Date: 10-25-16

To: U.S. Army Corps of Engineers

Project: Millennium Coal Export Terminal, Longview, WA

Subject: Ocean Acidifications Effect on The PNW shellfish industry.

From: Virginia Nugent

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Vancouver, WA 98686

Our oceans are rapidly becoming more acidic due to absorbing CO2 emissions caused by burning fossil fuels. Increased acidity means that shellfish can't form their shells and die. Between 2005-2009 the Pacific Northwest has experienced a disastrous die off of billions of oyster larvae.

Our states shellfish industry contributes $270 million and employs 3200 people. You must not put our state's shellfish industry at risk for a few dirty coal jobs. But this isn't just about protecting our shellfish industry, it is much bigger than that.

It is about protecting our oceans marine eco system. Science models show that that in just a few decades we will profoundly change the oceans chemistry. Such conditions haven't existed since the age of the dinosaurs. If we continue to pollute our atmosphere with CO2, in 100 years our oceans will be dead, devoid of marine life except for weeds and jelly fish.

It is imperative this project be denied.

I will be submitting the following documents for your consideration:

1. A Seattle Times Article, "Ocean Acidification Threatens Marine Life."
2. A Columbian article, "Rising Acidity Plagues Pacific coast Waters.

Thank you for your time,

Virginia Nugent

Ocean acidification threatens marine life

Sea chemistry changing at record pace due to CO2

By CRAIG WELCH
The Seattle Times

NORMANBY ISLAND, Papua New Guinea — Katharina Fabricius plunged from a dive boat into the Pacific Ocean of tomorrow.

A bleak portrait emerged: Instead of tiered jungles of branching, leafy corals, Fabricius saw mud, stubby spires and squat boulder corals. Snails and clams were mostly gone, as were worms, colorful sea squirts and ornate feather stars.

Instead of a brilliant coral reef like the one living a few hundred yards away, what the Australian Institute of Marine Sciences ecologist found resembled a slimy lake bottom. The cause: carbon dioxide.

OCEAN HEALTH
A three-part Seattle Times series on the effects of ocean acidification
PART ONE

In this volcanic region, pure CO2 escapes naturally through cracks in the ocean floor, altering the water's chemistry the same way rising CO2 from cars and power plants is changing the marine world.

As a result, this isolated bay offers a chilling view of the future of the seas under attack what fish eat.

Those changes pose risks for food supplies, from the fillets used in McDonald's fish sandwiches to the crab legs sold at seafood markets. Both are brought to the world by a Northwest fishing industry that nets half the nation's catch.

Sea-chemistry changes are coming as the oceans also warm, and that's comes at a price.

Reefs are just one way shifting ocean chemistry can harm fish.

In 2007, American biologist Danielle Dixson, then a graduate student at Australia's James Cook University, was studying the important ways clownfish use their noses to navigate the ocean. Then she bumped into James Cook professor Philip Munday.

Munday had been trying to see if carbon dioxide hurt fish. The pair decided, on a whim, to see if CO2 altered how fish use their noses. Their findings were a shock.

Exposed to high CO2, the fish lost their ability to distinguish among odors. Since clownfish use smell to stay safe, the scientists then exposed baby fish in high-CO2 water to bigger fish that eat young clownfish.

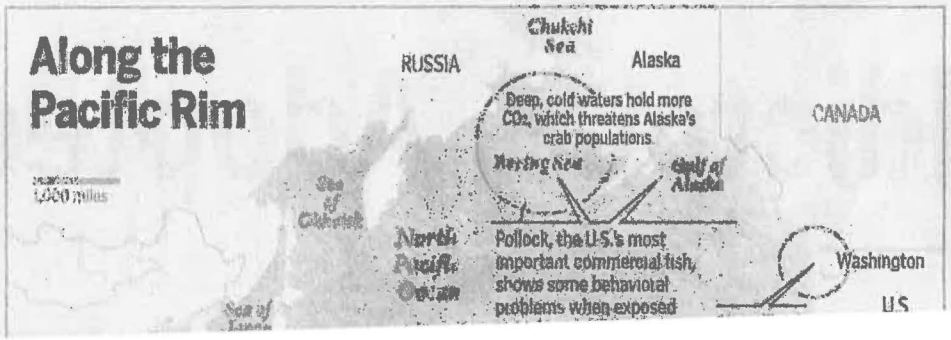
Normal clownfish always avoided the danger. The exposed fish lost all fear. They swam straight at predators.

Over the next few years, scientists learned CO2 changed many reef fishes' senses and behaviors: their sight, hearing, the propensity to turn left or right. Most important, that caused them to die two to five times more often.

Last year, researchers figured out why. Elevated CO2 disrupts brain signal-

Photos by STEVE RINGMAN/Seattle Times

Katharina Fabricius swims through carbon-dioxide bubbles off Papua New Guinea in January. The waters here offer a glimpse of how acidification is likely to transform the seas.



ocean acidification.

As the burning of coal, oil and natural gas belches carbon dioxide into the air, a quarter of it gets absorbed by the seas, changing ocean chemistry faster than at any time in human history.

To understand how that will alter the seas, The Seattle Times crisscrossed the Pacific Ocean from Papua New Guinea to Alaska, interviewed nearly 150 experts and people most likely to be affected, and reviewed most of the peer-reviewed studies.

The Times found that ocean acidification is helping push the seas toward a great unraveling that threatens to scramble marine life on a scale almost too big to fathom — and far faster than first expected.

Already, it has killed billions of oysters along the Washington coast and at nearby hatcheries. It's helped destroy mussels on some Northwest shores. It is a suspect in the softening of clam shells and in the death of some baby scallops. It already is dissolving tiny plankton, called pteropods, in Antarctica that are eaten by many ocean creatures — and that wasn't expected for 25 years.

The problem: When carbon dioxide mixes with water, it takes on a corrosive power that erodes some animals' shells or skeletons. It also robs the water of ingredients animals use to grow shells in the first place.

New science shows ocean acidification also can bedevil fish and the animals that eat them, from sharks to whales and seabirds. Shifting sea chemistry can cripple the reefs where fish live, rewire fish brains and expected to frequently amplify the impacts.

This transformation — once not expected until the end of the century — will be well under way, particularly along the West Coast, before today's preschoolers reach middle age.

"I used to think it was kind of hard to make things in the ocean go extinct," said James Barry, of the Monterey Bay Aquarium Research Institute in California. "But this change we're seeing is happening so fast it's almost instantaneous. I think it might be so important that we see large levels, high rates of extinction."

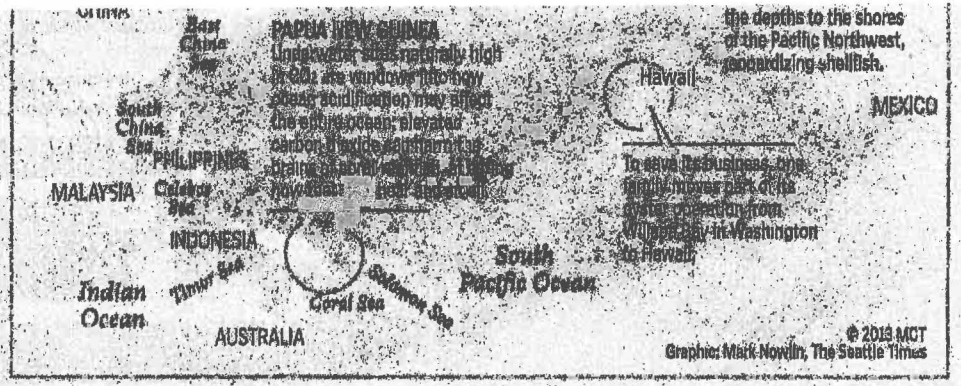
Globally, the world can arrest much of the damage by bringing down CO2 emissions soon. But the longer it takes, the more permanent these changes become.

"There's a train wreck coming, and we are in a position to slow that down and make it not so bad," said Stephen Palumbi, a professor of evolutionary and marine biology at Stanford University. "But if we don't start now, the wreck will be enormous."

The country isn't doing much about it. Combined nationwide spending on acidification research for eight federal agencies, including grants to university scientists by the National Science Foundation, totals about $30 million a year — less than the annual budget for the coastal Washington city of Hoquiam, population 10,000.

The federal government has spent more some years just studying sea lions in Alaska.

Species' reaction to high CO2 can vary dramatically. Acidification can kill baby



abalone and some crabs, deform squid and weaken brittle stars while making it tough for corals to grow. It tends to increase sea grasses, which can be good, and boost the toxicity of red tides, which is not. It makes many creatures less resilient to heavy metal pollution.

Roughly a quarter of organisms studied by researchers in laboratories do better in high CO2. Another quarter seem unaffected. But entire marine systems are built around the remaining half of susceptible plants and animals.

"Yes, there will be winners and losers, but the winners will mostly be the weeds," said Ken Caldeira, a climate expert at Stanford's Carnegie Institution for Science, who helped popularize the term ocean acidification.

Many species, from sea urchins to abalone, do show some capacity to adapt to high CO2. But they may not have time.

"It's almost like an arms race," said Gretchen Hofmann, a marine biologist at the University of California, Santa Barbara.

"We can see that the potential for rapid evolution is there. The question is, will the changes be so rapid and extreme that it will outstrip what they're capable of?"

Already, the oceans have grown 30 percent more acidic since the dawn of the industrial revolution — 15 percent since the 1990s. By the end of this century, scientists predict, seas may be 150 percent more acidic than they were in the 18th century.

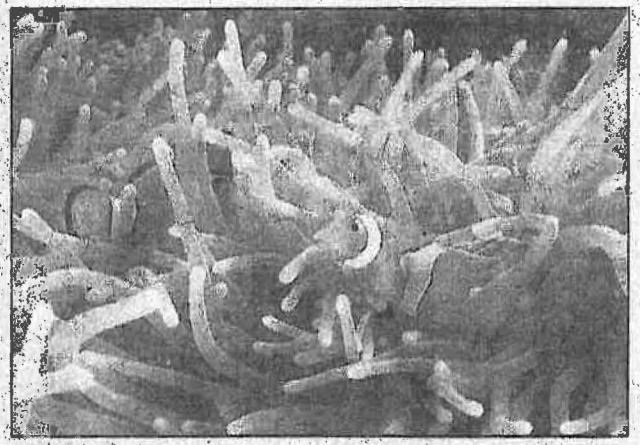
In fact, the current shift has come so quickly that scientists five years ago saw chemical changes off the U.S. West Coast that hadn't been expected for half a century.

Meanwhile, the Arctic and Antarctic are shifting even more rapidly because deep, cold seas absorb more CO2. The West Coast has seen consequences sooner because strong winds draw its CO2-rich water to the surface where vulnerable shellfish live.

Sea chemistry in the Northwest already is so bad during some windy periods that it kills young oysters in Washington's Willapa Bay. In less than 40 years, scientists predict, half the West Coast's surface waters will be that corrosive every day.

These chemical changes threaten to reduce the variety of life in the sea.

Study after study shows the same thing — the more reefs collapse and fleshy algae spreads, the more fish simply disappear. That loss



Clownfish swim through an anemone near Dobu Island, Papua New Guinea. Carbon dioxide can alter how clownfish see, hear and smell, which increases the chance of death.

clownfish story, in other words, was no longer just about clownfish.

So scientists have been testing the most important fish in America: pollock.

Fishermen in Alaska catch roughly 3 billion pounds of pollock a year in the North Pacific. It gets carved into fish sticks, sold overseas as imitation crab or packed in blocks. Seafood companies reel in $1 billion a year from that catch.

After tracking clownfish research, government scientists in Oregon exposed young pollock to high CO2 and introduced the scent of what they eat. The fish struggled to recognize their food.

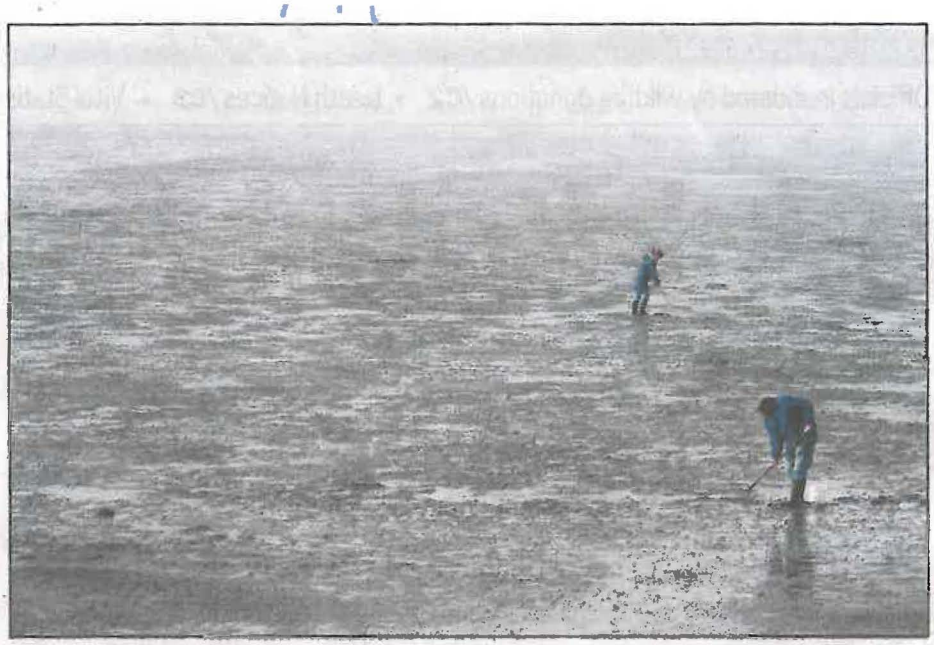
"In some of the very early work, it looks like pollock may show some of the same kinds of deficits that are seen in coral-reef fishes," said NOAA biologist Thomas Hurst.

To understand the future of the marine food web, government computer modelers have been studying how sea-chemistry changes could reverberate through the ocean.

Their initial results, looking at just the U.S. West Coast, are disturbing.

"Right now, for acidification in particular," said Isaac Kaplan, a NOAA researcher in Seattle, "the risks look pretty substantial."

Kaplan's early work projects potentially significant declines in sharks, skates and rays, some types of flounder, rockfish and sole, and Pacific whiting, also known as hake, the most frequently caught commercial fish off the coasts of Washington, Oregon and California.



BRIAN J. CANTWELL/The Seattle Times

People rake for clams on Willapa Bay in June 2012. Up and down the Pacific Coast, rising acidity in the water is causing shellfish larvae numbers to drop. Oyster larvae are even dying in nearby hatcheries, which use seawater to raise baby shellfish.

Rising acidity plagues Pacific Coast waters

Economic impacts to shellfish farms can be devastating

By REID WILSON
The Washington Post

Associated Press files

An oyster cultivator holds oyster seed before spreading it into the waters of Duxbury Bay in Duxbury, Mass., in September.

QUILCENE — For more than a century, Bill Taylor's family has used the calm, protected waters of Puget Sound to raise oysters, planting billions of larvae in underwater beds and then harvesting them to ship to some of the finest restaurants in the world.

But then something went wrong. After the hatchery produced peak levels of 7 billion larvae in 2006 and 2007, the numbers began to drop precipitously. In 2008, it had just half as many larvae. By 2009, it produced less than a third

seafood harvests will impact about 20 percent of Alaska's population, which relies on subsistence fish-

hatchery treats. "People like to use the word 'tipping point.'"

The dramatic changes

7 billion larvae in 2006 and 2007, the numbers began to drop precipitously. In 2008, it had just half as many larvae. By 2009, it produced less than a third of the peak.

Up and down the Pacific Coast, from California to British Columbia to Alaska, other shellfish farms experienced the same decline: Something was happening to their larvae at the formative stage of life when they build their shells. No one in the industry knew why.

"We didn't know that much about the water because we didn't have any problems," Taylor said. Once the larvae started dying off, they tested the water: It was much too acidic.

Scientists testing the water up and down the Pacific Coast found evidence of the same steep decline in pH. Studies have found more acidic water in Alaska is stunting the growth of red king crabs and tanner crabs. Plummeting pH levels across the Eastern Seaboard have been impacting the shellfish industry for decades.

The economic impacts of rising acidity can be devastating. At its peak in 1952, U.S. producers harvested 72 million pounds of eastern oysters, according to data collected by the National Marine Fisheries Service. In 2012, the last year for which data is available, farmers hauled in just 23.8 million pounds. Producers haven't harvested more than 30 million pounds since 1996.

In a new study published online in the scholarly journal Progress in Oceanography, a team of scientists from the National Oceanic and Atmospheric Administration found rural areas in southern Alaska are at high risk of losing hundreds of millions of dollars in commercial and subsistence fishing stocks. Declining seafood harvests will impact about 20 percent of Alaska's population, which relies on subsistence fishing for significant amounts of their diet, the NOAA report found.

The acidification of the world's oceans frightens scientists, who see it as evidence of a rapidly changing climate. Though not as evident as increasingly powerful storms or devastating droughts, ocean acidification may be the clearest example of man's impact on the changing climate.

Increased carbon

Acidification happens as a result of increased carbon in the atmosphere. The top layer of the world's oceans, perhaps the first 100 meters, absorb the elements in the atmosphere. The more carbon, the more acidic the water becomes. Currents take that layer of surface water and plunge it into the depths of the Pacific; decades later, the water is forced back to the surface as it reaches the West Coast, a process scientists call upwelling.

Because it takes so long for water to move from surface to bottom to surface, acidification is a kind of window into the past — and a preview of the future. The upwelling happening on the West Coast today is water that last mixed with the atmosphere in the 1950s or 1960s, when far less carbon was being spewed into the atmosphere. In 50 to 100 years, when water mixing with today's atmosphere upwells, the water will be even more corrosive.

"This bad layer is getting thicker and thicker," Benoit Eudeline, who oversees the nursery for Taylor Shellfish in Quilcene, said of the water in Puget Sound that the hatchery treats. "People like to use the word 'tipping point.'"

The dramatic changes to oyster farms in Washington, Oregon and California are only the beginning steps in what could be a systemic disturbance in the ocean ecosystem, a process that will only accelerate as more acidic water upwells in the coming decades. The last time the oceans changed so dramatically, about 59 million years ago, during a geologic time known as the Paleocene-Eocene Thermal Maximum, the rate of change was ten times slower than is occurring today.

"We're leaving that in our wake when you compare it to the rates we're looking at today," said Mark Green, an oceanographer and shellfish farmer at St. Joseph's College of Maine.

Today, during the height of the summer upwelling season, as much as 30 percent of the water on the West Coast has a pH low enough to be corrosive, said Richard Feely, a senior scientist at the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory and the University of Washington. By 2050, 50 to 70 percent of the water will be corrosive.

On the East Coast, instead of upwelling, acidification is a result of nutrification — adding nutrients such as agricultural waste, fertilizers and waste water. The Chesapeake Bay, which receives runoff from one of the most densely populated watersheds in the United States, is acidifying three times faster than the rest of the world's oceans. Long Island Sound, Narragansett Bay and the Gulf of Mexico are all showing signs of rapid acidification.