worldwide warming trend may be throwing off the pattern of natural climate regimes. But they don't know how that may eventually affect the California Current.

For now, biologists are looking at decades of records on success and failure rates of the Farallon seabirds to see what they reveal about the effects of climate.

Last spring, by watching the sensitive Cassin's auklet, a stocky, robin-sized bird, biologist Russell Bradley and his Farallones team were among the first scientists to note that the California Current was warming and that the upwelling was weakening even though there was no El Niño.

The auklets nest in rocks and in boxes that the biologists set out for them. Creeping up to the boxes to observe, Bradley saw that when a cold northwesterly wind switched to a southerly wind in April, auklets abandoned their nests.

Somehow they knew that the plankton they fed on wouldn't be there. And sure enough, the number of krill dropped.

The krill returned later in summer, but the auklets didn't produce many, if any, young last year.

On land, warming has already thrown off the synchronicity of nature. Butterfly populations have shifted north, ahead of the flowers on which they feed. Birds start to build nests at the wrong time. So with the auklets and krill.

"Timing is everything for the seabirds," said Bill Sydeman, a biologist who has spent more than 1,500 nights on the islands since he began as an intern 20 years ago.

Sydeman and others have tracked this pattern for three decades, seeing a decline in Cassin's auklets to about 16,200 in 2005 from about 105,000 in 1972, as the ocean warmed and as krill and other plankton declined.

David Ainley, a marine ecologist who has joined a National Oceanic and Atmospheric Administration cruise that monitors seabirds and marine mammals from Bodega Bay south to Monterey every year since 1985, agrees that the shifts in climate regimes that have been working for millennia may be out of kilter.

"Now the ocean and the atmosphere are warming, and it's causing the rules not to apply any more," he said. "El Niños are more frequent and more intense.

"It's a new ballgame. It's going to take some decades to figure out what the rules are now."

Pacific Grove

The 400 miles of shore between Mendocino and Santa Barbara are considered world-class for sea life because of the great biological diversity. Here lies an overlap of the warm-water creatures that inhabit the shoreline south to Baja California, and the cold-water species stretching north to the Bering Sea.

Below Cannery Row, biologist Pearse was searching for samples of warmer-water invertebrates that have increased in the tide pools over the last 60 years.

One was a large sunburst anemone with golden streaks radiating from its mouth. "That's just a beautiful animal," he said. "They're everywhere."

Pearse pointed to some stakes in the tide pools, remnants of a classic study that was conducted from 1931-33 by a Hopkins graduate student, Willis G. Hewatt, long before scientists noticed effects of climate change.

Hewatt had pounded brass plugs into the tidal rocks, laying out 108 yard-long strips where he counted every invertebrate he could find.

Sixty years later, Hewatt's count was updated -- only because of the persistence of Chuck Baxter, a professor at Stanford University, which runs the Hopkins lab.

Baxter had noticed that the tidal zone at Hopkins was starting to look different. With the appearance of a couple of new snails and other species, it looked more like Southern California than it had in the past. For years, he urged graduate students and post-doctoral fellows to retrace Hewatt's work.

"I couldn't get anyone to take me up on it," Baxter said one day at Hopkins.

Finally, in 1993, the last quarter before he retired, Baxter hit upon "two really great bright students" -- Raphael Sagarin, now at UCLA, and Sarah Gilman, now at the University of South Carolina -- who took on the task.

"They were out there when the tides were out at 2 a.m., searching for the old pegs," he said.

In 1995 the team, joined by Jim Barry, benthic ecologist at the Monterey Bay Aquarium Research Institute, published their study, the first of a large assembly of plants and animals responding to regional climate warming.

They noted a distinct shift as average shoreline water temperatures rose: Eight out of nine southern species increased significantly, and five out of eight northern species decreased significantly. The findings were consistent with predictions by models of global warming.

The power of a few degrees' change in water temperature is shown dramatically in a newer study by Jonathon Stillman, an assistant professor at the Romberg Tiburon Center for Environmental Studies, operated by San Francisco State University.

As a doctoral student at Hopkins studying the ability of ocean creatures to adapt to climate change, Stillman picked the porcelain crab. Some 20 species inhabit the tidal zone from Baja to Alaska, closely related but living in different thermal habitats.

Turning over rocks to find crabs, he took them to the lab and placed them in warmer water. Some crab species died of heart failure, in clenched contortions, when exposed to water less than 1 degree above the maximum temperature of their natural habitat.

The findings were an ominous warning for crabs living in the upper tidal zones along the coast. In Monterey Bay and the Gulf of California, Stillman found crabs are already living near their upper-thermal limit in nature and don't have the capacity to shift their heat tolerance.

"If the hottest summertime temperatures go up a degree in the Gulf of California or nearly 3 degrees warmer in Monterey Bay, these animals will not be able to survive," he said.

Based on the amount of warming that has already occurred in oceans, many animals have already been killed, scientists say.

Now Stillman is trying to learn if warmer water affects the crabs' organs or their molecular structure. He wants to know why some species of the crab have a greater capacity to adjust than others.

But he's certain about some things. "As the globe warms," he said, "these crabs and other animals won't have time to mutate and evolve."

La Jolla

Much of the world's global warming research is homegrown in California, on the shores of La Jolla at the Scripps Institution of Oceanography, operated by UC San Diego.

The giants in research stand out -- the late Roger Revelle and Charles David Keeling, and John McGowan, who is 80.

McGowan, one of the nation's foremost biologists studying ocean conditions and organisms, began with his doctoral studies at Scripps 50 years ago.

Retired, he divides his time between La Jolla, where he keeps his eye on his colleagues' research, and Bandon, Ore., where he walks the beach and thinks about the decades of research that have changed the way mainstream science views global warming.

First, he said, it was a question: Is there such a thing? Now, it's a reality, with new knowledge revealed as studies pour in from scientists around the world, frequently building on research begun more than a century ago.

One early breakthrough came from Scripps in the 1930s, when Revelle and colleagues found that the ocean absorbed only half of the carbon dioxide released by the burning of fossil fuels and other human activities. Scientists had thought the ocean absorbed 98 percent.

That led to research on atmospheric carbon dioxide, and in the 1950s Keeling confirmed there was more of it in the atmosphere.

But it wasn't until the 1970s that scientists began to be certain that life in the ocean was changing because of atmospheric and ocean warming, said McGowan, who contributed to those studies.

"It took a long time to demonstrate," he said. "The ocean is in equilibrium with the atmosphere. So if the atmosphere was warming, you'd expect the ocean to warm. But it was difficult proving it."

Much of the research was possible because Scripps, in the 1940s, helped establish what is now recognized as some of the world's best marine data kept over time on plankton, salinity, oxygen, nutrients and temperature.

The driving force in collecting that data was a decline in sardines.

In 1949, the state and federal governments, Scripps, Hopkins and the California Academy of Sciences started the California Cooperative Oceanic Fisheries Investigation. Its assignment: to figure out whether overfishing or natural cycles was behind a drop in commercial catches of sardines, anchovies and herring.

Since then, ships have traveled hundreds of miles out to sea from Baja to San Francisco, taking measurements to depths of 1,500 feet.

McGowan started monitoring the ocean in 1952 with other Scripps scientists, using data from the project. Ocean shifts due to climate change began to pop out.

In the 1970s, McGowan and his colleagues proved that the ocean was warming in equilibrium with the atmosphere. They found that as the atmosphere warmed, so did the ocean, after a lag

period. "If you apply heat to a pan of water, it heats up," he said.

In 1982, McGowan, Dudley Chelton and Patricio Bernal confirmed that there was a large-scale response of the ocean system and its sea life to climatic variation. Looking back over the longtime measurements, they saw the increase in temperature and a decrease in plankton.

"The ocean plankton varied with the ocean temperature over many years," McGowan said. "They were highly correlated."

In 1995, McGowan and another Scripps scientist, Dean Roemmich, reported a 70 percent reduction in zooplankton biomass off the coast of California since the 1950s.

By then, the scientists could say that the California Current had been gradually warming: The ups and downs are warmer ups and downs. And the current's warming is part of a global trend - one that is getting worse, McGowan said.

"We now know that many other parts of the ecosystem are involved," he said. "It's not just zooplankton anymore."

Nature out of sync

Sea life depends on the intricate workings of wind and current, driven by temperatures of ocean and air. Animals depend on the natural timing of seasons to find food. In the past 60 years, as ocean temperatures off the California coast warmed by about 3 degrees, the tiny animals at the base of the food chain declined by 70 percent.

The series

Chronicle environment writer Jane Kay and photographer Kat Wade traveled from Alaska to Mexico to see how global warming is changing life along the coast of North America.

Sunday: Polar bears signal changing ice cap in the Arctic.

Today: Subtle seaside transformation in California.

Tuesday: A family sees its way of life threatened in Mexico.

E-mail Jane Kay at jkay@sfnchronicle.com.

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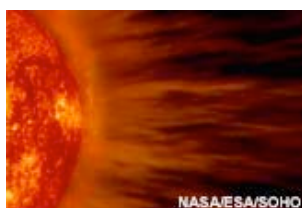


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Conflicting Claims on Global Warming and Why It's All Moot

By **Robert Roy Britt**
 LiveScience Managing Editor
 posted: 01 February 2006
 08:43 am ET

"Nine of the 10 warmest years on record have occurred since 1995."
 —Statement issued Monday by NOAA

A widely reported study last week said 2005 was the warmest on record. But headlines failed to note that the results were not concrete and a new study out this week challenges the findings.

Whatever the outcome, scientists say it is all moot: Last year was surprisingly warm and the record will fall soon enough.

The latest result came Monday from the National Climatic Data Center (NCDC), which is part of the National Oceanic and Atmospheric Administration (NOAA). These are the folks that run the National Weather Service. Their study concludes that the global temperature in 2005 can't be statistically distinguished from the record set in 1998.

Last year was a warm year at Earth's surface, especially considering the lack of a heat-producing El Nino, but for now experts do not agree whether it was a record.

Mixed results

Last week, The Associated Press and others [reported](#) that a NASA scientist said 2005 was the warmest year on record, nosing out 1998.

Lost in many of the headlines, however, was this quote from the report's lead researcher, James Hansen, director of NASA's Goddard Institute for Space Studies: "We couldn't say with 100 percent certainty that it's the warmest year, but I'm reasonably confident that it was."

Hansen looked at different data in different ways compared to the NOAA team. The NASA study considered in particular data from the Arctic, which is [warming faster](#) than the rest of the planet. And for the latter part of 2005 both reports relied on preliminary data, so the analyses could change.

In an email interview yesterday, Hansen reiterated his caveat.

"I believe that 2005 is the warmest year, because the main source of difference is the Arctic, and I believe it is likely that our estimate there is in the right ballpark even though it is based on some extrapolations," Hansen said. "However, I admit that it could be wrong, in which case 2005 might be slightly cooler than 1998."

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Other caveats

In both studies, there are margins of error. Much of the analysis involves satellite data that covers just the past three decades or so. Complicating matters, ground-based temperature-monitoring stations are sparse or nonexistent in many parts of the world, particularly in the Arctic. And a key to the results are satellite data that note sea surface temperatures since 1982. Prior years are gauged by less-precise data from ship logs.

Finally, reliable records for most ground locations go back only about a century, so setting records may not be as surprising as if they broke marks that had been around longer.

So while all leading experts agree the [planet has warmed](#) about 1 degree Fahrenheit in the past century (and NOAA says the rate has tripled since 1976) ranking the warmest years is a huge statistical challenge.

In fact the NOAA analysis yielded two results: One data set, in use since the late 1990s, found that 2005 was slightly cooler than 1998, with 2005 being 1.04 degrees Fahrenheit above the 1880-2004 average, while 1998 was 1.12 degrees above that norm.

The other NOAA data set and analysis technique (which will become the primary method used henceforth) puts 2005 slightly warmer than 1998. It has 2005 at 1.12 degrees above the norm and 1998 at 1.06 degrees above the norm. But the report states that "uncertainties associated with the various factors and methodologies used in data set development make 2005 statistically indistinguishable from 1998."

A third study

Still another study, led by John Christy, director of the Earth System Science Center at the University of Alabama in Huntsville, paints a different picture.

Christy [said in early January](#) that 2005 tied with 2002 for *second* place.

But Christy looked at entirely different data, and the results are not conflicting, he said. Christy examined the entire "bulk" troposphere, from the surface up to about 35,000 feet. In that measurement of the atmosphere, 2005 "clearly was not the warmest," he said in a telephone interview yesterday.

Christy said his approach, which relies on observations from satellites and balloons, is more systematic and global than the estimates provided in the surface-temperature studies. On the other hand, it does not incorporate data more than a few decades back in time.

Interestingly, the troposphere as a whole tends to lag behind rising surface temperatures, Christy said. So measurements over the next few months could show an increase in the troposphere.

The bottom line

Regardless where 2005 ends up, this statement from NOAA puts things in perspective: "Nine of the 10 warmest years on record have occurred since 1995."

And beyond the temperature data, there is plenty of stark evidence for significant warming at the surface. Ground in the Northern Hemisphere that's been frozen since the last Ice Age is [melting and collapsing](#). Animals are [changing](#) migration and mating habits. And glaciers are melting and shrinking at alarming rates.

Meanwhile, climatologists are impressed with nature's showing in 2005, because by conventional thinking it should not have been first *or* second on the all-time list. That's because 1998, the previous hottest year, saw temperatures boosted by a strong El Nino, which was not in place during 2005.

"The bottom line: 2005 was very warm," said Richard Heim, who worked on the NOAA report.

"2005 was not an El Nino year, yet we were toying with tying the 1998 El Nino year," Heim said. "If we had had an El Nino, how warm would it have been?"

NASA's Hansen is already looking ahead to years that he and most other experts [expect to be warmer](#).

"We may get a more definitive assessment from additional data, but it also may be that

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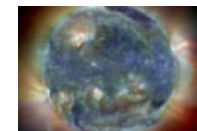
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we will never know for sure," he said. "However, it doesn't matter much. I am confident that we will exceed both of these years within the next few years."

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