Virginia Nugent
5111 NE 125th St
Vancouver, WA 98686

Public Comment

Coal EXPORT TERMINAL Longview, WA.

To: US. Army Corps of Engineers
WA Dept. of Ecology
Cowlitz County Commission

Date: 10- 09-13
To: WA Department of Ecology, Army Corp of Engineers, and Cowlitz county Commission
Public Comment on: The Proposed Coal Export Terminal in Longview WA.
From:
Virginia Nugent
5111 NE 125th St.
Vancouver WA 98686

I am a mother of two and grandmother of six. As a senior citizen I won't live long enough to see the tragic effects of Climate Change, Ocean Acidification, the death of our coral reefs, the extinction of nature's most beautiful animals, and even the human species. However, I need to speak out for future generations and beg you to do whatever you can to prevent coal export from the PNW.
I am submitting the following information for your thoughtful consideration:

1.) A copy of my 10-09-2013 public testimony.
2.) Governor Christine O. Gregoire's Executive Order #12-07, **Washington's Response to Ocean Acidification**. An order to, "advocate for reductions in emissions of carbon dioxide at a **global**, national, and regional level".
3.) An article titled, "Ocean Acidification Threatens Marine Life"
4.) A fact sheet from the video, "Acid Test: The Global challenge of Ocean Acidification." Produced by the Natural Resources Defense Council.
5.) Fast Facts: "Coral Reefs are being lost twice as fast as Rainforests."
6.) Comments from, "The State of The Ocean Report 2013", by the International Panel of Marine Scientists.

Date: 10-09-13
Public Comment On: Proposed Longview Export Terminal
To: U. S. Army Corps of Engineers, WA Department of Ecology, and Cowlitz County Commission
From:
Virginia Nugent
5111 NE 125th St.
Vancouver, WA 98686

As a mother and grandmother I'm deeply concerned about the harm we are doing to our oceans. I have always been awestruck by the vastness of the ocean and the beauty of the life it contains. I thought this treasure on earth, would last forever. Sadly, I was wrong.
Three hundred million years ago, the ocean became too acidic and sea life worldwide was wiped out. This became known as the Great Mass Extinction. And it could happen again.
Burning coal, releases CO2, which is absorbed by our oceans causing them to become more acidic. Ocean acidity is increasing at the fastest rate in at least 300 million years. In 100 years our oceans could be dead. How can we possibly explain to future generations that we selfishly destroyed a marine ecosystem that took 30 million years to evolve?
In 2005, oyster larvae started dying by the billions along the Pacific Northwest Coast. Increased ocean acidity prevents shellfish from forming their shells. They literally melt. Which is more important, our state's $270,000,000, that provides 3,200 jobs, or Milleniums promise of 100 dirty coal jobs for Longview?
I urge you to study the impact that exporting coal to Asia will have on our state's struggling shellfish industry, ocean acidification, and impact that climate change will have on the survival of the human race.

Thank you,

Virginia Nugent

Virginia Nugent
5111 NE 125th St
Vancouver, WA 98686

CHRISTINE O. GREGOIRE
Governor

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR
P.O. Box 40002 · Olympia, Washington 98504-0002 · (360) 753-6780 · www.governor.wa.gov

EXECUTIVE ORDER 12-07

WASHINGTON'S RESPONSE TO OCEAN ACIDIFICATION

WHEREAS, acidification of the world's oceans, measured by the lowering pH numbers and caused primarily by increasing levels of carbon dioxide in the atmosphere, has arrived on the West Coast sooner than predicted and is already reaching levels that are corrosive for shellfish and other marine organisms; and

WHEREAS, Washington's marine waters are particularly vulnerable to ocean acidification because they experience the effects of global carbon dioxide absorbed by the oceans in addition to regional and local factors. One of the most important regional factors is coastal upwelling, which occurs when strong northerly winds blow across the Pacific Ocean, bringing deeper water up to the surface, along the Washington coast, into coastal estuaries like Willapa Bay and Grays Harbor, and the Puget Sound basin. Today's upwelled water is rich in carbon dioxide and low in pH and oxygen, and was in contact with the atmospheric concentration of carbon dioxide from 30 to 50 years ago, meaning we will continue to see acidification for several decades after global carbon dioxide emissions begin to fall; and

WHEREAS, acidification near the coasts, and particularly in highly populated and developed areas, is often exacerbated by local sources of pollutants, such as nutrients and organic material, that generate additional carbon dioxide in marine waters; and

WHEREAS, between 2005 and 2009, the Pacific Northwest oyster hatcheries experienced disastrous production failures when billions of their youngest oysters, the larvae, died due to acidified seawater that dissolved shells or prevented their formation; and

WHEREAS, Washington is the country's top provider of farmed oysters, clams, and mussels. Our shellfish growers employ directly and indirectly more than 3,200 people around the state and provide an annual total economic contribution of $270 million statewide. The increasing levels of acidification in Washington's marine waters pose serious and immediate threats to our shellfish resources, and the revenue and jobs supported by the shellfish industry; and

WHEREAS, ocean acidification has important implications to Washington's tribal communities and fishermen who increasingly depend on shellfish species to support their families; and

WHEREAS, increasing levels of acidity also have implications for the broader marine ecosystem because many organisms that are important food sources for species such as salmon, whales, and seabirds, are dependent on their ability to form and maintain shells, skeletons, or other hard parts; and

WHEREAS, Washington is a national leader in addressing the problem of ocean acidification. World-class scientists are already working on ocean acidification; state agencies, businesses, tribes, and others are implementing innovative approaches to reduce carbon dioxide and nutrient runoff; federal partners are engaged on solutions to ocean acidification; the shellfish industry is committed to protecting ecosystems and cultivated resources; and diverse nonprofit organizations are ready to give voice to the problem; and

WHEREAS, to chart a course for addressing the effects of ocean acidification on Washington's shellfish resources and other marine organisms, I convened the Washington State Ocean Acidification Blue Ribbon Panel comprised of scientific experts, industry representatives, public opinion leaders, and state, local, federal, and tribal policy makers; and

WHEREAS, the Panel produced a *Scientific Summary of Ocean Acidification in Washington State Marine Waters* and a set of recommended actions in a document titled *Ocean Acidification: From Knowledge to Action – Washington's Strategic Response to Changing Ocean Chemistry*, documenting the understanding of ocean acidification in Washington, and recommending actions to reduce contributions to the problem, help the shellfish industry adapt to changes, advance our knowledge about acidification in Washington's marine waters, and educate and engage stakeholders, the public and decision makers in addressing the problem; and

WHEREAS, it is critical to our economic and environmental future that effective and immediate actions be implemented in a well-coordinated way and that we work collaboratively with federal, tribal, state, and local governments, universities, the shellfish industry, businesses, the agricultural sector, and the conservation/environmental community to address this emerging threat.

NOW, THEREFORE, I, Christine O. Gregoire, Governor of the state of Washington by virtue of the power invested in me by the Constitution and statutes of the state of Washington do, effective immediately, hereby order and direct:

1. The Office of the Governor and the cabinet agencies that report to the Governor to advocate for reductions in emissions of carbon dioxide at a global, national, and regional level. The Office of the Governor and cabinet agencies shall work on this effort with federal and regional partners (including at a minimum Oregon, California, and the Province of British Columbia) and shall consult with affected public and private entities.

2. The Director of the Department of Ecology to:

    a) Coordinate effective implementation of the Blue Ribbon Panel's recommendations. In doing so, the Department shall work with other state agencies, the Commissioner of Public Lands, the University of Washington, the National Oceanic and Atmospheric Agency (NOAA), the Environmental Protection Agency (EPA), Tribes, non-governmental organizations, and the shellfish industry. This effort will require coordination of numerous activities at the national and regional level aimed at protecting and restoring the health of our marine waters.

b) Work with the University of Washington (UW), the Commissioner of Public Lands, NOAA and other state agencies to establish a coordinating mechanism to: continue the focused and productive interaction between scientists and decision makers to enhance Washington's ability to respond to the problem of acidification; promote sharing of scientific information; and secure efficiencies in implementing the Panel's recommendations. In doing so the Department shall build on existing efforts such as the Puget Sound Strategic Science Plan, the UW coastal and marine research programs, NOAA Ocean Acidification Program, California Current Acidification Network, Pacific Shellfish Institute, and other related efforts.

c) Craft and execute a memorandum of understanding or other mechanisms among key state and federal agencies, including Departments of Natural Resources and Fish and Wildlife, NOAA, EPA, and U.S. Department of Interior, to support data sharing, collaboration, and leveraging and prioritizing of funds.

d) Work with the University of Washington to deliver the technical analysis recommended by the panel on the relative importance to ocean acidification of local land-based sources of nutrients and organic carbon and local air emissions.

e) Reduce nutrients and organic carbon in locations where these pollutants alone, or in combination with other pollutants, are causing or contributing to multiple water quality problems in our marine waters. This effort shall be coordinated with the Directors of the Department of Agriculture and Department of Health, and the Executive Director of the Conservation Commission. In implementing this directive, Ecology with its partners shall prioritize watersheds with the most significant water quality problems, regardless of the source(s) – urban storm water, septic tanks, large and small sewage treatment facilities, or rural runoff from agricultural lands. This effort shall be carried out in consultation with other agencies, affected local and tribal governments, federal agencies, landowners, and the environmental community. These efforts shall:

   i. build on existing programs;
   ii. utilize, where appropriate, the voluntary stewardship program established by RCW 36.70A.710; and
   iii. utilize other approaches, including technical assistance, funding, permitting and enforcement, where most appropriate and effective.

f) Formally request that EPA begin the assessment of water quality criteria relevant to ocean acidification and encourage EPA to work with scientists from NOAA, Ecology, and other agencies in carrying out this effort.

g) In consultation with the Department of Commerce and Department of Transportation, review unimplemented actions recommended by the Climate Action Team and identified in the State Energy Strategy and, where appropriate, propose a path forward to implement additional actions to reduce atmospheric

carbon dioxide. In developing the proposed actions, the Department of Ecology shall consult with affected stakeholders.

h) Work with other agencies, NOAA, universities, the Puget Sound Partnership, WA Sea Grant, shellfish growers, Tribes, non-governmental organizations, and various education and outreach networks to increase understanding of ocean acidification and its consequences among policymakers, interested organizations, and the public.

i) Work with other state agencies, the Commissioner of Public Lands, and appropriate federal agencies to engage agricultural, business, and other stakeholders; coastal communities; shellfish and fishery interests; and other affected or interested groups, in developing and implementing local solutions.

3. The Executive Director of the Puget Sound Partnership to work with its partners to advance the implementation of the Panel's recommendations by incorporating the scientific findings, and strategies and actions into the Puget Sound Action Agenda, the Biennial Science Work Plan, and ecosystem monitoring programs, by December 1, 2014.

4. In implementing this Executive Order, the state and its agencies shall invite consultation, on a government-to-government basis, with affected and interested Indian Tribes and Nations in Washington State.

5. The Director of the Department of Ecology, in cooperation with affected agencies, shall provide a progress report to the Governor by December 31, 2013.

Signed and sealed with the official seal of the state of Washington on this 27th day of November, 2012, at Olympia, Washington.

By:

/s/
Christine O. Gregoire
Governor

BY THE GOVERNOR:

/s/
Secretary of State

Virginia Nugent
5111 NE 125th St
Vancouver, WA 98686

Acid Test

The Global Challenge Of Ocean Acidification

Produced by Natural Resources Defense Council

"One hundred years ago our ocean was inexhaustible. You couldn't touch it. You couldn't harm it. Now, in 100 years it might be dead"

- **Our oceans are rapidly becoming more acidic due to CO2 emissions caused by burning fossil fuels.**
- **"Since the Industrial Revolution, the oceans acidity has increased by 30%. If we continue to emit CO2 at these rates, we will double the oceans acidity by the end of the century."**
- **"Science models show that in just a few decades we will profoundly change the ocean's chemistry. Such conditions haven't existed since the age of the dinosaurs. This is happening so quickly that many ocean species will be unable to adapt and become extinct."**
- **The bottom of the food chain, plankton and other species are having difficulty making their shells due to the increase in ocean acidity. Their shells are becoming thinner and dissolving away.**
- **"If the food chain is disrupted at the smallest level it will have a ripple effect and hurt the largest creatures in our ocean".**
- **"Once the food chain is broken, the ability for all species to survive is threatened. Our oceans could be dead, "a Sea of weeds" in 100 years."**
- **Warmer ocean temperatures and increasing acidity threaten coral reefs. Coral reefs are home to millions of species. We have ten years to reduce emissions or our coral reefs will be gone in 20-30 years.**
- **We caused this problem and we need to solve it. The solution is to reduce our CO2 emissions. We need to stop burning fossil fuels, and make a transition to green energy.**

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Fast Facts

Coral Reefs are being lost twice as fast as Rainforests

- One third of all **carbon dioxide emitted by humanity** has been **absorbed by the world's oceans.** This is making them more acidic than they have been for tens of millions of years.
- One of the greatest impacts that Ocean Acidification is having is on **reef building corals,** which are known as a 'framework species'. Without corals, reefs cannot exist. Ocean Acidification is already **slowing their growth rates.** Left unchecked they will soon stop growing and erode away.
- Direct effects on some important species of plankton and the sensitive larval stages of many marine organisms are now being reported in **globally respected scientific literature.**
- Ocean plankton **provide 50% of the oxygen that we breathe.** Due to Global Warming, that capacity to provide oxygen and support the fundamental food chains of the ocean has **decreased by 6%** over the last three decades.
- As oceans have warmed, oceanic nutrient deserts have **expanded by 6.6 million square km's** over the past two decades.
- There are approximately 10,000 Coral Reefs and **we are destroying one every other day.**
- Coral Reefs are being lost **more than twice as fast as the rainforests.** Current estimates reveal that we will lose the other 50% over the next 40 years.
- The Great Barrier Reef generates **over 6.5 billion dollars in tourism** revenue and 63,000 jobs.
- Left unchecked Ocean Acidification **could trigger a Great Mass Extinction Event.** Growing evidence suggests that four of the five Great Mass Extinctions have been associated with rapidly acidifying oceans – due to spikes in the concentration of atmospheric CO_2.

Oxygen levels are dropping and ocean waters are acidifying at the fastest rat e in at least 300 million years when the greatest marine extinction in earth's history took place according to **The State of the Ocean Report 2013** written by an international panel of marine scientists.

Today's explosive increase in human CO2 emissions and warming of the oceans are recreating the conditions of the great Permian extinction 300 million years ago when massive volcanic eruptions in Siberia triggered the release of enormous amounts of stored carbon. A leading theory is that **deoxygenation and acidification of t he oceans led to the bacterial production of toxic hydrogen sulfide gas which poisoned species dependent on oxygen.** By the end of this natural catastrophe 90% to 95% of all marine species were extinct. The biodiversity of the oceans took 30 million years for to recover.

The next mass extinction event may have already begun.

> the scale and rate of the present day carbon perturbation, and resulting ocean acidification, is unprecedented in Earth's known history. Today's rate of carbon release, at approximate ly 30Gt of CO2 per year, is at least 10 times faster than that which preceded the last major species extinction (the Paleocene Eocene Thermal Maximum extinction, or PETM, ca. 55 million years ago), while geological records indicate that the current acidification is unparalleled in at least the last 300 million years. We are entering an unknown territory of marine ecosystem change, and exposing organisms to intolerable evolutionary pressure. The next mass extinction event may have already begun.

A "deadly trio" of acidification, warming and deoxygenation

Human CO2 emissions directly cause both global warming and ocean acidification. But that's just the beginning. Mixing tends to decline in warming waters because a warm fresh surface layer is substantially lighter than colder middle and deep water. **The surface layer tends to float and not mix.** Organic carbon is always falling from the surface to deeper waters. Bacteria oxidize the fallen carbon to CO2. This process reduces oxygen levels and increases the acidity of the water. When the rate of mixing declines the residence time of water in a layer increases, so acidity levels tend to rise and oxygen levels drop in layers below the surface as the climate warms.

Hypoxic - low oxygen - water may be already killing keystone species in the Pacific northwest.

> COOS BAY — Something is killing large numbers of a keystone species off the Oregon Coast. Federal researchers say it could spell danger for the region's other marine life.
>
> Bill Peterson, an oceanographer with the National Oceanic and Atmospheric Administration's Hatfield Marine Science Center in Newport, said in the past few weeks millions of dead North Pacific krill have washed up on beaches between Newport and Eureka, Calif.
>
> Peterson said it's the largest die-off he's aware of in recent history. ...
>
> Joe Tyburczy, a researcher with the California Sea Grant extension office who has been looking into the dead krill with Peterson, said oceanographic cruises along the northern California coast did find lower oxygen levels than usually seen in Pacific Northwest waters.

"If it is hypoxia, there's a possibility of implicatio ns for other species like crab," he said.

Acidification of sea water in Washington State oyster hatcheries killed the developing oysters. **Please watch this outstanding video on ocean acidification.**

Oysters started dying by the billions along the Northwest coast in 2005, and have been strug gling ever since. When scientists cautiously linked the deaths to plummeting ocean pH in 2008 and 2009, few outside the West Coast's $110 million industry believed it.

By the time scientists confirmed it early last year, the region's several hundred oyster growers had become a global harbinger — the first tangible sign anywhere in the world that ocean acidification already was walloping marine life and hurting people.

Richard Feely and a team of scientists from Pacific Marine Environmental Lab were stunned to discover cold, acidic, low-oxygen water welling up to the surface along the northern California coast in 2007. Scientists had not expected acidification to hit the west coast for 50 to 100 years. Dr. Feely published his work and word of it reached oyster farmers who's hatcheries were failing.

The oyster farmers invited Feely to their annual conference.

Feely explained that when north winds blew, deep ocean water was drawn right to the beach, which meant this newly corrosive water probably got sucked into the hatchery. That same water also flowed into the Strait of Juan de Fuca and made its way to Hood Canal.

The oyster industry pleaded with Congress, which supplied money for new equipment. Over several years, the hatcheries tested their water using high-tech pH sensors. When the pH was low, it was very low and baby oysters died within two days. By drawing water only when the pH was normal, shellfish production got back on track.

"They told us it was like turning on headlights on a car — it was so clear what was going on," Feely said.

Moreover, because processes in the ocean are slow to change this deadly water would continue to affect the Pacific northwest for another 50 years if all human CO2 emissions stopped today. It will take 30 to 50 years for the most acidic water already present along the west coast to well up. This is the beginning of a disaster that we cannot stop. The best we can do is to keep it from growing far larger and far more deadly. The changes happening in the waters of the Pacific northwest are the first stages of a global marine catastrophe if CO2 emissions are not rapidly reduced.

Deadly t rio will have cascading consequences for marine biology & humans

It is the simultaneous occurrence of the "deadly trio" of acidification, warming and deoxygenation that is seriously effecting how productive and efficient the ocean is, as temperatures, chemistry, surface stratification, nutrient and oxygen supply are all implicated, meaning that many organisms will find themselves in unsuitable environments.

These impacts will have cascading consequences for marine biology, including altered food web dynamics and the expansion of pathogens. To make matters even worse, this is all happening to marine ecosystems already undermined by other human pressures such as overfishing, eutrophication and pollution.

The adaption of species to these altered conditions is in some cases possible – as is migration, though as warming demands a poleward migration while acidification encourages the movement to warmer more equatorial waters the "green pastures" will become increasingly scarce and competition for them fierce. Mass extinctions happen in the geological equivalent of overnight; we may already have entered into an extinction period and not yet realized it. What is certain is that current carbon perturbations will have huge implications

for humans, and may well be the most important challenge faced since the first hominids evolved.

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Dianne
" When the most powerful country ever to inhabit the earth finds it so easy to plunge into the horror of warfare but almost impossible to find adequate work for its people or to properly educate its young, it has lost its way entirely." Bob Herbert NYT

"As nightfall does not come all at once, neither does oppression. In both instances, there is a twilight when everything remains seemingly unchanged. And it is in such twilight that we all must be most aware of change in the air – however slight – lest we become unwitting victims of the darkness." – Supreme Court Justice William O. Douglas

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.

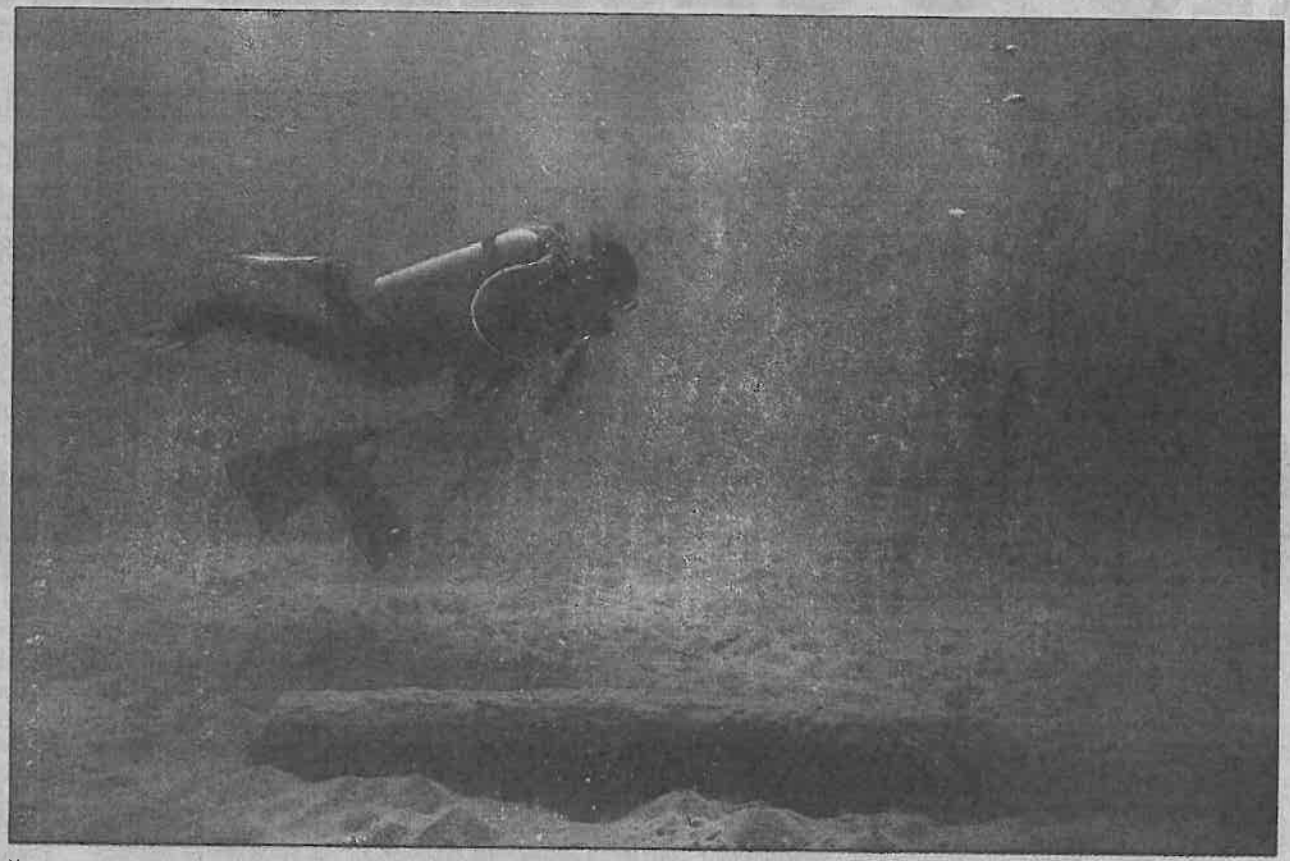
A bleak portrait emerged: Instead of tiered jungles of branching, leafy corals, Fabricius saw mud, stubby spires and squat boulder corals. Snails and clams were mostly gone, as were worms, colorful sea squirts and ornate feather stars.

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

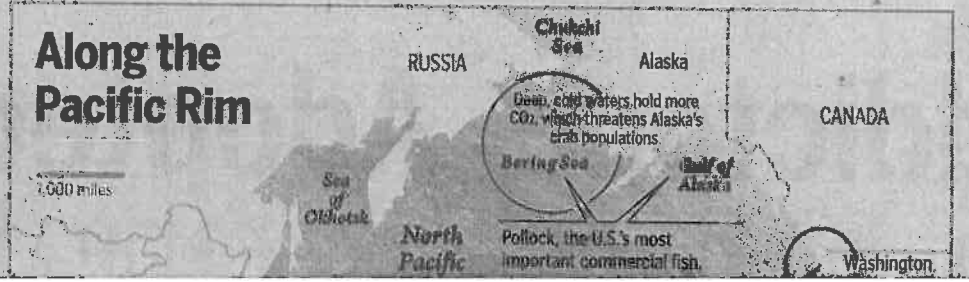


Photos by STEVE RINGMAN/Seattle Times

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.

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.



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

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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

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.

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.

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Last year, researchers figured out why. Elevated CO2 disrupts brain signaling in a manner common

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 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 of the marine food web, 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."

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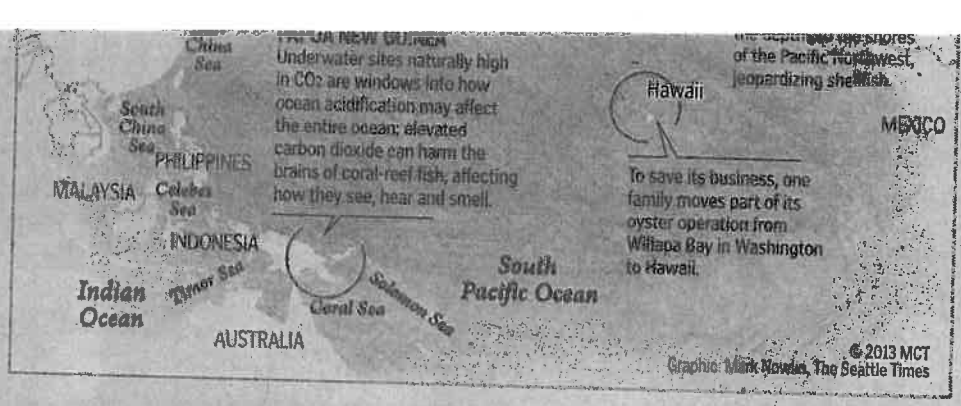
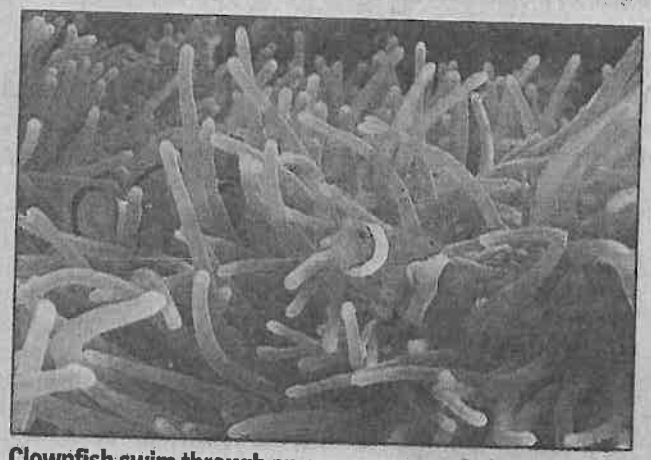




Clownfish swim through an anemone near Dobu Island, Papua New Guinea. Carbon dioxide can alter how clownfish see, hear and smell, which increases the chance of death.

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

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

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.

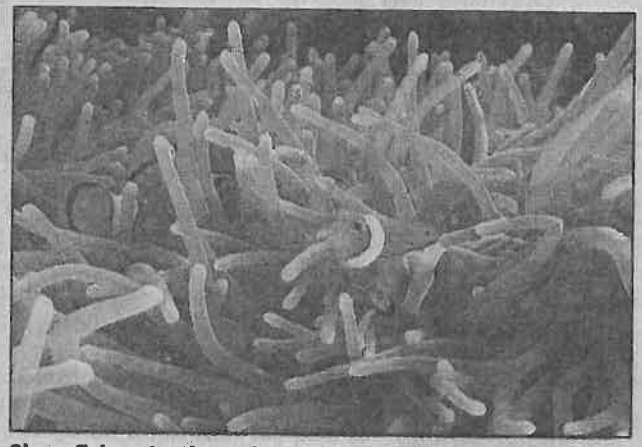
"Yes, there will be winners and losers, but the winners will mostly be the

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



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.

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

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.

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