

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#)  
**Subject:** a solution??  
**Date:** Thursday, October 01, 2015 5:02:06 PM

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And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

do we need the rest? ... by enhancing the uptake of carbon dioxide from the atmosphere.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [APPEL, Rebecca](#)  
Subject: acidification -- 3 edits (sorry)  
Date: Monday, October 05, 2015 3:36:08 PM  
Attachments: [Barton 5-18-15 \(3\) \(2\).pdf](#)

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Rebecca, sorry, just received this info... par 2 cites are on pg 137 of attached  
thank you and, unless there are questions, no more edits from our end -- *I promise*  
now have sign-offs from about 5,000 US and UK scientists -- a unusual feat!

### **par 2**

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals, and other marine organisms to grow, reproduce, and build their shells and skeletons. About 10 years ago, ocean acidification nearly collapsed the U.S. Pacific Northwest oyster industry, a prime contributor to the **annual \$117 million West Coast shellfish industry**, which supports **more than** 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed. Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

### **par 7**

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past **THREE** years, accelerating the ocean acidification process.



# Impacts of Coastal Acidification on the **Pacific Northwest Shellfish Industry**

## and Adaptation Strategies Implemented in Response

By Alan Barton, George Waldbusser, Richard Feely,  
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Teri King, Andy Suhrbier, and Karen McLaughlin

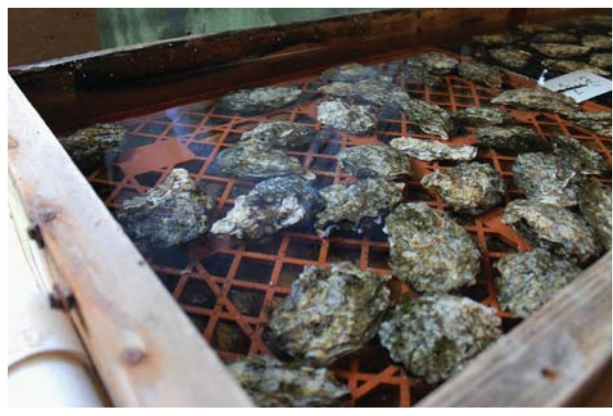


Photo credit:  
Sandra Barton Vickers

**ABSTRACT.** In 2007, the US west coast shellfish industry began to feel the effects of unprecedented levels of larval mortality in commercial hatcheries producing the Pacific oyster *Crassostrea gigas*. Subsequently, researchers at Whiskey Creek Shellfish Hatchery, working with academic and government scientists, showed a high correlation between aragonite saturation state ( $\Omega_{\text{arag}}$ ) of inflowing seawater and survival of larval groups, clearly linking increased  $\text{CO}_2$  to hatchery failures. This work led the Pacific Coast Shellfish Growers Association (PCSGA) to instrument shellfish hatcheries and coastal waters, establishing a monitoring network in collaboration with university researchers and the US Integrated Ocean Observing System. Analytical developments, such as the ability to monitor  $\Omega_{\text{arag}}$  in real time, have greatly improved the industry's understanding of carbonate chemistry and its variability and informed the development of commercial-scale water treatment systems. These treatment systems have generally proven effective, resulting in billions of additional oyster larvae supplied to Pacific Northwest oyster growers. However, significant challenges remain, and a multifaceted approach, including selective breeding of oyster stocks, expansion of hatchery capacity, continued monitoring of coastal water chemistry, and improved understanding of biological responses will all be essential to the survival of the US west coast shellfish industry.

## INTRODUCTION

The coastal ocean along the west coast of the United States supports some of the most productive fisheries in the world, including the 120-year-old Pacific Northwest shellfish industry. Seasonal coastal upwelling, which annually supplies nutrient-rich water to the inner continental shelf from late spring to early fall, drives this productivity. However, the same upwelling that fuels the industry also threatens it. Decomposition of organic matter at depth naturally raises  $\text{CO}_2$  in upwelled seawater, and increasing atmospheric  $\text{CO}_2$  concentrations have raised the baseline, leading to increased intensity, magnitude, and duration of acidified water over the continental shelf (Feely et al., 2008; Hauri et al., 2009, 2013; Gruber et al., 2012).

When gaseous  $\text{CO}_2$  dissolves in seawater, it reacts with the water to form a weak acid ( $\text{H}_2\text{CO}_3$ ), which dissociates to release a hydrogen ion ( $\text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$ ) or reacts directly to consume carbonate ions ( $\text{H}_2\text{CO}_3 + \text{CO}_3^{2-} \rightleftharpoons 2\text{HCO}_3^-$ ). This acidification process decreases the saturation state of aragonite ( $\Omega_{\text{arag}}$ ) and calcite ( $\Omega_{\text{cal}}$ ), the two mineral forms of calcium carbonate that most bivalves use to form their shells. A variety of shell-forming organisms have been shown to be highly sensitive to the effects of ocean

acidification (OA), such as reduced saturation state (Fabry et al., 2008; Hofmann et al., 2010; Hettinger et al., 2012; Bednaršek et al., 2012, 2014; Gazeau et al., 2013; Kroeker et al., 2010, 2013; Gaylord et al., 2014), including many commercially important shellfish species (Kurihara et al., 2007; Green et al., 2009; Miller et al., 2009; Talmage and Gobler, 2011; Barton et al., 2012; Hettinger et al., 2012; Waldbusser et al., 2013, 2015). Organisms that deposit calcareous shells or skeletons may respond to decreasing  $\Omega_{\text{arag}}$  at values as high as 2, and are expected to encounter increasing physiological challenges as carbonate saturation decreases in the ocean (Fabry et al., 2008; Barton et al., 2012; Bednaršek et al., 2012, 2014; Waldbusser et al., 2015). Except for a few studies at underwater seeps that vent  $\text{CO}_2$ , this research has almost exclusively been carried out in laboratories, where saturation states were reduced with  $\text{CO}_2$  and held constant to match the expected changes in surface ocean chemistry several decades in the future.

Recent research shows a clear link between natural variability in seawater  $\Omega_{\text{arag}}$  along the Oregon coast and commercial production of Pacific oyster larvae in a hatchery setting, where food and water temperatures are maintained at optimal levels, but the chemistry of

incoming seawater varies (Barton et al., 2012). Subsequent work, in part the result of monitoring larval oysters in shellfish hatcheries, documents a mechanism for direct  $\Omega_{\text{arag}}$  sensitivity in early shell formation of bivalve larvae (Waldbusser et al., 2013; 2015), responses previously thought to be related solely to changes in the organisms' acid-base chemistry (Pörtner, 2008). These findings have immediate implications for the Pacific Northwest shellfish industry, which has experienced a significant decline in seed production since 2007.

In nearshore California Current surface waters off the coast of Oregon, the increase in atmospheric  $\text{CO}_2$  has shifted the median  $\Omega_{\text{arag}}$  from approximately 2.5 to 2.0 (Feely et al., 2008; Harris et al., 2013), and values of  $\Omega_{\text{arag}}$  less than 2.0 are already common throughout the spring and summer across major sections of US Pacific coastal waters and Puget Sound (Feely et al., 2008, 2010, 2012b; Hauri et al., 2009). OA has contributed significantly to shoaling of Pacific Northwest aragonite and calcite saturation horizons (Feely et al., 2012b), and recent observations along the Oregon/Washington coast have recorded  $\Omega_{\text{arag}} < 1.0$  in upwelled water at the surface, a condition not expected in the open ocean for decades (Feely et al., 2008). Modeling of the California Current System predicts that this trend will continue and accelerate relative to the open oligotrophic ocean, with undersaturated conditions in surface waters predicted to be the norm more than 50% of the time during summer by 2050 (Gruber et al., 2012; Hauri et al., 2011, 2013).

These changes in Pacific Northwest ocean conditions have already resulted in major oyster seed production declines (Barton et al., 2012; Washington State Blue Ribbon Panel on Ocean Acidification, 2012), and the shellfish industry has adopted a comprehensive strategy to understand, and mitigate, further impacts on commercial production (Washington State Blue Ribbon Panel on Ocean Acidification, 2012). Using

funding from state, federal, and industry groups, shellfish hatcheries have forged partnerships with university researchers, and are now some of the best instrumented monitoring stations for collecting carbonate chemistry measurements in the coastal zone. Industry uses these monitoring data as a real-time management tool to optimize water treatment systems and improve commercial production of oyster larvae. Additionally, hatcheries provide a perfect environment for monitoring biological responses, given that typical hatchery protocols require routine tracking and measurement of larval cohorts. The industry has capitalized on this by forging relationships with physiologists and geneticists to determine the mechanisms behind larval mortality events and develop long-term strategies to adapt to further declines in water quality predicted for the coming decades.

More importantly, the shellfish farming industry has become a catalyst for change. The partnerships industry members have developed with the scientific community helped shift the focus of OA research from oceanic to coastal environments, where there are many additional drivers and more complex natural temporal patterns (Hinga, 1992; Frankignoulle et al., 1998; Ringwood and Keppler, 2002; Wootton et al., 2008; Juranek et al., 2009; Hofmann et al., 2010; Alin et al., 2012; Harris et al., 2013; Feely et al., 2012a; Waldbusser and Salisbury, 2014). In addition, the shellfish industry's challenges helped refocus OA management away from solely pursuing global carbon reduction, and encouraged managers to pursue actions that can be taken locally to mitigate OA effects on coastal waters throughout the Pacific Northwest (Kelly et al., 2011; Washington State Blue Ribbon Panel on Ocean Acidification, 2012). In 2013, Washington became the first state to develop a comprehensive management strategy to protect its resources from OA effects, largely in response to concerns raised by the shellfish industry. This paper describes the factors that drew the shellfish industry into this issue; how the

partnerships established among industry, academia, federal and state scientists, and the local management community flourished in ways that benefited all sectors; and the industry's strategy to adapt as OA continues to advance globally.

## PACIFIC NORTHWEST SHELLFISH INDUSTRY

Shellfish have been harvested in the Pacific Northwest for thousands of years, and commercial oyster farming has been an important cultural and economic part of coastal communities in the Northwest since the late 1800s. Today, shellfish farming supports over \$270 million in economic activity and over 3,000 family wage jobs in rural areas throughout the region. Although shellfish farms can be found throughout Oregon, Washington, Alaska, California, and Hawaii, most of the oysters harvested in the Pacific Northwest are produced in Washington. Large farms in Willapa Bay and southern Puget Sound make up the majority of the industry, and have existed in these areas for several generations (<http://pcsga.org/shellfish-initiative>).

Shellfish species farmed in the Pacific Northwest include Manila clams (*Venerupis philippinarum*), geoduck clams (*Panopea generosa*), mussels (*Mytilus trossulus* and *M. galloprovincialis*), and several species of oysters. Although Kumamoto oysters (*Crassostrea sikamea*), eastern oysters (*Crassostrea virginica*), and the native Olympia oyster (*Ostrea conchaphila*) represent important niche markets, the Pacific oyster (*Crassostrea gigas*) is the predominant species farmed in the region, comprising > 80% of the industry's total annual shellfish production by live weight (Table 1).

Pacific oysters from Japan were first brought to the United States in the early twentieth century, and naturalized populations became established in portions of Puget Sound and in Willapa Bay. Natural recruitment of seed oysters from these spawning populations helped support the industry for several decades, supplementing the supply of imported seed from

Japan. In the 1970s, the cost of importing seed became prohibitively expensive, and it became clear that growers could not rely solely on inconsistent natural spawning events (Dumbauld et al., 2011) to support their burgeoning industry (Gordon and Blanton, 2001).

By the late 1970s, successful commercial hatcheries were established in the Pacific Northwest and began supplying billions of "eyed" (setting size) larvae to growers each year. The three major commercial hatcheries that currently supply larvae to the West Coast shellfish industry are Whiskey Creek Shellfish Hatchery (Netarts Bay, OR), Taylor Shellfish Hatchery (Dabob Bay, WA), and Coast Seafoods Hatchery (Quilcene Bay, WA). These hatcheries combine with smaller hatcheries in Washington and Hawaii to produce 40–60 billion eyed larvae each year, and their 30 years of consistent production has helped build today's \$270 million per year shellfish industry (<http://pcsga.org/shellfish-initiative>).

## Hatchery Failures

High levels of larval mortality at the Whiskey Creek Shellfish Hatchery began in July 2007 and persisted to the end of the growing season in October. Some month-to-month variability in hatchery production is normal, but the magnitude and duration of the 2007 mortality events were unprecedented in the hatchery's 30-year history. Hatchery managers initially attributed the mortality to a large bloom of *Vibrio tubiashii* in Netarts Bay, a bacterium pathogenic to oyster larvae (Elston et al., 2008). However, larval mortality persisted even after successful elimination of the pathogen, forcing managers to search for another explanation for the die-offs.

By early summer of 2008, hatchery personnel shifted their focus away from biological pathogens and for the first time began investigating seawater chemistry as a potential explanation for the persistent summertime mortality events. A large mortality event in July 2008 triggered these investigations, which coincided

with a large upwelling event along the Washington-Oregon coast. This strong upwelling event brought seawater undersaturated with respect to aragonite to the surface and across the continental shelf into Netarts Bay, and hatchery managers recorded pH values as low as 7.6 near hatchery intakes (average ocean pH is 8.2). Preliminary experiments conducted in July and August 2008 showed a marked improvement in the survival and growth of larval cohorts when pH was adjusted by adding sodium carbonate, providing the first clear evidence that carbonate chemistry had affected hatchery production.

These findings came too late in the 2008 production season to be of immediate commercial benefit, however, and overall production at Whiskey Creek in 2008 was approximately 2.5 billion eyed larvae, about 25% of a normal season's production. Whiskey Creek is the primary supplier of larvae to many independent growers throughout the Pacific Northwest, and the shortage of larvae from the hatchery, combined with several consecutive years of poor natural recruitment of larvae from spawning

populations in Willapa Bay (Dumbauld et al., 2011), generated concern among growers across the entire West Coast shellfish industry.

The annual growers meeting held in September 2008 represented an important turning point for the industry, when the keynote speaker, Richard Feely, introduced oyster growers to the potential impacts of OA on shellfish. Combined with preliminary indications from Whiskey Creek that acidified seawater played a major role in the hatchery's production problems that summer, the meeting served as a call to action for the entire industry, and provided an initial forum for researchers, hatchery managers, and growers to discuss the problem face-to-face and propose a strategy to better understand OA's impacts on the industry.

## INSTRUMENTING THE HATCHERIES

### First Attempts at Monitoring (2009)

In spring 2009, Whiskey Creek Shellfish Hatchery initiated a comprehensive water quality monitoring program, funded

by the Pacific Coast Shellfish Growers Association (PCSGA) and the Willapa Bay Reserve Fund. This initial monitoring included continuous measurement of pH, dissolved oxygen, temperature, salinity, and pressure, as well as weekly discrete samples for bacteria, nutrient concentrations, and total carbonate chemistry. Carbonate chemistry samples were sent for analysis to the laboratory of author Hales at Oregon State University (<http://ceoas.oregonstate.edu/profile/hales>), establishing an important connection between the shellfish industry and the chemical oceanographic community.

Data collected throughout summer 2009 were then correlated against production metrics routinely recorded at the hatchery, and the results showed a clear link between  $\Omega_{\text{arag}}$  and the survival and growth of larval cohorts in the hatchery. In particular, these data showed that  $\Omega_{\text{arag}}$  during first-shell development (the first 24–48 hours after fertilization of eggs) was critical to the ultimate survival and growth of larval groups (Figure 1), and  $\Omega_{\text{arag}} > 1.7$  represented the “break-even” point for commercial

**TABLE 1.** US West Coast shellfish production estimates for 2009 (the most recent data available) compiled by the Pacific Coast Shellfish Growers Association (PCSGA). Shellfish sales are divided by species and by state, and when available, total sales are shown both by live weight and economic value.

		Oysters Current*	Clams Current*	Mussels Current*	Geoduck Current*	All Shellfish Larvae and Seed	Total Current
Washington	Pounds	61,000,000	9,520,000	2,750,000	1,650,000		74,920,000
	Sales	\$57,750,000	\$19,550,000	\$3,162,500	\$20,100,00	\$7,000,000	\$107,562,500
California	Pounds	9,270,995	741,463	315,000			10,327,458
	Sales	\$12,361,326	\$830,000	\$945,000		\$2,300,000	\$16,436,326
Oregon	Pounds	2,379,988					2,379,988
	Sales	\$2,253,135				\$750,000	\$3,003,135
Alaska	Pounds	206,709	7,839	1,988			216,536
	Sales	\$441,781	\$24,841	\$6,610		\$126,000	\$599,232
Total	Pounds	72,857,692	10,269,302	3,066,988	1,650,000		87,843,982
	Sales	\$72,806,242	\$20,404,841	\$4,114,110	\$20,100,000		\$117,425,193

\*All pounds converted to live weight/in the shell

Compiled by the Pacific Coast Shellfish Growers Association. All production data represent most recent info available from:

Alaska Dept of Fish and Game, (2009)

Oregon Dept of Agriculture (2009)

Powell, Seiler and Co, Certified Public Accountants for Willapa (2008)

Shellfish companies in California (2008) and Washington (2008, 2009)

Thanks to Jim Gibbons and Ted Kuiper for assistance in compiling data

production at Whiskey Creek (Barton et al., 2012). These findings offered the first clear evidence of OA impacts on larval organisms in the natural environment under naturally fluctuating conditions that have been magnified by increasing atmospheric CO<sub>2</sub> (Barton et al., 2012; Waldbusser et al., 2013).

Subsequent research confirmed that  $\Omega_{\text{arag}}$  values significantly > 1.0 are required to support proper development of Pacific oyster larvae (Barton et al., 2012; Waldbusser et al., 2013, 2015). Pacific oyster larvae develop from an egg (0% shell) to D-hinge oyster larvae (~80% shell) in a period of less than 24 hours (and it appears to be closer to a six-hour window; Waldbusser et al., 2015), representing a tremendous energetic bottleneck due to the rapid rate of calcification (Waldbusser et al., 2013). During this rapid shell development, analysis of stable C isotopes indicates that the shell is precipitated in greater contact with surrounding water, increasing

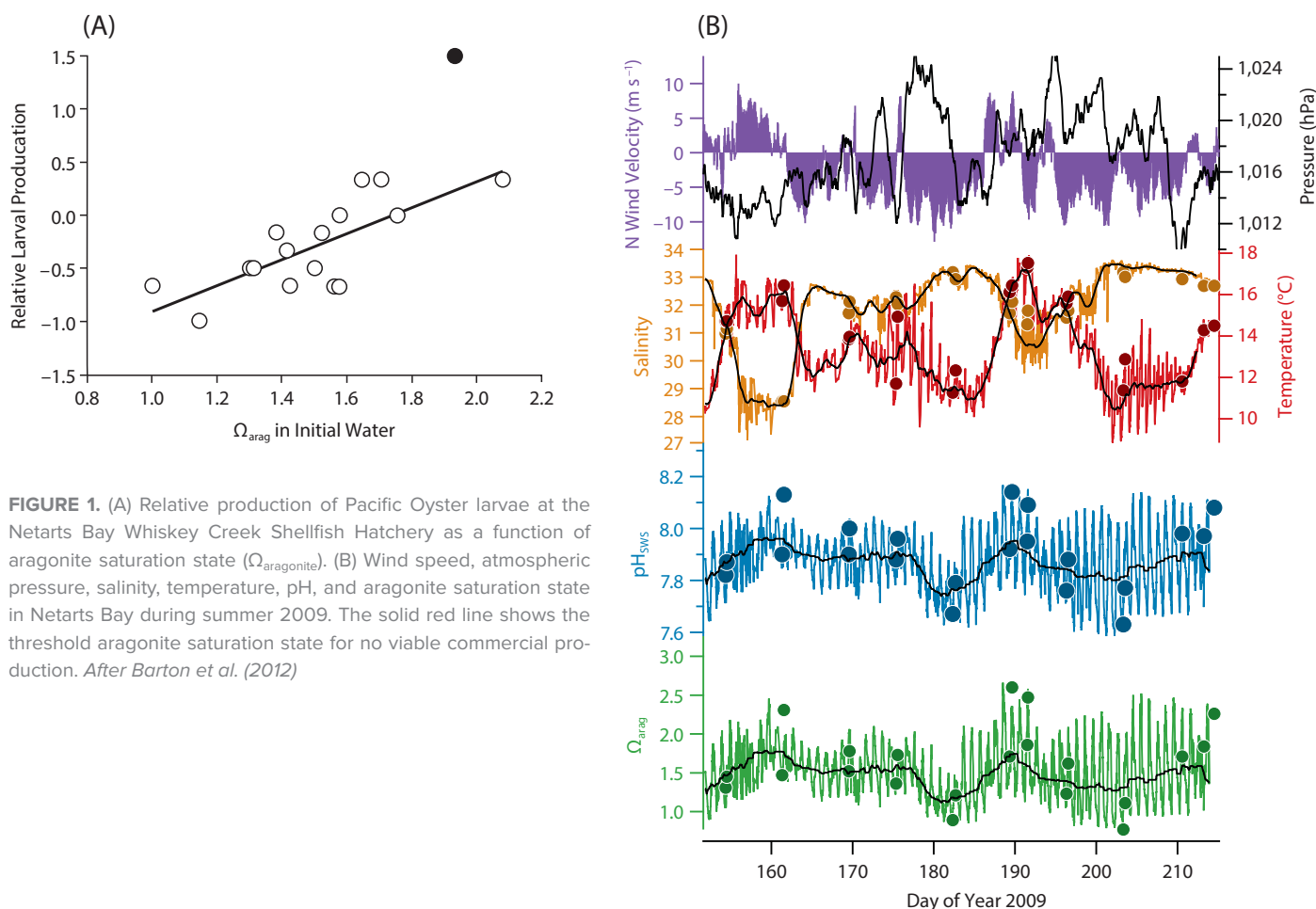
susceptibility to ambient water saturation state (Waldbusser et al., 2013; Figure 2). Recent experiments show that  $\Omega_{\text{arag}}$ , not pH or  $p\text{CO}_2$ , is the primary variable impacting larval development and growth during these early stages (Waldbusser et al., 2015).

Knowing that the first two days of development are critical to the survival of larval groups, managers timed their spawning to coincide with afternoon photosynthetic activity, which raised saturation states outside the hatchery. Although not a perfect strategy, managers saw immediate improvements in the survival and growth of larval cohorts, and using real-time monitoring to “pick their moments” allowed Whiskey Creek to significantly improve summertime larval production in 2009 and 2010. In 2011, large-scale buffering systems were installed in Whiskey Creek Hatchery, and in 2012, hatcheries shifted production cycles earlier in the year to increase seed production before upwelling begins.

## Development of the Pacific Coastal Shellfish Growers Association Monitoring Program

Whiskey Creek's initial success with water quality monitoring in 2009 produced two important findings for the entire shellfish industry: (1) understanding, and adapting to, water chemistry in commercial hatcheries is extremely important to seed production and, ultimately, to the economic resiliency of the Pacific Northwest shellfish industry; and (2) simple pH measurements are inadequate for developing a full understanding of the impacts of shifting carbonate chemistry on larvae; rather,  $\Omega_{\text{arag}}$  measurements are necessary for determining the impact of water chemistry on the initial development and ultimate survival of oyster larvae (Waldbusser et al., 2013, 2015).

In the winter of 2009–2010, PCSGA growers submitted a proposal to Senator Maria Cantwell's (WA) office, requesting funds to build a monitoring network in areas of commercial importance to



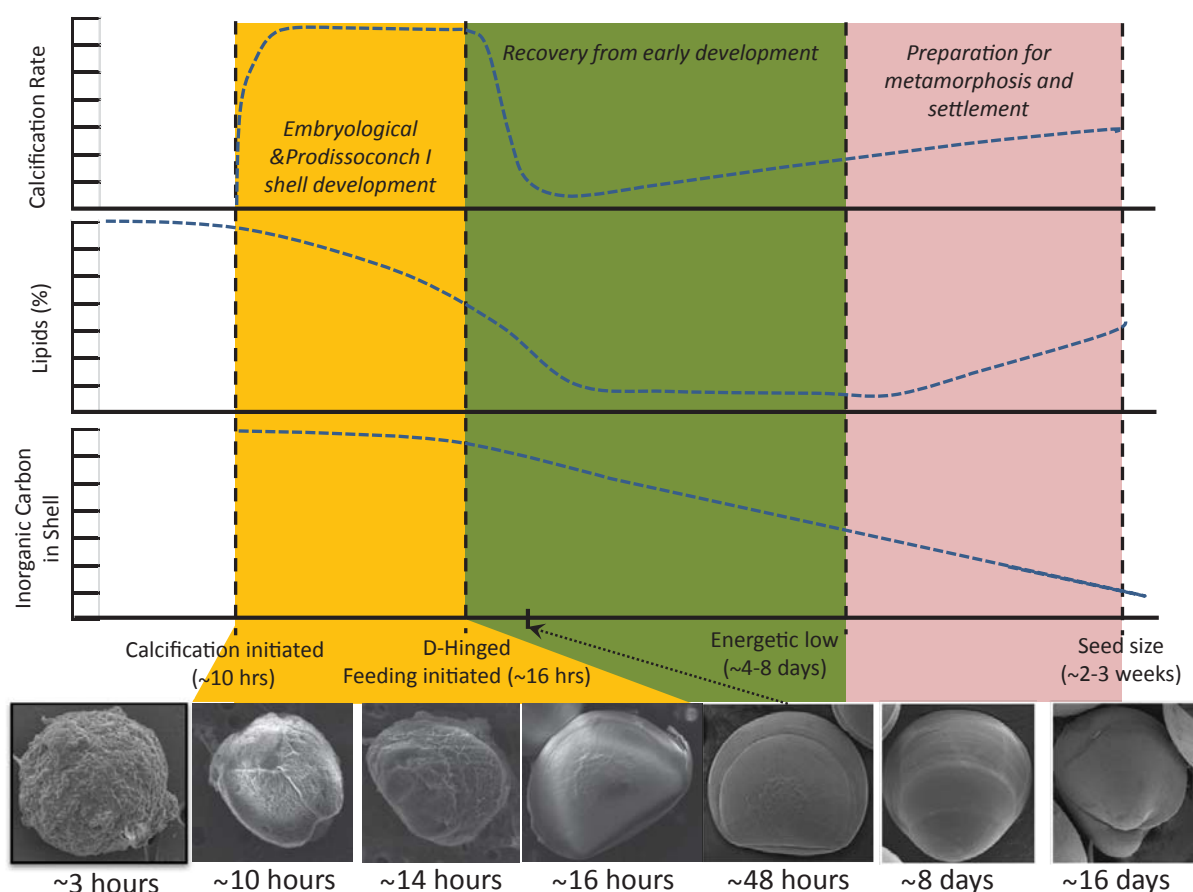
**FIGURE 1.** (A) Relative production of Pacific Oyster larvae at the Netarts Bay Whiskey Creek Shellfish Hatchery as a function of aragonite saturation state ( $\Omega_{\text{aragonite}}$ ). (B) Wind speed, atmospheric pressure, salinity, temperature, pH, and aragonite saturation state in Netarts Bay during summer 2009. The solid red line shows the threshold aragonite saturation state for no viable commercial production. After Barton et al. (2012)

the industry. This proposal stressed the immediacy of the industry's seed supply problems, and the potential for high-resolution, real-time data to improve seed supply for the entire industry. With Senator Cantwell's support, National Oceanic and Atmospheric Administration (NOAA) funds were allocated in early 2010, and PCSGA monitoring stations were quickly established to characterize water chemistry at Whiskey Creek Shellfish Hatchery, Taylor Shellfish Hatchery, the Lummi Nation Shellfish Hatchery, and at three sites in Willapa Bay (Tokeland, Bay Center, and Nahcotta) (Figure 3; Table 2). These funds allowed PCSGA to expand the model originally adopted at Whiskey Creek, and continuous data (pH, temperature, salinity, and dissolved oxygen)

from the monitoring sites were combined with routine discrete sampling for bacteria, nutrient concentrations, and total carbonate chemistry. The award also supported construction of three continuous (1 Hz)  $p\text{CO}_2$  monitoring systems that were designed and constructed at Oregon State University (<http://ceos.oregon-state.edu/profile/hales>). The first of these systems was installed at Whiskey Creek in April 2010, and by spring 2011, sensors were operational at Taylor Shellfish Hatchery and in Willapa Bay, with supplementary funding from the Educational Foundation of America (EFA).

The ability to observe carbonate chemistry data in real time has fundamentally altered the way shellfish hatchery managers view seawater chemistry in the Pacific

Northwest. The data streams generated at commercial hatcheries and distributed through the US Integrated Ocean Observing System (IOOS) regional Northwest Association of Networked Ocean Observing Systems (NANOOS) data portal serve as an important management tool for growers throughout the industry. For both Whiskey Creek and Taylor Shellfish hatcheries (and for growers utilizing monitoring data to improve commercial sets), the PCSGA Monitoring Program put the proverbial "headlights on the car." Access to real-time carbonate chemistry data provides a clear connection between OA and larval mortality as well as an explanation for the recent decline in commercial larval production.



**FIGURE 2.** Trends in relative biochemistry and shell morphology in Pacific oyster larvae raised in the Whiskey Creek Shellfish Hatchery. Bottom axis is time on a nonlinear scale, relating to stages of larval ontology from hours after fertilization to settlement two to three weeks later. Shell diameters in scanning electron microscope images increase from ~75  $\mu\text{m}$  to ~320  $\mu\text{m}$  at settlement size. Panels for calcification rate, % lipids, and inorganic carbon in shell are in relative scales to highlight the changes occurring in the early shell development stage (yellow), when the primary energy source is maternally derived lipids. During this initial period, there is high incorporation of seawater inorganic carbon and high sensitivity to saturation state effects. Even if larvae manage to develop under moderate saturation state stress, they are smaller at the completion of this period (Waldbusser et al., 2015), and fewer proceed to metamorphosis (Barton et al., 2012).

### Turning on the High Beams: Interactions with C-CAN, the Burke-O-Lator 3000, and New IOOS Sensor Development

Although real-time measurement of  $p\text{CO}_2$  provided essential data to commercial hatchery managers,  $p\text{CO}_2$  is, like pH, a proxy for seawater  $\Omega_{\text{arag}}$ , the parameter most closely associated with initial shell formation and survival of oyster larvae (Waldbusser et al., 2015). Gaining a true understanding of carbonate chemistry variability and its effects on shellfish larvae therefore required another technological leap forward for both the shellfish industry and the chemical

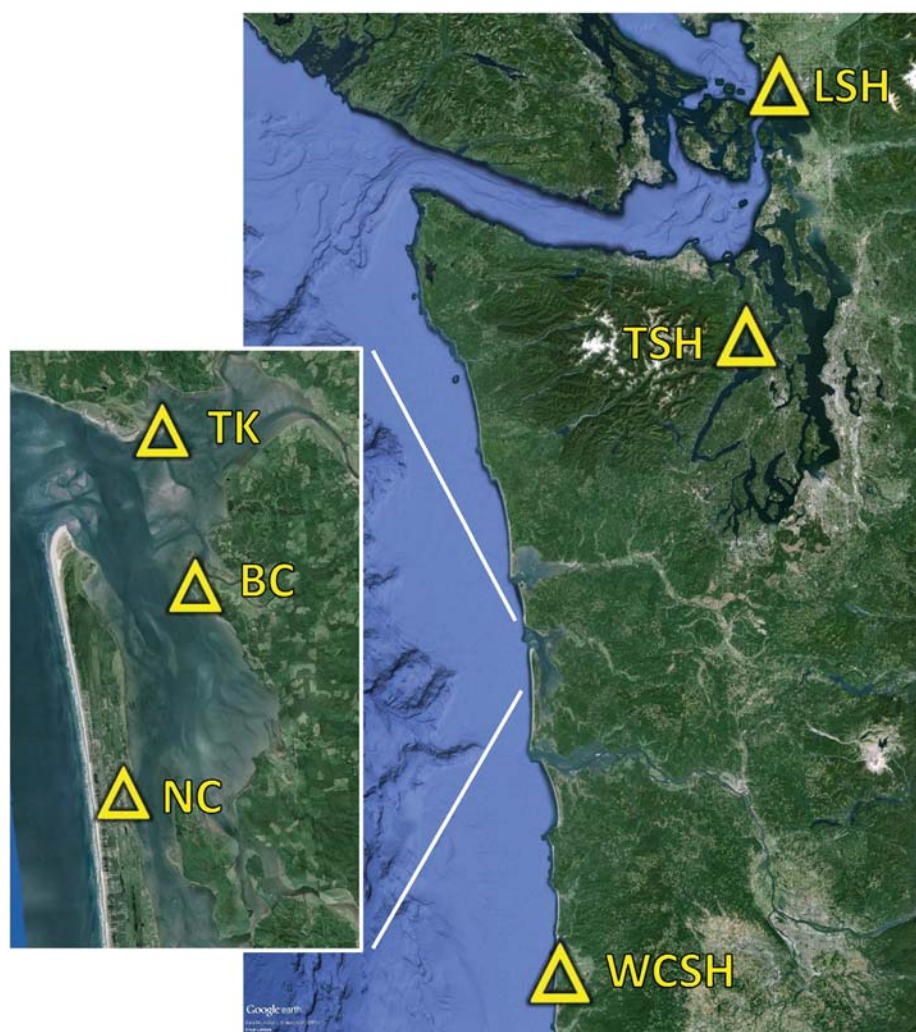
oceanographic community.

A workshop held in Costa Mesa, CA, in July 2010 facilitated this next step, bringing together a diverse group of scientists, shellfish industry representatives, commercial fishermen, and resource managers from local, state, federal, and tribal groups (Southern California Coastal Water Research Project, 2010). These parties recognized the threat OA poses to valuable commercial fisheries across the Pacific Northwest and the need for a coordinated regional approach to the problem. The workshop led to a partnership among these groups and recognition that coastal zone acidification represents

new scientific and management challenges compared to acidification studies in the open ocean. Until then, limited work on OA had been conducted in nearshore environments (e.g., Ringwood and Keppler, 2002; Green et al., 2009), with most oceanographic research focused on decadal-scale changes in the open ocean (Feely et al., 2008, 2012b). The workshop illustrated that coastal effects operate around tidal, diurnal, and seasonal patterns that were not well understood, requiring additional monitoring and analysis.

This workshop ultimately resulted in formation of the California Current Acidification Network (C-CAN), a unique partnership dedicated to: (1) encouraging development of an OA monitoring network for the West Coast, (2) understanding the linkages between oceanographic conditions and biological responses, (3) encouraging development of causal, predictive and economic models that characterize these linkages and forecast effects, and (4) facilitating communication and resource/data sharing among the many organizations that participate in C-CAN in collaboration with US IOOS (<http://c-can.msi.ucsb.edu>).

In subsequent workshops, C-CAN helped define the parameters most important to monitor in coastal systems and developed a detailed set of Core Monitoring Principles (McLaughlin et al., 2015, in this issue) to help industry representatives obtain research quality data from their monitoring systems. A major outcome of these workshops was definition of a benchmark that requires  $\Omega_{\text{arag}}$  to be measured within  $\pm 0.2$  in order to be biologically relevant, based on variance often seen in experimental studies of species responses. Although this level of accuracy is generally attainable in open-ocean systems, the complexities of dynamic coastal estuaries make it a more challenging task in these environments (Feely et al., 2010; Harris et al., 2013). C-CAN's Core Monitoring Principles provide specific direction to assist industry personnel in optimizing data quality,



**FIGURE 3.** Monitoring sites established in 2011 by the Pacific Coast Shellfish Growers Association (PCSGA). Main map: LSH = Lummi Shellfish Hatchery, Bellingham, WA. TSH = Taylor Shellfish Hatchery, Dabob Bay, WA. WCSH = Whiskey Creek Shellfish Hatchery, Netarts Bay, OR. Inset of Willapa Bay: TK = Tokeland. BC = Bay Center (Ekone Oyster Co.). NC = Nahcotta (Jolly Roger Oyster Co.). Three new sites were added in 2014, in Alaska and California, as partnerships between shellfish growers and NOAA, and additional sites are planned.

**TABLE 2.** Summary of monitoring sites of the Pacific Coast Shellfish Growers Association, insights gained from monitoring, and associated mitigation strategies.

Site	Location	Site Characteristics	Insights Gained from Monitoring	Mitigation Strategies
Whiskey Creek Shellfish Hatchery	Netarts Bay, OR	Netarts Bay is a very shallow (<10 m) deep, largely oceanic bay with little freshwater input  Strongly influenced by offshore conditions including direct intrusions of high salinity (>33 ppt) upwelled water during summertime	Identified large-scale shifts in seawater chemistry associated with the intrusion/relaxation of upwelled seawater into Netarts Bay (2009)	Buffered tanks using sodium carbonate  Increased frequency of spawning immediately after strong north winds began (because 24–48 hours of sustained north winds are required to advect upwelled water across the Oregon continental shelf and into Netarts Bay) to create large groups of larvae prior to intrusion of upwelled water into Netarts Bay
			Revealed large diel pH/O <sub>2</sub> variability associated with photosynthetic activity of eelgrass and algae in the bay (2009) and the estuary's dynamic responses to these forcings	"Picked their moments" to utilize afternoon (high pH, high O <sub>2</sub> ) water for spawning
			Provided hatchery with an understanding of how carbonate chemistry and oxygen levels evolve in the bay throughout the growing season. Conditions deteriorate in late summer/fall due to prolonged periods of upwelling and associated decomposition of high volumes of organic matter, both within Netarts Bay (eelgrass, etc.) and offshore over the Oregon continental shelf	Shifted production season earlier each year to place less reliance on late season (August–October) production  Refined treatment systems to oxidize incoming seawater. Additional work is required to address late season conditions at the hatchery
Taylor Shellfish Hatchery	Dabob Bay, WA	Dabob Bay is a deep (>100 m) bay off Hood Canal  Strongly influenced by local processes within Hood Canal due to long residence times once offshore water intrudes into the canal over a shallow (~25 m) sill at Admiralty Inlet	Monitoring revealed a marked difference in pCO <sub>2</sub> concentrations from shallow (5–15 m) and deep (100 m) water intakes at the hatchery. Deep water has persistently high pCO <sub>2</sub> (generally >800 µatm)	Provided an explanation for poor survival commonly observed when deep water was used for rearing oyster larvae (Figure 4)
			Monitoring revealed that periodic, wind-driven mixing of the entire water column in Dabob Bay leads to a significant increase in the pCO <sub>2</sub> water of surface waters outside the hatchery, with potential negative impacts on larval production	Developed treatment systems similar to those at Whiskey Creek to buffer and improve oxidation state of incoming seawater
Bay Center  Nahcotta  Tokeland	Willapa Bay, WA	Willapa Bay is a large coastal bay with long residence times in the southern portion of the bay (Banas et al., 2007) and significant freshwater input from coastal rivers, which may complicate or overwhelm the signal from an offshore upwelling event  Unlike hatcheries, larvae in the natural environment face wide variations in temperature, salinity, and food availability, and any of these factors may play important roles in determining the success or failure of a larval cohort (Ruesink et al., 2003)	Monitoring has shown that $\Omega_{\text{arag}}$ during the summer often falls well below the optimal threshold (of $\Omega_{\text{arag}} > 1.7$ ) for larval development  As OA advances in coming decades, the window of opportunity for spawning events to coincide with favorable water chemistry will continue to shrink (Ryckaczewski and Dunne, 2010; Gruber et al., 2012; Hauri et al., 2011, 2013; recent work of author Hales and colleagues), adding a significant stressor to the list of factors impacting the survival of shellfish larvae in natural systems	Bay Center: Growers use real-time data from NANOOS to time filling of setting tanks  Nahcotta: Some farms are now buffering setting tanks with carbonate  Tokeland: After seven to eight years of sub-par commercial sets (recruitment of naturally occurring larvae to shell bags placed in the bay (Dumbauld et al., 2011), many growers who relied on natural spawning events to seed their farms for decades have instead begun purchasing shell bags seeded with hatchery larvae, increasing overall demand for larvae
Lummi Hatchery	Bellingham, WA	The Lummi hatchery draws seawater from a large (700 acre) sea pond off Puget Sound	Monitoring has revealed significant differences between pond water and waters of the outer sound, where conditions are more variable	The pond may act as a buffer/refuge against extreme events in the surrounding ocean

including recommendations on available instrumentation, protocols for proper calibration of equipment, and recommendations for routine Quality Assurance/Quality Control with outside laboratories.

Additionally, C-CAN provided a forum for face-to-face interactions between industry personnel and researchers and

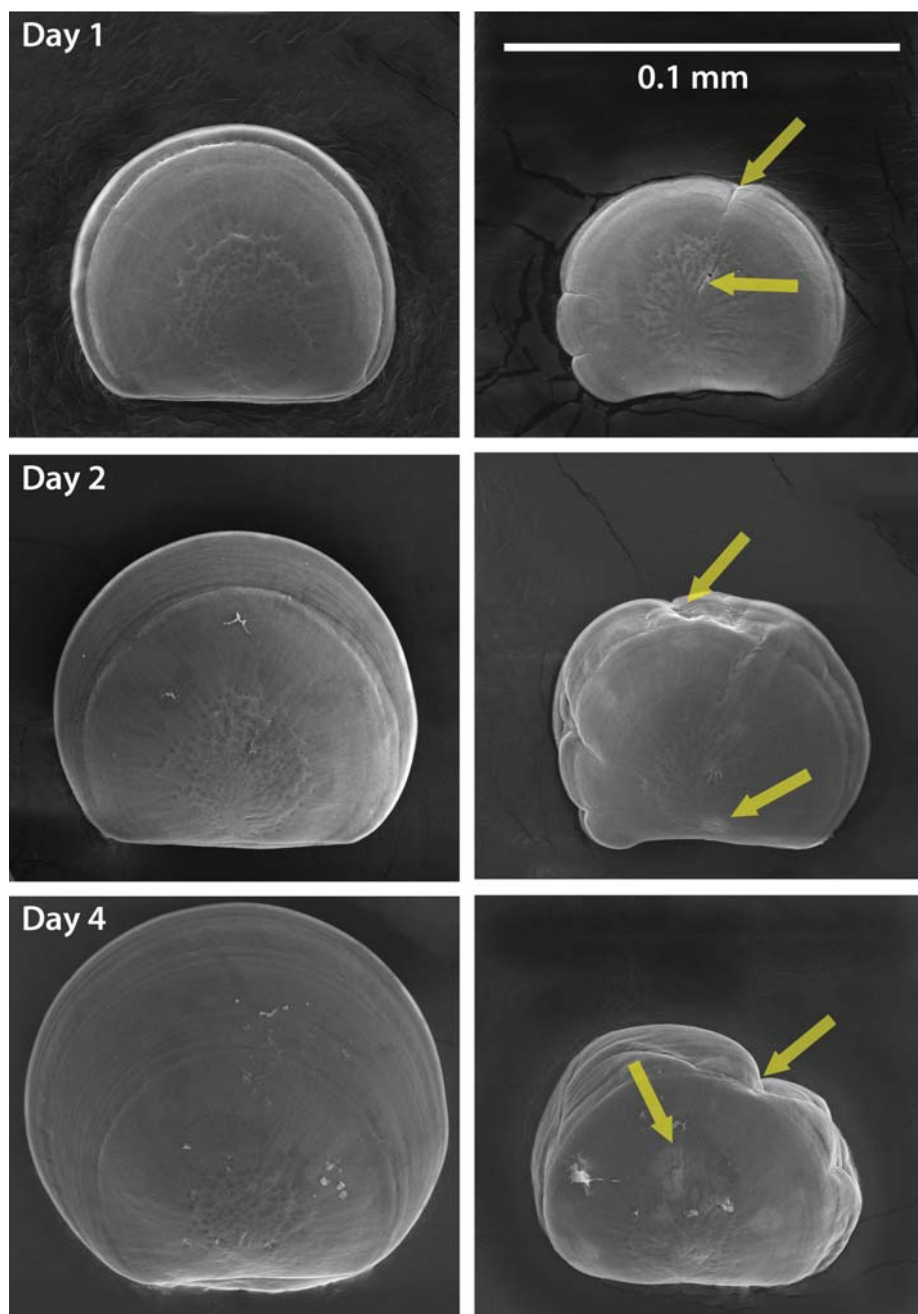
extended these interactions beyond the hatcheries to a wider audience of shellfish growers and commercial fishermen. These conversations allowed growers throughout the industry to obtain a basic understanding of how carbonate chemistry is measured and how those measurements can be used to calculate  $\Omega_{\text{arag}}$ , the

quantity of interest to shellfish farmers. These discussions helped greatly in refining the direction of PCSGA's monitoring effort, and can be summarized as follows:

$\Omega_{\text{arag}}$  can be calculated from any two of four measurable parameters in the carbonate system (pH,  $p\text{CO}_2$ , total alkalinity, and dissolved inorganic carbon [DIC]), if they are measured within a required level of precision and accuracy, and if accurate temperature and salinity measurements are recorded simultaneously. Although pH sensors are readily available, many are unable to achieve the level of precision required to calculate  $\Omega_{\text{arag}}$  within  $\pm 0.2$ ; selection of appropriate pH sensors, along with proper calibration, is therefore essential if they are to be used in calculating  $\Omega_{\text{arag}}$ . Instruments to measure  $p\text{CO}_2$  are costly, but are commercially available, making pH and  $p\text{CO}_2$  an obvious pair of parameters for shellfish growers to use in calculating  $\Omega_{\text{arag}}$ . However, pH and  $p\text{CO}_2$  co-vary and can both be highly dynamic in coastal systems, introducing error into the calculation of  $\Omega_{\text{arag}}$ . Therefore, it is preferable to use one of these quantities, paired with either DIC or total alkalinity (both of which are less variable in coastal environments), to have the best chance of reliably measuring  $\Omega_{\text{arag}}$  in coastal bays and estuaries.

Following C-CAN advice, PCSGA monitoring stations upgraded their pH sensor technology after the 2010 workshop. Combined with the  $p\text{CO}_2$  sensors installed at Whiskey Creek, Taylor Shellfish Hatchery, and in Willapa Bay, growers were for the first time able to generate real-time  $\Omega_{\text{arag}}$  estimates, albeit from measurements of pH and  $p\text{CO}_2$  only (or through use of emerging relationships between total alkalinity and salinity).

At the same time, the shellfish industry began working toward measuring DIC and  $p\text{CO}_2$  in near-real time to obtain the best possible measurement of  $\Omega_{\text{arag}}$ . Using funds provided under the NOAA/Cantwell award, Oregon State University



**FIGURE 4.** Pacific oyster larvae from the same spawn, raised by the Taylor Shellfish Hatchery in natural waters of Dabob Bay, WA, exhibiting favorable (shallow intake, left column,  $p\text{CO}_2 = 403$  ppm,  $\Omega_{\text{arag}} = 1.64$ , and  $\text{pH}_T = 8.00$ ) and unfavorable (deep intake, right column,  $p\text{CO}_2 = 1418$  ppm,  $\Omega_{\text{arag}} = 0.47$ , and  $\text{pH}_T = 7.49$ ) carbonate chemistry during the spawning period. Scanning Electron Microscopy (SEM) images show representative larval shells from each condition at one, two, and four days post-fertilization. Under more acidified conditions, shell development is impaired; arrows show defects (creases) and features (light patches on shell) suggestive of dissolution.

oceanographers modified the existing  $p\text{CO}_2$  monitoring system at Whiskey Creek into a combined  $p\text{CO}_2/\text{tCO}_2$  system, and by the end of 2013, the Burke-O-Lator 3000 emerged as a robust sensor for real time calculation of  $\Omega_{\text{arag}}$ , capable of meeting the C-CAN precision standard of  $\pm 0.2$  for extended periods of continuous use. The robustness of this system stems largely from recognizing that sensors will ultimately fail in dynamic coastal environments. Therefore, rather than relying solely on measurement of  $p\text{CO}_2$  and DIC to calculate  $\Omega_{\text{arag}}$ , the Whiskey Creek system also measures pH using a DuraFet III sensor, ensuring that three of the four parameters in the carbonate system are measured continuously. In addition, five years of routine data collection at Whiskey Creek have provided sufficient data for oceanographers to define the local relationship between total alkalinity and salinity, allowing salinity to be used a proxy measurement for alkalinity. Thus, the carbonate system can be fully constrained at Whiskey Creek.

This oversampling allows for calculation of  $\Omega_{\text{arag}}$  from several different pairs of carbonate system measurements, which can be compared against one another. Currently, the Whiskey Creek system is capable of calculating, and displaying in real time, five calculated values for  $\Omega_{\text{arag}}$  (from pH/DIC,  $p\text{CO}_2$ /DIC,  $p\text{CO}_2$ /TA, DIC/TA, pH/ $p\text{CO}_2$ ). By adding the capability for remote access to the system, the Hales laboratory can view data, make adjustments as needed, and quickly identify the need for system maintenance if any discrepancies arise between the independent calculations of  $\Omega_{\text{arag}}$ .

This capability is key to the success of any monitoring partnership between shellfish growers and oceanographers. Most growers lack the familiarity with carbonate chemistry to identify errors in a time series quickly, and budgetary constraints limit the amount of time that researchers can spend traveling to and from commercial hatcheries. Remote access to the data allows researchers to identify sensor failures quickly and

deploy technicians as needed to optimize the overall quality of the time series.

A newly awarded grant from US IOOS and the NOAA OA Program's "Ocean Technology Transition" competition will allow the Hales laboratory to develop new lower cost and higher accuracy  $p\text{CO}_2$  sensor technology for OA monitoring, with expansion to new sites as advised by PCSGA. It will also strengthen existing regional partnerships through IOOS regional associations along the Pacific coast to implement and provide quality-assured tests of the new sensors. Dubbed "turning the headlights on high," this project seeks to improve and institutionalize the partnerships and successes to date, while commercializing a more stable and less costly  $p\text{CO}_2$  sensor desired by shellfish growers.

### EXPANDING THE PARTNERSHIP WITH OA SCIENTISTS

The PCSGA Monitoring Program's insistence on a high level of precision has had an immediate synergistic effect. When researchers developed the capability to actively monitor time series and maximize the overall quality of the data stream, the monitoring program became not only a sophisticated tool for helping shellfish hatcheries but also a resource for high quality, publishable carbonate chemistry data from coastal locations previously undocumented in efforts to monitor the coastal ocean.

These data are particularly valuable for quantifying the impacts of OA on coastal estuaries throughout the Pacific Northwest because the chemical monitoring stations were co-located with biological monitoring systems (i.e., hatchery production records; Table 2). This co-location allowed researchers to develop a better understanding the response of biota to the chemical parameters and at what thresholds. Moreover, the continuous chemistry data helped refine laboratory-based acidification exposure studies. Whereas most physiological experiments prior to that time focused on changes in steady-state conditions, as might occur

in the open ocean, the new temporally intensive data provided information on episodic exposures relating to the diurnal and tidal changes encountered by biota in nearshore habitats.

As an example, the work conducted at Whiskey Creek by researchers from Oregon State University has greatly increased scientific understanding of early shell formation in Pacific oyster larvae (Waldbusser et al., 2015), in addition to providing valuable insights to hatchery managers (Figures 2 and 3). Importantly, the larvae used in these studies were not exposed to artificially acidified conditions in laboratory trials but rather showed OA impacts when grown in seawater drawn directly from Netarts Bay. Such collaborative work illustrates the role that the PCSGA Monitoring Program can play in engaging researchers to work in important shellfish growing areas and the mutual benefits to all parties as they attempt to understand, and adapt to, coastal acidification in the Pacific Northwest.

Similar partnerships have developed between researchers and shellfish growers throughout Washington State. The relocation of a NOAA buoy within Dabob Bay to waters adjacent to Taylor Shellfish Hatchery represents an example of the responsiveness of NOAA and University of Washington researchers to the needs of shellfish growers and the mutual benefits of comparing buoy data to instrumentation at the hatchery. These industry/research partnerships have spawned research in additional shellfish growing areas important to the industry (<http://www.pacshell.org/about-us.asp>; <http://www.ocean.washington.edu/home/Simone+Alin>), and helped identify potential sites for future expansion of the monitoring network.

### Making Data Available to the Larger Community Through Interactions with NANOOS

Early on in the development of the PCSGA Monitoring Program, the shellfish industry began to interact with IOOS, and in particular with NANOOS,

the regional IOOS authority responsible for the Pacific Northwest. NANOOS recognized the potential value of PCSGA's program in monitoring coastal locations not previously represented in the larger effort to monitor ocean conditions in the Pacific Northwest, and became an essential partner in the effort to display these data streams online.

The shellfish industry is very interested in sharing data online so that it is accessible to as many growers as possible. In areas like Willapa Bay, coastal monitoring has become a valuable tool for growers with commercial setting stations because it helps them maximize the quality of water used to fill setting tanks. This can have dramatic impact on setting success and seed survival, and ultimately, the "bottom line" for shellfish growers. The partnership with NANOOS makes these data widely available to growers throughout the Northwest, as well as to the scientists involved.

Based on the success of the PCSGA Monitoring Program, the NOAA Ocean Acidification Program (OAP) subsequently worked with IOOS to provide three new  $p\text{CO}_2$ /DIC combined systems, which were recently installed in California and Alaska. These instruments significantly increase the number of shellfish growing areas represented in coastal monitoring programs and greatly extend the geographic extent of near-shore carbonate chemistry monitoring in the Pacific Northwest. These data should enhance understanding of OA impacts on coastal estuaries throughout the region.

In 2013, a Blue Ribbon panel of experts in Washington State recommended that the state provide funding to continue the PCSGA Monitoring Program and provided a detailed set of recommendations to combat OA at the state level (Washington State Blue Ribbon Panel on Ocean Acidification, 2012). The resulting funding, along with an Oregon legislature award to support monitoring at Whiskey Creek, ensures that the monitoring network will continue to provide essential information to the shellfish

industry. This funding also supported an upgrade of the existing  $p\text{CO}_2$  monitoring system at Taylor Shellfish to a system capable of measuring  $p\text{CO}_2$  and DIC. The improvement in data quality should facilitate better collaboration, as both hatcheries attempt to understand, and mitigate, OA effects on commercial production. The new IOOS-OAP award, leveraged with support from Washington and Oregon state funds, should extend the monitoring effort at least several years into the future.

### DEVELOPMENT OF COMMERCIAL-SCALE TREATMENT SYSTEMS IN HATCHERIES

Research at Whiskey Creek Shellfish Hatchery has identified  $\Omega_{\text{arag}} > 1.7$  as the minimum threshold for development of commercially viable larvae groups (Barton et al., 2012), although higher saturation states are preferred by hatchery managers. Monitoring at Whiskey Creek has shown that  $\Omega_{\text{arag}}$  now rarely exceeds this minimum threshold throughout the growing season, although nearshore California Current waters were likely at least 0.5 units higher prior to large-scale  $\text{CO}_2$  emissions from fossil fuels (Harris et al., 2013). Even in the spring, before the summertime upwelling season,  $\Omega_{\text{arag}}$  is less than optimal, and the hatchery has responded by installing chemical buffering systems that modify  $\Omega_{\text{arag}}$  in the hatchery year-round. These systems have been quite effective, restoring 30–50% of productivity lost in previous seasons and resulting in billions of additional eyed larvae supplied to growers each year. Discovering the link between acidification and seed production, and installation of buffering systems to correct the problem, has therefore kept the hatchery in business, maintaining seed supply to dozens of growers in Oregon, Washington, and California.

Commercial treatment system development at Whiskey Creek has benefited greatly from close collaboration with Chris Langdon and the

Molluscan Broodstock Program (MBP) at Oregon State University's Hatfield Marine Science Center in Newport, OR (<http://fw.oregonstate.edu/content/chris-langdon>). MBP has been an industry partner since its inception in 1996, developing high-yield Pacific oyster stocks for industry use. To produce these stocks, MBP operates a small research hatchery in Yaquina Bay, where production failures began as early as 2005, prior to the major production failures first observed at Whiskey Creek in 2007. Since 2007, MBP has worked collaboratively with Whiskey Creek, and ongoing research at MBP continues to inform treatment system development at both Whiskey Creek and Taylor Shellfish hatcheries.

Although buffering systems have greatly improved production at Whiskey Creek, they are insufficient to completely repair water chemistry issues impacting commercial hatcheries. Just as OA affects larvae in the hatchery setting, it also has a potential impact on biology in coastal waters throughout the Pacific Northwest (Bednaršek et al., 2014). The link between persistent summertime upwelling and low oxygen/high carbon dioxide regions over the inner continental shelf has been well documented (Hales et al., 2005, 2006; Chan et al., 2008; Feely et al., 2008). These oceanic waters are advected into the many small estuaries along the Pacific Northwest coast and can result in decreased estuarine oxygen conditions (Brown and Power, 2011). In Netarts Bay, local natural processes add to the oceanic signal, and as large amounts of seagrass and benthic micro- and macro-algae generated through the summer season begin to decay in August–October each year, carbon dioxide is increased and oxygen decreased. Although there was no regular water chemistry monitoring in Netarts Bay prior to 2009, conditions at the hatchery were historically conducive to larvae growth in September and early October. Since 2007, however, September and October have been characterized by poor water quality in the bay, forcing an

early end to the growing season.

Treatment systems designed to combat these secondary effects of OA have met with some limited success and are undergoing further development both at Whiskey Creek and at Taylor Shellfish Hatchery. However, shellfish growers throughout the Pacific Northwest have much more work ahead to first understand, and then correct, the late season deterioration of water conditions in coastal bays.

## LONGER-TERM STRATEGIES TO COMBAT THE IMPACTS OF COASTAL OA ON THE INDUSTRY

### Selective Breeding for OA Tolerance

One strategy to combat the advancement of OA in the Pacific Northwest involves the use of selective breeding to develop resistant stocks. Selective breeding of Pacific oysters in the Northwest began in 1996 with creation of the MBP. Selected broodstock, from both MBP and industry-based breeding programs, is now commonly used in commercial hatcheries. Although these existing stocks were not specifically selected for OA resistance, they have been reared in the coastal waters of the Pacific Northwest for four to five generations and may have developed some natural resistance to acidification stress. At Whiskey Creek Shellfish Hatchery, managers have elected to use only MBP-selected broodstock, based on anecdotal evidence that these stocks perform better even in early larval stages. Ongoing research, supported by both the Oregon and Washington legislatures, is specifically focused on selecting stocks that perform well when exposed to reduced saturation state, with particular emphasis on exposing oysters to low  $\Omega_{\text{arag}}$  in early larval stages. These breeding efforts are unlikely to identify larvae that are totally resistant to OA, but the existing gene pool may produce larvae with some tolerance, representing another valuable tool for hatcheries to employ in combating acidification impacts on commercial larval production.

### Expansion of Hatchery Capacity in Locations Outside the Pacific Northwest

Another strategy adopted by the shellfish industry to deal with OA in the Pacific Northwest involves expansion of existing hatchery facilities and construction of new facilities in remote locations. In particular, hatchery operations in Hawaii have expanded dramatically in the past three to four years, with the hope that these sites will be less impacted by OA than sites in the Pacific Northwest. OA is a global problem, however, so these efforts at best represent a short-term solution to carry the industry forward for the next few decades. Shellfish growers are aware of this fact, and the sheer amount of capital investment going into these adaptation strategies speaks volumes about the level of concern felt among growers throughout the Northwest.

### EMERGENCE OF THE SHELLFISH INDUSTRY AS A SPOKESGROUP FOR THE EFFECTS OF OA ON THE COASTAL OCEAN

Shellfish growers are, by definition, environmentalists, because their livelihood depends entirely on the health of the coastal ocean. However, a cross section of oyster farmers is unlikely to reveal a num-

and into the day-to-day life of shellfish growers—who now recognize a very clear and immediate threat to their industry and possess a fairly advanced level of understanding of acidification and the coastal processes affecting it (Mabardy, 2014). A recent survey found that over 50% of the those in the West Coast industry have personal experience with effects of OA, and 75% were very or extremely concerned about OA (Mabardy, 2014). There is hope among the industry, however, in that 59% of respondents indicated they believed they were definitely or somewhat able to adapt to OA.

The direct effects of OA on shellfish larval shell formation are troubling to shellfish growers and to many other groups concerned about the health of shell-forming organisms. However, the more complex, and indirect, effects of OA on the general health of coastal systems are even more disconcerting to the Pacific Northwest shellfish industry. Reports of seed mortality in commercial nurseries become more widespread each season and are likely related to the challenging conditions seed experience once they leave the protected waters of commercial hatcheries. While building capacity for buffering of remote setting tanks at commercial farms should provide some

“Shellfish growers are, by definition, environmentalists, because their livelihood depends entirely on the health of the coastal ocean.”


ber of outspoken environmental activists. Rather, the industry is typified by dedicated businessmen who would much rather put their heads down and work than participate in environmental advocacy. However, OA has leapt suddenly out of hypothetical discussions for the future

resiliency, as early post-metamorphic stages of bivalves appear to be more sensitive to acidification than later juveniles (Waldbusser et al., 2010), at some point demands for algal production and infrastructure require out-planting. The Pacific Northwest shellfish industry cannot treat

the entire coastal ocean, and the general deterioration of coastal water quality is a pressing concern for the entire industry.

Growers understand that development of treatment systems and new hatchery capacity are only stopgap measures, and the only real solution to OA is to address its causes. This puts shellfish farmers in a unique position, as business owners dependent on fossil fuels to maintain their livelihood, yet also heavily dependent on the health of the coastal ocean to produce sensitive shellfish species. A visit to any shellfish hatchery in the Pacific Northwest will reveal thousands of gallons of diesel or propane fuel on site, used to heat seawater for larvae production. Hatchery managers work within a paradox of simultaneously releasing CO<sub>2</sub> into the atmosphere to exacerbate OA and adding carbonate to seawater to repair it. However, the fact that shellfish growers live and work in the real, fossil-fuel-dominated world makes the industry an important voice in the discussion to slow the advance of OA worldwide.

Industry representatives now devote a great deal of time and energy to discussing coastal OA's impacts on the Pacific Northwest shellfish industry (Bill Dewey, Taylor Shellfish Farms, *pers. comm.*, December 4, 2014). Industry involvement has helped expand the discussion of acidification management from the single issue of global carbon reduction to include practical actions that can be taken at the local level to reduce and mitigate acidification effects. These local decision makers are fundamentally different entities, with fundamentally different science questions, than the groups interested in international-scale discussions of carbon inputs to the atmosphere. The direct involvement of shellfish industry representatives has contributed significantly to a growing body of literature that outlines strategies by which management actions can be targeted toward reducing the effects of OA at the local level (e.g., Kelly et al., 2011; Washington State Blue Ribbon Panel on Ocean Acidification, 2012; Strong et al., 2014).

Shellfish industry outreach efforts have paired effectively with regional not-for-profit organizations (<http://sustainablefish.org/global-programs/global-ocean-health>), with the primary focus of making direct contact with shellfish growers and fishermen, not only in the Northwest but also on the US East Coast and throughout the world. Recent workshops regarding the Gulf of Maine, Chesapeake Bay, Mexico, and New Zealand have brought together industry representatives, policymakers, and researchers, and have yielded similar results: growers and fishermen throughout all these regions are very concerned about potential impacts of OA on their industry and are universally interested in the role water quality monitoring can play in helping their industry face these challenges. In this way, the shellfish industry acts as a bridging organization between scientists, policymakers, and other stakeholders. By building consensus among those who work around and depend on a healthy ocean for their livelihood and the urban diners who consume their products, shellfish growers can contribute a powerful voice to discussions of OA and influence the difficult decisions necessary to halt its advance in the global ocean. 

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**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Louise Loftus](#)  
**Subject:** acidification caption -- does this work? thank you  
**Date:** Wednesday, October 14, 2015 11:41:15 AM

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Pteropods, a vital marine food source, are shown here in laboratory conditions. Top image reflects pteropods living in normal conditions for six days. Bottom image shows effects of living in acidified water for the same time period. White lines indicate shell dissolution and why ocean acidification is often called "osteoporosis of the sea."

Credit: NOAA

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#)  
**Subject:** another question  
**Date:** Thursday, October 01, 2015 3:25:51 PM

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Dramatic change is also apparent in the Antarctic where the frigid waters can hold so much carbon dioxide that shelled creatures can dissolve in the corrosive conditions.

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[\[SBI\]](#) There has been no work to date on pteropod condition in the Arctic, only in the Antarctic.

should I change from Arctic to Antarctic? or are both correct?

thanks

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#)  
**Subject:** baby oysters?  
**Date:** Thursday, October 01, 2015 12:31:28 PM

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Ocean currents pushed acidified water into coastal areas, [draining] the energy baby oysters require to build protective shells and causing leaving them to float in coastal waters until they died.

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Madelyn Appelbaum - NOAA Federal](#)  
**Subject:** Barton...Pacific NW stats  
**Date:** Wednesday, October 07, 2015 1:02:28 PM  
**Attachments:** [Barton 5-18-15 \(3\) \(2\).pdf](#)

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# Impacts of Coastal Acidification on the **Pacific Northwest Shellfish Industry**

## and Adaptation Strategies Implemented in Response

By Alan Barton, George Waldbusser, Richard Feely,  
Stephen B. Weisberg, Jan Newton, Burke Hales,  
Sue Cudd, Benoit Eudeline, Chris Langdon, Ian Jefferds,  
Teri King, Andy Suhrbier, and Karen McLaughlin



Photo credit:  
Sandra Barton Vickers

**ABSTRACT.** In 2007, the US west coast shellfish industry began to feel the effects of unprecedented levels of larval mortality in commercial hatcheries producing the Pacific oyster *Crassostrea gigas*. Subsequently, researchers at Whiskey Creek Shellfish Hatchery, working with academic and government scientists, showed a high correlation between aragonite saturation state ( $\Omega_{\text{arag}}$ ) of inflowing seawater and survival of larval groups, clearly linking increased  $\text{CO}_2$  to hatchery failures. This work led the Pacific Coast Shellfish Growers Association (PCSGA) to instrument shellfish hatcheries and coastal waters, establishing a monitoring network in collaboration with university researchers and the US Integrated Ocean Observing System. Analytical developments, such as the ability to monitor  $\Omega_{\text{arag}}$  in real time, have greatly improved the industry's understanding of carbonate chemistry and its variability and informed the development of commercial-scale water treatment systems. These treatment systems have generally proven effective, resulting in billions of additional oyster larvae supplied to Pacific Northwest oyster growers. However, significant challenges remain, and a multifaceted approach, including selective breeding of oyster stocks, expansion of hatchery capacity, continued monitoring of coastal water chemistry, and improved understanding of biological responses will all be essential to the survival of the US west coast shellfish industry.

## INTRODUCTION

The coastal ocean along the west coast of the United States supports some of the most productive fisheries in the world, including the 120-year-old Pacific Northwest shellfish industry. Seasonal coastal upwelling, which annually supplies nutrient-rich water to the inner continental shelf from late spring to early fall, drives this productivity. However, the same upwelling that fuels the industry also threatens it. Decomposition of organic matter at depth naturally raises  $\text{CO}_2$  in upwelled seawater, and increasing atmospheric  $\text{CO}_2$  concentrations have raised the baseline, leading to increased intensity, magnitude, and duration of acidified water over the continental shelf (Feely et al., 2008; Hauri et al., 2009, 2013; Gruber et al., 2012).

When gaseous  $\text{CO}_2$  dissolves in seawater, it reacts with the water to form a weak acid ( $\text{H}_2\text{CO}_3$ ), which dissociates to release a hydrogen ion ( $\text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$ ) or reacts directly to consume carbonate ions ( $\text{H}_2\text{CO}_3 + \text{CO}_3^{2-} \rightleftharpoons 2\text{HCO}_3^-$ ). This acidification process decreases the saturation state of aragonite ( $\Omega_{\text{arag}}$ ) and calcite ( $\Omega_{\text{cal}}$ ), the two mineral forms of calcium carbonate that most bivalves use to form their shells. A variety of shell-forming organisms have been shown to be highly sensitive to the effects of ocean

acidification (OA), such as reduced saturation state (Fabry et al., 2008; Hofmann et al., 2010; Hettinger et al., 2012; Bednaršek et al., 2012, 2014; Gazeau et al., 2013; Kroeker et al., 2010, 2013; Gaylord et al., 2014), including many commercially important shellfish species (Kurihara et al., 2007; Green et al., 2009; Miller et al., 2009; Talmage and Gobler, 2011; Barton et al., 2012; Hettinger et al., 2012; Waldbusser et al., 2013, 2015). Organisms that deposit calcareous shells or skeletons may respond to decreasing  $\Omega_{\text{arag}}$  at values as high as 2, and are expected to encounter increasing physiological challenges as carbonate saturation decreases in the ocean (Fabry et al., 2008; Barton et al., 2012; Bednaršek et al., 2012, 2014; Waldbusser et al., 2015). Except for a few studies at underwater seeps that vent  $\text{CO}_2$ , this research has almost exclusively been carried out in laboratories, where saturation states were reduced with  $\text{CO}_2$  and held constant to match the expected changes in surface ocean chemistry several decades in the future.

Recent research shows a clear link between natural variability in seawater  $\Omega_{\text{arag}}$  along the Oregon coast and commercial production of Pacific oyster larvae in a hatchery setting, where food and water temperatures are maintained at optimal levels, but the chemistry of

incoming seawater varies (Barton et al., 2012). Subsequent work, in part the result of monitoring larval oysters in shellfish hatcheries, documents a mechanism for direct  $\Omega_{\text{arag}}$  sensitivity in early shell formation of bivalve larvae (Waldbusser et al., 2013; 2015), responses previously thought to be related solely to changes in the organisms' acid-base chemistry (Pörtner, 2008). These findings have immediate implications for the Pacific Northwest shellfish industry, which has experienced a significant decline in seed production since 2007.

In nearshore California Current surface waters off the coast of Oregon, the increase in atmospheric  $\text{CO}_2$  has shifted the median  $\Omega_{\text{arag}}$  from approximately 2.5 to 2.0 (Feely et al., 2008; Harris et al., 2013), and values of  $\Omega_{\text{arag}}$  less than 2.0 are already common throughout the spring and summer across major sections of US Pacific coastal waters and Puget Sound (Feely et al., 2008, 2010, 2012b; Hauri et al., 2009). OA has contributed significantly to shoaling of Pacific Northwest aragonite and calcite saturation horizons (Feely et al., 2012b), and recent observations along the Oregon/Washington coast have recorded  $\Omega_{\text{arag}} < 1.0$  in upwelled water at the surface, a condition not expected in the open ocean for decades (Feely et al., 2008). Modeling of the California Current System predicts that this trend will continue and accelerate relative to the open oligotrophic ocean, with undersaturated conditions in surface waters predicted to be the norm more than 50% of the time during summer by 2050 (Gruber et al., 2012; Hauri et al., 2011, 2013).

These changes in Pacific Northwest ocean conditions have already resulted in major oyster seed production declines (Barton et al., 2012; Washington State Blue Ribbon Panel on Ocean Acidification, 2012), and the shellfish industry has adopted a comprehensive strategy to understand, and mitigate, further impacts on commercial production (Washington State Blue Ribbon Panel on Ocean Acidification, 2012). Using

funding from state, federal, and industry groups, shellfish hatcheries have forged partnerships with university researchers, and are now some of the best instrumented monitoring stations for collecting carbonate chemistry measurements in the coastal zone. Industry uses these monitoring data as a real-time management tool to optimize water treatment systems and improve commercial production of oyster larvae. Additionally, hatcheries provide a perfect environment for monitoring biological responses, given that typical hatchery protocols require routine tracking and measurement of larval cohorts. The industry has capitalized on this by forging relationships with physiologists and geneticists to determine the mechanisms behind larval mortality events and develop long-term strategies to adapt to further declines in water quality predicted for the coming decades.

More importantly, the shellfish farming industry has become a catalyst for change. The partnerships industry members have developed with the scientific community helped shift the focus of OA research from oceanic to coastal environments, where there are many additional drivers and more complex natural temporal patterns (Hinga, 1992; Frankignoulle et al., 1998; Ringwood and Keppler, 2002; Wootton et al., 2008; Juranek et al., 2009; Hofmann et al., 2010; Alin et al., 2012; Harris et al., 2013; Feely et al., 2012a; Waldbusser and Salisbury, 2014). In addition, the shellfish industry's challenges helped refocus OA management away from solely pursuing global carbon reduction, and encouraged managers to pursue actions that can be taken locally to mitigate OA effects on coastal waters throughout the Pacific Northwest (Kelly et al., 2011; Washington State Blue Ribbon Panel on Ocean Acidification, 2012). In 2013, Washington became the first state to develop a comprehensive management strategy to protect its resources from OA effects, largely in response to concerns raised by the shellfish industry. This paper describes the factors that drew the shellfish industry into this issue; how the

partnerships established among industry, academia, federal and state scientists, and the local management community flourished in ways that benefited all sectors; and the industry's strategy to adapt as OA continues to advance globally.

## PACIFIC NORTHWEST SHELLFISH INDUSTRY

Shellfish have been harvested in the Pacific Northwest for thousands of years, and commercial oyster farming has been an important cultural and economic part of coastal communities in the Northwest since the late 1800s. Today, shellfish farming supports over \$270 million in economic activity and over 3,000 family wage jobs in rural areas throughout the region. Although shellfish farms can be found throughout Oregon, Washington, Alaska, California, and Hawaii, most of the oysters harvested in the Pacific Northwest are produced in Washington. Large farms in Willapa Bay and southern Puget Sound make up the majority of the industry, and have existed in these areas for several generations (<http://pcsga.org/shellfish-initiative>).

Shellfish species farmed in the Pacific Northwest include Manila clams (*Venerupis philippinarum*), geoduck clams (*Panopea generosa*), mussels (*Mytilus trossulus* and *M. galloprovincialis*), and several species of oysters. Although Kumamoto oysters (*Crassostrea sikamea*), eastern oysters (*Crassostrea virginica*), and the native Olympia oyster (*Ostrea conchaphila*) represent important niche markets, the Pacific oyster (*Crassostrea gigas*) is the predominant species farmed in the region, comprising > 80% of the industry's total annual shellfish production by live weight (Table 1).

Pacific oysters from Japan were first brought to the United States in the early twentieth century, and naturalized populations became established in portions of Puget Sound and in Willapa Bay. Natural recruitment of seed oysters from these spawning populations helped support the industry for several decades, supplementing the supply of imported seed from

Japan. In the 1970s, the cost of importing seed became prohibitively expensive, and it became clear that growers could not rely solely on inconsistent natural spawning events (Dumbauld et al., 2011) to support their burgeoning industry (Gordon and Blanton, 2001).

By the late 1970s, successful commercial hatcheries were established in the Pacific Northwest and began supplying billions of "eyed" (setting size) larvae to growers each year. The three major commercial hatcheries that currently supply larvae to the West Coast shellfish industry are Whiskey Creek Shellfish Hatchery (Netarts Bay, OR), Taylor Shellfish Hatchery (Dabob Bay, WA), and Coast Seafoods Hatchery (Quilcene Bay, WA). These hatcheries combine with smaller hatcheries in Washington and Hawaii to produce 40–60 billion eyed larvae each year, and their 30 years of consistent production has helped build today's \$270 million per year shellfish industry (<http://pcsga.org/shellfish-initiative>).

## Hatchery Failures

High levels of larval mortality at the Whiskey Creek Shellfish Hatchery began in July 2007 and persisted to the end of the growing season in October. Some month-to-month variability in hatchery production is normal, but the magnitude and duration of the 2007 mortality events were unprecedented in the hatchery's 30-year history. Hatchery managers initially attributed the mortality to a large bloom of *Vibrio tubiashii* in Netarts Bay, a bacterium pathogenic to oyster larvae (Elston et al., 2008). However, larval mortality persisted even after successful elimination of the pathogen, forcing managers to search for another explanation for the die-offs.

By early summer of 2008, hatchery personnel shifted their focus away from biological pathogens and for the first time began investigating seawater chemistry as a potential explanation for the persistent summertime mortality events. A large mortality event in July 2008 triggered these investigations, which coincided

with a large upwelling event along the Washington-Oregon coast. This strong upwelling event brought seawater undersaturated with respect to aragonite to the surface and across the continental shelf into Netarts Bay, and hatchery managers recorded pH values as low as 7.6 near hatchery intakes (average ocean pH is 8.2). Preliminary experiments conducted in July and August 2008 showed a marked improvement in the survival and growth of larval cohorts when pH was adjusted by adding sodium carbonate, providing the first clear evidence that carbonate chemistry had affected hatchery production.

These findings came too late in the 2008 production season to be of immediate commercial benefit, however, and overall production at Whiskey Creek in 2008 was approximately 2.5 billion eyed larvae, about 25% of a normal season's production. Whiskey Creek is the primary supplier of larvae to many independent growers throughout the Pacific Northwest, and the shortage of larvae from the hatchery, combined with several consecutive years of poor natural recruitment of larvae from spawning

populations in Willapa Bay (Dumbauld et al., 2011), generated concern among growers across the entire West Coast shellfish industry.

The annual growers meeting held in September 2008 represented an important turning point for the industry, when the keynote speaker, Richard Feely, introduced oyster growers to the potential impacts of OA on shellfish. Combined with preliminary indications from Whiskey Creek that acidified seawater played a major role in the hatchery's production problems that summer, the meeting served as a call to action for the entire industry, and provided an initial forum for researchers, hatchery managers, and growers to discuss the problem face-to-face and propose a strategy to better understand OA's impacts on the industry.

## INSTRUMENTING THE HATCHERIES

### First Attempts at Monitoring (2009)

In spring 2009, Whiskey Creek Shellfish Hatchery initiated a comprehensive water quality monitoring program, funded

by the Pacific Coast Shellfish Growers Association (PCSGA) and the Willapa Bay Reserve Fund. This initial monitoring included continuous measurement of pH, dissolved oxygen, temperature, salinity, and pressure, as well as weekly discrete samples for bacteria, nutrient concentrations, and total carbonate chemistry. Carbonate chemistry samples were sent for analysis to the laboratory of author Hales at Oregon State University (<http://ceoas.oregonstate.edu/profile/hales>), establishing an important connection between the shellfish industry and the chemical oceanographic community.

Data collected throughout summer 2009 were then correlated against production metrics routinely recorded at the hatchery, and the results showed a clear link between  $\Omega_{\text{arag}}$  and the survival and growth of larval cohorts in the hatchery. In particular, these data showed that  $\Omega_{\text{arag}}$  during first-shell development (the first 24–48 hours after fertilization of eggs) was critical to the ultimate survival and growth of larval groups (Figure 1), and  $\Omega_{\text{arag}} > 1.7$  represented the “break-even” point for commercial

**TABLE 1.** US West Coast shellfish production estimates for 2009 (the most recent data available) compiled by the Pacific Coast Shellfish Growers Association (PCSGA). Shellfish sales are divided by species and by state, and when available, total sales are shown both by live weight and economic value.

		Oysters Current*	Clams Current*	Mussels Current*	Geoduck Current*	All Shellfish Larvae and Seed	Total Current
Washington	Pounds	61,000,000	9,520,000	2,750,000	1,650,000		74,920,000
	Sales	\$57,750,000	\$19,550,000	\$3,162,500	\$20,100,00	\$7,000,000	\$107,562,500
California	Pounds	9,270,995	741,463	315,000			10,327,458
	Sales	\$12,361,326	\$830,000	\$945,000		\$2,300,000	\$16,436,326
Oregon	Pounds	2,379,988					2,379,988
	Sales	\$2,253,135				\$750,000	\$3,003,135
Alaska	Pounds	206,709	7,839	1,988			216,536
	Sales	\$441,781	\$24,841	\$6,610		\$126,000	\$599,232
Total	Pounds	72,857,692	10,269,302	3,066,988	1,650,000		87,843,982
	Sales	\$72,806,242	\$20,404,841	\$4,114,110	\$20,100,000		\$117,425,193

\*All pounds converted to live weight/in the shell

Compiled by the Pacific Coast Shellfish Growers Association. All production data represent most recent info available from:

Alaska Dept of Fish and Game, (2009)

Oregon Dept of Agriculture (2009)

Powell, Seiler and Co, Certified Public Accountants for Willapa (2008)

Shellfish companies in California (2008) and Washington (2008, 2009)

Thanks to Jim Gibbons and Ted Kuiper for assistance in compiling data

production at Whiskey Creek (Barton et al., 2012). These findings offered the first clear evidence of OA impacts on larval organisms in the natural environment under naturally fluctuating conditions that have been magnified by increasing atmospheric CO<sub>2</sub> (Barton et al., 2012; Waldbusser et al., 2013).

Subsequent research confirmed that  $\Omega_{\text{arag}}$  values significantly > 1.0 are required to support proper development of Pacific oyster larvae (Barton et al., 2012; Waldbusser et al., 2013, 2015). Pacific oyster larvae develop from an egg (0% shell) to D-hinge oyster larvae (~80% shell) in a period of less than 24 hours (and it appears to be closer to a six-hour window; Waldbusser et al., 2015), representing a tremendous energetic bottleneck due to the rapid rate of calcification (Waldbusser et al., 2013). During this rapid shell development, analysis of stable C isotopes indicates that the shell is precipitated in greater contact with surrounding water, increasing

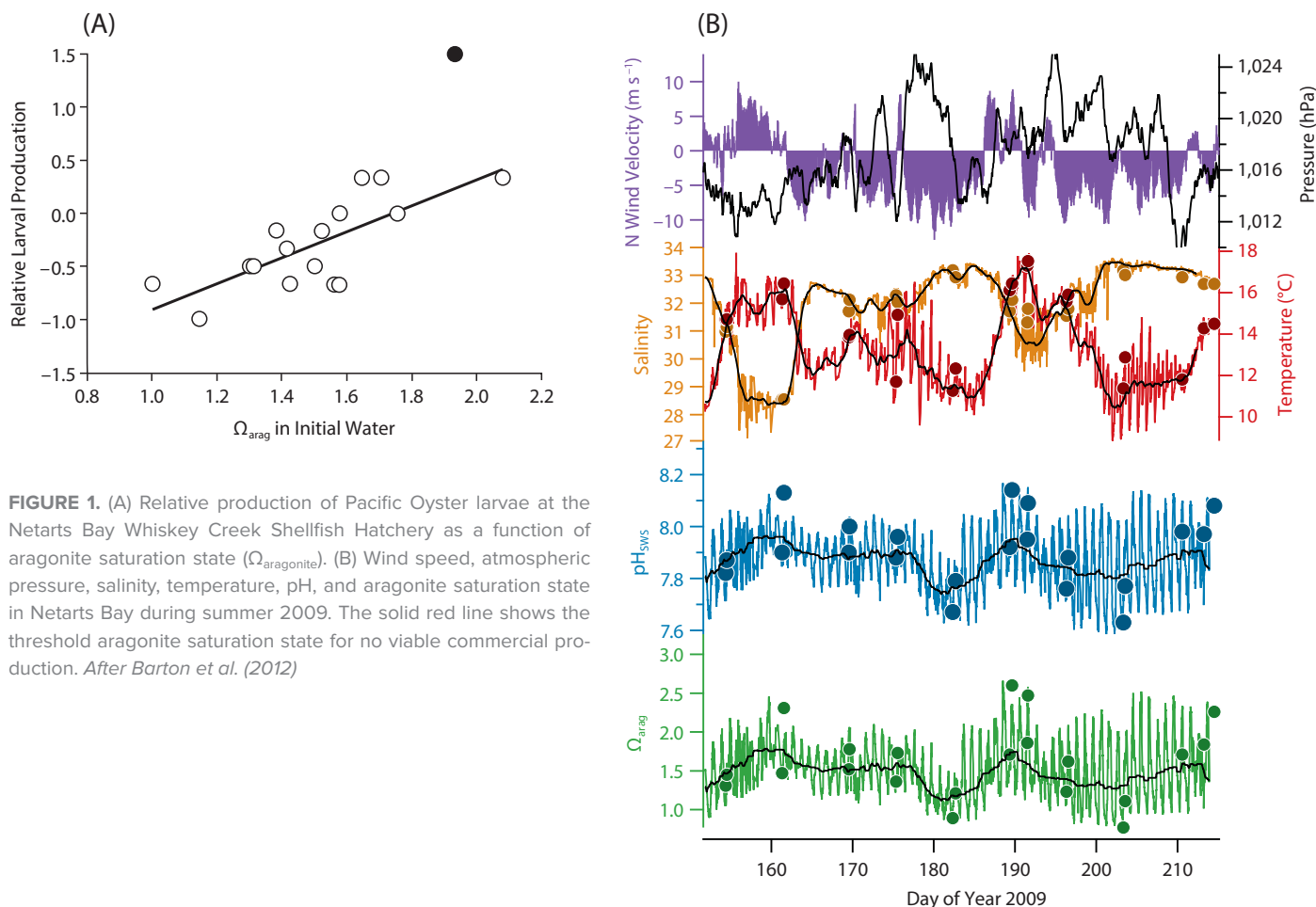
susceptibility to ambient water saturation state (Waldbusser et al., 2013; Figure 2). Recent experiments show that  $\Omega_{\text{arag}}$ , not pH or  $p\text{CO}_2$ , is the primary variable impacting larval development and growth during these early stages (Waldbusser et al., 2015).

Knowing that the first two days of development are critical to the survival of larval groups, managers timed their spawning to coincide with afternoon photosynthetic activity, which raised saturation states outside the hatchery. Although not a perfect strategy, managers saw immediate improvements in the survival and growth of larval cohorts, and using real-time monitoring to “pick their moments” allowed Whiskey Creek to significantly improve summertime larval production in 2009 and 2010. In 2011, large-scale buffering systems were installed in Whiskey Creek Hatchery, and in 2012, hatcheries shifted production cycles earlier in the year to increase seed production before upwelling begins.

## Development of the Pacific Coastal Shellfish Growers Association Monitoring Program

Whiskey Creek's initial success with water quality monitoring in 2009 produced two important findings for the entire shellfish industry: (1) understanding, and adapting to, water chemistry in commercial hatcheries is extremely important to seed production and, ultimately, to the economic resiliency of the Pacific Northwest shellfish industry; and (2) simple pH measurements are inadequate for developing a full understanding of the impacts of shifting carbonate chemistry on larvae; rather,  $\Omega_{\text{arag}}$  measurements are necessary for determining the impact of water chemistry on the initial development and ultimate survival of oyster larvae (Waldbusser et al., 2013, 2015).

In the winter of 2009–2010, PCSGA growers submitted a proposal to Senator Maria Cantwell's (WA) office, requesting funds to build a monitoring network in areas of commercial importance to



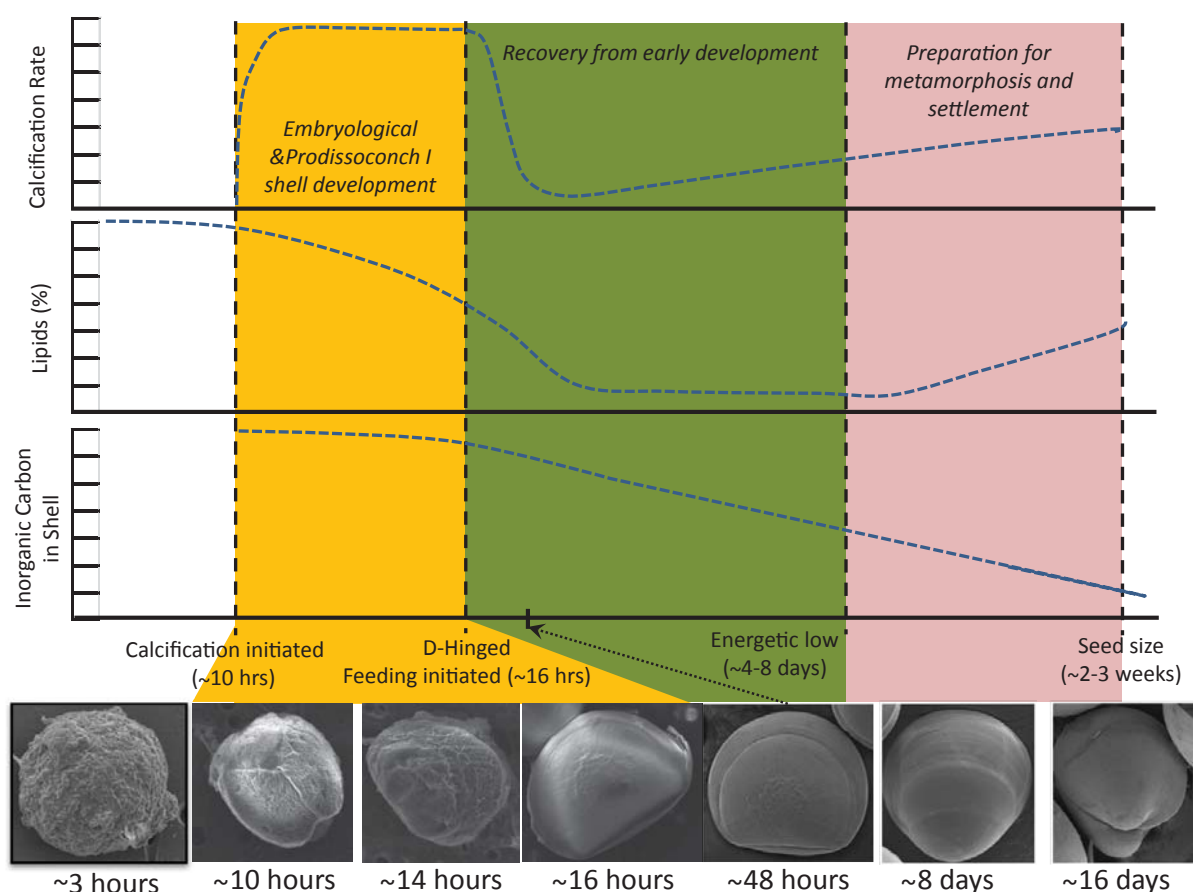
**FIGURE 1.** (A) Relative production of Pacific Oyster larvae at the Netarts Bay Whiskey Creek Shellfish Hatchery as a function of aragonite saturation state ( $\Omega_{\text{aragonite}}$ ). (B) Wind speed, atmospheric pressure, salinity, temperature, pH, and aragonite saturation state in Netarts Bay during summer 2009. The solid red line shows the threshold aragonite saturation state for no viable commercial production. After Barton et al. (2012)

the industry. This proposal stressed the immediacy of the industry's seed supply problems, and the potential for high-resolution, real-time data to improve seed supply for the entire industry. With Senator Cantwell's support, National Oceanic and Atmospheric Administration (NOAA) funds were allocated in early 2010, and PCSGA monitoring stations were quickly established to characterize water chemistry at Whiskey Creek Shellfish Hatchery, Taylor Shellfish Hatchery, the Lummi Nation Shellfish Hatchery, and at three sites in Willapa Bay (Tokeland, Bay Center, and Nahcotta) (Figure 3; Table 2). These funds allowed PCSGA to expand the model originally adopted at Whiskey Creek, and continuous data (pH, temperature, salinity, and dissolved oxygen)

from the monitoring sites were combined with routine discrete sampling for bacteria, nutrient concentrations, and total carbonate chemistry. The award also supported construction of three continuous (1 Hz)  $p\text{CO}_2$  monitoring systems that were designed and constructed at Oregon State University (<http://ceos.oregon-state.edu/profile/hales>). The first of these systems was installed at Whiskey Creek in April 2010, and by spring 2011, sensors were operational at Taylor Shellfish Hatchery and in Willapa Bay, with supplementary funding from the Educational Foundation of America (EFA).

The ability to observe carbonate chemistry data in real time has fundamentally altered the way shellfish hatchery managers view seawater chemistry in the Pacific

Northwest. The data streams generated at commercial hatcheries and distributed through the US Integrated Ocean Observing System (IOOS) regional Northwest Association of Networked Ocean Observing Systems (NANOOS) data portal serve as an important management tool for growers throughout the industry. For both Whiskey Creek and Taylor Shellfish hatcheries (and for growers utilizing monitoring data to improve commercial sets), the PCSGA Monitoring Program put the proverbial "headlights on the car." Access to real-time carbonate chemistry data provides a clear connection between OA and larval mortality as well as an explanation for the recent decline in commercial larval production.



**FIGURE 2.** Trends in relative biochemistry and shell morphology in Pacific oyster larvae raised in the Whiskey Creek Shellfish Hatchery. Bottom axis is time on a nonlinear scale, relating to stages of larval ontology from hours after fertilization to settlement two to three weeks later. Shell diameters in scanning electron microscope images increase from ~75  $\mu\text{m}$  to ~320  $\mu\text{m}$  at settlement size. Panels for calcification rate, % lipids, and inorganic carbon in shell are in relative scales to highlight the changes occurring in the early shell development stage (yellow), when the primary energy source is maternally derived lipids. During this initial period, there is high incorporation of seawater inorganic carbon and high sensitivity to saturation state effects. Even if larvae manage to develop under moderate saturation state stress, they are smaller at the completion of this period (Waldbusser et al., 2015), and fewer proceed to metamorphosis (Barton et al., 2012).

### Turning on the High Beams: Interactions with C-CAN, the Burke-O-Lator 3000, and New IOOS Sensor Development

Although real-time measurement of  $p\text{CO}_2$  provided essential data to commercial hatchery managers,  $p\text{CO}_2$  is, like pH, a proxy for seawater  $\Omega_{\text{arag}}$ , the parameter most closely associated with initial shell formation and survival of oyster larvae (Waldbusser et al., 2015). Gaining a true understanding of carbonate chemistry variability and its effects on shellfish larvae therefore required another technological leap forward for both the shellfish industry and the chemical

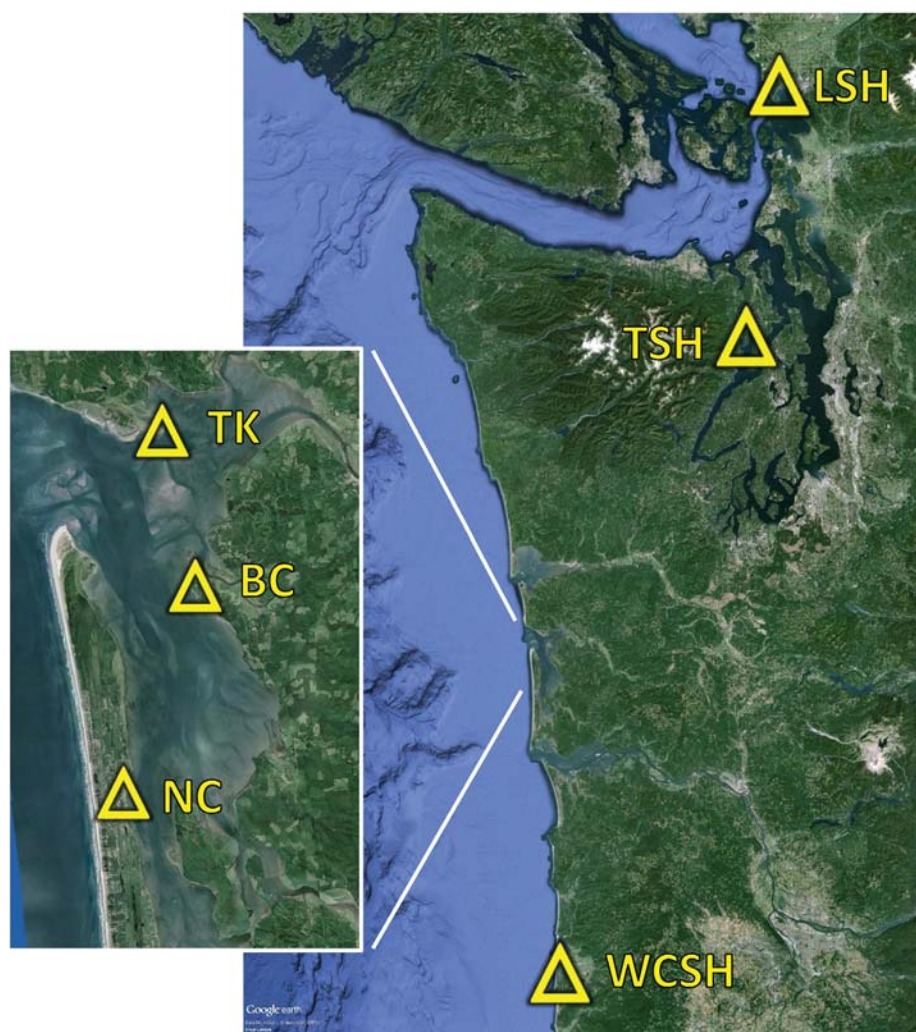
oceanographic community.

A workshop held in Costa Mesa, CA, in July 2010 facilitated this next step, bringing together a diverse group of scientists, shellfish industry representatives, commercial fishermen, and resource managers from local, state, federal, and tribal groups (Southern California Coastal Water Research Project, 2010). These parties recognized the threat OA poses to valuable commercial fisheries across the Pacific Northwest and the need for a coordinated regional approach to the problem. The workshop led to a partnership among these groups and recognition that coastal zone acidification represents

new scientific and management challenges compared to acidification studies in the open ocean. Until then, limited work on OA had been conducted in nearshore environments (e.g., Ringwood and Keppler, 2002; Green et al., 2009), with most oceanographic research focused on decadal-scale changes in the open ocean (Feely et al., 2008, 2012b). The workshop illustrated that coastal effects operate around tidal, diurnal, and seasonal patterns that were not well understood, requiring additional monitoring and analysis.

This workshop ultimately resulted in formation of the California Current Acidification Network (C-CAN), a unique partnership dedicated to: (1) encouraging development of an OA monitoring network for the West Coast, (2) understanding the linkages between oceanographic conditions and biological responses, (3) encouraging development of causal, predictive and economic models that characterize these linkages and forecast effects, and (4) facilitating communication and resource/data sharing among the many organizations that participate in C-CAN in collaboration with US IOOS (<http://c-can.msi.ucsb.edu>).

In subsequent workshops, C-CAN helped define the parameters most important to monitor in coastal systems and developed a detailed set of Core Monitoring Principles (McLaughlin et al., 2015, in this issue) to help industry representatives obtain research quality data from their monitoring systems. A major outcome of these workshops was definition of a benchmark that requires  $\Omega_{\text{arag}}$  to be measured within  $\pm 0.2$  in order to be biologically relevant, based on variance often seen in experimental studies of species responses. Although this level of accuracy is generally attainable in open-ocean systems, the complexities of dynamic coastal estuaries make it a more challenging task in these environments (Feely et al., 2010; Harris et al., 2013). C-CAN's Core Monitoring Principles provide specific direction to assist industry personnel in optimizing data quality,



**FIGURE 3.** Monitoring sites established in 2011 by the Pacific Coast Shellfish Growers Association (PCSGA). Main map: LSH = Lummi Shellfish Hatchery, Bellingham, WA. TSH = Taylor Shellfish Hatchery, Dabob Bay, WA. WCSH = Whiskey Creek Shellfish Hatchery, Netarts Bay, OR. Inset of Willapa Bay: TK = Tokeland. BC = Bay Center (Ekone Oyster Co.). NC = Nahcotta (Jolly Roger Oyster Co.). Three new sites were added in 2014, in Alaska and California, as partnerships between shellfish growers and NOAA, and additional sites are planned.

**TABLE 2.** Summary of monitoring sites of the Pacific Coast Shellfish Growers Association, insights gained from monitoring, and associated mitigation strategies.

Site	Location	Site Characteristics	Insights Gained from Monitoring	Mitigation Strategies
Whiskey Creek Shellfish Hatchery	Netarts Bay, OR	Netarts Bay is a very shallow (<10 m) deep, largely oceanic bay with little freshwater input  Strongly influenced by offshore conditions including direct intrusions of high salinity (>33 ppt) upwelled water during summertime	Identified large-scale shifts in seawater chemistry associated with the intrusion/relaxation of upwelled seawater into Netarts Bay (2009)	Buffered tanks using sodium carbonate  Increased frequency of spawning immediately after strong north winds began (because 24–48 hours of sustained north winds are required to advect upwelled water across the Oregon continental shelf and into Netarts Bay) to create large groups of larvae prior to intrusion of upwelled water into Netarts Bay
			Revealed large diel pH/O <sub>2</sub> variability associated with photosynthetic activity of eelgrass and algae in the bay (2009) and the estuary's dynamic responses to these forcings	"Picked their moments" to utilize afternoon (high pH, high O <sub>2</sub> ) water for spawning
			Provided hatchery with an understanding of how carbonate chemistry and oxygen levels evolve in the bay throughout the growing season. Conditions deteriorate in late summer/fall due to prolonged periods of upwelling and associated decomposition of high volumes of organic matter, both within Netarts Bay (eelgrass, etc.) and offshore over the Oregon continental shelf	Shifted production season earlier each year to place less reliance on late season (August–October) production  Refined treatment systems to oxidize incoming seawater. Additional work is required to address late season conditions at the hatchery
Taylor Shellfish Hatchery	Dabob Bay, WA	Dabob Bay is a deep (>100 m) bay off Hood Canal  Strongly influenced by local processes within Hood Canal due to long residence times once offshore water intrudes into the canal over a shallow (~25 m) sill at Admiralty Inlet	Monitoring revealed a marked difference in pCO <sub>2</sub> concentrations from shallow (5–15 m) and deep (100 m) water intakes at the hatchery. Deep water has persistently high pCO <sub>2</sub> (generally >800 µatm)	Provided an explanation for poor survival commonly observed when deep water was used for rearing oyster larvae (Figure 4)
			Monitoring revealed that periodic, wind-driven mixing of the entire water column in Dabob Bay leads to a significant increase in the pCO <sub>2</sub> water of surface waters outside the hatchery, with potential negative impacts on larval production	Developed treatment systems similar to those at Whiskey Creek to buffer and improve oxidation state of incoming seawater
Bay Center  Nahcotta  Tokeland	Willapa Bay, WA	Willapa Bay is a large coastal bay with long residence times in the southern portion of the bay (Banas et al., 2007) and significant freshwater input from coastal rivers, which may complicate or overwhelm the signal from an offshore upwelling event  Unlike hatcheries, larvae in the natural environment face wide variations in temperature, salinity, and food availability, and any of these factors may play important roles in determining the success or failure of a larval cohort (Ruesink et al., 2003)	Monitoring has shown that $\Omega_{\text{arag}}$ during the summer often falls well below the optimal threshold (of $\Omega_{\text{arag}} > 1.7$ ) for larval development  As OA advances in coming decades, the window of opportunity for spawning events to coincide with favorable water chemistry will continue to shrink (Ryckaczewski and Dunne, 2010; Gruber et al., 2012; Hauri et al., 2011, 2013; recent work of author Hales and colleagues), adding a significant stressor to the list of factors impacting the survival of shellfish larvae in natural systems	Bay Center: Growers use real-time data from NANOOS to time filling of setting tanks  Nahcotta: Some farms are now buffering setting tanks with carbonate  Tokeland: After seven to eight years of sub-par commercial sets (recruitment of naturally occurring larvae to shell bags placed in the bay (Dumbauld et al., 2011), many growers who relied on natural spawning events to seed their farms for decades have instead begun purchasing shell bags seeded with hatchery larvae, increasing overall demand for larvae
Lummi Hatchery	Bellingham, WA	The Lummi hatchery draws seawater from a large (700 acre) sea pond off Puget Sound	Monitoring has revealed significant differences between pond water and waters of the outer sound, where conditions are more variable	The pond may act as a buffer/refuge against extreme events in the surrounding ocean

including recommendations on available instrumentation, protocols for proper calibration of equipment, and recommendations for routine Quality Assurance/Quality Control with outside laboratories.

Additionally, C-CAN provided a forum for face-to-face interactions between industry personnel and researchers and

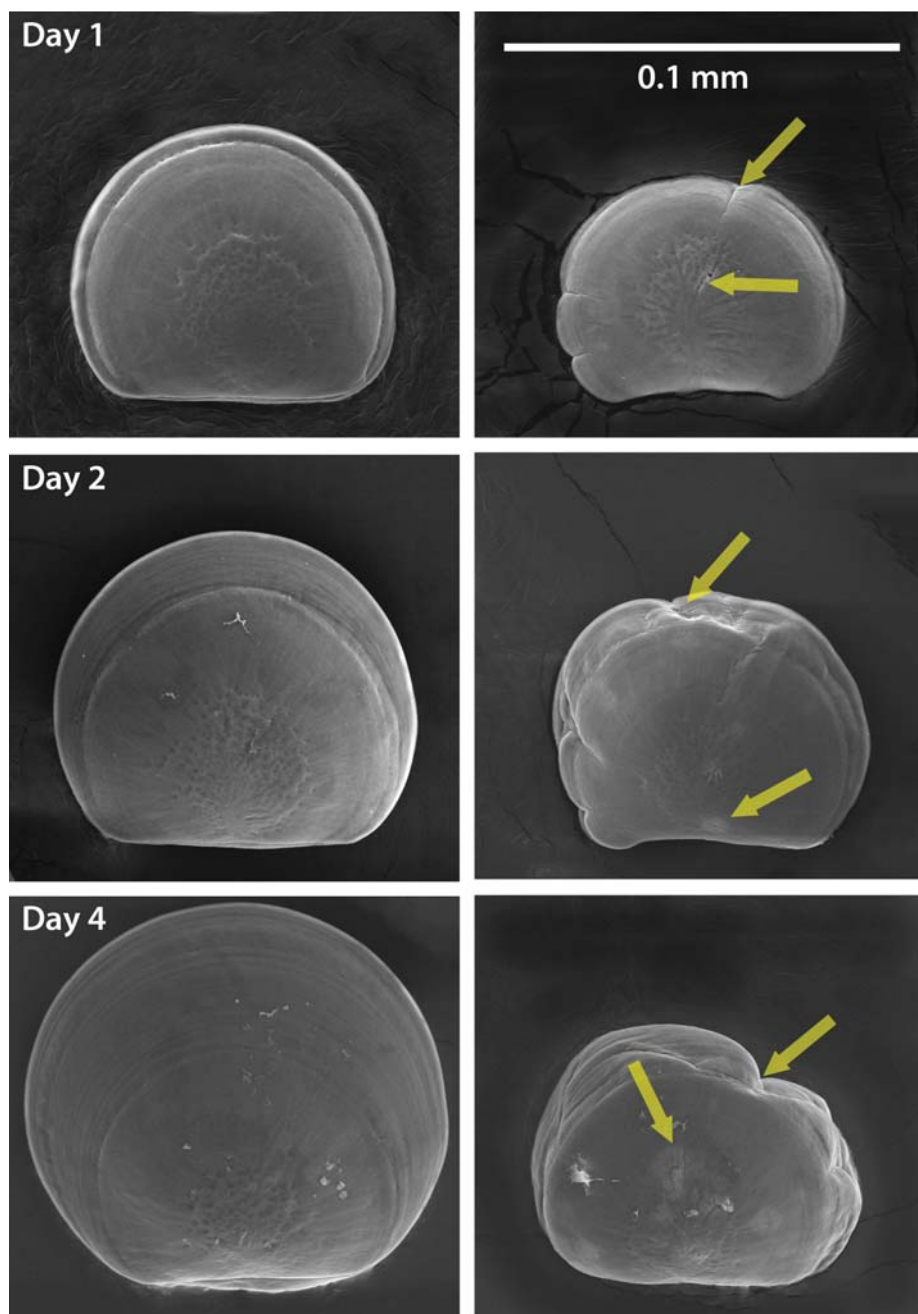
extended these interactions beyond the hatcheries to a wider audience of shellfish growers and commercial fishermen. These conversations allowed growers throughout the industry to obtain a basic understanding of how carbonate chemistry is measured and how those measurements can be used to calculate  $\Omega_{\text{arag}}$ , the

quantity of interest to shellfish farmers. These discussions helped greatly in refining the direction of PCSGA's monitoring effort, and can be summarized as follows:

$\Omega_{\text{arag}}$  can be calculated from any two of four measurable parameters in the carbonate system (pH,  $p\text{CO}_2$ , total alkalinity, and dissolved inorganic carbon [DIC]), if they are measured within a required level of precision and accuracy, and if accurate temperature and salinity measurements are recorded simultaneously. Although pH sensors are readily available, many are unable to achieve the level of precision required to calculate  $\Omega_{\text{arag}}$  within  $\pm 0.2$ ; selection of appropriate pH sensors, along with proper calibration, is therefore essential if they are to be used in calculating  $\Omega_{\text{arag}}$ . Instruments to measure  $p\text{CO}_2$  are costly, but are commercially available, making pH and  $p\text{CO}_2$  an obvious pair of parameters for shellfish growers to use in calculating  $\Omega_{\text{arag}}$ . However, pH and  $p\text{CO}_2$  co-vary and can both be highly dynamic in coastal systems, introducing error into the calculation of  $\Omega_{\text{arag}}$ . Therefore, it is preferable to use one of these quantities, paired with either DIC or total alkalinity (both of which are less variable in coastal environments), to have the best chance of reliably measuring  $\Omega_{\text{arag}}$  in coastal bays and estuaries.

Following C-CAN advice, PCSGA monitoring stations upgraded their pH sensor technology after the 2010 workshop. Combined with the  $p\text{CO}_2$  sensors installed at Whiskey Creek, Taylor Shellfish Hatchery, and in Willapa Bay, growers were for the first time able to generate real-time  $\Omega_{\text{arag}}$  estimates, albeit from measurements of pH and  $p\text{CO}_2$  only (or through use of emerging relationships between total alkalinity and salinity).

At the same time, the shellfish industry began working toward measuring DIC and  $p\text{CO}_2$  in near-real time to obtain the best possible measurement of  $\Omega_{\text{arag}}$ . Using funds provided under the NOAA/Cantwell award, Oregon State University



**FIGURE 4.** Pacific oyster larvae from the same spawn, raised by the Taylor Shellfish Hatchery in natural waters of Dabob Bay, WA, exhibiting favorable (shallow intake, left column,  $p\text{CO}_2 = 403$  ppm,  $\Omega_{\text{arag}} = 1.64$ , and  $\text{pH}_T = 8.00$ ) and unfavorable (deep intake, right column,  $p\text{CO}_2 = 1418$  ppm,  $\Omega_{\text{arag}} = 0.47$ , and  $\text{pH}_T = 7.49$ ) carbonate chemistry during the spawning period. Scanning Electron Microscopy (SEM) images show representative larval shells from each condition at one, two, and four days post-fertilization. Under more acidified conditions, shell development is impaired; arrows show defects (creases) and features (light patches on shell) suggestive of dissolution.

oceanographers modified the existing  $p\text{CO}_2$  monitoring system at Whiskey Creek into a combined  $p\text{CO}_2/\text{tCO}_2$  system, and by the end of 2013, the Burke-O-Lator 3000 emerged as a robust sensor for real time calculation of  $\Omega_{\text{arag}}$ , capable of meeting the C-CAN precision standard of  $\pm 0.2$  for extended periods of continuous use. The robustness of this system stems largely from recognizing that sensors will ultimately fail in dynamic coastal environments. Therefore, rather than relying solely on measurement of  $p\text{CO}_2$  and DIC to calculate  $\Omega_{\text{arag}}$ , the Whiskey Creek system also measures pH using a DuraFet III sensor, ensuring that three of the four parameters in the carbonate system are measured continuously. In addition, five years of routine data collection at Whiskey Creek have provided sufficient data for oceanographers to define the local relationship between total alkalinity and salinity, allowing salinity to be used a proxy measurement for alkalinity. Thus, the carbonate system can be fully constrained at Whiskey Creek.

This oversampling allows for calculation of  $\Omega_{\text{arag}}$  from several different pairs of carbonate system measurements, which can be compared against one another. Currently, the Whiskey Creek system is capable of calculating, and displaying in real time, five calculated values for  $\Omega_{\text{arag}}$  (from pH/DIC,  $p\text{CO}_2$ /DIC,  $p\text{CO}_2$ /TA, DIC/TA, pH/ $p\text{CO}_2$ ). By adding the capability for remote access to the system, the Hales laboratory can view data, make adjustments as needed, and quickly identify the need for system maintenance if any discrepancies arise between the independent calculations of  $\Omega_{\text{arag}}$ .

This capability is key to the success of any monitoring partnership between shellfish growers and oceanographers. Most growers lack the familiarity with carbonate chemistry to identify errors in a time series quickly, and budgetary constraints limit the amount of time that researchers can spend traveling to and from commercial hatcheries. Remote access to the data allows researchers to identify sensor failures quickly and

deploy technicians as needed to optimize the overall quality of the time series.

A newly awarded grant from US IOOS and the NOAA OA Program's "Ocean Technology Transition" competition will allow the Hales laboratory to develop new lower cost and higher accuracy  $p\text{CO}_2$  sensor technology for OA monitoring, with expansion to new sites as advised by PCSGA. It will also strengthen existing regional partnerships through IOOS regional associations along the Pacific coast to implement and provide quality-assured tests of the new sensors. Dubbed "turning the headlights on high," this project seeks to improve and institutionalize the partnerships and successes to date, while commercializing a more stable and less costly  $p\text{CO}_2$  sensor desired by shellfish growers.

### EXPANDING THE PARTNERSHIP WITH OA SCIENTISTS

The PCSGA Monitoring Program's insistence on a high level of precision has had an immediate synergistic effect. When researchers developed the capability to actively monitor time series and maximize the overall quality of the data stream, the monitoring program became not only a sophisticated tool for helping shellfish hatcheries but also a resource for high quality, publishable carbonate chemistry data from coastal locations previously undocumented in efforts to monitor the coastal ocean.

These data are particularly valuable for quantifying the impacts of OA on coastal estuaries throughout the Pacific Northwest because the chemical monitoring stations were co-located with biological monitoring systems (i.e., hatchery production records; Table 2). This co-location allowed researchers to develop a better understanding the response of biota to the chemical parameters and at what thresholds. Moreover, the continuous chemistry data helped refine laboratory-based acidification exposure studies. Whereas most physiological experiments prior to that time focused on changes in steady-state conditions, as might occur

in the open ocean, the new temporally intensive data provided information on episodic exposures relating to the diurnal and tidal changes encountered by biota in nearshore habitats.

As an example, the work conducted at Whiskey Creek by researchers from Oregon State University has greatly increased scientific understanding of early shell formation in Pacific oyster larvae (Waldbusser et al., 2015), in addition to providing valuable insights to hatchery managers (Figures 2 and 3). Importantly, the larvae used in these studies were not exposed to artificially acidified conditions in laboratory trials but rather showed OA impacts when grown in seawater drawn directly from Netarts Bay. Such collaborative work illustrates the role that the PCSGA Monitoring Program can play in engaging researchers to work in important shellfish growing areas and the mutual benefits to all parties as they attempt to understand, and adapt to, coastal acidification in the Pacific Northwest.

Similar partnerships have developed between researchers and shellfish growers throughout Washington State. The relocation of a NOAA buoy within Dabob Bay to waters adjacent to Taylor Shellfish Hatchery represents an example of the responsiveness of NOAA and University of Washington researchers to the needs of shellfish growers and the mutual benefits of comparing buoy data to instrumentation at the hatchery. These industry/research partnerships have spawned research in additional shellfish growing areas important to the industry (<http://www.pacshell.org/about-us.asp>; <http://www.ocean.washington.edu/home/Simone+Alin>), and helped identify potential sites for future expansion of the monitoring network.

### Making Data Available to the Larger Community Through Interactions with NANOOS

Early on in the development of the PCSGA Monitoring Program, the shellfish industry began to interact with IOOS, and in particular with NANOOS,

the regional IOOS authority responsible for the Pacific Northwest. NANOOS recognized the potential value of PCSGA's program in monitoring coastal locations not previously represented in the larger effort to monitor ocean conditions in the Pacific Northwest, and became an essential partner in the effort to display these data streams online.

The shellfish industry is very interested in sharing data online so that it is accessible to as many growers as possible. In areas like Willapa Bay, coastal monitoring has become a valuable tool for growers with commercial setting stations because it helps them maximize the quality of water used to fill setting tanks. This can have dramatic impact on setting success and seed survival, and ultimately, the "bottom line" for shellfish growers. The partnership with NANOOS makes these data widely available to growers throughout the Northwest, as well as to the scientists involved.

Based on the success of the PCSGA Monitoring Program, the NOAA Ocean Acidification Program (OAP) subsequently worked with IOOS to provide three new  $p\text{CO}_2$ /DIC combined systems, which were recently installed in California and Alaska. These instruments significantly increase the number of shellfish growing areas represented in coastal monitoring programs and greatly extend the geographic extent of near-shore carbonate chemistry monitoring in the Pacific Northwest. These data should enhance understanding of OA impacts on coastal estuaries throughout the region.

In 2013, a Blue Ribbon panel of experts in Washington State recommended that the state provide funding to continue the PCSGA Monitoring Program and provided a detailed set of recommendations to combat OA at the state level (Washington State Blue Ribbon Panel on Ocean Acidification, 2012). The resulting funding, along with an Oregon legislature award to support monitoring at Whiskey Creek, ensures that the monitoring network will continue to provide essential information to the shellfish

industry. This funding also supported an upgrade of the existing  $p\text{CO}_2$  monitoring system at Taylor Shellfish to a system capable of measuring  $p\text{CO}_2$  and DIC. The improvement in data quality should facilitate better collaboration, as both hatcheries attempt to understand, and mitigate, OA effects on commercial production. The new IOOS-OAP award, leveraged with support from Washington and Oregon state funds, should extend the monitoring effort at least several years into the future.

### DEVELOPMENT OF COMMERCIAL-SCALE TREATMENT SYSTEMS IN HATCHERIES

Research at Whiskey Creek Shellfish Hatchery has identified  $\Omega_{\text{arag}} > 1.7$  as the minimum threshold for development of commercially viable larvae groups (Barton et al., 2012), although higher saturation states are preferred by hatchery managers. Monitoring at Whiskey Creek has shown that  $\Omega_{\text{arag}}$  now rarely exceeds this minimum threshold throughout the growing season, although nearshore California Current waters were likely at least 0.5 units higher prior to large-scale  $\text{CO}_2$  emissions from fossil fuels (Harris et al., 2013). Even in the spring, before the summertime upwelling season,  $\Omega_{\text{arag}}$  is less than optimal, and the hatchery has responded by installing chemical buffering systems that modify  $\Omega_{\text{arag}}$  in the hatchery year-round. These systems have been quite effective, restoring 30–50% of productivity lost in previous seasons and resulting in billions of additional eyed larvae supplied to growers each year. Discovering the link between acidification and seed production, and installation of buffering systems to correct the problem, has therefore kept the hatchery in business, maintaining seed supply to dozens of growers in Oregon, Washington, and California.

Commercial treatment system development at Whiskey Creek has benefited greatly from close collaboration with Chris Langdon and the

Molluscan Broodstock Program (MBP) at Oregon State University's Hatfield Marine Science Center in Newport, OR (<http://fw.oregonstate.edu/content/chris-langdon>). MBP has been an industry partner since its inception in 1996, developing high-yield Pacific oyster stocks for industry use. To produce these stocks, MBP operates a small research hatchery in Yaquina Bay, where production failures began as early as 2005, prior to the major production failures first observed at Whiskey Creek in 2007. Since 2007, MBP has worked collaboratively with Whiskey Creek, and ongoing research at MBP continues to inform treatment system development at both Whiskey Creek and Taylor Shellfish hatcheries.

Although buffering systems have greatly improved production at Whiskey Creek, they are insufficient to completely repair water chemistry issues impacting commercial hatcheries. Just as OA affects larvae in the hatchery setting, it also has a potential impact on biology in coastal waters throughout the Pacific Northwest (Bednaršek et al., 2014). The link between persistent summertime upwelling and low oxygen/high carbon dioxide regions over the inner continental shelf has been well documented (Hales et al., 2005, 2006; Chan et al., 2008; Feely et al., 2008). These oceanic waters are advected into the many small estuaries along the Pacific Northwest coast and can result in decreased estuarine oxygen conditions (Brown and Power, 2011). In Netarts Bay, local natural processes add to the oceanic signal, and as large amounts of seagrass and benthic micro- and macro-algae generated through the summer season begin to decay in August–October each year, carbon dioxide is increased and oxygen decreased. Although there was no regular water chemistry monitoring in Netarts Bay prior to 2009, conditions at the hatchery were historically conducive to larvae growth in September and early October. Since 2007, however, September and October have been characterized by poor water quality in the bay, forcing an

early end to the growing season.

Treatment systems designed to combat these secondary effects of OA have met with some limited success and are undergoing further development both at Whiskey Creek and at Taylor Shellfish Hatchery. However, shellfish growers throughout the Pacific Northwest have much more work ahead to first understand, and then correct, the late season deterioration of water conditions in coastal bays.

## LONGER-TERM STRATEGIES TO COMBAT THE IMPACTS OF COASTAL OA ON THE INDUSTRY

### Selective Breeding for OA Tolerance

One strategy to combat the advancement of OA in the Pacific Northwest involves the use of selective breeding to develop resistant stocks. Selective breeding of Pacific oysters in the Northwest began in 1996 with creation of the MBP. Selected broodstock, from both MBP and industry-based breeding programs, is now commonly used in commercial hatcheries. Although these existing stocks were not specifically selected for OA resistance, they have been reared in the coastal waters of the Pacific Northwest for four to five generations and may have developed some natural resistance to acidification stress. At Whiskey Creek Shellfish Hatchery, managers have elected to use only MBP-selected broodstock, based on anecdotal evidence that these stocks perform better even in early larval stages. Ongoing research, supported by both the Oregon and Washington legislatures, is specifically focused on selecting stocks that perform well when exposed to reduced saturation state, with particular emphasis on exposing oysters to low  $\Omega_{\text{arag}}$  in early larval stages. These breeding efforts are unlikely to identify larvae that are totally resistant to OA, but the existing gene pool may produce larvae with some tolerance, representing another valuable tool for hatcheries to employ in combating acidification impacts on commercial larval production.

### Expansion of Hatchery Capacity in Locations Outside the Pacific Northwest

Another strategy adopted by the shellfish industry to deal with OA in the Pacific Northwest involves expansion of existing hatchery facilities and construction of new facilities in remote locations. In particular, hatchery operations in Hawaii have expanded dramatically in the past three to four years, with the hope that these sites will be less impacted by OA than sites in the Pacific Northwest. OA is a global problem, however, so these efforts at best represent a short-term solution to carry the industry forward for the next few decades. Shellfish growers are aware of this fact, and the sheer amount of capital investment going into these adaptation strategies speaks volumes about the level of concern felt among growers throughout the Northwest.

### EMERGENCE OF THE SHELLFISH INDUSTRY AS A SPOKESGROUP FOR THE EFFECTS OF OA ON THE COASTAL OCEAN

Shellfish growers are, by definition, environmentalists, because their livelihood depends entirely on the health of the coastal ocean. However, a cross section of oyster farmers is unlikely to reveal a num-

and into the day-to-day life of shellfish growers—who now recognize a very clear and immediate threat to their industry and possess a fairly advanced level of understanding of acidification and the coastal processes affecting it (Mabardy, 2014). A recent survey found that over 50% of the those in the West Coast industry have personal experience with effects of OA, and 75% were very or extremely concerned about OA (Mabardy, 2014). There is hope among the industry, however, in that 59% of respondents indicated they believed they were definitely or somewhat able to adapt to OA.

The direct effects of OA on shellfish larval shell formation are troubling to shellfish growers and to many other groups concerned about the health of shell-forming organisms. However, the more complex, and indirect, effects of OA on the general health of coastal systems are even more disconcerting to the Pacific Northwest shellfish industry. Reports of seed mortality in commercial nurseries become more widespread each season and are likely related to the challenging conditions seed experience once they leave the protected waters of commercial hatcheries. While building capacity for buffering of remote setting tanks at commercial farms should provide some

“Shellfish growers are, by definition, environmentalists, because their livelihood depends entirely on the health of the coastal ocean.”


ber of outspoken environmental activists. Rather, the industry is typified by dedicated businessmen who would much rather put their heads down and work than participate in environmental advocacy. However, OA has leapt suddenly out of hypothetical discussions for the future

resiliency, as early post-metamorphic stages of bivalves appear to be more sensitive to acidification than later juveniles (Waldbusser et al., 2010), at some point demands for algal production and infrastructure require out-planting. The Pacific Northwest shellfish industry cannot treat

the entire coastal ocean, and the general deterioration of coastal water quality is a pressing concern for the entire industry.

Growers understand that development of treatment systems and new hatchery capacity are only stopgap measures, and the only real solution to OA is to address its causes. This puts shellfish farmers in a unique position, as business owners dependent on fossil fuels to maintain their livelihood, yet also heavily dependent on the health of the coastal ocean to produce sensitive shellfish species. A visit to any shellfish hatchery in the Pacific Northwest will reveal thousands of gallons of diesel or propane fuel on site, used to heat seawater for larvae production. Hatchery managers work within a paradox of simultaneously releasing CO<sub>2</sub> into the atmosphere to exacerbate OA and adding carbonate to seawater to repair it. However, the fact that shellfish growers live and work in the real, fossil-fuel-dominated world makes the industry an important voice in the discussion to slow the advance of OA worldwide.

Industry representatives now devote a great deal of time and energy to discussing coastal OA's impacts on the Pacific Northwest shellfish industry (Bill Dewey, Taylor Shellfish Farms, *pers. comm.*, December 4, 2014). Industry involvement has helped expand the discussion of acidification management from the single issue of global carbon reduction to include practical actions that can be taken at the local level to reduce and mitigate acidification effects. These local decision makers are fundamentally different entities, with fundamentally different science questions, than the groups interested in international-scale discussions of carbon inputs to the atmosphere. The direct involvement of shellfish industry representatives has contributed significantly to a growing body of literature that outlines strategies by which management actions can be targeted toward reducing the effects of OA at the local level (e.g., Kelly et al., 2011; Washington State Blue Ribbon Panel on Ocean Acidification, 2012; Strong et al., 2014).

Shellfish industry outreach efforts have paired effectively with regional not-for-profit organizations (<http://sustainablefish.org/global-programs/global-ocean-health>), with the primary focus of making direct contact with shellfish growers and fishermen, not only in the Northwest but also on the US East Coast and throughout the world. Recent workshops regarding the Gulf of Maine, Chesapeake Bay, Mexico, and New Zealand have brought together industry representatives, policymakers, and researchers, and have yielded similar results: growers and fishermen throughout all these regions are very concerned about potential impacts of OA on their industry and are universally interested in the role water quality monitoring can play in helping their industry face these challenges. In this way, the shellfish industry acts as a bridging organization between scientists, policymakers, and other stakeholders. By building consensus among those who work around and depend on a healthy ocean for their livelihood and the urban diners who consume their products, shellfish growers can contribute a powerful voice to discussions of OA and influence the difficult decisions necessary to halt its advance in the global ocean. 

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## ARTICLE CITATION

Barton, A., G. Waldbusser, R. Feely, S.B. Weisberg, J. Newton, B. Hales, S. Cudd, B. Eudeline, C. Langdon, I. Jefferds, T. King, A. Suhrbier, and K. McLaughlin. 2015. Impacts of coastal acidification on the Pacific Northwest shellfish industry and adaptation strategies implemented in response. *Oceanography* 28(2):xx–xx, <http://dx.doi.org/10.5670/oceanog.2015.xx>.

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Rebecca APPEL](#)  
**Cc:** [David Lawrence](#)  
**Subject:** consent forms  
**Date:** Thursday, October 15, 2015 8:00:56 AM

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Rebecca,  
Ian's form will be sent shortly. Rick's will be sent in about 2 hours.  
Many thanks,  
Madelyn

Sent from my iPhone

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: edits  
Date: Thursday, October 01, 2015 12:47:06 PM

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would this be ok? I think the energy drain is important, if we can keep it in, since editor is pushing for details

[Ocean currents pushed acidified water into coastal areas, depleting the energy baby oysters require to build protective shells. Without their shells, they drift with the tides until they die.](#)

Already oyster hatcheries on the West Coast of the United States are using technology [\[ocean observing buoys?\]](#) to adapt to ocean acidification and monitor water quality so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification. [\[line or 2 re how?\]](#)

thanks, Chris

From: [Phillip Williamson \(ENV\)](#)  
To: [rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov); [Boyd, Ian \(Defra\)](#); [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
Cc: [david.lawrence@defra.gsi.gov.uk](mailto:david.lawrence@defra.gsi.gov.uk); [errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov); [jayne.phenton@gmail.com](mailto:jayne.phenton@gmail.com); [Carol Turley](#)  
Subject: Fw: Ocean acidification  
Date: Thursday, October 15, 2015 11:36:01 AM

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Dear all

I'm very pleased to see that the Op-Ed has been published.

If any additional "scientific ammunition" is required, then there is a steady stream of reputable findings that could be cited; for example, see today's newsfeed (below) from the IAEA-hosted Ocean Acidification International Coordination Centre. If the links don't work, I'm happy to provide original articles.

Regards

Phil

\*\*\*\*\*

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School of Environmental Sciences  
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Norwich NR4 7TJ, UK  
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**From:** noreply+feedproxy@google.com <noreply+feedproxy@google.com> on behalf of Ocean acidification <noreply+feedproxy@google.com>

**Sent:** 15 October 2015 14:03

**To:** Phillip Williamson (ENV)

**Subject:** Ocean acidification

## Ocean acidification

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- **Ocean acidification could kill off marine life in the next few decades**
- **New research maps areas most vulnerable to ocean acidification**
- **Including high-frequency variability in coastal ocean acidification projections**
- **Don't forget the ocean!**
- **Unraveling ocean acidification's mysteries along the coast**

**Ocean acidification could kill off marine life in the next few decades**

Posted: 15 Oct 2015 05:43 AM PDT

A new paper published in the journal Proceedings of the National Academy of Sciences describes that marine animals dealing with warming waters and ocean acidification may have a “limited scope” for adaptation and survival. The study says that very few species will likely escape the increasingly negative impact of rising carbon dioxide levels dissolving into [...]

## New research maps areas most vulnerable to ocean acidification

Posted: 15 Oct 2015 05:40 AM PDT

New NOAA-led research maps the distribution of aragonite saturation state in both surface and subsurface waters of the global ocean and provides further evidence that ocean acidification is happening on a global scale. The study identifies the Arctic and Antarctic oceans, and the upwelling ocean waters off the west coasts of North America, South America [...]



## Including high-frequency variability in coastal ocean acidification projections

Posted: 15 Oct 2015 01:36 AM PDT

Assessing the impacts of anthropogenic ocean acidification requires knowledge of present-day and future environmental conditions. Here, we present a simple model for upwelling margins that projects anthropogenic acidification trajectories by combining high-temporal-resolution sensor data, hydrographic surveys for source water characterization, empirical relationships of the CO<sub>2</sub> system, and the atmospheric CO<sub>2</sub> record. This model characterizes CO<sub>2</sub> [...]

## Don't forget the ocean!

Posted: 15 Oct 2015 01:18 AM PDT

Around here, we're always thinking about the ocean. But sometimes the ocean isn't always top-of-mind for world leaders, who must balance many pressing concerns. Nevertheless, dozens of world political, scientific, and environmental leaders made time to attend the second “Our Ocean” conference in Valparaiso, Chile last week. Continuing the momentum developed at the first “Our [...]

## Unraveling ocean acidification's mysteries along the coast

Posted: 15 Oct 2015 01:15 AM PDT

In the past, we've shared good news with you about ocean acidification research funds allocated by the Federal government. Ever wonder what sorts of research projects NOAA supports with this money? A few days ago, NOAA announced three new awards to universities totaling \$1.3 million to study how ocean acidification is changing the coastal ocean. [...]



From: [Lawrence, David \(DEFRA\)](#)  
To: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
Subject: FW: your acidification op-ed  
Date: Thursday, October 15, 2015 5:50:38 AM

---

Hi Madelyn,

I would like to tweet Ian's piece when it goes live. Do you think you could link me to it when it does?

Many thanks

David

**David Lawrence** | Communications Officer |  
Department for Environment, Food and Rural Affairs  
Direct Line: **0207 238 6299** | Mobile: 0747114108 | Out of Hours: **0345 051 8486**  
Nobel House | 17 Smith Square | London, SW1P 3JR

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From: Madelyn Appelbaum - NOAA Federal [<mailto:madelyn.appelbaum@noaa.gov>]  
Sent: Wednesday, October 14, 2015 06:12 PM  
To: Boyd, Ian (Defra)  
Cc: Carol Turley <[CT@pml.ac.uk](mailto:CT@pml.ac.uk)>; Phillip Williamson <[P.Williamson@uea.ac.uk](mailto:P.Williamson@uea.ac.uk)>;  
[jayne.phenton@gmail.com](mailto:jayne.phenton@gmail.com) <[jayne.phenton@gmail.com](mailto:jayne.phenton@gmail.com)>  
Subject: your acidification op-ed

Dear Professor Boyd:

Unless there is an unexpected hold-up, your acidification op-ed will appear in tomorrow's International New York Times and online at NYTimes.com. I am delighted it will finally be published!.

Many thanks to you and Carol and Phil, and to Jayne for non-stop assistance almost every day over the past two months. I am extremely grateful to all of you.

Best wishes,  
Madelyn

Department for Environment, Food and Rural Affairs (Defra)

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: article amends from this end!  
Date: Wednesday, September 30, 2015 8:09:38 AM  
Attachments: [Untitled attachment 04109.htm](#)  
[INVT - draft of 29 Sept from Madelyn Applebaum \(PW\)\(CT\)V2 30September15.docx](#)

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Hi Chris,

I am working through all comments today and will send draft for your (again!) review. Sorry for so many rounds. Here's what landed from the UK...

Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Date:** September 30, 2015 at 8:06:16 AM EDT  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject:** Fwd: article amends from this end!

Sent from my iPhone

Begin forwarded message:

**From:** "Phenton, Jayne (DEFRA)"  
<[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)>  
**Date:** September 30, 2015 at 5:41:03 AM EDT  
**To:** "Madelyn Appelbaum - NOAA Federal  
([madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov))" <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject:** article amends from this end!

Hi Madelyn

The team have added some examples (Nemo the clown fish a particularly good one I think!) and a few thoughts. This is not a clean copy – I've left their comments in because I thought it might be helpful for you to see the reasoning, but if a tidy copy would be better, let me know and I can do that straight away.

Let me know what you think. By the by, I was thinking we should offer this to a national broadsheet here – be great for a comment piece on the Guardian website I think. Let me know if you have any thoughts – I don't

it would matter if it had already appeared in the NY Times although of course we would acknowledge that.

Hope all well there.

Best wishes

Jayne

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
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Department for Environment, Food and Rural Affairs (Defra)

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Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

**Comment [PW(1):** 'Currently' is necessary – since the average is not over the past 200 years.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH.

Seafloor areas where carbon dioxide naturally bubbles to the surface give a window to the future, causing dramatic biodiversity losses, reducing the size of surviving sea-snails, and changing fish behaviour. The west coast oyster industry has already suffered hatchery failures, threatening livelihoods.

Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution by plastics is now ubiquitous; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/

[Part covered by above] In Washington state, water treatment is now routinely used for the oyster hatcheries – but that can't protect the vast majority of marine wildlife. Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE? These changes are insidious, and many have gone un-noticed. We

have only very recently realised that ocean acidification

Some of the most dramatic changes are in polar seas where acidified seawater in polar seas is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will

**Comment [PW(2):** If we want these sentences to be more dramatic, the figures should be tons of CO2 rather than carbon. Then they are 550 (instead of 150) and 54 (instead of 15). But for greatest impact, US figures should be used\*: "On average, each citizen is currently responsible for the release of 770 lb of carbon dioxide into the atmosphere each week, of which around 20 lb then enters the ocean. These figures compare to a weekly domestic trash production of around 30 lb per person per week". If that construction is used, the coal train analogy doesn't work – since that is in terms of carbon (coal), not CO2.

**Comment [CT3]:** I don't like the use of "acidified" as implies pH is below 7. Better to use "....realised that ocean acidification in polar seas...."

become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that its consequences will ~~behave a~~ profound. Hearing loss in impairment in Nemo, the coral clownfish, is just one of many potential impacts that have been identified in laboratory studies effect on the structure of marine ecosystems. TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED. Other fFish around the world are likely to may be affected by food-web changes, since some microscopic plankton are likely to die out, whilst others may flourish, as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. Ocean acidification won't make seawater dangerous to swim in, but it will change the balance between the thousands of species that occur in every drop. Such changesIt will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

**Comment [CT4]:** Deafness and loss implies total loss of hearing. Perhaps better to use "Hearing impairment"

To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN? Whilst other stressors, such as pollution by plastics, may have different causes, the any weakening impacts of any one can worsen the consequences of the others.

**Comment [CT5]:** Not sure where you are going here. So could be a bit clearer. Do you mean as impact of one stressor weakens ecosystems the impact of other stressors is heightened?

Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: article on ocean acidification for the NYT  
Date: Thursday, October 01, 2015 1:03:09 PM

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this is terrific!  
after you sign off, I will immediately send to Rick  
goal will be to get this to paper by tomorrow am in Paris

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Thu, Oct 1, 2015 at 12:42 PM  
Subject: Re: article on ocean acidification for the NYT  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Madelyn, do you have a sense yet of when the authors might refile their op-ed?  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

On Mon, Sep 28, 2015 at 5:42 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

we will definitely beef it up  
many thanks  
Madelyn

Sent from my iPhone

> On Sep 28, 2015, at 11:19 AM, GREGORY, Joe <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)> wrote:

>

> [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum

> [202 482 4858](tel:2024824858)

> [202 340 6310](tel:2023406310) cell

>

>

> Dear Madelyn Appelbaum,

>

> Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?

> Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.

> I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,

> Best Wishes,

> Joe Gregory, INYT Opinion Pages

>

>

> Richard W. Spinrad

> Ian Boyd

- >
- >
- > Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.
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- > Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

- >
- > We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. **TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED.** Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.
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- > **ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?**
- > Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.
- > When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.
- >
- > Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs
- >

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Cc: [Rick Spinrad - NOAA Federal](#)  
Subject: Fwd: article on ocean acidification for the NYT  
Date: Monday, September 28, 2015 12:02:24 PM

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Hi Chris,  
Given your terrific help to this point...  
Perhaps you can respond to questions, too?  
Thank you,  
Madelyn

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Mon, Sep 28, 2015 at 11:55 AM  
Subject: Fwd: article on ocean acidification for the NYT  
To: Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>

Hi Rick,  
Didn't get anywhere in NY, but went to the international bureau in Paris where I know the staff.  
Asap, can you please send bullets in response to questions and I'll work them in along with the UK's responses  
Will send full op-ed back to you before resubmitting  
Many thanks,  
Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Mon, Sep 28, 2015 at 11:19 AM  
Subject: article on ocean acidification for the NYT  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
[202 482 4858](tel:2024824858)  
[202 340 6310](tel:2023406310) cell

Dear Madelyn Appelbaum,

Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?  
Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.  
I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING? WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/ Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will

become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. **TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED.** Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process. **ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?**

Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: baby oysters?  
Date: Thursday, October 01, 2015 12:33:35 PM

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depleting instead of draining?

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 12:31 PM  
Subject: baby oysters?  
To: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>

Ocean currents pushed acidified water into coastal areas, [draining] the energy baby oysters require to build protective shells and causing leaving them to float in coastal waters until they died.

From: [Rick Spinrad - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#)  
Subject: Fwd: Joint NOAA-UK OA Op-ed  
Date: Saturday, September 05, 2015 9:59:13 AM

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RESENDING ... I got an "Error in sending" message. Please confirm receipt

RS

*Chief Scientist*  
*National Oceanic and Atmospheric Administration*

Sent from my iPad

Begin forwarded message:

**From:** Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)>  
**Date:** September 5, 2015 at 6:56:44 AM PDT  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Cc:** Ciaran Clayton - NOAA Federal <[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)>  
**Subject: Re: Joint NOAA-UK OA Op-ed**

Madelyn - This is excellent. My only recommendation is to provide specific citation information for the two NOAA studies referred to (shellfish industry impacts, and CO2 emission rates). I think the tone and content are good.

RS

*Chief Scientist*  
*National Oceanic and Atmospheric Administration*

Sent from my iPad

On Sep 4, 2015, at 6:48 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Here is Ian Boyd's signed-off op-ed copy. Much of the initial content and flow remain intact, but our version was deemed a "bit too emotive," so attached is toned down. I have been ping-ponging with Boyd and several on his staff since Aug 6 and hope attached will be ok. But if anything gives you heartburn, I will revisit. I suggest taking a first shot with the NY Times and international version, although some of what I believe would have captured the editors' attention is now drained out.

Many thanks and have a terrific holiday weekend,  
Madelyn

<NOAA-DEFRA ocean acidification op-ed Sept 4 15.docx>

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Phenton, Jayne \(DEFRA\)](#)  
Subject: Fwd: Oped for NYT final version  
Date: Tuesday, October 06, 2015 8:17:32 AM  
Attachments: [spinrad.final.docx](#)

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Ivan's affiliation wasn't yet corrected, but otherwise looks intact. A relief!  
If you think necessary, please run by Ivan, if at all possible today, but this is the version he's already signed off on.  
"alarm" is out...so are Maine references that were questioned  
a nice going away gift for you!!

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Tue, Oct 6, 2015 at 7:54 AM  
Subject: Oped for NYT final version  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Hello Madelyn, Here is the final version, incorporating the fixes you sent. Please give it a close read and make any final changes IN CAPITAL LETTERS ON THIS VERSION.  
I expect this will run soon, we will let you know when we publish,  
Thanks for your efforts,  
Joe

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed. Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other

materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the British government's Department of Environment, Food and Rural Affairs

madelyn.appelbaum@noaa.govMadelyn Appelbaum

202 482 4858

202 340 6310 cell

Contact: Madelyn Appelbaum/NOAA

+1 202 482 4858 office

+1 202 340 6310 cell

In a High CO<sub>2</sub> World, Dangerous Waters Ahead

Richard W. Spinrad

Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it

will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#); [Ian Boyd](#)  
Cc: [Errin Holmes - NOAA Federal](#)  
Subject: Fwd: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 4:38:28 AM  
Attachments: [Untitled attachment 02640.htm](#)  
[Contributor package w W9.pdf](#)

---

Can you please sign and return the attached ASAP today, or let me know that I can sign on your behalf?

Thanks,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** "APPEL, Rebecca" <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject:** Publication of Op-Ed in INYT

Dear Madelyn,

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At this stage, could you please have them each sign and email back a copy of our contributor contract, attached here, or do so on their behalf? (Just ignore the W9.)

Don't hesitate to ask if you have any questions, and thanks again for all your help.

Best,

Rebecca

Rebecca Appel

International New York Times Editorial Page

+44 207 061 6676

620 EIGHTH AVENUE  
NEW YORK, N.Y. 10018

Congratulations. Your opinion submission to The New York Times/The International New York Times has been provisionally accepted. We need you to take three steps right away:

1. Read the attached fact-checking policy and assist us in protecting you from making errors.
2. Read, sign and return the attached contributor's agreement, preferably via e-mail to

## FACT-CHECKING POLICY FOR OPINION CONTRIBUTORS

Dear Contributor:

Before we publish your article — whether in print on the Op-Ed page, in the Sunday Review section, in The International New York Times, or online-only — it must be fact-checked. Our process is intended as much to protect you, the writer, as it is to protect us. Our readers are well-informed, skeptical and often eager to point out even the smallest of errors, as you can see from the corrections The Times publishes each day, in print and online. **A factual error at best detracts from, and at worst can seriously undermine, the credibility of an article and its author.**

Typically, we focus our checking on verifiable facts (e.g. the number of Americans without health insurance, the median household income, the date a law was enacted). However, we also investigate broader factual assertions (e.g. “No one named to the court in the postwar period was as conservative as Justice Scalia or as liberal as Justice Brennan,” “Laos is one of the world’s most corrupt nations”) that may need to be qualified, explained or stated with greater precision or nuance — so that, if challenged, they are completely defensible.

While we usually do not contact the original speaker to check quotations from interviews, we always verify facts within those quotations and, in cases of public remarks, confirm that the quotation is rendered and attributed accurately. We look at empirical evidence to verify that the methodology is sound and that the data is presented with precision and balance. If we determine that a particular fact cannot be verified or defended, we will not publish it.

**To assist in this process, please send your editor an annotated copy of your article, in which you list the relevant source(s) following each factual assertion.** Sources include books, newspaper and magazine articles, academic papers and Web sites. We prefer primary sources (e.g. an N.I.H. research paper) to secondary ones (e.g. a news article about the paper’s findings). In most cases, where an online source is available, provide the Web link. Attach, in e-mail, documents not easily found online (e.g. journal articles that are behind pay walls). **Provide page numbers.** Include phone numbers and e-mail addresses of anyone you have interviewed and quoted. Your editor, or a fact-checker, will follow up with additional questions as needed.

**We will work to verify the facts in your article, but as the writer, you bear the ultimate responsibility for the accuracy of your work. We cannot “fix” anything post-publication without appending a correction — and corrections are permanently archived. Past errors are a factor when we consider whether to accept future work from a writer.**

Thank you for your cooperation.

— The Editors

# The New York Times

NEW YORK — LONDON — PARIS — HONG KONG

Dear Opinion Contributor:

This letter sets forth the terms of your Agreement with The New York Times Company (“The Times”) with respect to all material (the “Material”) you submit to the opinion sections of *The New York Times* and the *International New York Times*, across all print and electronic editions, including any to be later developed.

1. (a) You agree to prepare such articles as you and your editors may agree upon for publication, in print and/or online. Subject to the acceptance and publication of the Material, The Times will pay you a fee.

(b) The Material will be submitted by a mutually agreed-upon deadline. You agree to cooperate with The Times’s normal editing processes, including making and reviewing revisions as requested. You will also comply with The Times’s fact-checking policy, which is attached.

2. (a) You acknowledge that the Material has been commissioned by The Times as a contribution to a collective work and that The Times’s interest therein arises as a “work-for-hire” under the United States Copyright Act. The Times hereby assigns to you a joint copyright interest in the Material, such that it shall be deemed joint work owned by The Times and by you. (In the event the Material is deemed not to be a “work-for-hire,” you hereby assign to The Times a joint copyright interest in the Material, to effect joint copyright ownership.)

(b) As joint copyright owners, The Times and you shall each have the irrevocable, non-exclusive right to exercise any and all rights granted by the United States Copyright Act, including, but not limited to, the right to reproduce, display, distribute, sell, translate and transmit the Material throughout the world, in any media now known or later developed, and to sublicense the foregoing rights and to create derivative works — provided that neither you nor The Times shall have the right to grant rights in the Material that would purport to restrict the rights of the other party under this Agreement, and provided that your exercise of these rights shall be subject to paragraph 3 below and shall begin 30 days after The Times first publishes the Material.

(c) Neither party shall be obligated to share revenues from exercise of the foregoing rights, except that The Times will pay you fifty percent (50%) of the net receipts (that is, receipts after deduction of syndication expenses) from any one-time syndication of the Material (“Syndication Fee”). Material is “syndicated” when it is sold individually to a third party for republication in any form. (The use of Material by regular clients of The New York Times Syndicate is not a “syndication” for which compensation would be owed.) If any Material is syndicated for use in an advertisement or promotion, there will be a maximum Syndication Fee.

3. You will require any republication of the Material authorized by you to indicate that the Material was originally published in *The New York Times* or the *International New York Times*. (However, failure by the subsequent publisher or other user to provide such credit will not be deemed a breach of this Agreement, if you can demonstrate that you required crediting as a condition of the grant of rights.) Except for the foregoing requirement, The Times must give you prior written approval to use its name in connection with your use or licensing of the Material.

4. The Times shall have the right to use your name and approved likeness in connection with the advertising or promotion of *The New York Times* and the *International New York Times*.

5. You warrant that the Material will be original and will not plagiarize another’s work, infringe another’s copyright or violate any person’s rights, including the right of privacy; that the Material will not contain libelous, unlawful, false or misleading material; and that the Material will not have appeared elsewhere, in whole or in part,



# Request for Taxpayer Identification Number and Certification

Give Form to the  
requester. Do not  
send to the IRS.

Print or type See Specific Instructions on page 2.	Name (as shown on your income tax return)	
	Business name/disregarded entity name, if different from above	
	Check appropriate box for federal tax classification: <input type="checkbox"/> Individual/sole proprietor <input type="checkbox"/> C Corporation <input type="checkbox"/> S Corporation <input type="checkbox"/> Partnership <input type="checkbox"/> Trust/estate  <input type="checkbox"/> Limited liability company. Enter the tax classification (C=C corporation, S=S corporation, P=partnership) ▶ _____  <input type="checkbox"/> Other (see instructions) ▶ _____	Exemptions (see instructions):  Exempt payee code (if any) _____ Exemption from FATCA reporting code (if any) _____
	Address (number, street, and apt. or suite no.)	Requester's name and address (optional)
	City, state, and ZIP code	
List account number(s) here (optional)		

## Part I Taxpayer Identification Number (TIN)

Enter your TIN in the appropriate box. The TIN provided must match the name given on the "Name" line to avoid backup withholding. For individuals, this is your social security number (SSN). However, for a resident alien, sole proprietor, or disregarded entity, see the Part I instructions on page 3. For other entities, it is your employer identification number (EIN). If you do not have a number, see *How to get a TIN* on page 3.

**Note.** If the account is in more than one name, see the chart on page 4 for guidelines on whose number to enter.

Social security number								
				-				
Employer identification number								
				-				

## Part II Certification

Under penalties of perjury, I certify that:

1. The number shown on this form is my correct taxpayer identification number (or I am waiting for a number to be issued to me), and
2. I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding, and
3. I am a U.S. citizen or other U.S. person (defined below), and
4. The FATCA code(s) entered on this form (if any) indicating that I am exempt from FATCA reporting is correct.

**Certification instructions.** You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return. For real estate transactions, item 2 does not apply. For mortgage interest paid, acquisition or abandonment of secured property, cancellation of debt, contributions to an individual retirement arrangement (IRA), and generally, payments other than interest and dividends, you are not required to sign the certification, but you must provide your correct TIN. See the instructions on page 3.

Sign  
Here

Signature of  
U.S. person ▶

Date ▶

## General Instructions

Section references are to the Internal Revenue Code unless otherwise noted.

**Future developments.** The IRS has created a page on IRS.gov for information about Form W-9, at [www.irs.gov/w9](http://www.irs.gov/w9). Information about any future developments affecting Form W-9 (such as legislation enacted after we release it) will be posted on that page.

## Purpose of Form

A person who is required to file an information return with the IRS must obtain your correct taxpayer identification number (TIN) to report, for example, income paid to you, payments made to you in settlement of payment card and third party network transactions, real estate transactions, mortgage interest you paid, acquisition or abandonment of secured property, cancellation of debt, or contributions you made to an IRA.

Use Form W-9 only if you are a U.S. person (including a resident alien), to provide your correct TIN to the person requesting it (the requester) and, when applicable, to:

1. Certify that the TIN you are giving is correct (or you are waiting for a number to be issued),
2. Certify that you are not subject to backup withholding, or
3. Claim exemption from backup withholding if you are a U.S. exempt payee. If applicable, you are also certifying that as a U.S. person, your allocable share of any partnership income from a U.S. trade or business is not subject to the

withholding tax on foreign partners' share of effectively connected income, and

4. Certify that FATCA code(s) entered on this form (if any) indicating that you are exempt from the FATCA reporting, is correct.

**Note.** If you are a U.S. person and a requester gives you a form other than Form W-9 to request your TIN, you must use the requester's form if it is substantially similar to this Form W-9.

**Definition of a U.S. person.** For federal tax purposes, you are considered a U.S. person if you are:

- An individual who is a U.S. citizen or U.S. resident alien,
- A partnership, corporation, company, or association created or organized in the United States or under the laws of the United States,
- An estate (other than a foreign estate), or
- A domestic trust (as defined in Regulations section 301.7701-7).

**Special rules for partnerships.** Partnerships that conduct a trade or business in the United States are generally required to pay a withholding tax under section 1446 on any foreign partners' share of effectively connected taxable income from such business. Further, in certain cases where a Form W-9 has not been received, the rules under section 1446 require a partnership to presume that a partner is a foreign person, and pay the section 1446 withholding tax. Therefore, if you are a U.S. person that is a partner in a partnership conducting a trade or business in the United States, provide Form W-9 to the partnership to establish your U.S. status and avoid section 1446 withholding on your share of partnership income.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#); [Ian Boyd](#)  
Cc: [Errin Holmes - NOAA Federal](#)  
Subject: Fwd: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 5:30:45 AM  
Attachments: [Untitled attachment 02604.htm](#)  
[Contributor package w W9.pdf](#)

---

Should clarify that you do not need to bother with most of attached. The article has already been thoroughly fact-checked and cited. There is just a box to insert basic contact info and the required signature. Form can be scanned and e-mailed to NY Times in NY.

This is the last step. Thank you!

Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>, Ian Boyd <[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject:** Fwd: Publication of Op-Ed in INYT

Can you please sign and return the attached ASAP today, or let me know that I can sign on your behalf?

Thanks,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** "APPEL, Rebecca" <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
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(Just

ignore the W9.)

Don't hesitate to ask if you have any questions, and thanks again for  
all

your help.

Best,

Rebecca

Rebecca Appel

International New York Times Editorial Page

+44 207 061 6676

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Errin Holmes - NOAA Federal](#)  
Subject: Fwd: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 7:54:03 AM

---

Errin, can you please handle this, or we can do it together so Rick's signature is on the form.  
Hope form can be signed assp this am.

Thanks,

Sent from my iPhone

Begin forwarded message:

**From:** Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)>  
**Date:** October 15, 2015 at 7:45:11 AM EDT  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Cc:** Ian Boyd <[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>, Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject: Re: Publication of Op-Ed in INYT**

Madelyn - I'm in Boulder. Either you can sign for me, or Errin can insert my signature electronically.

RS

*Chief Scientist  
National Oceanic and Atmospheric Administration*

Sent from my iPad

On Oct 15, 2015, at 2:38 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Can you please sign and return the attached ASAP today, or let me know that I can sign on your behalf?

Thanks,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** "APPEL, Rebecca" <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
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Rebecca  
Rebecca Appel  
International New York Times Editorial Page  
+44 207 061 6676

<Contributor package w W9.pdf>

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [David Lawrence](#)  
Subject: Fwd: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 7:45:54 AM  
Attachments: [Untitled attachment 02577.htm](#)  
[Contributor package w W9.pdf](#)

---

David,  
Can you see the below messages and let me know if the form is being taken care of  
Thank you,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>, Ian Boyd  
<[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
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<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>, Ian  
Boyd <[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject:** Fwd: Publication of Op-Ed in INYT

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Sent from my iPhone

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email back a copy  
of our contributor contract, attached here, or do so on  
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ignore the W9.)  
Don't hesitate to ask if you have any questions, and  
thanks again for all  
your help.  
Best,  
Rebecca  
Rebecca Appel  
International New York Times Editorial Page  
+44 207 061 6676

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: question  
Date: Thursday, October 01, 2015 2:47:03 PM

---

meant multitude of microscopic life...  
seems that may work best  
ok?

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 2:45 PM  
Subject: question  
To: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>

Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic **life** that can be found in every drop of seawater.

Chris, should this revert to plants and animals? multitudes of microscopic life?  
"lives" doesn't work

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Jennifer Mintz - NOAA Federal](#)  
Subject: Fwd: quick request  
Date: Wednesday, October 14, 2015 1:43:10 PM

---

for future reference

----- Forwarded message -----

From: **Denis Allemand (CSM)** <[allemand@centrescientifique.mc](mailto:allemand@centrescientifique.mc)>  
Date: Wed, Oct 14, 2015 at 1:09 PM  
Subject: Fwd: quick request  
To: Stéphanie Reynaud <[sreynaud@centrescientifique.mc](mailto:sreynaud@centrescientifique.mc)>  
Cc: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Dear Stéphanie

Do you have a picture illustrating the fact of OA on corals among those you took in Papouasia New Guinea?

Thanks in advance.

Denis

Début du message réexpédié :

**De:** Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Objet:** quick request  
**Date:** 14 octobre 2015 16:43:10 UTC+2  
**À:** Denis Allemand <[allemand@centrescientifique.mc](mailto:allemand@centrescientifique.mc)>, Carol Turley  
<[CT@pml.ac.uk](mailto:CT@pml.ac.uk)>, Phillip Williamson <[P.Williamson@uea.ac.uk](mailto:P.Williamson@uea.ac.uk)>

NY Times is about to run acidification op-ed from NOAA/UK  
will send you the link

any chance of a high resolution image that shows acidification damage to  
corals/seabed?  
deadline is tight

thanks,  
Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: Rick's edits  
Date: Thursday, August 06, 2015 10:06:51 AM  
Attachments: [NOAA UK oped 8 6 15.docx](#)

---

Chris, whatever you think best but it seems both additions could seamlessly work at the end of this par?

Smart investments in monitoring and observing are critical to building resilience and hedging risk. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential. **[Without them, we would not have the forecasting capability to predict hotspots in many regions. However, there is still a crucial need to measure regions such as Antartica where...**

**we also need the capability to predict at [scales-- simple language], enabling, for example, daily adjustments to water intake at shellfish farms which can determine whether an industry thrives or [crashes] and to long-term planning for ocean-based infrastructure so pivotal to...]**

or please ditch and address his edits differently

thanks, Chris

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Aug 6, 2015 at 9:21 AM  
Subject: Rick's edits  
To: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>

Good morning, Chris.

Rick really likes the op-ed, and I explained how indispensable you've been in developing it. He's asked for just a few edits, most of which I can handle, but perhaps you can flesh out these

2

and plug them into the op-ed, or I can do that once I have the right substance to work with? Started fleshing them out myself, then realized you'd change the text anyway so sending to you upfront

and this truly is the last round, pre-UK...honest

thanks yet again!

Madelyn

We should emphasize that we know about these hot spots because we've been able to measure in these hot spots, but there are many areas of the ocean where we don't have measurements, like parts of the Antarctic where it's critical to measure because...

I'd like to include something about being able to predict at multiple spatial and temporal scales (stated more eloquently than that, of course), because the applications of such predictive products include uses from daily adjustments for water-intake at shellfish farms, to long-term planning for ocean-based infrastructure such as...

## In a High CO<sub>2</sub> World, Ocean Hotspots Tell a Disturbing Story

In waters around the world, ocean hotspots are beginning to tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, threatening the chemical balance of our ocean and coastal waters and their fragile, finite marine life. Over the past 200 years, the sea has absorbed more than 150 billion metric tons of carbon from human activities. It's now absorbing more than 2.5 billion metric tons every year, enough to fill a coal train long enough to encircle the equator 13 times.

The consequences of disrupting what has been a relatively stable ocean environment for tens of millions of years are beginning to show. As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating conditions that eat away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs, plants and much more are at risk, especially since, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each stressor is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. This year the first nationwide study of the vulnerability of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of hotspots: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Acidity also is apparent off the Alaskan coast, which accounts for nearly 60 percent of the U.S. commercial fish catch and supports more than 100,000 jobs.

There are concerns in the Mediterranean Sea and in waters around the UK and Germany. In the UK... [more *from UK*] Ocean acidification is weakening coral structures in the Great Barrier Reef, and threatening native fisheries in the Patagonian waters of southern Chile. The most dramatic change is already occurring in the Arctic where water can be corrosive enough to dissolve nearby shelled creatures. **In coming decades, the Southern Ocean in Antarctica is expected to see comparable changes, but direct measurements there and in other remote ocean regions are still sparse. To better prepare for hotspots, more regions must be studied.**

There is urgency to substantially reducing carbon dioxide emissions. A recent NOAA study found that, over the past 15 years, the rate of global warming has been as fast or faster than seen during the latter half of the 20<sup>th</sup> century. There has been no downward trend in our high CO<sub>2</sub> world and both of our nations have called for unprecedented actions to reduce emissions. Tackling ocean acidification is a steep challenge. But it's also a dynamic opportunity to inspire profound advances in our understanding of the ocean. In July, an enterprising team from a small **company** in Montana won the **Wendy Schmidt Ocean Health XPrize** for developing breakthrough technologies to measure ocean acidity. To better understand the sea's response to CO<sub>2</sub>, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

continued

Smart investments in monitoring and observing are critical to building resilience and hedging risk **that can directly affect community, regional and global economies**. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential. **Studying local and regional variability, for example, will allow scientists to predict chemical changes near shellfish farms so growers can adjust water chemistry for the short-term, and develop adaptation strategies for the long-term.**

We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals. The new 30-nation network still has gaps in global coverage, and more nations are needed to fill them. **[deleted...To understand the sea, we must first observe it.]** The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. Locally to globally, we are all the stakeholders.

###

Authors:

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Contacts:

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[Madelyn.Appelbaum@noaa.gov](mailto:Madelyn.Appelbaum@noaa.gov)  
001 202 482 4858  
011 292 349 6310 cell

Jayne Phenton – UK  
[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)

011 44 20 7238 6600

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: rush question  
Date: Thursday, October 01, 2015 3:58:32 PM

---

Rick changed my wording...  
Can you validate this statement?  
Couldn't reach Mark via phone.  
Thanks,  
Madelyn

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 3:57 PM  
Subject: rush question  
To: Mark Green <[mgreen@sjcme.edu](mailto:mgreen@sjcme.edu)>

*In Maine, clam farmers can no longer fill their buckets to the top because shells on the bottom will shatter from the weight.*

Hi Mark,  
Way back you helped with an OA question. I am now rushing with an op-ed for Rick Spinrad (due 8 am tomorrow in Europe) and want to again fact-check.

Many thanks and hope all is well.

Madelyn Appelbaum/NOAA

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Boyd, Ian \(Defra\)](#)  
Cc: [Carol Turley](#); [Phillip Williamson](#)  
Subject: Fwd: Thank you  
Date: Thursday, October 15, 2015 10:17:47 AM

---

Please see below.

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Thu, Oct 15, 2015 at 10:13 AM  
Subject: Re: Thank you  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Cc: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>, "APPEL, Rebecca" <[rappel@nytimes.com](mailto:rappel@nytimes.com)>

Hello Madelyn, thanks for your help. Regarding the title, our style is to use British government so we would stick with that, it certainly is clear about his position, Best Wishes,  
Joe

On Thu, Oct 15, 2015 at 4:11 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Joe, many, many thanks. I also appreciate the work of Louise and Rebecca.

Ian uses this title so wonder if that edit can be made?

Ian Boyd is the chief scientific adviser to the **UK** government's Department of Environment,  
Food and Rural Affairs.

Best wishes and continuing success,  
Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: thank you  
Date: Thursday, October 01, 2015 4:55:27 PM

---

should I leave as is?  
or please decipher...

(and why should you believe me but I truly think this is the last question)

----- Forwarded message -----

From: **Mark Green** <[mgreen@sjcme.edu](mailto:mgreen@sjcme.edu)>  
Date: Thu, Oct 1, 2015 at 4:52 PM  
Subject: Re: thank you  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Try something like this. If I've messed up your word quota you at least get the idea of what it should say.

Good luck with the deadline. Thanks.

And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution. When excess nutrients are added to the coastal ocean an increase in microscopic plants called phytoplankton occurs. When this phytoplankton dies and decomposes acid, in the form of CO<sub>2</sub>, is produced lowering the pH of the seawater.

> On Oct 1, 2015, at 4:45 PM, Madelyn Appelbaum - NOAA Federal  
> <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

>

> And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification by enhancing the uptake of carbon dioxide from the atmosphere.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Jennifer Mintz - NOAA Federal](#)  
Subject: Fwd: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:41:06 AM  
Attachments: [spirad.draft.docx](#)

---

or seabed harm...

----- Forwarded message -----

From: **Loftus, Louise** <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>  
Date: Wed, Oct 14, 2015 at 10:27 AM  
Subject: your oped in NYT >> request  
To: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
Cc: Joe GREGORY <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>

Hello,

I'm one of the web editors for the opinion section. I was talking to Joe today about the possibility of including before/after images of coral or areas of the sea bed that show the impact that acidification has had.

Does your organization have images that illustrate this that we could use on [nytimes.com](http://nytimes.com) (your piece will have an illustration in print, this is for online only).

If so, please do send along with information on how these should be captioned and credited.

For it to be possible I'd need to receive the images sometime today. Sorry for the short notice and if it's not possible then not to worry, if it is possible -- great!

Thanks,

Louise

Louise Loftus  
Staff Editor, International Opinion  
The New York Times

18 Museum Street, London WC1A 1JN, United Kingdom

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Wed, Oct 14, 2015 at 2:47 PM  
Subject: spinrad draft  
To: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

madelyn.appelbaum@noaa.govMadelyn Appelbaum  
[202 482 4858](tel:2024824858)  
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In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

madelyn.appelbaum@noaa.govMadelyn Appelbaum  
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[+1 202 340 6310](tel:+12023406310) cell

In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters **IS CHANGING AND A GROWING THREAT TO MARINE ECOSYSTEMS**. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and

observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

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In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad

Ian Boyd

madelyn.appelbaum@noaa.govMadelyn Appelbaum

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## In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad

Ian Boyd

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About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

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We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration

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When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#); [Mark Eakin - NOAA Federal](#)  
Subject: Fwd: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:35:59 AM  
Attachments: [spirad.draft.docx](#)

---

Hi and any chance for a before/after corals image reflecting injury from ocean acidification?  
This is for NY Times and needed quickly.  
Thank you.  
Madelyn

----- Forwarded message -----

From: **Loftus, Louise** <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>  
Date: Wed, Oct 14, 2015 at 10:27 AM  
Subject: your oped in NYT >> request  
To: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
Cc: Joe GREGORY <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>

Hello,

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Does your organization have images that illustrate this that we could use on [nytimes.com](http://nytimes.com) (your piece will have an illustration in print, this is for online only).

If so, please do send along with information on how these should be captioned and credited.

For it to be possible I'd need to receive the images sometime today. Sorry for the short notice and if it's not possible then not to worry, if it is possible -- great!

Thanks,

Louise

Louise Loftus  
Staff Editor, International Opinion  
The New York Times

18 Museum Street, London WC1A 1JN, United Kingdom

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Wed, Oct 14, 2015 at 2:47 PM

Subject: spinrad draft  
To: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
[202 482 4858](tel:2024824858)  
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Contact: Madelyn Appelbaum/NOAA  
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In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

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Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters IS CHANGING AND A GROWING THREAT TO MARINE ECOSYSTEMS. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it

dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability

to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Fwd: your op-ed  
Date: Thursday, October 01, 2015 3:50:13 PM  
Attachments: [OA op-ed 1 10 2015 RWS.docx](#)

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minor edits from Rick  
thanks!!

On Thu, Oct 1, 2015 at 2:23 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Rick, given tight timing, can you please return any edits in red and as an attachment?  
Thanks.

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 2:15 PM  
Subject: your op-ed  
To: Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>  
Cc: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>, Ciaran Clayton - NOAA  
Federal <[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)>

...wirth an endless list of thanks to Chris  
unless you have a mega edit and I need to go another round with UK, will get this to paper  
as soon as you sign off

thank you and let's hope this one flies!  
new text in red

Madelyn

--

*Dr. Rick Spinrad  
Chief Scientist  
National Oceanic and Atmospheric Administration*

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that is going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce, and build their shells and skeletons. ~~About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. Without these shells, they drift with the tides until they die. In effect, the crop was nearly destroyed. In Maine, a clam farmers reported that he could no longer fill his their buckets to the top because shells on the bottom would shatter from the weight.~~ Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster when waters are more acidic. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; ~~pollution from plastics and other materials, is pervasive~~; and in general we over-exploit the resources of the ocean. Each stressor is cause for concern, but all of them affecting the oceans at one time are cause for alarm. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean, and in the cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, ~~reducing critical habitat for fish and the resilience of the entire reef system.~~ Dramatic change is also apparent in the Arctic where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, ~~affecting food sources for indigenous people, fish, birds and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse.~~ To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. ~~Research already points to the unnatural behavior of Nemo when the coral clownfish is studied in an acidic environment. He These fish wanders farther away from his protective [RICK...descriptive word for~~

~~home?]~~ ~~home~~ natural protection, making ~~him~~ them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms —called pteropods — that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic plants and animals that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the acute challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting prediction by integrating existing observations from gliders, hydrographic surveys, unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification by enhancing the uptake of carbon dioxide from the atmosphere.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

Contact: Madelyn Appelbaum/NOAA  
+1 202 482 4858 office  
+1 202 340 6310 cell

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Subject: Fwd: your op-ed  
Date: Thursday, October 01, 2015 2:23:07 PM

---

Rick, given tight timing, can you please return any edits in red and as an attachment?  
Thanks.

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 2:15 PM  
Subject: your op-ed  
To: Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>  
Cc: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>, Ciaran Clayton - NOAA Federal <[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)>

...wirth an endless list of thanks to Chris  
unless you have a mega edit and I need to go another round with UK, will get this to paper as soon as you sign off

thank you and let's hope this one flies!  
new text in red

Madelyn

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#)  
**Subject:** Help!  
**Date:** Thursday, October 01, 2015 9:19:56 PM

---

Chris, this just hit...

Is "increasing acidity" at opening of 3rd par incorrect?

if anyone flagged it, I missed it

thanks

Sent from my iPhone

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: INYT done deal please see asap  
Date: Monday, October 05, 2015 11:12:13 AM

---

best fact checker for #1?  
I'll handle the rest  
thanks!

----- Forwarded message -----

From: **APPEL, Rebecca** <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
Date: Mon, Oct 5, 2015 at 10:57 AM  
Subject: Spinrad/Boyd op-ed for INYT-- follow up questions  
To: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)

Dear Madelyn,

I work with Joe Gregory on the INYT Op-ed pages, and am helping him to factcheck the upcoming Spinrad/Boyd column. I've gone through it and have just a few questions for you, pasted below. Could you please take a look and respond to these as soon as possible? Don't hesitate to ask if anything is unclear.

Many thanks in advance, and all best,  
Rebecca

Rebecca Appel

International New York Times Editorial Page

 [+44 207 061 6676](tel:+442070616676)

1. About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs

I'm seeing a different figure for the value of the Pacific Northwest oyster industry, and also that the 3,000 jobs refer to the entire West Coast shellfish industry, not Pac Northwest oyster production specifically: "Oyster production represents \$84 million of the West Coast shellfish industry, which supports more than 3,000 jobs." See:  
[http://www.noaa.gov/features/01\\_economic/pacificoysters.html](http://www.noaa.gov/features/01_economic/pacificoysters.html) and  
<http://www.pmel.noaa.gov/co2/story/Pacific+Oysters+Gain+from+Ocean+Acidification+Data>.

Can you please confirm both of these points, and send a source?

2. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever

Can you please send a link to this study, or a copy of the report?

3. We are pleased that representatives of our two nations lead the pioneering [Global Ocean Acidification Observing Network](#),

Should we rephrase here? It looks like the current co-chairs are from the U.S. and Australia, right?

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Jennifer Mintz - NOAA Federal](#)  
**Date:** Wednesday, October 14, 2015 12:22:27 PM

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Pteropods, sometimes called sea butterflies, are a vital food source for fish such as salmon and herring. Left, a pteropod that has lived in normal conditions in a laboratory for six days, and, on the right, a pteropod showing the effects of living in acidified water for the same time period. The white lines indicate shell dissolution, showing why ocean acidification is often called "osteoporosis of the sea."

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Libby Jewett - NOAA Federal](#)  
Subject: NOAA- UK op-Ed  
Date: Thursday, September 03, 2015 1:41:22 PM  
Attachments: [Untitled attachment 05561.htm](#)  
[Proposed DEFRA- NOAA OA op-ed 2Sept FINAL.docx](#)

---

My computer isn't working so hope this forwards ok. Talk to you at 2 45 re next steps.  
Thanks,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** "Phenton, Jayne (DEFRA)" <[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)>  
**Date:** September 3, 2015 at 12:23:04 PM EDT  
**To:** "Madelyn Appelbaum - NOAA Federal ([madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov))" <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject:** Oean acidification op ed

Hi Madelyn

Ooh it's been a bit of a journey, but I think we're finally here – at least from this end!!

A few things:

1. Prof Ian Boyd is not keen on emotive language so it's a bit devoid of adjectives now!
2. Our marine colleagues were very particular about how we described what the seawater does to the shellfish
3. They're not aware of any evidence for the effect on native fisheries in southern Chile, so have taken it out, but if you have evidence to the contrary we can share that with them if you particularly want to keep it in
4. They were keen to re-insert the stat in the first paragraph highlighting the amount of carbon generated by individuals (rather than the world average) but I thought this rather unfairly highlighted the fact that by this measure US citizens are the highest contributors and it didn't seem very politic!!
5. Tried to amalgamate the last couple of paragraphs – to reduce length and Prof Boyd's discomfiture at emotive language! He agreed to leave in 'The stakes are high' as the last line if we substituted 'risks' for 'stakes'.

I hope this doesn't make it all too much of a compromise Madelyn. Do let me know your thoughts and I'm very happy to go back to them with amends or edits so we're all content.

Thanks again for your help and patience.

Best wishes

Jayne

PS: I have applied the suffix 'FINAL' to the document, but more in hope than expectation!! Ha!

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
Nobel House | 17 Smith Square | London SW1P 3JR

Department for Environment, Food and Rural Affairs (Defra)

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## **Navigating the impact of climate change on our oceans**

Oceans around the world are now showing signs of increasingly being affected by climate change. Over the past 200 years the world's seas have absorbed more than 150 billion metric tons of carbon released into the atmosphere by human activities. That's currently a worldwide average of 15lbs or 7kg per person a week and enough each year to fill 13 coal trains on parallel tracks encircling the equator.

We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbon dioxide and is changing the water's chemistry now at a faster rate than for millions of years. This process is known as ocean acidification. It creates conditions which erode the minerals much of our marine life rely on making it difficult for shellfish and corals to grow, reproduce and build their shells and skeletons.

Along with this increasing acidity are other stressors. The ocean is warming, the oxygen critical to marine life is decreasing in many places and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time is a problem. The implications for food supplies, economies, jobs, and vital consumer goods and services are immense not just for some of the most vulnerable communities in the developing world, but for developed countries too.

A recent nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 per cent of the US commercial fish catch and supports more than 100,000 jobs.

Ocean acidification is weakening coral structures, not just in the Great Barrier Reef and the Caribbean, but also in the cold-water coral reefs found in deeper waters off Scotland and Norway. Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, small marine snails, an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become

increasingly hostile to shell producing animals and plants, even if the rate of future ocean acidification is slowed.

We cannot predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know it will have a profound effect on the structure of marine ecosystems. Fish around the world may be affected by food-web changes as sea life in coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including our future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with better modelling of marine ecological systems. We also need to change how we use the ocean, both by reducing emissions, and therefore the rate of acidification, and managing other stressors. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies.

There is urgency to such investments. A recent NOAA study has shown that the rate of global warming has not recently slowed, as had been thought; furthermore, emissions of carbon are rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases has widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations.

The network is based on the premise that we can't manage what we don't measure, and is designed to provide the basis for the robust forecasting we need. There are gaps in global coverage but the network will build on the success of US and UK teams who recently came first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable and accurate sensor technology.

Such technology will help coastal countries around the world obtain the environmental information they need to underpin sound policy and build

community resilience. Already oyster hatcheries on the west coast of US are using monitoring technology like this to adapt to current periodic ocean acidification events.

Ocean acidification cannot be tackled in isolation and by addressing the root cause we will also tackle the other stressors. The ambitions of our two nations to reduce carbon emissions will benefit future generations not only by conserving our oceans, but by preserving our own well-being and the health and economic viability of our planet. The risks are now very high.

###

Authors:

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Contacts:

Jayne Phenton – UK

[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)

011 44 20 7238 6600

Formatted: Default Paragraph Font, Font: 14 pt

Madelyn Appelbaum – US

[Madelyn.Appelbaum@noaa.gov](mailto:Madelyn.Appelbaum@noaa.gov)

001 202 482 4858

011 292 349 6310 cell

Formatted: Default Paragraph Font, Font: 14 pt, Pattern: Clear

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Libby Jewett - NOAA Federal](#); [Schaaf, Kenli A \(OES\)](#)  
Subject: NOAA/DEFRA op-ed  
Date: Thursday, October 15, 2015 9:45:04 AM

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[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

one down!  
will be in print tomorrow in the International NY Times  
(definitely not our proposed title)

thanks,  
Madelyn

From: [Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov) (via Google Docs)  
To: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
Cc: [ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov); [libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)  
Subject: NOAA-DEFRA ocean acidification op-ed Sept 17 15.docx - Invitation to edit  
Date: Thursday, September 17, 2015 11:57:14 AM

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[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov) has invited you to **edit** the following document:



**NOAA-DEFRA ocean acidification op-ed Sept 17  
15.docx**



A few minor edits inserted, and one point of clarification needing  
followup.

[Open in Docs](#)

Google Docs: Create and edit documents online.



**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Madelyn Appelbaum - NOAA Federal](#)  
**Subject:** OA NYTimes Rick  
**Date:** Thursday, October 15, 2015 2:46:13 PM  
**Attachments:** [OA NY Times 10 15 15.docx](#)

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# The New York Times

The Opinion Pages | OP-ED CONTRIBUTORS

Our Deadened, Carbon-Soaked Seas

By **RICHARD W. SPINRAD** and **IAN BOYD**

OCT. 15, 2015

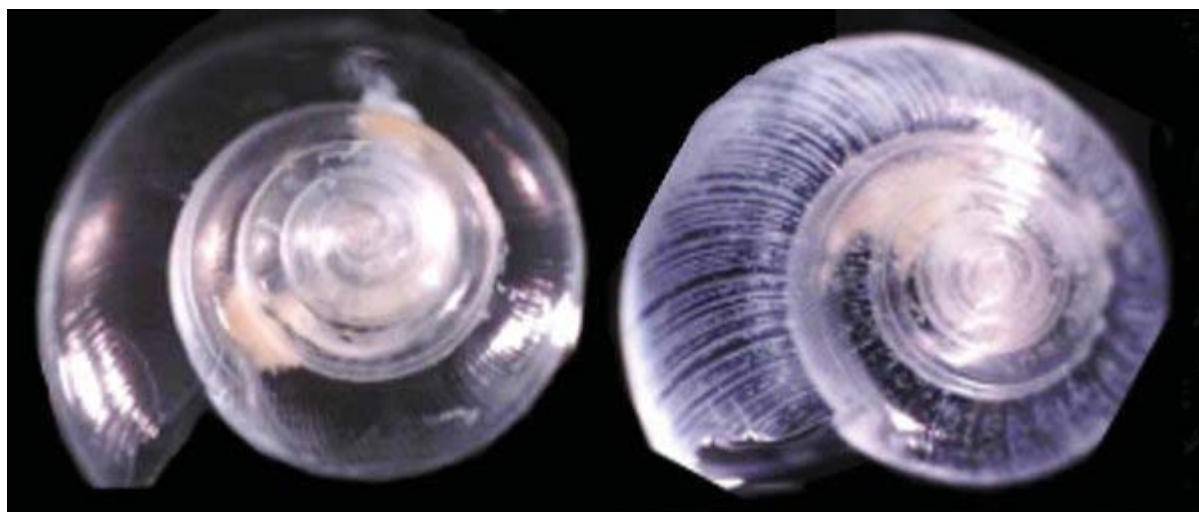


CreditAlec Doherty

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters is changing and a growing threat to marine ecosystems. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.



Pteropods, sometimes called sea butterflies, are a vital food source for Salmon and Herring. Left, a pteropod that has lived in normal waters in a laboratory for six days, and, on the right, a pteropod showing the effects of living in acidified water for the same time period. The white lines indicate shell dissolution, showing why ocean acidification is often called "osteoporosis of the sea."

Credit: National Oceanic and Atmospheric Administration

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we overexploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and services are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, the Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Acidification won't make

seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life found in every drop of seawater. Such changes will almost certainly affect seafood supplies and the ocean's ability to store pollutants, including future carbon emissions.

To understand where the challenges lie, we need better ocean-measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

Both the United States and Britain recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 countries. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the British government's Department of Environment, Food and Rural Affairs.

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[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#); [Chris Sabine - NOAA Federal](#); [Errin Holmes - NOAA Federal](#)  
Subject: OA op-ed -- done deal!  
Date: Tuesday, October 06, 2015 8:41:28 AM

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Hi Rick,  
Good news! Thanks for your guidance and below is precisely what you have already reviewed. I am amazed that it's running without editing. Please note that all Maine references are out. Thanks again and hope to have your final sign-off today, if doable.  
Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Tue, Oct 6, 2015 at 7:54 AM  
Subject: Oped for NYT final version  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Hello Madelyn, Here is the final version, incorporating the fixes you sent. Please give it a close read and make any final changes IN CAPITAL LETTERS ON THIS VERSION. You have been an exceptional pleasure to work with, and thanks for being so steadfast. I expect this will run soon, we will let you know when we publish,  
Joe

Contact: Madelyn Appelbaum/NOAA  
[+1 202 482 4858](tel:+12024824858) office  
[+1 202 340 6310](tel:+12023406310) cell

In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such

changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

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When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the British government's Department of Environment, Food and Rural Affairs

Ian's affiliation to read: **UK Government's Department...**

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Ciaran Clayton - NOAA Federal](#); [Scott Smullen - NOAA Federal](#)  
Subject: OA op-ed  
Date: Thursday, October 15, 2015 10:07:03 AM

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[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

Rick's op-ed finally landed (with a horrendous title)

Tomorrow it will be in print in the International New York Times, but doesn't appear as if it will appear in print here -- am really disappointed about that and plan to take one more shot this morning

Madelyn

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#); [Libby Jewett - NOAA Federal](#); [Ciaran Clayton - NOAA Federal](#); [Pieter Tans - NOAA Federal](#); [Jan Newton](#); [Shallin Busch - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#); [Richard Feely - NOAA Federal](#); [Brady Phillips - NOAA Federal](#)  
**Cc:** [Rick Spinrad - NOAA Federal](#)  
**Subject:** OA op-ed...thank you!  
**Date:** Thursday, October 15, 2015 10:28:49 AM

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[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

Thanks everyone. Rick's op-ed with his UK colleague finally landed today (sorry about the title).

Tomorrow it appears in print in the International NY Times.

Chris and each of you were extremely helpful and patient through mega rounds of questions and edits, and I am very grateful. So lucky to be working with you!

Best wishes,  
Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#); [Shallin Busch - NOAA Federal](#)  
Subject: OA op-ed  
Date: Thursday, October 15, 2015 9:46:50 AM

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[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

Thanks so much for your help.

Shallin, I know you're cringing at the title -- I am, too, but we have no control over that.

Tomorrow this will be in the International NY Times

Cheers,  
Madelyn

**From:** [Phenton, Jayne \(DEFRA\)](#)  
**To:** [Madelyn Appelbaum - NOAA Federal \(madelyn.appelbaum@noaa.gov\)](mailto:madelyn.appelbaum@noaa.gov)  
**Subject:** Ocean acidification op ed draft  
**Date:** Friday, August 28, 2015 11:38:47 AM  
**Attachments:** [Proposed DEFRA- NOAA OA op-ed 21August 2015.ctpw JP cleancopy28Aug15.docx](#)

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Here you go – latest version attached. As soon as Ian's had a last look all good to go. I'll come back with the final version early next week.

Thanks for your help and your patience with this. Have a fabulous weekend.

Best wishes

Jayne

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
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#### Department for Environment, Food and Rural Affairs (Defra)

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## **Dangerous waters ahead: need to take bearings, change course**

The ocean, which we so often take for granted, is now showing disturbing signs of increasingly being affected by climate change. Over the past 200 years it has been our faithful friend, absorbing more than 150 billion metric tons of carbon released into the atmosphere by human activities. That's currently around 49lb (22 kg) of carbon per week for every US citizen, 20lb (9 kg) per week for the average European or the worldwide average of 15 lb (7 kg) per person per week. In total, that's enough each year to fill 13 coal trains on parallel tracks encircling the equator.

We can't see this massive amount of carbon that's going into the ocean, since it's dissolving as carbon dioxide, but it is changing the water's chemistry and at a faster rate than has occurred for many millions of years. These changes, known as ocean acidification, have now been detected in coastal waters, polar seas and at various open ocean sites. They have implications, not only for all life in the sea, but also for ourselves. There is particular concern for shellfish and corals, since ocean acidification slows their growth and may even dissolve their shells and skeletons. Fish are also under threat.

Alongside this increasing acidity, the ocean is warming, and the oxygen critical to marine life is decreasing in many places. Each stressor is a problem, but all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. A recent nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 per cent of the US commercial fish catch and supports more than 100,000 jobs.

Ocean acidification is weakening coral structures, not just in the Great Barrier Reef and the Caribbean, but also in the cold-water coral reefs found in deeper waters off Scotland and Norway. Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies in some regions. These planktonic snails are important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell producing animals and plants, even if the rate of future ocean acidification is slowed.

We cannot predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know it will have a profound effect on the structure of marine ecosystems. This will almost certainly affect future supplies of seafood, but also the ocean's future ability to take up and safely store pollutants, including our future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with better modelling of marine ecological systems. We also need to change how we use the ocean, both by reducing emissions, and therefore the rate of acidification, and managing other stressors.

Some work is already underway. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. The network is based on the premise that we can't manage what we don't measure, and is designed to provide the basis for the robust forecasting we need. There are gaps in global coverage but

the network will build on the success of US and UK teams who recently came first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable and accurate pH sensor technology.

This technology will help coastal countries around the world obtain the environmental information they need to underpin sound policy and build community resilience in a future high CO<sub>2</sub> world. Already oyster hatcheries on the west coast of US are using monitoring technology like this to adapt to current periodic ocean acidification events.

Tackling the cause of ocean acidification will not be easy. Nevertheless, both our nations recognize that carbon dioxide emissions are responsible, not just for global warming, but for the circulation changes that reduce the oxygen supply to the sea. The unprecedented actions our two nations are planning to reduce carbon emissions, will not just benefit our future generations, but also, the wonderful and diverse organisms that dwell in the largest ecosystem on Earth, the ocean.

###

Authors:

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

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**From:** [Phenton, Jayne \(DEFRA\)](#)  
**To:** [Madelyn Appelbaum - NOAA Federal \(madelyn.appelbaum@noaa.gov\)](mailto:madelyn.appelbaum@noaa.gov)  
**Subject:** Ocean acidification op ed  
**Date:** Thursday, September 03, 2015 12:23:09 PM  
**Attachments:** [Proposed DEFRA- NOAA OA op-ed 2Sept FINAL.docx](#)

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Hi Madelyn

Ooh it's been a bit of a journey, but I think we're finally here – at least from this end!!

A few things:

1. Prof Ian Boyd is not keen on emotive language so it's a bit devoid of adjectives now!
2. Our marine colleagues were very particular about how we described what the seawater does to the shellfish
3. They're not aware of any evidence for the effect on native fisheries in southern Chile, so have taken it out, but if you have evidence to the contrary we can share that with them if you particularly want to keep it in
4. They were keen to re-insert the stat in the first paragraph highlighting the amount of carbon generated by individuals (rather than the world average) but I thought this rather unfairly highlighted the fact that by this measure US citizens are the highest contributors and it didn't seem very politic!!
5. Tried to amalgamate the last couple of paragraphs – to reduce length and Prof Boyd's discomfiture at emotive language! He agreed to leave in 'The stakes are high' as the last line if we substituted 'risks' for 'stakes'.

I hope this doesn't make it all too much of a compromise Madelyn. Do let me know your thoughts and I'm very happy to go back to them with amends or edits so we're all content.

Thanks again for your help and patience.

Best wishes

Jayne

PS: I have applied the suffix 'FINAL' to the document, but more in hope than expectation!! Ha!

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
Nobel House | 17 Smith Square | London SW1P 3JR

Department for Environment, Food and Rural Affairs (Defra)

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From: [Libby Jewett - NOAA Federal](#)  
To: [Ciaran Clayton - NOAA Federal](#)  
Bcc: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
Subject: Op Ed on Ocean Acidification: Need Madelyn's help!  
Date: Thursday, July 02, 2015 10:56:37 AM

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Ciaran,

I know that Madelyn has been doing a great job with writing a variety of Op Eds recently. I REALLY need her help with another one in the coming months.

Several years ago, NOAA supported two widely-praised and referenced op-eds. The first, on space weather, was initially to be co-signed by Jane Lubchenco and Sir John Beddington, John Holdren's UK counterpart, but was quickly bumped up to Holdren. The second, on ocean acidification, was co-signed by Jane and Sir John. Madelyn rapidly (literally overnight) and effectively developed both op-eds, proving quite adept at creating an editorial article that Holdren immediately approved. Both articles were published in both The New York Times and the International Herald Tribune.

Now, Ian Boyd, chief scientific advisor to the UK's Department for the Environment, is very interested in doing another Op Ed on ocean acidification, and our team hopes that Madelyn can be assigned to develop it, with either Dr Sullivan or Rick Spinrad as co-signer. The article would fit well with NOAA's resilience and observational priorities and could go an important distance in recognizing NOAA's leadership in growing an international ocean observing system. Ideally, the op-ed could appear in the fall prior to the second ocean conference at which Secretary Kerry and ocean acidification will be prominent. We want visibility for NOAA's pioneering global leadership to be prominent, too! I hope we can begin moving on the op-ed with a NOAA co-signer this month.

What do you think?

Libby

--

Libby Jewett, PhD  
Director, Ocean Acidification Program  
National Oceanic and Atmospheric Administration  
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phone: 301-734-1075

Follow me on Twitter: [@LibbyJewett](#)  
OAP Website: [OceanAcidification.NOAA.gov](http://OceanAcidification.NOAA.gov)  
Global OA Observing Network: [www.goa-on.org](http://www.goa-on.org)  
Follow the NOAA Ocean Acidification Program on [Facebook](#) and [Twitter](#)

Note: The content of this message does not reflect any position of the U.S. Government or of NOAA unless otherwise specified.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [GREGORY, Joe](#)  
Subject: Oped for NYT final version  
Date: Tuesday, October 06, 2015 10:22:49 AM

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Just edits in opening par and Ian's affiliation  
Thanks so much

I am also very grateful for Rebecca's assistance.

Continuing success -- we are proud to be on your page!  
Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Tue, Oct 6, 2015 at 7:54 AM  
Subject: Oped for NYT final version  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Hello Madelyn, Here is the final version, incorporating the fixes you sent. Please give it a close read and make any final changes IN CAPITAL LETTERS ON THIS VERSION.  
I expect this will run soon, we will let you know when we publish,  
Thanks for your efforts,  
Joe

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
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In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters **IS CHANGING AND A GROWING THREAT TO**

**MARINE ECOSYSTEMS.** Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

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About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

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points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

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The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the **UK GOVERNMENT'S** Department of Environment, Food and Rural Affairs

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Subject: op-ed heads up  
Date: Thursday, October 01, 2015 1:13:07 PM

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Hi Rick,  
UK just signed off and Chris Sabine is helping me with a few late edits.  
Will get op-ed to you asap today -- and really really hope you can review it by tonight so editor has it tomorrow am in Paris.  
Sorry for the crunch -- op-ed is basically what you reviewed before but with more descriptive explanation.  
Unless you require a major edit, I have UK ok to send to paper.  
Thanks,  
Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Thu, Oct 1, 2015 at 12:42 PM  
Subject: Re: article on ocean acidification for the NYT  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Madelyn, do you have a sense yet of when the authors might refile their op-ed?  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

On Mon, Sep 28, 2015 at 5:42 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

we will definitely beef it up  
many thanks  
Madelyn

Sent from my iPhone

> On Sep 28, 2015, at 11:19 AM, GREGORY, Joe <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)> wrote:  
>

> [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
> [202 482 4858](tel:2024824858)  
> [202 340 6310](tel:2023406310) cell  
>

>

>

> Dear Madelyn Appelbaum,

>

> Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?

> Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.

> I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,

> Best Wishes,  
> Joe Gregory, INYT Opinion Pages

>

>

> Richard W. Spinrad

> Ian Boyd

>

>

> Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

>

> We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

> WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

> Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

>

> Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/ Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

>

> Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT

## WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

> Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

>

> We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. **TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED.** Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

>

> To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

> **ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?**

> Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

> When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

>

> Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

>

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#); [Boyd, Ian \(Defra\)](#)  
Cc: [Lawrence, David \(DEFRA\)](#); [Jayne Phenton](#); [Errin Holmes - NOAA Federal](#); [Carol Turley](#); [Phillip Williamson](#)  
Subject: op-ed online  
Date: Thursday, October 15, 2015 9:40:27 AM

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[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

thanks everyone  
will appear in print tomorrow in the International NY Times

(not the title we chose!)

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#)  
Subject: op-ed  
Date: Wednesday, October 14, 2015 12:10:38 PM

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Hi Rick,

Unless there is a snag, your op-ed will run in tomorrow's INYT and NY Times online. Visuals are running with both so editor is giving it really good visibility. Still iffy re US paper (please see below from opinion editor of INYT). If op-ed isn't in US paper, I will try again with NY and also via NYTimes DC staff. Will send you link and get a few hard copies.

Many thanks to you and Ciaran for being on board with this.

Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Wed, Oct 14, 2015 at 12:03 PM  
Subject: Re: acidification op-ed...quick question  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Hello Madelyn, it will run in the international editions and on the NYT web site. Not sure about the U.S. Don't worry, it will get plenty of attention, Joe

On Wed, Oct 14, 2015 at 6:01 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi and getting excited!

Since your page was the clear priority, didn't think to ask until now, but will acidification op-ed run in US paper, too? I am not sure how things work these days.

If not set for US, think you might flag if you have a chance, especially since Long Island Sound is a recently named acidification hotspot?

Again, so many thanks for helping us make this piece fit for print.

Best wishes,  
Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Phenton, Jayne \(DEFRA\)](#)  
Subject: op-ed  
Date: Tuesday, October 06, 2015 9:02:20 AM

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this seems to be the one edit that wasn't caught and I'll make sure it is

Rick just signed off

thanks, Jayne

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters **IS CHANGING AND A GROWING THREAT TO MARINE ECOSYSTEMS**. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [GREGORY, Joe](#)  
Subject: PLEASE SEE THIS ONE ocean acidification op-ed  
Date: Thursday, October 01, 2015 5:59:54 PM

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wanted to include a line that was just finally vetted  
thank you

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 5:18 PM  
Subject: ocean acidification op-ed  
To: "GREGORY, Joe" <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>

Hi Mr. Gregory,  
Thanks so very much for remembering us.  
If only we could clone you...  
Hope this now flies!  
Please advise about whatever more may be needed, and we'll address it immediately.  
Thanks again,  
Madelyn

### **In a High CO2 World, Dangerous Waters Ahead**

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals, and other marine organisms to grow, reproduce, and build their shells and skeletons. About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed. In Maine, entire populations of soft-shell clams and blue mussels have almost entirely disappeared from coastal waters. Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm

people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is cause for concern, but all of them affecting the oceans at one time are cause for alarm. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability,

linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

Contact: Madelyn Appelbaum/NOAA

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From: [Carol Turley](#)  
To: [Libby Jewett - NOAA Federal](#)  
Cc: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Possible Op-Ed  
Date: Friday, June 19, 2015 5:43:00 AM

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Dear Libby

I had a briefing with Prof Ian Boyd, the Chief Scientist for Defra (UK Department of environment, food and rural affairs) about the lead up to the UNFCCC COP21, Paris this week. I mentioned to him the success of the Op-Ed between Jane Lubchenco and Sir John Beddington at Rio+20 and very casually brought up the possibility to do similar between the Chief Scientists of Defra and NOAA. He seemed very keen (he is a marine scientist, previously the Director of the Sea Mammal Research Unit in the UK) and is genuinely concerned about the ocean. Here are more details on Ian before and after taking up his current post as CSA:

<https://www.gov.uk/government/people/ian-boyd>  
<http://www.csap.cam.ac.uk/network/ian-boyd/>

Without anyone feeling compelled to progress this or loosing face I wonder if you could test the water about NOAA's Chief Scientist, Richard Spinrad partnering the Op-ed? I guess the timing would have to be after the Our Common Future conference in July but before the COP.

Any further thoughts on a side event in the US Center?

Best wishes

Carol

Please visit our new website at [www.pml.ac.uk](http://www.pml.ac.uk) and follow us on Twitter @PlymouthMarine

Winner of the Environment & Conservation category, the Charity Awards 2014.

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Phenton, Jayne \(DEFRA\)](#)  
Cc: [Rick Spinrad - NOAA Federal](#); [Ciaran Clayton - NOAA Federal](#); [Chris Sabine - NOAA Federal](#)  
Subject: Proposed DEFRA-NOAA OA Op-ed  
Date: Thursday, August 06, 2015 7:20:55 PM  
Attachments: [Proposed DEFRA- NOAA OA op-ed 6 August 2015.docx](#)

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Hi Jayne,

Attached is the op-ed proposed from this end.

Please let Professor Boyd know we worked really hard to retain the themes he suggested, but with non-scientific text for a general public. Your ability to reference Miley Cyrus in one of his blogs was extremely reassuring!

For a major newspaper, the word count is already about max but, as needed, we can adjust before submission, which we can discuss once op-ed is cleared to go.

I have enjoyed talking with you -- and many thanks for moving this, hopefully before everyone on your side of the pond takes off for the rest of August.

Best wishes, and please let me know if you have questions.

Madelyn

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[+1 202 340 6310](#) cell

## **In a High CO<sub>2</sub> World, Ocean Hotspots Tell a Disturbing Story**

In waters around the world, ocean hotspots are beginning to tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, threatening the chemical balance of our ocean and coastal waters and their fragile, finite marine life. Over the past 200 years, the sea has absorbed more than 150 billion metric tons of carbon from human activities. It's now absorbing more than 2.5 billion metric tons every year, enough to fill a coal train long enough to encircle the equator 13 times.

The consequences of disrupting what has been a relatively stable ocean environment for tens of millions of years are beginning to show. As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating conditions that eat away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs, plants and much more are at risk, especially since, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each stressor is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. This year the first nationwide study of the vulnerability of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of hotspots: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Acidity also is apparent off the Alaskan coast, which accounts for nearly 60 percent of the U.S. commercial fish catch and supports more than 100,000 jobs.

There are concerns in the Mediterranean Sea and in waters around the UK and Germany. In the UK... **[more re UK?]** Ocean acidification is weakening coral structures in the Great Barrier Reef, and threatening native fisheries in the Patagonian waters of southern Chile. The most dramatic change is already occurring in the Arctic where water can be corrosive enough to dissolve nearby shelled creatures. In coming decades, the Southern Ocean around Antarctica is expected to see comparable changes, but direct measurements there and in other remote ocean regions are sparse. To better prepare for hotspots, more regions must be studied.

There is urgency to substantially reducing carbon dioxide emissions. A recent NOAA study found that, over the past 15 years, the rate of global warming has been as fast or faster than seen during the latter half of the 20<sup>th</sup> century. There has been no downward trend in our high CO<sub>2</sub> world and both of our nations have called for unprecedented actions to reduce emissions. Tackling ocean acidification is a steep challenge. But it's also a dynamic opportunity to inspire profound advances in our understanding of the ocean. In July, an enterprising team from a small company in Montana won the Wendy Schmidt Ocean Health XPrize for developing breakthrough technologies to measure ocean acidity. To better understand the sea's response to CO<sub>2</sub>, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

continued

## **In a High CO<sub>2</sub> World, Ocean Hotspots Tell a Disturbing Story**

In waters around the world, ocean hotspots are beginning to tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, threatening the chemical balance of our ocean and coastal waters and their fragile, finite marine life. Over the past 200 years, the sea has absorbed more than 150 billion metric tons of carbon from human activities. It's now absorbing more than 2.5 billion metric tons every year, enough to fill a coal train long enough to encircle the equator 13 times.

The consequences of disrupting what has been a relatively stable ocean environment for tens of millions of years are beginning to show. As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating conditions that eat away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs, plants and much more are at risk, especially since, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each stressor is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. This year the first nationwide study of the vulnerability of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of hotspots: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Acidity also is apparent off the Alaskan coast, which accounts for nearly 60 percent of the U.S. commercial fish catch and supports more than 100,000 jobs.

There are concerns in the Mediterranean Sea and in waters around the UK and Germany. In the UK... [more *from UK*] Ocean acidification is weakening coral structures in the Great Barrier Reef, and threatening native fisheries in the Patagonian waters of southern Chile. The most dramatic change is already occurring in the Arctic where water can be corrosive enough to dissolve nearby shelled creatures.

There is urgency to substantially reducing carbon dioxide emissions. A recent NOAA study found that, over the past 15 years, the rate of global warming has been as fast or faster than seen during the latter half of the 20<sup>th</sup> century. There has been no downward trend in our high CO<sub>2</sub> world and both of our nations have called for unprecedented actions to reduce emissions. Tackling ocean acidification is a steep challenge. But it's also a dynamic opportunity to inspire profound advances in our understanding of the ocean. In July, an enterprising team from a small farm in Montana won the X-Prize for developing breakthrough technologies to measure ocean acidity. To better understand the sea's response to CO<sub>2</sub>, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

Smart investments in monitoring and observing are critical to building resilience and hedging risk. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential.

continued

We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals. The new 30-nation network still has gaps in global coverage, and more nations are needed to fill them. To understand the sea, we must first observe it. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. Locally to globally, we are all the stakeholders.

###

Authors:

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
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011 44 20 7238 6600

Smart investments in monitoring and observing are critical to building resilience and hedging risk that can directly affect community, regional and global economies. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential. Studying local and regional variability, for example, will allow scientists to predict chemical changes near shellfish farms so growers can adjust water chemistry for the short-term, and develop adaptation strategies for the long-term.

We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals. The new 30-nation network still has gaps in global coverage, and more nations are needed to fill them. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. Locally to globally, we are all the stakeholders.

###

Authors:

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Contacts:

Jayne Phenton – UK  
[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)  
011 44 20 7238 6600

Madelyn Appelbaum – US  
[Madelyn.Appelbaum@noaa.gov](mailto:Madelyn.Appelbaum@noaa.gov)  
001 202 482 4858  
011 292 349 6310 cell

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#)  
Subject: Proposed OA Op-ed  
Date: Wednesday, August 05, 2015 1:19:39 PM  
Attachments: [NOAA UK oped 8 5 15.docx](#)

---

Hi Rick,

Here's suggested op-ed with Ian Boyd.

Chris Sabine has vetted and both he and Ciaran have signed off.

Hope you'll think it works, or is close.

Also hope to send to UK asap. With a bit more text from UK about OA experiences there, the word count is on target. Because Pacific NW oyster hatchery/IOOS mitigation was highlighted in a 2012 OA op-ed, it is not included here where aim is to make info seem fresh.

Thanks for your review and hope all is well.

Best wishes,

Madelyn

x4858

## **In a High CO<sub>2</sub> World, Ocean Hotspots Tell a Disturbing Story**

In waters around the world, ocean hotspots are beginning to tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, threatening the chemical balance of our ocean and coastal waters and their fragile, finite marine life. Over the past 200 years, the sea has absorbed more than 150 billion metric tons of carbon from human activities. It's now absorbing more than 2.5 billion metric tons every year, enough to fill a coal train long enough to encircle the equator 13 times.

The consequences of disrupting what has been a relatively stable ocean environment for tens of millions of years are beginning to show. As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating conditions that eat away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs, plants and much more are at risk, especially since, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each stressor is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. This year the first nationwide study of the vulnerability of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of hotspots: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Acidity also is apparent off the Alaskan coast, which accounts for nearly 60 percent of the U.S. commercial fish catch and supports more than 100,000 jobs.

There are concerns in the Mediterranean Sea and in waters around the UK and Germany. In the UK... [more *from UK*] Ocean acidification is weakening coral structures in the Great Barrier Reef, and threatening native fisheries in the Patagonian waters of southern Chile. The most dramatic change is already occurring in the Arctic where water can be corrosive enough to dissolve nearby shelled creatures.

There is urgency to substantially reducing carbon dioxide emissions. A recent NOAA study found that, over the past 15 years, the rate of global warming has been as fast or faster than seen during the latter half of the 20<sup>th</sup> century. There has been no downward trend in our high CO<sub>2</sub> world and both of our nations have called for unprecedented actions to reduce emissions. Tackling ocean acidification is a steep challenge. But it's also a dynamic opportunity to inspire profound advances in our understanding of the ocean. In July, an enterprising team from a small farm in Montana won the X-Prize for developing breakthrough technologies to measure ocean acidity. To better understand the sea's response to CO<sub>2</sub>, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

Smart investments in monitoring and observing are critical to building resilience and hedging risk. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential.

continued

We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals. The new 30-nation network still has gaps in global coverage, and more nations are needed to fill them. To understand the sea, we must first observe it. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. Locally to globally, we are all the stakeholders.

###

Authors:

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Contacts:

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Jayne Phenton – UK  
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011 44 20 7238 6600

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#)  
**Subject:** PS  
**Date:** Monday, August 03, 2015 12:50:13 PM

---

Chris,  
Unfortunately, I can't repeat oyster hatchery story used in 2012, but  
hope there's another way, in a few words, to plug IOOS in? Perhaps in  
assets referenced with GOA-ON?  
Thanks again for your review,  
Madelyn

Sent from my iPhone

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#)  
**Subject:** question  
**Date:** Thursday, October 01, 2015 2:45:57 PM

---

Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic **life** that can be found in every drop of seawater.

Chris, should this revert to plants and animals? multitudes of microscopic life?  
"lives" doesn't work

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Louise Loftus](#)  
Subject: quick question  
Date: Wednesday, October 14, 2015 11:46:14 AM

---

just to inform the troops on this end...  
will both INYT and US paper carry op-ed in print, or just INYT?  
not sure how things work these days

thanks so much for your work on all this  
I love the NYT online -- it always looks terrific and so clearly organized

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Denis Allemand](#); [Carol Turley](#); [Phillip Williamson](#)  
Subject: quick request  
Date: Wednesday, October 14, 2015 10:43:10 AM

---

NY Times is about to run acidification op-ed from NOAA/UK  
will send you the link

any chance of a high resolution image that shows acidification damage to corals/seabed?  
deadline is tight

thanks,  
Madelyn

From: [Loftus, Louise](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Jennifer Mintz - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 12:10:18 PM

---

Have quickly edited this caption just so we're ready to go tomorrow, since I believe you're in the U.S. Thanks again for your help and for being so responsive.

Pteropods, sometimes called sea butterflies <<RIGHT?>>, are a vital food source for <<WHAT? one or two examples that readers will recognize please?>>. Left, a pteropod that has lived in normal conditions for six days, and, on the right, a pteropod showing the effects of living in acidified water for the same time period. The white lines indicate shell dissolution, showing why ocean acidification is often called "osteoporosis of the sea."

On Wed, Oct 14, 2015 at 4:58 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

sure  
thanks for that, too

On Wed, Oct 14, 2015 at 11:57 AM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:  
Received, thank you! And finally, can we share these with the piece on social media?

On Wed, Oct 14, 2015 at 4:47 PM, Jennifer Mintz - NOAA Federal  
<[jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov)> wrote:

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The images are attached.

Thanks!

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<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

coming very shortly  
being retrieved now

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Credit: NOAA

--

Jenn Bennett Mintz

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From: [Loftus, Louise](#)  
To: [Jennifer Mintz - NOAA Federal](#)  
Cc: [Madelyn Appelbaum - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:57:17 AM

---

Received, thank you! And finally, can we share these with the piece on social media?

On Wed, Oct 14, 2015 at 4:47 PM, Jennifer Mintz - NOAA Federal

<[jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov)> wrote:

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Thanks!

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Credit: NOAA

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Jenn Bennett Mintz

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From: [Jennifer Mintz - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:51:59 AM

---

of course!

On Wed, Oct 14, 2015 at 11:49 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:  
thanks very much

On Wed, Oct 14, 2015 at 11:47 AM, Jennifer Mintz - NOAA Federal  
<[jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov)> wrote:  
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Credit: NOAA

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From: [Jennifer Mintz - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Loftus, Louise](#); [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:47:23 AM  
Attachments: [Pteropods\\_BuschS\\_acidified.jpg](#)  
[Pteropods\\_BuschS\\_normal.jpg](#)

---

Hello,

The images are attached.

Thanks!

On Wed, Oct 14, 2015 at 11:43 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

coming very shortly  
being retrieved now

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Credit: NOAA

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Jenn Bennett Mintz

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To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:43:00 AM

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Credit: NOAA

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To: [Loftus, Louise](#)  
Cc: [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:43:56 AM

---

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being retrieved now

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Credit: NOAA

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:49:55 AM

---

thanks very much

On Wed, Oct 14, 2015 at 11:47 AM, Jennifer Mintz - NOAA Federal  
<[jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov)> wrote:

Hello,

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:52:41 AM

---

some day I will call when not in a rush!  
are you ok, post flood??

On Wed, Oct 14, 2015 at 11:51 AM, Jennifer Mintz - NOAA Federal  
<[jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov)> wrote:  
of course!

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Credit: NOAA

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To: [Loftus, Louise](#)  
Cc: [Jennifer Mintz - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 11:58:44 AM

---

sure  
thanks for that, too

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On Wed, Oct 14, 2015 at 4:41 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Pteropods, a vital marine food source, are shown here in laboratory conditions. Top image reflects pteropods living in normal conditions for six days. Bottom image shows effects of living in acidified water for the same time period. White lines indicate shell dissolution and why ocean acidification is often called "osteoporosis of the sea."

Credit: NOAA

--

Jenn Bennett Mintz

*\*Please note email address change*

Education & Outreach Coordinator  
NOAA Ocean Acidification Program  
Hollings Marine Laboratory

331 Ft. Johnson Rd. # A121M

Charleston, SC 29412

Office: [\(843\)762-8896](tel:(843)762-8896)

Cell: [\(831\) 325-1634](tel:(831)325-1634)

Email: [jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov) (formerly [jennifer.bennett@noaa.gov](mailto:jennifer.bennett@noaa.gov))

Website: [oceanacidification.noaa.gov](http://oceanacidification.noaa.gov)

Follow the NOAA Ocean Acidification Program on [Facebook](#) and [Twitter](#)

Note: The content of this message does not reflect any position  
of the U.S. Government or of NOAA unless otherwise specified.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Loftus, Louise](#)  
Cc: [Jennifer Mintz - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 12:23:56 PM

---

ok? we need to state laboratory...

Pteropods, sometimes called sea butterflies, are a vital food source for fish such as salmon and herring. Left, a pteropod that has lived in normal waters in a laboratory for six days, and, on the right, a pteropod showing the effects of living in acidified water for the same time period. The white lines indicate shell dissolution, showing why ocean acidification is often called "osteoporosis of the sea."

On Wed, Oct 14, 2015 at 12:10 PM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:

Have quickly edited this caption just so we're ready to go tomorrow, since I believe you're in the U.S. Thanks again for your help and for being so responsive.

Pteropods, sometimes called sea butterflies <<RIGHT?>>, are a vital food source for <<WHAT? one or two examples that readers will recognize please?>>. Left, a pteropod that has lived in normal conditions for six days, and, on the right, a pteropod showing the effects of living in acidified water for the same time period. The white lines indicate shell dissolution, showing why ocean acidification is often called "osteoporosis of the sea."

On Wed, Oct 14, 2015 at 4:58 PM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

sure  
thanks for that, too

On Wed, Oct 14, 2015 at 11:57 AM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:

Received, thank you! And finally, can we share these with the piece on social media?

On Wed, Oct 14, 2015 at 4:47 PM, Jennifer Mintz - NOAA Federal

<[jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov)> wrote:

Hello,

The images are attached.

Thanks!

On Wed, Oct 14, 2015 at 11:43 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

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Credit: NOAA

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*\*Please note email address change*

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Email: [jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov) (formerly [jennifer.bennett@noaa.gov](mailto:jennifer.bennett@noaa.gov))

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From: [Loftus, Louise](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Jennifer Mintz - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: acidification caption -- does this work? thank you  
Date: Wednesday, October 14, 2015 12:32:18 PM

---

Looks great. Thanks again.

On Wed, Oct 14, 2015 at 5:23 PM, Madelyn Appelbaum - NOAA Federal

[<madelyn.appelbaum@noaa.gov>](mailto:madelyn.appelbaum@noaa.gov) wrote:

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Email: [jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov) (formerly [jennifer.bennett@noaa.gov](mailto:jennifer.bennett@noaa.gov))

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Note: The content of this message does not reflect any position of the U.S. Government or of NOAA unless otherwise specified.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [GREGORY, Joe](#)  
Subject: Re: acidification op-ed...quick question  
Date: Wednesday, October 14, 2015 12:04:56 PM

---

absolutely no worries  
we are delighted and very appreciative

On Wed, Oct 14, 2015 at 12:03 PM, GREGORY, Joe <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)> wrote:  
Hello Madelyn, it will run in the international editions and on the NYT web site. Not sure about the U.S. Don't worry, it will get plenty of attention, Joe

On Wed, Oct 14, 2015 at 6:01 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi and getting excited!

Since your page was the clear priority, didn't think to ask until now, but will acidification op-ed run in US paper, too? I am not sure how things work these days.

If not set for US, think you might flag if you have a chance, especially since Long Island Sound is a recently named acidification hotspot?

Again, so many thanks for helping us make this piece fit for print.

Best wishes,  
Madelyn

From: [GREGORY, Joe](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: acidification op-ed...quick question  
Date: Wednesday, October 14, 2015 12:03:55 PM

---

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Again, so many thanks for helping us make this piece fit for print.

Best wishes,  
Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: another question  
Date: Thursday, October 01, 2015 3:31:11 PM

---

thanks and did change to acidified (some day, please explain...Jane used acidic all the time, but perhaps more is now jknown?)

that is only change I made

many thanks

On Thu, Oct 1, 2015 at 3:28 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

I have added my comments to her comments in the attached. I would leave the Arctic statement as it is, but there are a couple of other changes in wording that I agree with.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 12:25 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Dramatic change is also apparent in the Antarctic where the frigid waters can hold so much carbon dioxide that shelled creatures can dissolve in the corrosive conditions.

---

[SB1]There has been no work to date on pteropod condition in the Arctic, only in the Antarctic.

should I change from Arctic to Antarctic? or are both correct?

thanks

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: article amends from this end!  
Date: Wednesday, September 30, 2015 3:30:56 PM

---

just looked, too  
apparently one study called Nemo "deaf," -- problem was attributed to brain damage that affected capability to hear  
I'll word carefully

sending shortly

thanks, Chris

On Wed, Sep 30, 2015 at 3:18 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Madelyn,

I have asked everyone I can reach and nobody is aware of a study that suggests that Nemo's hearing would be impaired by ocean acidification. I did find one article on the web that suggested the opposite. I am aware of studies indicating that Nemo would lose sense of smell or ability to detect predators and therefore would be more likely to be eaten. Perhaps you can ask the UK people to check on that sentence.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Wed, Sep 30, 2015 at 5:09 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi Chris,

I am working through all comments today and will send draft for your (again!) review.

Sorry for so many rounds. Here's what landed from the UK...

Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Date:** September 30, 2015 at 8:06:16 AM EDT  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject:** Fwd: article amends from this end!

Sent from my iPhone

Begin forwarded message:

**From:** "Phenton, Jayne (DEFRA)"  
<[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)>  
**Date:** September 30, 2015 at 5:41:03 AM EDT  
**To:** "Madelyn Appelbaum - NOAA Federal"  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject:** article amends from this end!

Hi Madelyn

The team have added some examples (Nemo the clown fish a particularly good one I think!) and a few thoughts. This is not a clean copy – I've left their comments in because I thought it might be helpful for you to see the reasoning, but if a tidy copy would be better, let me know and I can do that straight away.

Let me know what you think. By the by, I was thinking we should offer this to a national broadsheet here – be great for a comment piece on the Guardian website I think. Let me know if you have any thoughts – I don't it would matter if it had already appeared in the NY Times although of course we would acknowledge that.

Hope all well there.

Best wishes

Jayne

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
Nobel House | 17 Smith Square | London SW1P 3JR

Department for Environment, Food and Rural Affairs (Defra)

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Whilst this email and associated attachments will have been checked for known viruses whilst within Defra systems we can accept no responsibility once it has left our systems. Communications on Defra's computer systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: article on ocean acidification for the NYT  
Date: Thursday, October 01, 2015 1:06:27 PM

---

looking at it immediately

On Thu, Oct 1, 2015 at 1:05 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

How about the attached?

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 10:03 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

this is terrific!  
after you sign off, I will immediately send to Rick  
goal will be to get this to paper by tomorrow am in Paris

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Thu, Oct 1, 2015 at 12:42 PM  
Subject: Re: article on ocean acidification for the NYT  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Madelyn, do you have a sense yet of when the authors might refile their op-ed?  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

On Mon, Sep 28, 2015 at 5:42 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

we will definitely beef it up  
many thanks  
Madelyn

Sent from my iPhone

> On Sep 28, 2015, at 11:19 AM, GREGORY, Joe <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)> wrote:  
>  
> madelyn.appelbaum@noaa.gov  
> Madelyn Appelbaum  
> [202 482 4858](tel:2024824858)

> 202 340 6310 cell

>

>

> Dear Madelyn Appelbaum,

>

> Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?

> Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.

> I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,

> Best Wishes,

> Joe Gregory, INYT Opinion Pages

>

>

> Richard W. Spinrad

> Ian Boyd

>

>

> Ocean and coastal waters around the world are beginning to tell a disturbing story.

The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

>

> We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

> WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

> Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

>

> Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the

coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/ Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

>

> Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

> Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

>

> We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED. Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

>

> To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

> ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

> Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the

world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

> When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

>

> Richard W. Spinrad is the chief scientist of the U.S, National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

>

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Cc: [Rick Spinrad - NOAA Federal](#); [Libby Jewett - NOAA Federal](#); [Shallin Busch - NOAA Federal](#); [Ciaran Clayton - NOAA Federal](#)  
Subject: Re: article on ocean acidification for the NYT  
Date: Monday, September 28, 2015 1:41:39 PM

---

Thanks, Chris. I will work with your info and what comes from the UK, along with what Shallin and Libby may wish to plug in and send back for your review, then on to Rick. The initial version that you were so helpful with is actually much closer to what the editor is looking for but, given that he thinks this is close and, after much angst, the UK has signed-off on this one, I am hesitant to step back too much, although I concur with your suggestion.

Thank you!

Madelyn

On Mon, Sep 28, 2015 at 1:18 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Hi Madelyn,

My brief, "off the top of my head" responses are given below. If Rick wants to pursue this, then we can work to wordsmith a properly crafted formal response.

CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING? WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

We have seen shells dissolving off of live pteropods in the Southern Ocean and in the upwelling areas off the west coast of the US which certainly impacts their abundance. Pteropods are an important food source for juvenile salmon, but I am not aware of any quantitative impact on salmon recruitment specifically related to ocean acidification impacts on pteropods. We have many of the pieces so I would feel comfortable making a qualitative statement about the potential impacts. We have demonstrated that the near collapse of the shellfish industry in the pacific northwest was caused by ocean acidification. This has undoubtedly increased prices, but I would have to look into how much if you need a number. I also know that at least one shellfish grower has moved their operations from Washington State to Hawaii because the ocean acidification effects are less dramatic there. Ocean acidification does not make people ill, so that angle will not work.

AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/

The shellfish story has been well documented in scientific papers as well as the media, but we can tell it again if you like. I thought this article was intended to be more broad reaching than this.

IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT

IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

Ocean acidification is stronger in the high latitude oceans than the lower latitudes because of basic chemistry (can explain if needed). Ocean acidification typically manifests itself as an additional stress on calcifying organisms (and other organisms to some degree). Typically it isn't ocean acidification itself that directly kills the organism, but it makes the organism more susceptible to other factors (e.g. predation, disease, bleaching). Coral reefs, of course, are found in the low latitudes but they are among the most susceptible to ocean acidification. For example, there has been a 50% reduction in coral cover on the Great Barrier Reef off Australia over the last 30 years. This has been primarily attributed to crown of thorns starfish, cyclones and coral bleaching, but underlying all of those factors is the fact that the corals are so stressed from ocean acidification that they can't recover from those other impacts the way they used to be able to recover. Ocean acidification does not result in dead fish washing up on the shore and it doesn't give swimmers skin rashes.

TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED.

You already talk about the oysters...the point of this paragraph is that there are impacts on entire marine ecosystems that will have cascading effects. By the time we see those cascading effects it will be too late to do anything about it.

ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

I am not exactly sure what they are asking here. There are many factors of human activity that increase the CO<sub>2</sub> content of the ocean and consequently ocean acidification. These are the same factors that are well discussed in terms of climate change so I don't know that they need to be rehashed here. Plastics do not increase ocean acidification, but they do provide one more stressor on the system that contributes to the overall degradation of the marine environment. We do see a strong connection between coastal eutrophication and acidification. Human activities that add nutrients to the coastal waters causing algal blooms that then die and decompose, will result in hypoxia (low oxygen levels) and ocean acidification (high CO<sub>2</sub> levels) in coastal waters.

I think it would be useful to take a step back and think about the overall point of this article. What is it that you are really trying to say? How is your message new or different and why now? I think if we can clearly answer those questions, the OpEd will be better received. I hope this is helpful.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:2065266800)  
fax: [\(206\) 526-4576](tel:2065264576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Mon, Sep 28, 2015 at 9:02 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi Chris,  
Given your terrific help to this point...  
Perhaps you can respond to questions, too?  
Thank you,  
Madelyn

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Mon, Sep 28, 2015 at 11:55 AM  
Subject: Fwd: article on ocean acidification for the NYT  
To: Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>

Hi Rick,  
Didn't get anywhere in NY, but went to the international bureau in Paris where I know the staff.  
Asap, can you please send bullets in response to questions and I'll work them in along with the UK's responses  
Will send full op-ed back to you before resubmitting  
Many thanks,  
Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Mon, Sep 28, 2015 at 11:19 AM  
Subject: article on ocean acidification for the NYT  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
[202 482 4858](tel:2024824858)  
[202 340 6310](tel:2023406310) cell

Dear Madelyn Appelbaum,

Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?  
Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.  
I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/ Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. **TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED.** Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

**ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?**

Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

From: [Phenton, Jayne \(DEFRA\)](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: RE: checking in  
Date: Thursday, September 17, 2015 8:04:47 AM

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Hi Madelyn

My apologies (AGAIN!) for being slow coming back (AGAIN!) - there are one or two concerns. This may be a cultural thing, but I think the feeling is that as this is written by scientists it should be scientifically accurate both for reputation and credibility sake. So below are some thoughts - they're quite technical - hope they don't seem too pedantic.

1. 'Hotspots' is ambiguous: it would seem likely to be mis-understood as areas of higher water temperature (presumably not intended?)
2. The ocean is not taking up CO2 "just like a sponge". The latter process is a liquid-solid interaction that is purely physical (capillary action/surface tension effects); the former is a gas-liquid interaction that is a mix of physics (solubility) and chemistry (carbonate system dynamics). If the phrase were written by a journalist, then it might be excusable; authored by senior science advisors, I don't think it is - and there is risk of credibility being lost. The issue could be avoided by saying "similar to a sponge", but that then reduces much of the impact of the phrase.

There would also now seem to be a lack of clarity regarding the "coal train encircling the equator" analogy, that I think relates to the annual total but now is likely to be (mis-)interpreted as the weekly amount.

Let me know your thoughts.

Best wishes

Jayne

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
Nobel House | 17 Smith Square | London SW1P 3JR

-----Original Message-----

From: Madelyn Appelbaum - NOAA Federal [<mailto:madelyn.appelbaum@noaa.gov>]  
Sent: 17 September 2015 04:31  
To: Phenton, Jayne (DEFRA)  
Subject: checking in

Hi Jayne,  
Can we please get the op-ed this week?  
Thanks,  
Madelyn  
Department for Environment, Food and Rural Affairs (Defra)

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**From:** [Phenton, Jayne \(DEFRA\)](#)  
**To:** [Madelyn Appelbaum - NOAA Federal](#)  
**Subject:** RE: edits are terrific...thank you!  
**Date:** Wednesday, September 30, 2015 9:36:52 AM

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Marvellous – let me know if there's anything else you need!

**From:** Madelyn Appelbaum - NOAA Federal [mailto:madelyn.appelbaum@noaa.gov]  
**Sent:** 30 September 2015 14:16  
**To:** Phenton, Jayne (DEFRA)  
**Subject:** edits are terrific...thank you!

Department for Environment, Food and Rural Affairs (Defra)

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: edits  
Date: Thursday, October 01, 2015 1:01:46 PM

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ok...will fix

On Thu, Oct 1, 2015 at 12:51 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

It is not that the ocean acidification is depleting their energy reserves, but that they do not have the energy reserves to fight against the changing chemistry.

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 9:47 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

would this be ok? I think the energy drain is important, if we can keep it in, since editor is pushing for details

[Ocean currents pushed acidified water into coastal areas, depleting the energy baby oysters require to build protective shells. Without their shells, they drift with the tides until they die.](#)

Already oyster hatcheries on the West Coast of the United States are using technology [\[ocean observing buoys?\]](#) to adapt to ocean acidification and monitor water quality so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification. [\[line or 2 re how?\]](#)

thanks, Chris

From: [Boyd, Ian \(Defra\)](#)  
To: [Madelyn Appelbaum - NOAA Federal](#); [Carol Turley](#)  
Cc: [Davidson, Ian \(Defra\)](#); [Phenton, Jayne \(DEFRA\)](#); [Libby Jewett - NOAA Federal](#); [P.Williamson@uea.ac.uk](mailto:P.Williamson@uea.ac.uk); [Thecla Keizer](#); [Kelvin Root](#)  
Subject: RE: FW: UK-US Ocean op-ed  
Date: Saturday, July 25, 2015 4:04:42 AM

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Madelyn,

It would be good if you could work with Jayne on this.

As a guide from my end, I see it as important this this is not just another regurgitation of standard rhetoric on ocean acidification – doom and gloom doesn't go down well and just causes people to stop listening. It probably needs to be as much a challenge to the scientific community as it is to the policy community.

Here are a few themes I'd welcome:

1. There is strong evidence that atmospheric CO<sub>2</sub> concentrations are increasing and the reason for this is the combustion of fossil fuels.
2. This gaseous CO<sub>2</sub> is in equilibrium with dissolved CO<sub>2</sub> in the ocean and as concentrations increase in the atmosphere CO<sub>2</sub> will be taken up by the ocean, although with a time lag that extends to many centuries duration.
3. Although seawater performs like a chemical buffer, i.e. its chemistry is such that its acidity is fairly constant, the addition of dissolved CO<sub>2</sub> forms carbonic acid and this will tend to make seawater slightly more acidic.
4. The acidity of seawater varies depending upon where measurements are taken. Some of the most acid locations are more acid than the average predicted from uptake of CO<sub>2</sub> so future ocean acidification could lie within the range of current experience. [Note: this needs to be checked, I am working from memory]. But turning the whole of the ocean in to something closer to a current extreme will have important consequences.
5. Standard chemistry predicts that greater seawater acidity presents considerable challenges for some organisms that are important in the ocean ecosystem. Those that have calcareous shells, such as molluscs, coccolithophores and many other planktonic species may find it harder to manufacture and sustain their shells in more acid conditions.
6. The eggs and larvae of many species, including some fish, also do not thrive when conditions are more acid.
7. This adds up to a prediction that ocean acidification will lead to many of the organisms that form key parts of the current ocean ecosystem being at a competitive disadvantage to others that are more resilient. Acidification of the ocean is likely, therefore, to result in a profound shift in the structure and function of ocean ecosystems and it is difficult to predict the consequence of this.
8. Research needs to build our understanding of how much of an impact ocean acidification is likely to have and to build a picture of the way that marine ecosystem dynamics could change as a result of acidification. For example, early studies that suggested high sensitivity of some organisms have been superseded and we are now recognising that, with exposure over multiple generations, many organisms have greater adaptive capacities than first recognised. However, some key organisms will not be able to adapt.
9. It is hard to see a solution to this problem other than to reduce CO<sub>2</sub> emissions. There are few, if any, other direct solutions that can be applied to mitigate the effects on marine organisms. Because of the time lags involved it would also take many hundreds of years to unwind the current effects of high atmospheric CO<sub>2</sub> on the ocean. However, acidification is just one of many stressors applied by man to the oceans and mitigation could be applied indirectly by reducing other stresses that we can control. By reducing these the ocean system overall is likely to have greater resilience to the stress of acidification. These other stresses include over-fishing, chemical and physical pollution, coastal development and coastal sedimentation caused by soil erosion on land.
10. Consequently, if we are to engineer a solution to ocean acidification it is most likely to come about through knowledge of how the whole ocean system works. This is not an easy problem to solve but it is one that researchers need to tackle with more effectively than until now. If this can be matched by similar capacity to manage human activities and influences on the ocean, for example, through improved ocean governance, then we can look forward to a constructive relationship between research and policy. However, while the time lags involved in ocean CO<sub>2</sub> uptake may be measured in terms of centuries, those involved in both improving knowledge of how the ocean works as a system and in ocean governance have time lags of multiple decades. We need to push on with both these strands of work as fast as possible.

I hope all this helps.  
Ian

**From:** Madelyn Appelbaum - NOAA Federal [mailto:madelyn.appelbaum@noaa.gov]  
**Sent:** 25 July 2015 00:49  
**To:** Carol Turley  
**Cc:** Boyd, Ian (Defra); Davidson, Ian (Defra); Phenton, Jayne (DEFRA); Libby Jewett - NOAA Federal; P.Williamson@uea.ac.uk; Thecla Keizer; Kelvin Boot  
**Subject:** Re: FW: UK-US Ocean op-ed

Hello,  
I am eager to begin.  
Can we please schedule a conference call next week so I understand your priorities upfront?  
Thank you,  
Madelyn

----- Forwarded message -----

**From:** **Carol Turley** <[CT@pml.ac.uk](mailto:CT@pml.ac.uk)>  
**Date:** Wed, Jul 15, 2015 at 5:53 AM  
**Subject:** FW: UK-US Ocean op-ed  
**To:** "Boyd, Ian (Defra)" <[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>, "Davidson, Ian (Defra)" <[ian.davidson@defra.gsi.gov.uk](mailto:ian.davidson@defra.gsi.gov.uk)>  
**Cc:** "Jayne.Phenton@defra.gsi.gov.uk" <[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)>, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>, Libby Jewett - NOAA Federal <[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)>, "P.Williamson@uea.ac.uk" <[P.Williamson@uea.ac.uk](mailto:P.Williamson@uea.ac.uk)>, Thecla Keizer <[tke@pml.ac.uk](mailto:tke@pml.ac.uk)>, Kelvin Boot <[kelota@pml.ac.uk](mailto:kelota@pml.ac.uk)>

Dear Ian and Ian

Let me introduce you to Libby Jewett (Director of the NOAA Ocean Acidification programme) and Madelyn Appelbaum (NOAA's communications team). They have had the go-ahead for a NOAA-Defra Chief Scientists' Op-Ed on the ocean as we discussed at our meeting last month (see email below). I know you wanted to involve Defra's communications team, so have copied in Jayne Phenton (Defra Comms) and of course, Phil Williamson, the Science Coordinator for UKOA. I am also copying in Thecla Keizer and Kelvin Boot (both from PML). Thecla is leading applications and logistics for COP side events, Oceans Day and liaising with the Ocean and Climate Platform at Paris during the COP and Kelvin is a member of the PML Comms team.

This Op-Ed opportunity, as Madelyn has quite rightly suggested, should be different from the 2012 Op-Ed ([http://www.nytimes.com/2012/06/19/opinion/acid-test-for-oceans-and-marine-life.html?\\_r=0](http://www.nytimes.com/2012/06/19/opinion/acid-test-for-oceans-and-marine-life.html?_r=0)) and I would like to propose that the multi-stressor approach would be a timely, strong and relevant approach to take especially as the ocean is truly at the frontline of climate change.

A recent Science paper (produced to come out just before the 'Our Common Future Under Climate Change conference' in Paris last week) clearly shows that even RCP2.6 (2°C "target") still brings high risk from climate related ocean stressors to economically important and iconic marine ecosystems. For a copy of the paper please visit : [http://www.obs-vlfr.fr/~gattuso/science\\_reprint.php](http://www.obs-vlfr.fr/~gattuso/science_reprint.php). This conference was the largest forum for the scientific community to come together ahead of the 21st UNFCCC Conference of the Parties (COP21) and building on the results of IPCC 5th Assessment Report. It was organized under the umbrella of ICSU, Future Earth, UNESCO and major French research institutions, with the support of the French Government.

When the paper and related topics were presented at the conference it was clear from the scientists that we should keep well below the RCP2.6. This 'guardrail' concept, in which up to 2 °C of warming is considered safe, is inadequate and would therefore be better seen as an upper limit, a defence line that needs to be stringently defended, while less warming/acidification/deoxygenation/sea level rise would be preferable. And note the

2°C refers to atmospheric warming, not ocean warming and it is based on GHG equivalents not CO<sub>2</sub>. Which brings me to the talk I gave at the conference in Paris (attached FYI). The first few slides are background slides on OA (and other climate related stressors)– the second half of the talk focuses on why the ocean should be mentioned in the negotiation text for COP-21 and how the ocean and its impacts from GHG sit within the UNFCCC mandate. Some of these reasons are very positive such as inclusion of the risk to ocean ecosystems and the goods and services they provide may encourage more nations to reduce emissions. While I don't think that we will get the word "ocean" in the COP-21 outcome document I think it is important to try and be seen to be trying in order that the profile for the ocean is raised higher than it is in the Post 2015 agenda. In my opinion, there is a risk that if we don't push now, it won't be noticed post Paris. Note that the ocean has a SDG goal and OA is mentioned as part of this, so it would be nice to see some join up between the SDGs and the UNFCCC agenda.

The outcome statement of the conference in Paris, which is worth reading, can be found here:

[http://poolo.kermeet.com/Data/kmewexV7/block/F\\_bedaa0dbe3d01a517f0fa7eb11d4b1a4559fae1ae868b.pdf](http://poolo.kermeet.com/Data/kmewexV7/block/F_bedaa0dbe3d01a517f0fa7eb11d4b1a4559fae1ae868b.pdf)

These are some personal thoughts and quotes from the speakers from the conference that will give you a flavour of the event:

For me the science was quite clear at this conference– humans are changing the Earth system and if we continue there will be a very different planet, the ecological, economic and societal costs will be great. The key note on biodiversity said starkly "species can migrate, die or adapt" and whilst the human species is very good at adaptation we have had 100,000 years of stable climate in which to develop but the adaptation strategy of one group or sector could increase risk for another. Human migration is already occurring and is likely to increase; adaptation capacity and choices will decrease as CO<sub>2</sub> increases and become more costly. "We need to avoid having to be resilient as that accepts that we will change the Earth System irrevocably, that is we are normalising resilience, rather we need to avoid a future warmer world – we need to resist climate change."

However, there was a glimmer of hope from some of the plenary discussions:

An analogy was made with the abolition of slavery. Three factors contributed (fear, industrial development to replace slave labour and morals/ethics) with the latter a driving force once the first two were in place. This resulted in the UK abolishing slavery and this was eventually followed by other countries (different countries had different time scales). It initially cost the UK 2% of GDP but then after that investment it prospered as it was first off the mark.

Today we have all three factors: fear of impacts of climate change, development of technology that is fossil fuel free and morals of creating an unimaginable future for future generations. We also have figures of around 2% GDP for implementing this, although there were arguments that if you stack co-benefits (energy security and pollution reduction) the costs for mitigating climate change are around 1% GDP.

The focus of the UNFCCC COPs has been global agreement and implementation however it was argued in the final plenary that what was needed was a starting point (as in the abolition of slavery) with a narrative for a decarbonised future: "a low carbon economy is the future and can be achieved by a bottom up and top down coalition of willing and working states and players. They will be joined by others, each moving at different speeds. This will be transformational and we need to create a vision of an exciting world without carbon that is positive. There will be short term costs now but long major term gains in the future." Some of the scientists in the final plenary called for a recommendation to remove subsidies to the fossil fuel industries (\$800B/a) which was an interesting thought!

I therefore think that the scene has been set at the Our Common Future Conference – a call from all scientists to avoid dangerous climate change. An Op-Ed on the ocean climate related stressors will therefore be timely

and appropriate especially if it can be delivered before the UNFCCC COP21 (30 November - 12 December 2015).

Please let me know if I can be of any further assistance.

Best wishes

Carol

Dr Carol Turley OBE  
Plymouth Marine Laboratory  
Knowledge Exchange Coordinator, UK Ocean Acidification Research Programme  
<http://www.oceanacidification.org.uk/>

**From:** Madelyn Appelbaum - NOAA Federal [<mailto:madelyn.appelbaum@noaa.gov>]  
**Sent:** 13 July 2015 20:10  
**To:** Carol Turley  
**Cc:** Libby Jewett - NOAA Federal  
**Subject:** op-ed

Hi Carol,  
Libby prodded, and I now have the green light to develop an op-ed with Rick Spinrad, our chief scientist, as co-author. Beyond stressors, what do you think Prof Boyd would like to focus on? And what is new?? For the op-ed to fly, it can't look like the prior one.

Thanks,

Madelyn

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Winner of the Environment & Conservation category, the Charity Awards 2014.

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Department for Environment, Food and Rural Affairs (Defra)

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Richard Feely](#)  
Cc: [Chris Sabine - NOAA Federal](#); [Simone Alin - NOAA Federal](#)  
Subject: Re: Fwd: INYT done deal please see asap  
Date: Monday, October 05, 2015 1:14:46 PM

---

many thanks

On Mon, Oct 5, 2015 at 12:53 PM, Richard Feely <[richard.a.feely@noaa.gov](mailto:richard.a.feely@noaa.gov)> wrote:  
Chris et al:

Based on the Barton et al (2015) paper in Oceanography I would say that the West coast oyster industry's net income is approximately \$117 Million (see page 149 in the attached article). Total shellfish farming supports over \$270 Million in total economic activity and 3000 family wage jobs in the Pacific Northwest.

Best regards,

Richard Feely

On 10/5/15 8:18 AM, Chris Sabine - NOAA Federal wrote:

Dick and Simone,

Can you please provide the correct numbers and credible reference for #1 below?

Thanks,  
Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Mon, Oct 5, 2015 at 8:12 AM  
Subject: INYT done deal please see asap  
To: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>

best fact checker for #1?  
I'll handle the rest  
thanks!

----- Forwarded message -----

From: **APPEL, Rebecca** <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
Date: Mon, Oct 5, 2015 at 10:57 AM  
Subject: Spinrad/Boyd op-ed for INYT-- follow up questions

To: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)

Dear Madelyn,

I work with Joe Gregory on the INYT Op-ed pages, and am helping him to factcheck the upcoming Spinrad/Boyd column. I've gone through it and have just a few questions for you, pasted below. Could you please take a look and respond to these as soon as possible? Don't hesitate to ask if anything is unclear.

Many thanks in advance, and all best,  
Rebecca

Rebecca Appel

International New York Times Editorial Page

 [+44 207 061 6676](tel:+442070616676)

1. About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs

I'm seeing a different figure for the value of the Pacific Northwest oyster industry, and also that the 3,000 jobs refer to the entire West Coast shellfish industry, not Pacific Northwest oyster production specifically: "Oyster production represents \$84 million of the West Coast shellfish industry, which supports more than 3,000 jobs." See: [http://www.noaa.gov/features/01\\_economic/pacificoysters.html](http://www.noaa.gov/features/01_economic/pacificoysters.html) and <http://www.pmel.noaa.gov/co2/story/Pacific+Oysters+Gain+from+Ocean+Acidification+Data>.

Can you please confirm both of these points, and send a source?

2. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever

Can you please send a link to this study, or a copy of the report?

3. We are pleased that representatives of our two nations lead the pioneering [Global Ocean Acidification Observing Network](#),

Should we rephrase here? It looks like the current co-chairs are from the U.S. and Australia, right?

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Clarke, Laura \(DEFRA\)](#)  
Subject: Re: Fwd: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 11:33:12 AM  
Attachments: [Ian Boyd contract.pdf](#)

---

thanks again  
signed contract for your files

On Thu, Oct 15, 2015 at 10:35 AM, Clarke, Laura (DEFRA)  
<[Laura.Clarke@defra.gsi.gov.uk](mailto:Laura.Clarke@defra.gsi.gov.uk)> wrote:

Dear Madelyn,

Just to confirm that we are happy for you to sign this article off on Ian's behalf.

Many thanks,

Laura

**Laura Clarke**

Office of the Chief Scientific Adviser and Office of the Chief Economist

Department for Environment, Food & Rural Affairs  
Area 6C Nobel House

17 Smith Square, London, SW1P 3JR

Tel: 0207 238 1154

Email: [laura.clarke@defra.gsi.gov.uk](mailto:laura.clarke@defra.gsi.gov.uk)

---

**From:** Madelyn Appelbaum - NOAA Federal [<mailto:madelyn.appelbaum@noaa.gov>]  
**Sent:** Thursday, October 15, 2015 10:30 AM  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>; Boyd, Ian (Defra)  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject:** Fwd: Publication of Op-Ed in INYT

Should clarify that you do not need to bother with most of attached. The article has already been thoroughly fact-checked and cited. There is just a box to insert basic contact info and the required signature. Form can be scanned and e-mailed to NY Times in NY.

This is the last step. Thank you!

Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>, Ian Boyd  
<[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject: Fwd: Publication of Op-Ed in INYT**

Can you please sign and return the attached ASAP today, or let me know that I can sign on your behalf?

Thanks,

Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** "APPEL, Rebecca" <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
**To:** Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject: Publication of Op-Ed in INYT**

Dear Madelyn,

This is just to let you know that Richard Spinrad and Ian Boyd's op-ed will be running in tomorrow's print editions of the INYT, and will be online later today.

At this stage, could you please have them each sign and email back  
a copy  
of our contributor contract, attached here, or do so on their behalf?  
(Just  
ignore the W9.)

Don't hesitate to ask if you have any questions, and thanks again  
for all  
your help.

Best,

Rebecca

Rebecca Appel  
International New York Times Editorial Page

[+44 207 061 6676](tel:+442070616676)

Department for Environment, Food and Rural Affairs (Defra)

This email and any attachments is intended for the named recipient only. If you have  
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whilst within Defra systems we can accept no responsibility once it has left our systems.  
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the effective operation of the system and for other lawful purposes.

**W-9**

Rev. April 2009  
Department of the Treasury  
Internal Revenue Service

# Request for Taxpayer Identification Number and Certification

Give Form to the  
requester. Do not  
send to the IRS.

Name (as shown on your income tax return)

Business name/disregarded entity name (if different from above)

Check appropriate box for federal tax classification:

- ☐ Individual sole proprietor ☐ C Corporation ☐ S Corporation ☐ Partnership ☐ Trust/Volunteer  
☐ Limited liability company (LLC) for tax classification (C or S corporation, S corporation, Partnership)  
☐ Other (see instruction 1)

Exempt from FATCA reporting (if any)

Exemption code (if any)

Exemption from FATCA reporting code (if any)

Address (number, street, and apt. or suite no.)

Requester's name and address (optional)

City, state, and ZIP code

List account number(s) here (optional)

## Taxpayer Identification Number (TIN)

Enter your TIN in the appropriate box. The TIN provided must match the name given on the "Name" line to avoid backup withholding. For individuals, this is your social security number (SSN). NowGov, for a resident alien, sole proprietor, or disregarded entity, see the Part I instructions on page 3. For other entities, it is your employer identification number (EIN). If you do not have a number, see *How to get a TIN* on page 3.

**Note.** If the name is in more than one name, see the chart on page II for guidelines on whose number to enter.

Social Security number

ITC-0J-11111

Employer identification number

OJ-11111

## Certification

Under penalties of perjury, I certify that:

- The number shown on this form is my correct taxpayer identification number (or I am waiting for a number to be issued to me), and
- I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding, and
- I am a U.S. citizen or other U.S. person (defined below), and
- The FATCA code(s) entered on this form (if any) indicating that I am exempt from FATCA reporting is correct.

**Certification Instructions.** You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return. For real estate transactions, item 2 does not apply. For mortgage interest, paid, acquisition or abandonment of secured property, cancellation of debt, contributions to an individual retirement arrangement (IRA), and generally payments of 10% or more interest and dividends, you are not required to sign the certification, but you must provide your correct TIN. See the instructions on page 3.

Sign  
Here

Signature of  
U.S. person...

Date...

## General Instructions

Get the latest version of the Internal Revenue Code unless otherwise noted.

**Future developments.** The IRS has created a page on IRS.gov for information about the W-9, Changes, and Updates. In addition, the IRS will post updates to the W-9 (such as changes in instructions or other updates) on that page.

## Purpose of Form

A person who is required to file an information return with the IRS must obtain your correct taxpayer identification number (TIN) to report tax-exempt income paid to you, payments made to you in settlement of payment card and third-party network transactions, real estate transactions, mortgage interest, or paid acquisition or abandonment of secured property, cancellation of debt, or contributions to an IRA.

U.S. persons only. If you are a U.S. person (including a resident alien), you must provide your correct TIN to the person requesting it. U.S. persons who are not required to do so:

1. Certify that the TIN you are giving is correct (or you are waiting for a number to be issued).
2. Certify that you are not subject to backup withholding, or
3. Check exemption from backup withholding if you are a U.S. exempt payee. If applicable, you are also certifying that as a U.S. person, your allocable share of any business income from a U.S. trade or business is not subject to the

withholding tax on foreign partner's share of effectively connected income and

4. Certify that FATCA code(s) entered on this form (if any) indicating that you are exempt from FATCA reporting is correct.

**Note.** If you are a U.S. person and a requester gives you a form other than Form W-9 to request your TIN, you must use the requester's form if it is substantially similar to this Form W-9.

**Definition of a U.S. person for federal tax purposes.** You are considered a U.S. person if you are:

- An individual who is a U.S. citizen or U.S. resident alien
- A partnership, corporation, company, or association created or organized in the United States or under the laws of the United States
- An estate (other than a foreign estate)
- A domestic trust, as defined in Regulations under Section 671(b)(1)

**Special rules for partnerships.** Partnerships that conduct a trade or business in the United States are generally required to pay a withholding tax under section 1446 on any foreign partner's share of effectively connected taxable income from that business. Further, in condoleases where a Form W-9 has not been received, the rules under section 1446 require a partnership to presume that a partner is a foreign person, and pay the section 1446 withholding tax. Therefore, if you are a U.S. person that is a partner in a partnership conducting a trade or business in the United States, provide Form W-9 to the partnership to establish your U.S. status and avoid section 1446 withholding on your share of partnership income.



**From:** [Clarke, Laura \(DEFRA\)](#)  
**To:** [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
**Subject:** RE: Fwd: Publication of Op-Ed in INYT  
**Date:** Thursday, October 15, 2015 10:35:37 AM

---

Dear Madelyn,

Just to confirm that we are happy for you to sign this article off on Ian's behalf.

Many thanks,  
Laura

**Laura Clarke**

Office of the Chief Scientific Adviser and Office of the Chief Economist

Department for Environment, Food & Rural Affairs  
Area 6C Nobel House  
17 Smith Square, London, SW1P 3JR

Tel: 0207 238 1154  
Email: [laura.clarke@defra.gsi.gov.uk](mailto:laura.clarke@defra.gsi.gov.uk)

---

**From:** Madelyn Appelbaum - NOAA Federal [<mailto:madelyn.appelbaum@noaa.gov>]  
**Sent:** Thursday, October 15, 2015 10:30 AM  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>; Boyd, Ian (Defra)  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject:** Fwd: Publication of Op-Ed in INYT

Should clarify that you do not need to bother with most of attached. The article has already been thoroughly fact-checked and cited. There is just a box to insert basic contact info and the required signature. Form can be scanned and e-mailed to NY Times in NY.

This is the last step. Thank you!

Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>, Ian Boyd <[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject:** Fwd: Publication of Op-Ed in INYT

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Thanks,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** "APPEL, Rebecca" <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
**To:** Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
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Dear Madelyn,

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At this stage, could you please have them each sign and email back a copy of our contributor contract, attached here, or do so on their behalf? (Just ignore the W9.)

Don't hesitate to ask if you have any questions, and thanks again for all your help.

Best,

Rebecca

Rebecca Appel  
International New York Times Editorial Page

+44 207 061 6676

Department for Environment, Food and Rural Affairs (Defra)

This email and any attachments is intended for the named recipient only. If you have received it in error you have no authority to use, disclose, store or copy any of its contents and you should destroy it and inform the sender. Whilst this email and associated attachments will have been checked for known viruses whilst within Defra systems we can accept no responsibility once it has left our systems. Communications on Defra's computer systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Clarke, Laura \(DEFRA\)](#)  
Subject: Re: Fwd: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 10:40:45 AM

---

thank you

On Thu, Oct 15, 2015 at 10:35 AM, Clarke, Laura (DEFRA)  
<[Laura.Clarke@defra.gsi.gov.uk](mailto:Laura.Clarke@defra.gsi.gov.uk)> wrote:

Dear Madelyn,

Just to confirm that we are happy for you to sign this article off on Ian's behalf.

Many thanks,

Laura

**Laura Clarke**

Office of the Chief Scientific Adviser and Office of the Chief Economist

Department for Environment, Food & Rural Affairs  
Area 6C Nobel House

17 Smith Square, London, SW1P 3JR

Tel: 0207 238 1154

Email: [laura.clarke@defra.gsi.gov.uk](mailto:laura.clarke@defra.gsi.gov.uk)

---

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**Sent:** Thursday, October 15, 2015 10:30 AM  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>; Boyd, Ian (Defra)  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
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<[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
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<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject: Publication of Op-Ed in INYT**

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for all  
your help.

Best,

Rebecca

Rebecca Appel  
International New York Times Editorial Page

[+44 207 061 6676](tel:+442070616676)

Department for Environment, Food and Rural Affairs (Defra)

This email and any attachments is intended for the named recipient only. If you have received it in error you have no authority to use, disclose, store or copy any of its contents and you should destroy it and inform the sender. Whilst this email and associated attachments will have been checked for known viruses whilst within Defra systems we can accept no responsibility once it has left our systems. Communications on Defra's computer systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: Help!  
Date: Thursday, October 01, 2015 9:34:49 PM

---

thank you!

Sent from my iPhone

On Oct 1, 2015, at 9:33 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Hi Madelyn,

It is way too late for you to be still working on this.

I don't think it is a big deal, but I suppose to be consistent we should say  
"Increasing acidification is..."

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 6:19 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Chris, this just hit...

Is "increasing acidity" at opening of 3rd par incorrect?

if anyone flagged it, I missed it

thanks

Sent from my iPhone

From: [Chris Sabine - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: Help!  
Date: Thursday, October 01, 2015 9:33:20 PM

---

Hi Madelyn,

It is way too late for you to be still working on this.

I don't think it is a big deal, but I suppose to be consistent we should say "Increasing acidification is..."

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 6:19 PM, Madelyn Appelbaum - NOAA Federal  
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Is "increasing acidity" at opening of 3rd par incorrect?

if anyone flagged it, I missed it

thanks

Sent from my iPhone

From: [Rick Spinrad - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#)  
Subject: Re: Joint NOAA-UK OA Op-ed  
Date: Saturday, September 05, 2015 9:56:46 AM

---

Madelyn - This is excellent. My only recommendation is to provide specific citation information for the two NOAA studies referred to (shellfish industry impacts, and CO2 emission rates). I think the tone and content are good.

RS

*Chief Scientist  
National Oceanic and Atmospheric Administration*

Sent from my iPad

On Sep 4, 2015, at 6:48 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Here is Ian Boyd's signed-off op-ed copy. Much of the initial content and flow remain intact, but our version was deemed a "bit too emotive," so attached is toned down. I have been ping-ponging with Boyd and several on his staff since Aug 6 and hope attached will be ok. But if anything gives you heartburn, I will revisit. I suggest taking a first shot with the NY Times and international version, although some of what I believe would have captured the editors' attention is now drained out.

Many thanks and have a terrific holiday weekend,  
Madelyn

<NOAA-DEFRA ocean acidification op-ed Sept 4 15.docx>

**From:** [Ciaran Clayton - NOAA Federal](#)  
**To:** [Madelyn Appelbaum - NOAA Federal](#)  
**Subject:** Re: NOAA UK Op-ed  
**Date:** Wednesday, August 05, 2015 1:04:01 PM

---

Madelyn

I think this looks very solid! Go ahead and send to Rick.

Thanks

Sent from my iPhone

> On Aug 5, 2015, at 10:35 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

>

> Hi Ciaran,

> Here's proposed op-ed from Rick and his UK counterpart, Ian Boyd.

> Chris Sabine vetted it yesterday.

> Rick and UK folks haven't yet seen this but discussed content upfront with both, and I believe this fills expectations.

> My hope is that op-ed can be submitted to the NY Times and international edition, but there may be concerns, which I will discuss with you. When NOAA published an OA op-ed in the NYT and the then International Herald Tribune in 2012, the Pacific NW oyster story was highlighted, so it's not included in the attached. This approach/copy need to be 100% different.

> I hope op-ed can go to Rick this week. He'll review it quickly, then we can move it to UK before everyone disappears for the rest of Aug.

> Thanks -- next up is Katrina for MS Clarion-Ledger and Naples op-ed with IBHS.

> Madelyn

>

>

> <NOAA UK oped 8 5 15.docx>

From: [Libby Jewett - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: NOAA/DEFRA op-ed  
Date: Thursday, October 15, 2015 9:51:12 AM

---

I am so sorry that I didn't get back to you. I was out of the country last week. Phil W. did step down as co-chair of the GOA-ON and I am now co-chairing with a scientist from Australia.

So maybe we can do an Op Ed with Australia next??

On Thu, Oct 15, 2015 at 9:45 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

one down!

will be in print tomorrow in the International NY Times  
(definitely not our proposed title)

thanks,  
Madelyn

--

Libby Jewett, PhD  
Director, Ocean Acidification Program  
National Oceanic and Atmospheric Administration  
SSMC 3; Rm 10356  
phone: 301-734-1075

Follow me on Twitter: @LibbyJewett

OAP Website: [OceanAcidification.NOAA.gov](http://OceanAcidification.NOAA.gov)

Global OA Observing Network: [www.goa-on.org](http://www.goa-on.org)

Follow the NOAA Ocean Acidification Program on [Facebook](#) and [Twitter](#)

Note: The content of this message does not reflect any position of the U.S. Government or of NOAA unless otherwise specified.

From: [Libby Jewett - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Schaaf, Kenli A \(OES\)](#)  
Subject: Re: NOAA/DEFRA op-ed  
Date: Thursday, October 15, 2015 9:49:00 AM

---

Awesome. Thanks for all your hard work on this. You rock.

On Thu, Oct 15, 2015 at 9:45 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

one down!

will be in print tomorrow in the International NY Times  
(definitely not our proposed title)

thanks,  
Madelyn

--

Libby Jewett, PhD  
Director, Ocean Acidification Program  
National Oceanic and Atmospheric Administration  
SSMC 3; Rm 10356  
phone: 301-734-1075

Follow me on Twitter: [@LibbyJewett](#)

OAP Website: [OceanAcidification.NOAA.gov](http://OceanAcidification.NOAA.gov)

Global OA Observing Network: [www.goa-on.org](http://www.goa-on.org)

Follow the NOAA Ocean Acidification Program on [Facebook](#) and [Twitter](#)

Note: The content of this message does not reflect any position  
of the U.S. Government or of NOAA unless otherwise specified.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Libby Jewett - NOAA Federal](#)  
Subject: Re: NOAA/DEFRA op-ed  
Date: Thursday, October 15, 2015 9:51:40 AM

---

as always, you are being super kind  
thank you, Libby

on to Al's...maybe Jane's...

On Thu, Oct 15, 2015 at 9:48 AM, Libby Jewett - NOAA Federal <[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)> wrote:

Awesome. Thanks for all your hard work on this. You rock.

On Thu, Oct 15, 2015 at 9:45 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

one down!  
will be in print tomorrow in the International NY Times  
(definitely not our proposed title)

thanks,  
Madelyn

--

Libby Jewett, PhD  
Director, Ocean Acidification Program  
National Oceanic and Atmospheric Administration  
SSMC 3; Rm 10356  
phone: [301-734-1075](tel:301-734-1075)

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Libby Jewett - NOAA Federal](#)  
Subject: Re: NOAA/DEFRA op-ed  
Date: Thursday, October 15, 2015 9:55:19 AM

---

maybe after Christmas?  
and I retained UK via "help lead" since that is still valid

hope you had a wonderful trip and we can catch up again soon  
may drop GEO from upcoming performance plan but am going to straight-out refuse to totally drop OA

On Thu, Oct 15, 2015 at 9:50 AM, Libby Jewett - NOAA Federal <[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)> wrote:

I am so sorry that I didn't get back to you. I was out of the country last week.  
Phil W. did step down as co-chair of the GOA-ON and I am now co-chairing with a scientist from Australia.

So maybe we can do an Op Ed with Australia next??

On Thu, Oct 15, 2015 at 9:45 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

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From: [Libby Jewett - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: NOAA/DEFRA op-ed  
Date: Thursday, October 15, 2015 9:53:24 AM

---

You deserve it!

On Thu, Oct 15, 2015 at 9:51 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

as always, you are being super kind  
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Note: The content of this message does not reflect any position  
of the U.S. Government or of NOAA unless otherwise specified.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Subject: Re: NOAA-DEFRA Op-ed  
Date: Thursday, September 17, 2015 1:21:16 PM

---

searched a few times and couldn't find others, but resent the full google doc back to UK

On Thu, Sep 17, 2015 at 1:09 PM, Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)> wrote:

Yes. Note other minor edits. Shouldn't be an issue with our British colleagues.

RS

On Thu, Sep 17, 2015 at 12:03 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

thanks and "carbonate" my screw-up  
will check with UK  
otherwise, good to go?

On Thu, Sep 17, 2015 at 11:57 AM, Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)> wrote:

Thanks, Madelyn - I just shared with you a Google docs version with a few minor edits and one followup for clarification.

RS

On Thu, Sep 17, 2015 at 11:40 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

at last...a sign-off from UK on joint ocean acidification op-ed

Rick and Ciaran, this is very close to what you reviewed before but, to make it a bit more op-ed page friendly, I worked some of the initial wording back in. Chris Sabine signed-off again, and Libby's edits and some from State are also incorporated. Once you ok, I will submit to the NY Times, and we'll see.... If that doesn't fly, I can take a shot with the Washington Post.

Thanks everyone for your patience, and please let me know if you have questions.  
Madelyn

--

*Dr. Rick Spinrad  
Chief Scientist  
National Oceanic and Atmospheric Administration*

--

*Dr. Rick Spinrad*  
*Chief Scientist*  
*National Oceanic and Atmospheric Administration*

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Lawrence, David \(DEFRA\)](#)  
Subject: Re: OA on social media  
Date: Thursday, October 15, 2015 12:16:35 PM

---

will forward  
many thanks

On Thu, Oct 15, 2015 at 12:06 PM, Lawrence, David (DEFRA)  
<[David.Lawrence@defra.gsi.gov.uk](mailto:David.Lawrence@defra.gsi.gov.uk)> wrote:

Hi Madelyn – Ian is on Twitter - @defrachiefscien in case NYTimes wanted to include it in their tweet?

David

**David Lawrence** | Communications Officer |

Department for Environment, Food and Rural Affairs

Direct Line: **0207 238 6299** | Mobile: 0747114108 | Out of Hours: **0345 051 8486**

Nobel House | 17 Smith Square | London, SW1P 3JR

**From:** Madelyn Appelbaum - NOAA Federal [mailto:[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)]  
**Sent:** 15 October 2015 17:00  
**To:** Rick Spinrad - NOAA Federal; Boyd, Ian (Defra)  
**Cc:** Ciaran Clayton - NOAA Federal; Scott Smullen - NOAA Federal; Libby Jewett - NOAA Federal; Lawrence, David (DEFRA); Jennifer Mintz - NOAA Federal  
**Subject:** OA on social media

Happy to let you know that the NY Times selects a few articles each day to highlight on its array of social media platforms. Your op-ed is on today's list. Hope others also will amplify.

Thanks,

Madelyn

Department for Environment, Food and Rural Affairs (Defra)

This email and any attachments is intended for the named recipient only. If you have received it in error you have no authority to use, disclose, store or copy any of its contents and you should destroy it and inform the sender.

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Communications on Defra's computer systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

From: [Richard Feely](#)  
To: [Madelyn Appelbaum - NOAA Federal](#); [Chris Sabine - NOAA Federal](#)  
Cc: [Libby Jewett - NOAA Federal](#); [Ciaran Clayton - NOAA Federal](#); [Pieter Tans - NOAA Federal](#); [Jan Newton](#); [Shallin Busch - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#); [Brady Phillips - NOAA Federal](#); [Rick Spinrad - NOAA Federal](#)  
Subject: Re: OA op-ed...thank you!  
Date: Thursday, October 15, 2015 12:18:46 PM

---

Madelyn et al:

Very nice job with this OP ED By Rick and Ian. These are very important actions by our leaders.

Glad I could help.

Dick

On 10/15/15 7:57 AM, Madelyn Appelbaum - NOAA Federal wrote:

right back at you, Chris  
many late hours for you, even with the time change, and countless questions could not have completed this without you

On Thu, Oct 15, 2015 at 10:54 AM, Chris Sabine - NOAA Federal  
<[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Hi Madelyn,

The title is quite inflammatory and the graphic the Times created doesn't help, but I know that was not under your control. I think you did a fantastic job with the text and I know all the late hours and frustrating exchanges you had to go through to get this done. Congratulations on getting this published.

Cheers,  
Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 15, 2015 at 7:28 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

Thanks everyone. Rick's op-ed with his UK colleague finally landed today (sorry about the title).  
Tomorrow it appears in print in the International NY Times.  
Chris and each of you were extremely helpful and patient through mega rounds of questions and edits, and I am very grateful. So lucky to be working

with you!

Best wishes,  
Madelyn

From: [Pieter Tans - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: OA op-ed...thank you!  
Date: Thursday, October 15, 2015 11:10:35 AM

---

Madelyn,

The Op-Ed reads well. Thank you for making sure it is also accurate.

Pieter

On Thu, Oct 15, 2015 at 8:28 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

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Madelyn

From: [Libby Jewett - NOAA Federal](#)  
To: [Brady Phillips - NOAA Federal](#)  
Cc: [Madelyn Appelbaum - NOAA Federal](#); [Chris Sabine - NOAA Federal](#); [Ciaran Clayton - NOAA Federal](#); [Pieter Tans - NOAA Federal](#); [Jan Newton](#); [Shallin Busch - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#); [Richard Feely - NOAA Federal](#); [Rick Spinrad - NOAA Federal](#)  
Subject: Re: OA op-ed...thank you!  
Date: Thursday, October 15, 2015 10:40:58 AM

---

indeed!

On Thu, Oct 15, 2015 at 10:37 AM, Brady Phillips - NOAA Federal

<[brady.phillips@noaa.gov](mailto:brady.phillips@noaa.gov)> wrote:

Excellent job to Madelyn, for coalescing a lot of brilliant minds and thought into a well written OpEd! And thanks to the many other who helped her put your ideas and thoughts into the piece.

Cheers, Brady

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Best wishes,  
Madelyn

--

Brady Phillips  
Public Affairs Specialist & National NOAA Landscape Conservation Cooperatives  
Coordinator  
National Oceanic and Atmospheric Administration  
Office of Communications and External Affairs  
14th and Constitution Avenue, NW, Room 60028  
Washington, DC 20230 USA  
Office: [202-482-2365](tel:202-482-2365)  
Cell: [202-407-1298](tel:202-407-1298)  
E-mail: [Brady.Phillips@noaa.gov](mailto:Brady.Phillips@noaa.gov)  
Web: [www.noaa.gov](http://www.noaa.gov)  
Twitter: @BradyNOAA

--

Libby Jewett, PhD  
Director, Ocean Acidification Program  
National Oceanic and Atmospheric Administration  
SSMC 3; Rm 10356  
phone: 301-734-1075

Follow me on Twitter: @LibbyJewett  
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From: [Brady Phillips - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Chris Sabine - NOAA Federal](#); [Libby Jewett - NOAA Federal](#); [Ciaran Clayton - NOAA Federal](#); [Pieter Tans - NOAA Federal](#); [Jan Newton](#); [Shallin Busch - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#); [Richard Feely - NOAA Federal](#); [Rick Spinrad - NOAA Federal](#)  
Subject: Re: OA op-ed...thank you!  
Date: Thursday, October 15, 2015 10:37:52 AM

---

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<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

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E-mail: [Brady.Phillips@noaa.gov](mailto:Brady.Phillips@noaa.gov)  
Web: [www.noaa.gov](http://www.noaa.gov)  
Twitter: @BradyNOAA

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Brady Phillips - NOAA Federal](#)  
Subject: Re: OA op-ed...thank you!  
Date: Thursday, October 15, 2015 10:42:09 AM

---

thanks, Brady  
very kind

On Thu, Oct 15, 2015 at 10:37 AM, Brady Phillips - NOAA Federal

<[brady.phillips@noaa.gov](mailto:brady.phillips@noaa.gov)> wrote:

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Subject: Re: OA op-ed...thank you!  
Date: Thursday, October 15, 2015 10:57:28 AM

---

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Madelyn

From: [Rick Spinrad - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Chris Sabine - NOAA Federal](#); [Libby Jewett - NOAA Federal](#); [Ciaran Clayton - NOAA Federal](#); [Pieter Tans - NOAA Federal](#); [Jan Newton](#); [Shallin Busch - NOAA Federal](#); [Jennifer Mintz - NOAA Federal](#); [Richard Feely - NOAA Federal](#); [Brady Phillips - NOAA Federal](#)  
Subject: Re: OA op-ed...thank you!  
Date: Thursday, October 15, 2015 12:33:47 PM

---

You all did the hard work and deserve the credit. Great job, all!

Sent from my iPhone

On Oct 15, 2015, at 8:28 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

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Best wishes,  
Madelyn

From: [Chris Sabine - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: one last round...  
Date: Tuesday, August 04, 2015 11:11:24 AM

---

Madelyn,

You can use "CO2 overload" if you like, but I am not sure exactly what that means. How is it an overload? The oceans can certainly hold more CO2 so I would not say it is overloaded. Just my scientific precision kicking in.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Tue, Aug 4, 2015 at 12:40 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Chris, thanks again.

Your edits make a nice (needed!) difference, and sending it to Rick with your blessing will definitely ease the review.

Just a few last questions on attached..

Also, can I refer to "Co2 overload?" If not a problem, I'll find somewhere to plug it in.

Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Ciaran Clayton - NOAA Federal](#)  
Subject: Re: Op Ed on Ocean Acidification: Need Madelyn's help!  
Date: Monday, July 13, 2015 2:50:00 PM

---

ok, thanks  
will talk with him so I have his thoughts upfront

On Mon, Jul 13, 2015 at 2:40 PM, Ciaran Clayton - NOAA Federal

<[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)> wrote:

Based on titles, Libby's recommendation is Rick.

On Mon, Jul 13, 2015 at 2:34 PM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

do you envision this for Kathy or Rick?

On Mon, Jul 13, 2015 at 2:33 PM, Ciaran Clayton - NOAA Federal

<[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)> wrote:

Madelyn,

Can you give Libby a call about this opportunity this week? I've green lit you working on it; I do want to stay involved in the drafting/messaging/editing.

Note that we're working on an op-ed signed by Rick that may include pitching the Times, so we'll need to stay coordinated.

Thanks,

Ciaran

----- Forwarded message -----

From: **Libby Jewett - NOAA Federal** <[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)>

Date: Fri, Jul 10, 2015 at 3:22 PM

Subject: Re: Op Ed on Ocean Acidification: Need Madelyn's help!

To: Ciaran Clayton - NOAA Federal <[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)>

Cc: Scott Smullen <[scott.smullen@noaa.gov](mailto:scott.smullen@noaa.gov)>

Thanks, Ciaran.

In response to your questions:

A close UK science colleague of mine who works regularly and closely with UK government officials has determined that Ian is interested in co-signing an op-ed that underscores growing global concerns about ocean acidification, including how OA erodes food security and environmental and economic resilience and what it will take (in large part, a comprehensive observational infrastructure) to mitigate it. On OA research, building resilience, and an emerging observational infrastructure, NOAA is demonstrating pioneering leadership. The rationale for an op-ed is to point to the threats, indicate approaches to addressing them, and highlight NOAA's effectiveness.

Since we were not directly advocating policy, State did not need to weigh in on the prior OA op-ed that Madelyn developed for the NY Times and the International Herald Tribune, even though it was also tied to a major international conference. The hope is to again develop an op-ed for both the Times and its international version. I work quite closely with State on OA and, as needed, believe the vetting can move quickly and smoothly. I understand that Madelyn is already working on local op-eds, including for 4 New England states where OA is a fast-growing concern, but the proposed NY Times op-ed would integrate an international focus and be much bigger picture than one for local papers. For the Jan conference in Monaco, Madelyn crafted a knock-out speech and a good portion of the content would be suitable for the op-ed.

There is strong, growing OA interest on the Hill, and NOAA has an expansive story to tell. I hope we can tell it. Since Rick's position is more closely aligned with Ian's than Dr. Sullivan's, perhaps he could be the co-signee. Given that he energetically prodded the creation of NOAA's OA Program, I believe he would

sign-on.

Thanks again for considering. I hope to get back to our UK colleagues asap.

Let me know? We want to start moving forward on this as soon as possible.

Libby

On Mon, Jul 6, 2015 at 4:42 PM, Ciaran Clayton - NOAA Federal

<[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)> wrote:

Hi Libby

Thanks for reaching out. I think this seems promising, but I think we have to consider a few things before moving forward:

Did Ian propose an angle/thesis/argument for the op-ed? Or is that TBD?

Would he be the co-signatory for this piece (in addition to either Rick or Kathy)?

What outlet was he hoping to pitch? (We have a very robust op-ed calendar in place targeting Tier I and II outlets across the country, so I want to make sure we're not running afoul of other opportunities/plans).

If this is timed around the conference, we'd have to clear this with State, which takes time.

If you don't have the answers right now, we can certainly put Madelyn in touch with the appropriate staff in the UK to suss out what opportunity might exist.

Thanks,  
Ciaran

On Thu, Jul 2, 2015 at 10:56 AM, Libby Jewett - NOAA Federal

<[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)> wrote:

Ciaran,

I know that Madelyn has been doing a great job with writing a variety of Op Eds recently. I REALLY need her help with another one in the coming months.

Several years ago, NOAA supported two widely-praised and referenced op-eds. The first, on space weather, was initially to be co-signed by Jane Lubchenco and Sir John Beddington, John Holdren's UK counterpart, but was quickly bumped up to Holdren. The second, on ocean acidification, was co-signed by Jane and Sir John. Madelyn rapidly (literally overnight) and effectively developed both op-eds, proving quite adept at creating an editorial article that Holdren immediately approved. Both articles were published in both The New York Times and the International Herald Tribune.

Now, Ian Boyd, chief scientific advisor to the UK's Department for the Environment, is very interested in doing another Op Ed on ocean acidification, and our team hopes that Madelyn can be assigned to develop it, with either Dr Sullivan or Rick Spinrad as co-signer. The article would fit well with NOAA's resilience and observational priorities and could go an important distance in recognizing NOAA's leadership in growing an international ocean observing system. Ideally, the op-ed could appear in the fall prior to the second ocean

conference at which Secretary Kerry and ocean acidification will be prominent. We want visibility for NOAA's pioneering global leadership to be prominent, too! I hope we can begin moving on the op-ed with a NOAA co-signer this month.

What do you think?

Libby

--

Libby Jewett, PhD  
Director, Ocean Acidification Program  
National Oceanic and Atmospheric Administration  
SSMC 3; Rm 10356  
phone: [301-734-1075](tel:301-734-1075)

Follow me on Twitter: @LibbyJewett  
OAP Website: [OceanAcidification.NOAA.gov](http://OceanAcidification.NOAA.gov)  
Global OA Observing Network: [www.goa-on.org](http://www.goa-on.org)  
Follow the NOAA Ocean Acidification Program on [Facebook](#) and [Twitter](#)

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--

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Ciaran Clayton - NOAA Federal](#)  
Cc: [Scott Smullen](#)  
Subject: Re: Op Ed on Ocean Acidification: Need Madelyn's help!  
Date: Monday, July 13, 2015 2:34:57 PM

---

do you envision this for Kathy or Rick?

On Mon, Jul 13, 2015 at 2:33 PM, Ciaran Clayton - NOAA Federal

<[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)> wrote:

Madelyn,

Can you give Libby a call about this opportunity this week? I've green lit you working on it; I do want to stay involved in the drafting/messaging/editing. Note that we're working on an op-ed signed by Rick that may include pitching the Times, so we'll need to stay coordinated.

Thanks,  
Ciaran

----- Forwarded message -----

From: **Libby Jewett - NOAA Federal** <[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)>  
Date: Fri, Jul 10, 2015 at 3:22 PM  
Subject: Re: Op Ed on Ocean Acidification: Need Madelyn's help!  
To: Ciaran Clayton - NOAA Federal <[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)>  
Cc: Scott Smullen <[scott.smullen@noaa.gov](mailto:scott.smullen@noaa.gov)>

Thanks, Ciaran.

In response to your questions:

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Thanks,  
Ciaran

On Thu, Jul 2, 2015 at 10:56 AM, Libby Jewett - NOAA Federal  
<[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)> wrote:

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What do you think?

Libby

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [GREGORY, Joe](#)  
Subject: Re: Oped for NYT final version  
Date: Tuesday, October 06, 2015 8:02:10 AM

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Will run it by Rick and Ivan and try to return today or early tomorrow.

We are thrilled and grateful.

Thank you.

Sent from my iPhone

> On Oct 6, 2015, at 7:54 AM, GREGORY, Joe <jgregory@nytimes.com> wrote:

>

> Hello Madelyn, Here is the final version, incorporating the fixes you sent. Please give it a close read and make any final changes IN CAPITAL LETTERS ON THIS VERSION.

> I expect this will run soon, we will let you know when we publish,

> Thanks for your efforts,

> Joe

>

> madelyn.appelbaum@noaa.govMadelyn Appelbaum

> 202 482 4858

> 202 340 6310 cell

>

> Contact: Madelyn Appelbaum/NOAA

> +1 202 482 4858 office

> +1 202 340 6310 cell

>

>

>

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> In a High CO2 World, Dangerous Waters Ahead

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> Richard W. Spinrad

> Ian Boyd

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>

>

> Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

>

> We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

> About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

> Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

- >
- > Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.
- >
- > This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.
- >
- > Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.
- >
- > We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.
- >
- > To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.
- >
- > Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.
- >
- > The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience.
- > Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.
- > When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.
- >

> Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian  
Boyd is the chief scientific adviser to the British government's Department of Environment, Food and Rural Affairs  
>  
>  
> <spinrad.final.docx>

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Subject: Re: op-ed heads up  
Date: Thursday, October 01, 2015 1:36:44 PM

---

yep, they are in red but throughout  
thank you!

On Thu, Oct 1, 2015 at 1:34 PM, Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)> wrote:

Madelyn - I will review what you send to me. If you can highlight changes that will expedite my review.

Thanks,  
RS

On Thu, Oct 1, 2015 at 1:13 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi Rick,  
UK just signed off and Chris Sabine is helping me with a few late edits.  
Will get op-ed to you asap today -- and really really hope you can review it by tonight so editor has it tomorrow am in Paris.  
Sorry for the crunch -- op-ed is basically what you reviewed before but with more descriptive explanation.  
Unless you require a major edit, I have UK ok to send to paper.  
Thanks,  
Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Thu, Oct 1, 2015 at 12:42 PM  
Subject: Re: article on ocean acidifation for the NYT  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Madelyn, do you have a sense yet of when the authors might refile their op-ed?  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

On Mon, Sep 28, 2015 at 5:42 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

we will definitely beef it up  
many thanks  
Madelyn

Sent from my iPhone

> On Sep 28, 2015, at 11:19 AM, GREGORY, Joe <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)> wrote:  
>  
> [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)Madelyn Appelbaum

> [202 482 4858](#)

> [202 340 6310](#) cell

>

>

> Dear Madelyn Appelbaum,

>

> Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?

> Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.

> I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,

> Best Wishes,

> Joe Gregory, INYT Opinion Pages

>

>

> Richard W. Spinrad

> Ian Boyd

>

>

> Ocean and coastal waters around the world are beginning to tell a disturbing story.

The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

>

> We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

> WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

> Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

>

> Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/ Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

>

> Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

> Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

>

> We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED. Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

>

> To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

> ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

> Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable,

accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

> When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

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> Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

>

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*Dr. Rick Spinrad*

*Chief Scientist*

*National Oceanic and Atmospheric Administration*

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Subject: Re: op-ed online  
Date: Thursday, October 15, 2015 9:56:44 AM

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thanks, Rick  
will pull together the full list of other names so you can send thanks at one shot

On Thu, Oct 15, 2015 at 9:55 AM, Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)> wrote:

Great. Many thanks to all who helped!

RS

Sent from my iPhone

On Oct 15, 2015, at 7:40 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

thanks everyone  
will appear in print tomorrow in the International NY Times

(not the title we chose!)

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Boyd, Ian \(Defra\)](#)  
Cc: [Lawrence, David \(DEFRA\)](#); [Jayne Phenton](#); [Errin Holmes - NOAA Federal](#); [Carol Turley](#); [Phillip Williamson](#)  
Subject: Re: op-ed online  
Date: Thursday, October 15, 2015 10:14:50 AM

---

Please note that, in your title, I have changed "British" to UK in 3 e-mails and 2 phone calls, and just requested change again.  
Puzzling...and I apologize.  
Madelyn

On Thu, Oct 15, 2015 at 9:40 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

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Cc: [Boyd, Ian \(Defra\)](#); [Lawrence, David \(DEFRA\)](#); [Jayne Phenton](#); [Errin Holmes - NOAA Federal](#); [Carol Turley](#); [Phillip Williamson](#)  
Subject: Re: op-ed online  
Date: Thursday, October 15, 2015 9:55:37 AM

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will appear in print tomorrow in the International NY Times

(not the title we chose!)

From: [Rick Spinrad - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#)  
Subject: Re: op-ed  
Date: Wednesday, October 14, 2015 12:21:57 PM

---

And thanks for your great work on this, Madelyn.

RS

On Wed, Oct 14, 2015 at 12:10 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi Rick,

Unless there is a snag, your op-ed will run in tomorrow's INYT and NY Times online.

Visuals are running with both so editor is giving it really good visibility. Still iffy re US paper (please see below from opinion editor of INYT). If op-ed isn't in US paper, I will try again with NY and also via NYTimes DC staff. Will send you link and get a few hard copies.

Many thanks to you and Ciaran for being on board with this.

Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>

Date: Wed, Oct 14, 2015 at 12:03 PM

Subject: Re: acidification op-ed...quick question

To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Hello Madelyn, it will run in the international editions and on the NYT web site. Not sure about the U.S. Don't worry, it will get plenty of attention, Joe

On Wed, Oct 14, 2015 at 6:01 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi and getting excited!

Since your page was the clear priority, didn't think to ask until now, but will acidification op-ed run in US paper, too? I am not sure how things work these days.

If not set for US, think you might flag if you have a chance, especially since Long Island Sound is a recently named acidification hotspot?

Again, so many thanks for helping us make this piece fit for print.

Best wishes,  
Madelyn

*Dr. Rick Spinrad*  
*Chief Scientist*  
*National Oceanic and Atmospheric Administration*

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#)  
Subject: Re: Proposed OA Op-ed  
Date: Thursday, August 06, 2015 9:09:36 AM

---

thanks, speedy!  
will factor in edits today and send back for your review  
hope you're having a terrific trip  
Madelyn

On Thu, Aug 6, 2015 at 8:48 AM, Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)> wrote:

Madelyn - I like this. It's got a fresh tone, and it balances the depressing news with a hopeful message. A few changes/edits I'd like you to address:

- The award won last week (and they were not from a "farm" in Montana, but a small company) was the "Wendy Schmidt Ocean Health XPrize"
- We should emphasize that we know about these hot spots because we've been able to measure in these hot spots, but there are many areas of the ocean where we don't have measurements, like parts of the Antarctic.
- We say, in essence, "to measure is to know" in a few places in the op-ed. No need to be redundant.
- I'd like to include something about being able to predict at multiple spatial and temporal scales (stated more eloquently than that, of course), because the applications of such predictive products include uses from daily adjustments for water-intake at shellfish farms, to long-term planning for ocean-based infrastructure.

RS

*Chief Scientist  
National Oceanic and Atmospheric Administration*

Sent from my iPad

On Aug 5, 2015, at 10:19 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi Rick,  
Here's suggested op-ed with Ian Boyd.  
Chris Sabine has vetted and both he and Ciaran have signed off.  
Hope you'll think it works, or is close.  
Also hope to send to UK asap. With a bit more text from UK about OA experiences there, the word count is on target. Because Pacific NW oyster hatchery/IOOS mitigation was highlighted in a 2012 OA op-ed, it is not included here where aim is to make info seem fresh.  
Thanks for your review and hope all is well.  
Best wishes,  
Madelyn  
x4858

<NOAA UK oped 8 5 15.docx>

From: [Rick Spinrad - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Ciaran Clayton - NOAA Federal](#)  
Subject: Re: Proposed OA Op-ed  
Date: Thursday, August 06, 2015 8:48:42 AM

---

Madelyn - I like this. It's got a fresh tone, and it balances the depressing news with a hopeful message. A few changes/edits I'd like you to address:

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*Chief Scientist*  
*National Oceanic and Atmospheric Administration*

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Madelyn  
x4858

<NOAA UK oped 8 5 15.docx>

From: [Errin Holmes - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Rick Spinrad - NOAA Federal](#)  
Subject: Re: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 10:30:22 AM  
Attachments: [R. Spinrad signed N.Y. Times contributor contract.pdf](#)

---

Good morning Madelyn,

Here is Dr. Spinrad's signed Contributor's contract.

Sincerely,  
Errin

On Thu, Oct 15, 2015 at 4:38 AM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Can you please sign and return the attached ASAP today, or let me know that I can sign on your behalf?

Thanks,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** "APPEL, Rebecca" <[rappel@nytimes.com](mailto:rappel@nytimes.com)>  
**To:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Subject:** Publication of Op-Ed in INYT

Dear Madelyn,

This is just to let you know that Richard Spinrad and Ian Boyd's op-ed will be running in tomorrow's print editions of the INYT, and will be online later today.

At this stage, could you please have them each sign and email back a copy of our contributor contract, attached here, or do so on their behalf? (Just ignore the W9.)

Don't hesitate to ask if you have any questions, and thanks again for all your help.

Best,

Rebecca

Rebecca Appel

International New York Times Editorial Page

[+44 207 061 6676](tel:+442070616676)

[Mail](#)

7. For 30 days from publication of the Material, you will not permit any article by you on a similar subject matter to appear in any other publication without prior written approval.

8. This Agreement sets forth the complete understanding and agreement of the parties regarding the Material submitted pursuant to this Agreement, and shall supersede all prior agreements on the Material. This Agreement may not be modified except in writing and signed by both parties. This Agreement has been made in, and shall be construed and enforced in accordance with, the laws of the State of New York. Any action to enforce this Agreement shall be brought in the federal or state courts in the County of New York.

Please sign and return this Agreement by scanning and e-mailing it to [opedcon@nytimes.com](mailto:opedcon@nytimes.com). If you are unable to do this, you may fax it to +1 212 556-4100 or mail it to The New York Times, Editorial Department, 620 Eighth Avenue, 13th Floor, New York, NY 10018, USA (if your editor is in New York), or fax it to +33 1 4143 9332 or mail it to The International New York Times, Opinion Department, CS10001, 92052 Paris La Défense Cedex, FRANCE (if your editor is in Paris, London or Hong Kong).

Trish Halp

Trish Hall  
Deputy Editorial Page Editor, The New York Times  
THE NEW YORK TIMES COMPANY

*Op-Ed Standard Agreement*  
#52166

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Lawrence, David \(DEFRA\)](#)  
Subject: Re: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 7:48:48 AM

---

Terrific  
Thanks.

Sent from my iPhone

On Oct 15, 2015, at 7:46 AM, Lawrence, David (DEFRA)  
<[David.Lawrence@defra.gsi.gov.uk](mailto:David.Lawrence@defra.gsi.gov.uk)> wrote:

It is yep!

**David Lawrence** | Communications Officer |  
Department for Environment, Food and Rural Affairs  
Direct Line: **0207 238 6299** | Mobile: 0747114108 | Out of Hours: **0345 051 8486**  
Nobel House | 17 Smith Square | London, SW1P 3JR

---

**From:** Madelyn Appelbaum - NOAA Federal [<mailto:madelyn.appelbaum@noaa.gov>]  
**Sent:** 15 October 2015 12:46  
**To:** Lawrence, David (DEFRA)  
**Subject:** Fwd: Publication of Op-Ed in INYT

David,  
Can you see the below messages and let me know if the form is being taken care of  
Thank you,  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**To:** Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>, Ian  
Boyd <[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject: Fwd: Publication of Op-Ed in INYT**

Should clarify that you do not need to bother with most of attached.  
The article has already been thoroughly fact-checked and cited.  
There is just a box to insert basic contact info and the required  
signature. Form can be scanned and e-mailed to NY Times in NY.  
This is the last step. Thank you!  
Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**To:** Rick Spinrad - NOAA Federal  
<[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>, Ian Boyd  
<[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)>  
**Cc:** Errin Holmes - NOAA Federal  
<[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)>  
**Subject:** Fwd: Publication of Op-Ed in INYT

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Thanks,  
Madelyn

Sent from my iPhone

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ignore the W9.)

Don't hesitate to ask if you have any  
questions, and thanks again for all  
your help.

Best,

Rebecca

Rebecca Appel  
International New York Times Editorial  
Page

+44 207 061 6676

Department for Environment, Food and Rural Affairs (Defra)

This email and any attachments is intended for the named recipient only. If you have received it in error you have no authority to use, disclose, store or copy any of its contents and you should destroy it and inform the sender. Whilst this email and associated attachments will have been checked for known viruses whilst within Defra systems we can accept no responsibility once it has left our systems.

Communications on Defra's computer systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Errin Holmes - NOAA Federal](#)  
Subject: Re: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 10:43:18 AM

---

terrific  
just got the ok to sign for Ian, his co-author  
it would be my name on his behalf but need scanning help  
is that ok?

On Thu, Oct 15, 2015 at 10:30 AM, Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)> wrote:

Good morning Madelyn,

Here is Dr. Spinrad's signed Contributor's contract.

Sincerely,  
Errin

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Best,

Rebecca

Rebecca Appel

International New York Times Editorial Page

[+44 207 061 6676](tel:+442070616676)

--

[Mail](#)

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Errin Holmes - NOAA Federal](#)  
Subject: Re: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 10:55:32 AM

---

thanks very much and it's ok  
Althea is helping so you don't need to bother

On Thu, Oct 15, 2015 at 10:50 AM, Errin Holmes - NOAA Federal <[errin.holmes@noaa.gov](mailto:errin.holmes@noaa.gov)> wrote:

Madelyn,

Here is a word version of the document. Are you asking me to scan after you sign?

Errin

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Rebecca Appel

International New York Times Editorial Page

[+44 207 061 6676](tel:+442070616676)

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[Mail](#)

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[Mail](#)

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Errin Holmes - NOAA Federal](#)  
Subject: Re: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 10:48:17 AM

---

thanks but now have scanning help in my shop  
I appreciate your signing Rick's so quickly

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International New York Times Editorial Page  
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[Mail](#)

From: [Errin Holmes - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: Publication of Op-Ed in INYT  
Date: Thursday, October 15, 2015 10:50:09 AM  
Attachments: [Contributor package w W9 \(1\).doc](#)

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Rebecca Appel

International New York Times Editorial Page

[+44 207 061 6676](tel:+442070616676)

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[Mail](#)

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[Mail](#)

620 EIGHTH AVENUE  
NEW YORK, N.Y. 10018

**Congratulations. Your opinion submission to The New York Times/The International New York Times has been provisionally accepted. We need you to take three steps right away:**

- 1. Read the attached fact-checking policy and assist us in protecting you from making errors.**
- 2. Read, sign and return the attached contributor's agreement, preferably via e-mail to**

## FACT-CHECKING POLICY FOR OPINION CONTRIBUTORS

Dear Contributor:

Before we publish your article — whether in print on the Op-Ed page, in the Sunday Review section, in The International New York Times, or online-only — it must be fact-checked. Our process is intended as much to protect you, the writer, as it is to protect us. Our readers are well-informed, skeptical and often eager to point out even the smallest of errors, as you can see from the corrections The Times publishes each day, in print and online. **A factual error at best detracts from, and at worst can seriously undermine, the credibility of an article and its author.**

Typically, we focus our checking on verifiable facts (e.g. the number of Americans without health insurance, the median household income, the date a law was enacted). However, we also investigate broader factual assertions (e.g. “No one named to the court in the postwar period was as conservative as Justice Scalia or as liberal as Justice Brennan,” “Laos is one of the world’s most corrupt nations”) that may need to be qualified, explained or stated with greater precision or nuance — so that, if challenged, they are completely defensible.

While we usually do not contact the original speaker to check quotations from interviews, we always verify facts within those quotations and, in cases of public remarks, confirm that the quotation is rendered and attributed accurately. We look at empirical evidence to verify that the methodology is sound and that the data is presented with precision and balance. If we determine that a particular fact cannot be verified or defended, we will not publish it.

**To assist in this process, please send your editor an annotated copy of your article, in which you list the relevant source(s) following each factual assertion.** Sources include books, newspaper and magazine articles, academic papers and Web sites. We prefer primary sources (e.g. an N.I.H. research paper) to secondary ones (e.g. a news article about the paper’s findings). In most cases, where an online source is available, provide the Web link. Attach, in e-mail, documents not easily found online (e.g. journal articles that are behind pay walls). **Provide page numbers.** Include phone numbers and e-mail addresses of anyone you have interviewed and quoted. Your editor, or a fact-checker, will follow up with additional questions as needed.

**We will work to verify the facts in your article, but as the writer, you bear the ultimate responsibility for the accuracy of your work. We cannot “fix” anything post-publication without appending a correction — and corrections are permanently archived. Past errors are a factor when we consider whether to accept future work from a writer.**

Thank you for your cooperation.

— The Editors

# The New York Times

NEW YORK — LONDON — PARIS — HONG KONG

Dear Opinion Contributor:

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1. (a) You agree to prepare such articles as you and your editors may agree upon for publication, in print and/or online. Subject to the acceptance and publication of the Material, The Times will pay you a fee.

(b) The Material will be submitted by a mutually agreed-upon deadline. You agree to cooperate with The Times’s normal editing processes, including making and reviewing revisions as requested. You will also comply with The Times’s fact-checking policy, which is attached.

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(b) As joint copyright owners, The Times and you shall each have the irrevocable, non-exclusive right to exercise any and all rights granted by the United States Copyright Act, including, but not limited to, the right to reproduce, display, distribute, sell, translate and transmit the Material throughout the world, in any media now known or later developed, and to sublicense the foregoing rights and to create derivative works — provided that neither you nor The Times shall have the right to grant rights in the Material that would purport to restrict the rights of the other party under this Agreement, and provided that your exercise of these rights shall be subject to paragraph 3 below and shall begin 30 days after The Times first publishes the Material.

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Oato 1>

**Special rules for partnerships.** Partnerships that conduct a business in the United States are generally required to pay a withholding tax on the 1446 or any foreign partner's share of effectively connected taxable income from U.S. business. Further, in certain cases where a Form W-9 has not been received, the rules under section 1446 require a partnership to presume that a partner is a foreign person and pay the section 1446 withholding tax. Therefore, if you are a U.S. person that has a partnership conducting a trade or business in the United States, provide Form W-9 to the partner that is entitled to your share of the partnership's income.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [APPEL, Rebecca](#)  
Subject: Re: question re agreement  
Date: Thursday, October 15, 2015 5:19:37 AM

---

Thanks. I have forwarded to Ian and Rick, requesting ok to sign for them or fast return to you. Have also written to their staff indicating form needs to be moved quickly. I can consent for Riick now (he most likely is sleeping), but probably should get Ian's permission. I will stay on it so you receive forms today.  
Thanks again, Rebecca.

Sent from my iPhone

On Oct 15, 2015, at 5:09 AM, APPEL, Rebecca <[rappel@nytimes.com](mailto:rappel@nytimes.com)> wrote:

That's right, thanks very much. But if you're having computer problems you can just consent by email now and send through later on. Not a problem.

On Thu, Oct 15, 2015 at 9:55 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Rebecca, my computer system is down so peering at agreement on my iPhone -- a very bad idea!

Since you have already conducted a thorough (and very helpful) fact-check, and they cannot accept any payment, I am assuming that just the section with basic contact info needs to be filled in and the form signed, Is that correct!?

Thanks,  
Madelyn

Sent from my iPhone

From: [APPEL, Rebecca](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: question re agreement  
Date: Thursday, October 15, 2015 5:09:47 AM

---

That's right, thanks very much. But if you're having computer problems you can just consent by email now and send through later on. Not a problem.

On Thu, Oct 15, 2015 at 9:55 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Rebecca, my computer system is down so peering at agreement on my iPhone -- a very bad idea!

Since you have already conducted a thorough (and very helpful) fact-check, and they cannot accept any payment, I am assuming that just the section with basic contact info needs to be filled in and the form signed, Is that correct!?

Thanks,  
Madelyn

Sent from my iPhone

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: question  
Date: Thursday, October 01, 2015 2:52:03 PM

---

got it  
thanks

On Thu, Oct 1, 2015 at 2:50 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

I suggest:

Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the **multitudes of microscopic life** that can be found in every drop of seawater.

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 11:45 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic **life** that can be found in every drop of seawater.

Chris, should this revert to plants and animals? multitudes of microscopic life?  
"lives" doesn't work

From: [Loftus, Louise](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: quick question  
Date: Wednesday, October 14, 2015 11:47:50 AM

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As far as I know this is running in INYT print and [nytimes.com](http://nytimes.com), Joe would know if it's any different.

On Wed, Oct 14, 2015 at 4:46 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

just to inform the troops on this end...  
will both INYT and US paper carry op-ed in print, or just INYT?  
not sure how things work these days

thanks so much for your work on all this  
I love the NYT online -- it always looks terrific and so clearly organized

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Loftus, Louise](#)  
Subject: Re: quick question  
Date: Wednesday, October 14, 2015 11:49:34 AM

---

thank you

On Wed, Oct 14, 2015 at 11:47 AM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:  
As far as I know this is running in INYT print and [nytimes.com](http://nytimes.com), Joe would know if it's any different.

On Wed, Oct 14, 2015 at 4:46 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:  
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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Loftus, Louise](#)  
Subject: Re: quick question  
Date: Wednesday, October 14, 2015 12:35:46 PM

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my pleasure, for sure

On Wed, Oct 14, 2015 at 12:12 PM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:  
Missed the compliment first time. Thank you, appreciated!

On Wed, Oct 14, 2015 at 4:49 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:  
thank you

On Wed, Oct 14, 2015 at 11:47 AM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:  
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From: [Loftus, Louise](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: quick question  
Date: Wednesday, October 14, 2015 12:12:23 PM

---

Missed the compliment first time. Thank you, appreciated!

On Wed, Oct 14, 2015 at 4:49 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:  
thank you

On Wed, Oct 14, 2015 at 11:47 AM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:  
As far as I know this is running in INYT print and [nytimes.com](http://nytimes.com), Joe would know if it's  
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<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:  
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thanks so much for your work on all this  
I love the NYT online -- it always looks terrific and so clearly organized

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Phillip Williamson \(ENV\)](#)  
Cc: [Denis Allemand](#); [Carol Turley](#)  
Subject: Re: quick request  
Date: Wednesday, October 14, 2015 11:16:24 AM

---

thanks -- I think we're now set  
best wishes,  
madelyn

On Wed, Oct 14, 2015 at 11:15 AM, Phillip Williamson (ENV) <[P.Williamson@uea.ac.uk](mailto:P.Williamson@uea.ac.uk)> wrote:

Madelyn -

I don't have anything at hand that unequivocally shows OA "damage to corals/seabed" .  
Images from CO2 vent sites could be used, but they really need the nearby control site for the comparison.

Attached is an image of a pteropod (sea butterfly) from Nina Bednarsek, NOAA and University of Washington - that she's happy to be used without re-approval if credited.

Regards

Phil

\*\*\*\*\*

School of Environmental Sciences  
University of East Anglia  
Norwich NR4 7TJ  
Tel + (0)1603 593111  
Mobile + (0)7749092287

---

**From:** Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
**Sent:** 14 October 2015 15:43  
**To:** Denis Allemand; Carol Turley; Phillip Williamson (ENV)  
**Subject:** quick request

NY Times is about to run acidification op-ed from NOAA/UK

will send you the link

any chance of a high resolution image that shows acidification damage to corals/seabed?  
deadline is tight

thanks,  
Madelyn

**From:** [Phillip Williamson \(ENV\)](#)  
**To:** [Madelyn Appelbaum - NOAA Federal](#); [Denis Allemand](#); [Carol Turley](#)  
**Subject:** Re: quick request  
**Date:** Wednesday, October 14, 2015 11:15:23 AM  
**Attachments:** [Pteropod image \(from Nina Bednarsek\).jpg](#)

---

Madelyn -

I don't have anything at hand that unequivocally shows OA "damage to corals/seabed" .  
Images from CO2 vent sites could be used, but they really need the nearby control site for the comparison.

Attached is an image of a pteropod (sea butterfly) from Nina Bednarsek, NOAA and University of Washington - that she's happy to be used without re-approval if credited.

Regards  
Phil

\*\*\*\*\*

School of Environmental Sciences  
University of East Anglia  
Norwich NR4 7TJ  
Tel +(0)1603 593111  
Mobile +(0)7749092287

---

**From:** Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>  
**Sent:** 14 October 2015 15:43  
**To:** Denis Allemand; Carol Turley; Phillip Williamson (ENV)  
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will send you the link

any chance of a high resolution image that shows acidification damage to corals/seabed?  
deadline is tight

thanks,  
Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: rush question  
Date: Thursday, October 01, 2015 4:49:28 PM

---

thanks and didn't include it  
editor would probably delete anyway

Sent from my iPhone

On Oct 1, 2015, at 4:48 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

My only concern was with the addition of "-called pteropods-". You could use pteropods as an example, but there are other species like coccoliths that are also vulnerable so I prefer the more generic statement. It sounds like you already got rid of that wording anyway.

Thanks for changing the acidic.

I think it is good to go...

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 1:35 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

thanks and comments are really minor  
(he left in acidic, or didn't notice but I have changed it)

also left out "pteropods" because editor will most likely pull it out anyway

On Thu, Oct 1, 2015 at 4:31 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Hi,

Just back from lunch.

I cannot confirm nor deny the clam farmer story. I think adding that "they

reported" should cover you if you do not hear back from Mark.

I will look at the rest of Rick's comments now.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 1:01 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

if Mark doesn't respond in a few hours, I think this will work...

In Maine, clam farmers reported they could no longer fill their buckets to the top  
because shells on the bottom shattered from the weight.

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal**  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 3:58 PM  
Subject: Fwd: rush question  
To: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>

Rick changed my wording...  
Can you validate this statement?  
Couldn't reach Mark via phone.  
Thanks,  
Madelyn

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal**  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 3:57 PM  
Subject: rush question  
To: Mark Green <[mgreen@sjcme.edu](mailto:mgreen@sjcme.edu)>

*In Maine, clam farmers can no longer fill their buckets to the top because shells  
on the bottom will shatter from the weight.*

Hi Mark,  
Way back you helped with an OA question. I am now rushing with an op-ed for  
Rick Spinrad (due 8 am tomorrow in Europe) and want to again fact-check.

Many thanks and hope all is well.

Madelyn Appelbaum/NOAA

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: thank you  
Date: Thursday, October 01, 2015 4:58:32 PM

---

actually...it seems ok as is -- it just doesn't factor in the process  
isn't bottom line the same?

thanks, Chris

On Thu, Oct 1, 2015 at 4:54 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Additional nutrients in coastal waters cause phytoplankton to bloom. The additional productivity takes up CO2 that draws in more CO2 from the atmosphere. Then the plankton die, sink deeper in the water and decompose, releasing the CO2 back into the water column enhancing ocean acidification. I am confident in that part of the statement.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 1:50 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

"enhancing"

On Thu, Oct 1, 2015 at 4:49 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

What exactly is his concern with the statement?

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
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Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 1:47 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

just reached Mark and we're ok re buckets but he's concerned about this and now pondering  
op-ed goes to paris no later than 2 am so we actually have some time

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Date: Thu, Oct 1, 2015 at 4:45 PM

Subject: thank you

To: Mark Green <[mgreen@sjcme.edu](mailto:mgreen@sjcme.edu)>

And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification by enhancing the uptake of carbon dioxide from the atmosphere.

From: [GREGORY, Joe](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Louise Loftus](#); [APPEL, Rebecca](#)  
Subject: Re: Thank you  
Date: Thursday, October 15, 2015 10:14:00 AM

---

Hello Madelyn, thanks for your help. Regarding the title, our style is to use British government so we would stick with that, it certainly is clear about his position, Best Wishes,  
Joe

On Thu, Oct 15, 2015 at 4:11 PM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Joe, many, many thanks. I also appreciate the work of Louise and Rebecca.

Ian uses this title so wonder if that edit can be made?

Ian Boyd is the chief scientific adviser to the **UK** government's Department of Environment,  
Food and Rural Affairs.

Best wishes and continuing success,  
Madelyn

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Re: thank you  
Date: Thursday, October 01, 2015 4:56:11 PM

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thanks but too complicated  
ok to leave as is, or is there one sentence?

On Thu, Oct 1, 2015 at 4:54 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Additional nutrients in coastal waters cause phytoplankton to bloom. The additional productivity takes up CO2 that draws in more CO2 from the atmosphere. Then the plankton die, sink deeper in the water and decompose, releasing the CO2 back into the water column enhancing ocean acidification. I am confident in that part of the statement.

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fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 1:50 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

"enhancing"

On Thu, Oct 1, 2015 at 4:49 PM, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

What exactly is his concern with the statement?

Chris

Christopher L. Sabine, PhD.  
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web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 1:47 PM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

just reached Mark and we're ok re buckets but he's concerned about this and now pondering  
op-ed goes to paris no later than 2 am so we actually have some time

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Date: Thu, Oct 1, 2015 at 4:45 PM

Subject: thank you

To: Mark Green <[mgreen@sjcme.edu](mailto:mgreen@sjcme.edu)>

And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification by enhancing the uptake of carbon dioxide from the atmosphere.

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Boyd, Ian \(Defra\)](#)  
Subject: Re: your acidification op-ed  
Date: Wednesday, October 14, 2015 2:58:55 PM

---

my pleasure

On Wed, Oct 14, 2015 at 2:54 PM, Boyd, Ian (Defra) <[Ian.Boyd@defra.gsi.gov.uk](mailto:Ian.Boyd@defra.gsi.gov.uk)> wrote:  
| [Madelyn](#) - thank you very much. Ian

---

**From:** Madelyn Appelbaum - NOAA Federal [mailto:[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)]  
**Sent:** Wednesday, October 14, 2015 06:12 PM  
**To:** Boyd, Ian (Defra)  
**Cc:** Carol Turley <[CT@pml.ac.uk](mailto:CT@pml.ac.uk)>; Phillip Williamson <[P.Williamson@uea.ac.uk](mailto:P.Williamson@uea.ac.uk)>;  
[jayne.phenton@gmail.com](mailto:jayne.phenton@gmail.com) <[jayne.phenton@gmail.com](mailto:jayne.phenton@gmail.com)>  
**Subject:** your acidification op-ed

Dear Professor Boyd:

Unless there is an unexpected hold-up, your acidification op-ed will appear in tomorrow's International New York Times and online at NYTimes.com. I am delighted it will finally be published!.

Many thanks to you and Carol and Phil, and to Jayne for non-stop assistance almost every day over the past two months. I am extremely grateful to all of you.

Best wishes,  
Madelyn

Department for Environment, Food and Rural Affairs (Defra)

This email and any attachments is intended for the named recipient only. If you have received it in error you have no authority to use, disclose, store or copy any of its contents and you should destroy it and inform the sender. Whilst this email and associated attachments will have been checked for known viruses whilst within Defra systems we can accept no responsibility once it has left our systems. Communications on Defra's computer systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

From: [Jayne Phenton](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Boyd, Ian \(Defra\)](#); [Carol Turley](#); [Phillip Williamson](#)  
Subject: Re: your acidification op-ed  
Date: Thursday, October 15, 2015 4:57:44 AM

---

Well that is good news!

Thanks everyone for your help and especially to Madelyn for her patience and tenacity and thank you for letting me know it's coming out.

best wishes

Jayne

On 14 October 2015 at 18:12, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Dear Professor Boyd:

Unless there is an unexpected hold-up, your acidification op-ed will appear in tomorrow's International New York Times and online at NYTimes.com. I am delighted it will finally be published!.

Many thanks to you and Carol and Phil, and to Jayne for non-stop assistance almost every day over the past two months. I am extremely grateful to all of you.

Best wishes,  
Madelyn

From: [Jennifer Mintz - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:55:43 AM

---

Hi Madelyn,

I think the image at the top in the article and the one off to the right would show a healthy vs. unhealthy reef

[http://www.aoml.noaa.gov/keynotes/keynotes\\_0115\\_galapagos.html](http://www.aoml.noaa.gov/keynotes/keynotes_0115_galapagos.html)

If you think these would work I will contact the Derek and Erica Rule to let them know they are being used but the caption and credit info is there.

What do you think?

Jenn

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Date: Wed, Oct 14, 2015 at 10:34 AM

Subject: Re: your oped in NYT >> request

To: "Loftus, Louise" <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

Cc: Joe GREGORY <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>

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Louise Loftus  
Staff Editor, International Opinion  
The New York Times

18 Museum Street, London WC1A 1JN, United Kingdom

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Date: Wed, Oct 14, 2015 at 2:47 PM

Subject: spinrad draft

To: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

madelyn.appelbaum@noaa.govMadelyn Appelbaum  
[202 482 4858](tel:2024824858)  
[202 340 6310](tel:2023406310) cell

Contact: Madelyn Appelbaum/NOAA  
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In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

madelyn.appelbaum@noaa.govMadelyn Appelbaum  
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Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

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Jenn Bennett Mintz

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Education & Outreach Coordinator

NOAA Ocean Acidification Program  
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331 Ft. Johnson Rd. # A121M  
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To: [Madelyn Appelbaum - NOAA Federal](#)  
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Date: Wednesday, October 14, 2015 10:47:29 AM

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In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
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## In a High CO<sub>2</sub> World, Dangerous Waters Ahead

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To: [Madelyn Appelbaum - NOAA Federal](#)  
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Subject: Re: your oped in NYT >> request  
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In a High CO2 World, Dangerous Waters Ahead

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--

Jenn Bennett Mintz

*\*Please note email address change*

Education & Outreach Coordinator  
NOAA Ocean Acidification Program  
Hollings Marine Laboratory  
331 Ft. Johnson Rd. # A121M  
Charleston, SC 29412  
Office: [\(843\)762-8896](tel:8437628896)  
Cell: [\(831\) 325-1634](tel:8313251634)  
Email: [jennifer.mintz@noaa.gov](mailto:jennifer.mintz@noaa.gov) (formerly [jennifer.bennett@noaa.gov](mailto:jennifer.bennett@noaa.gov))

Website: [oceanacidification.noaa.gov](http://oceanacidification.noaa.gov)

Follow the NOAA Ocean Acidification Program on [Facebook](#) and [Twitter](#)

Note: The content of this message does not reflect any position of the U.S. Government or of NOAA unless otherwise specified.

From: [Loftus, Louise](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Cc: [Joe GREGORY](#)  
Subject: Re: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:43:27 AM

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18 Museum Street, London WC1A 1JN, United Kingdom

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Date: Wed, Oct 14, 2015 at 2:47 PM

Subject: spinrad draft

To: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum

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In a High CO2 World, Dangerous Waters Ahead

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Ian Boyd

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To: [Loftus, Louise](#)  
Cc: [Joe GREGORY](#)  
Subject: Re: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:34:29 AM

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Date: Wed, Oct 14, 2015 at 2:47 PM  
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In a High CO2 World, Dangerous Waters Ahead

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From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Loftus, Louise](#)  
Subject: Re: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:46:41 AM

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I think we have something  
lab depiction of what a vital food source looks like in normal and in acidified water  
we have one from National Geographic but trying to get you high res NOAA one  
thank you!

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In a High CO2 World, Dangerous Waters Ahead

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To: [Loftus, Louise](#)  
Cc: [Joe GREGORY](#)  
Subject: Re: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:51:47 AM

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18 Museum Street, London WC1A 1JN, United Kingdom

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Date: Wed, Oct 14, 2015 at 2:47 PM  
Subject: spinrad draft  
To: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

madelyn.appelbaum@noaa.gov Madelyn Appelbaum  
[202 482 4858](tel:2024824858)  
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Contact: Madelyn Appelbaum/NOAA  
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In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

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Department of Environment, Food and Rural Affairs

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To: [Loftus, Louise](#)  
Cc: [Joe GREGORY](#)  
Subject: Re: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:58:22 AM

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To: [Loftus, Louise](#)  
Cc: [Jennifer Mintz - NOAA Federal](#)  
Subject: Re: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 11:07:13 AM

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high res coming shortly...  
will rework caption info and send in a few minutes  
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Thanks! Look forward to seeing them.

Best, Lou

On Wed, Oct 14, 2015 at 3:34 PM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

many thanks and not sure we have corals, but digging now and will get back shortly are corals the only illustration that will work?

also, would this be for both INYT and US?

On Wed, Oct 14, 2015 at 10:27 AM, Loftus, Louise <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)> wrote:  
Hello,

I'm one of the web editors for the opinion section. I was talking to Joe today about the possibility of including before/after images of coral or areas of the sea bed that show the impact that acidification has had.

Does your organization have images that illustrate this that we could use on [nytimes.com](http://nytimes.com) (your piece will have an illustration in print, this is for online only).

If so, please do send along with information on how these should be captioned and credited.

For it to be possible I'd need to receive the images sometime today. Sorry for the short notice and if it's not possible then not to worry, if it is possible -- great!

Thanks,

Louise

Louise Loftus  
Staff Editor, International Opinion  
The New York Times

18 Museum Street, London WC1A 1JN, United Kingdom

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>

Date: Wed, Oct 14, 2015 at 2:47 PM

Subject: spinrad draft

To: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum

[202 482 4858](tel:2024824858)

[202 340 6310](tel:2023406310) cell

Contact: Madelyn Appelbaum/NOAA

[+1 202 482 4858](tel:+12024824858) office

[+1 202 340 6310](tel:+12023406310) cell

## In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
[202 482 4858](tel:2024824858)  
[202 340 6310](tel:2023406310) cell

Contact: Madelyn Appelbaum/NOAA  
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## In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters IS CHANGING AND A GROWING THREAT TO MARINE ECOSYSTEMS. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and

marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than

during the past three years, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Rick Spinrad - NOAA Federal](#)  
Subject: Re: your op-ed  
Date: Thursday, October 01, 2015 3:49:30 PM

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terrific  
many thanks

On Thu, Oct 1, 2015 at 3:47 PM, Rick Spinrad - NOAA Federal <[rick.spinrad@noaa.gov](mailto:rick.spinrad@noaa.gov)> wrote:

attached edits

On Thu, Oct 1, 2015 at 2:23 PM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Rick, given tight timing, can you please return any edits in red and as an attachment?  
Thanks.

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Date: Thu, Oct 1, 2015 at 2:15 PM

Subject: your op-ed

To: Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>

Cc: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>, Ciaran Clayton - NOAA Federal <[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)>

...wirth an endless list of thanks to Chris

unless you have a mega edit and I need to go another round with UK, will get this to paper  
as soon as you sign off

thank you and let's hope this one flies!  
new text in red

Madelyn

--

*Dr. Rick Spinrad  
Chief Scientist  
National Oceanic and Atmospheric Administration*

From: [Rick Spinrad - NOAA Federal](#)  
To: [Madelyn Appelbaum - NOAA Federal](#)  
Subject: Re: your op-ed  
Date: Thursday, October 01, 2015 3:47:58 PM  
Attachments: [QA op-ed 1 10 2015 RWS.docx](#)

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attached edits

On Thu, Oct 1, 2015 at 2:23 PM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Rick, given tight timing, can you please return any edits in red and as an attachment?  
Thanks.

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Date: Thu, Oct 1, 2015 at 2:15 PM

Subject: your op-ed

To: Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>

Cc: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>, Ciaran Clayton - NOAA Federal <[ciaran.clayton@noaa.gov](mailto:ciaran.clayton@noaa.gov)>

...wirth an endless list of thanks to Chris  
unless you have a mega edit and I need to go another round with UK, will get this to paper  
as soon as you sign off

thank you and let's hope this one flies!  
new text in red

Madelyn

--

*Dr. Rick Spinrad  
Chief Scientist  
National Oceanic and Atmospheric Administration*

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that is going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce, and build their shells and skeletons. ~~About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. Without these shells, they drift with the tides until they die. In effect, the crop was nearly destroyed.~~ In Maine, ~~a clam farmers reported that he could no longer fill his their buckets to the top because shells on the bottom would shatter from the weight.~~ Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster when waters are more acidic. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; ~~pollution from plastics and other materials, is pervasive~~; and in general we over-exploit the resources of the ocean. Each stressor is cause for concern, but all of them affecting the oceans at one time are cause for alarm. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean, and in the cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, ~~reducing critical habitat for fish and the resilience of the entire reef system.~~ Dramatic change is also apparent in the Arctic where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, ~~affecting food sources for indigenous people, fish, birds and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse.~~ To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. ~~Research already points to the unnatural behavior of Nemo when the coral clownfish is studied in an acidic environment. He These fish wanders farther away from his protective~~ ~~[RICK...descriptive word for~~

home?]-home natural protection, making him them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms —called pteropods — that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic plants and animals that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the acute challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting prediction by integrating existing observations from gliders, hydrographic surveys, unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification by enhancing the uptake of carbon dioxide from the atmosphere.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

Contact: Madelyn Appelbaum/NOAA  
+1 202 482 4858 office  
+1 202 340 6310 cell

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Chris Sabine - NOAA Federal](#)  
Subject: Rick's edits  
Date: Thursday, August 06, 2015 9:21:53 AM  
Attachments: [NOAA UK oped 8 6 15.docx](#)

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Good morning, Chris.

Rick really likes the op-ed, and I explained how indispensable you've been in developing it. He's asked for just a few edits, most of which I can handle, but perhaps you can flesh out these

2

and plug them into the op-ed, or I can do that once I have the right substance to work with? Started fleshing them out myself, then realized you'd change the text anyway so sending to you upfront

and this truly is the last round, pre-UK...honest

thanks yet again!

Madelyn

We should emphasize that we know about these hot spots because we've been able to measure in these hot spots, but there are many areas of the ocean where we don't have measurements, like parts of the Antarctic where it's critical to measure because...

I'd like to include something about being able to predict at multiple spatial and temporal scales (stated more eloquently than that, of course), because the applications of such predictive products include uses from daily adjustments for water-intake at shellfish farms, to long-term planning for ocean-based infrastructure such as...

## **In a High CO<sub>2</sub> World, Ocean Hotspots Tell a Disturbing Story**

In waters around the world, ocean hotspots are beginning to tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, threatening the chemical balance of our ocean and coastal waters and their fragile, finite marine life. Over the past 200 years, the sea has absorbed more than 150 billion metric tons of carbon from human activities. It's now absorbing more than 2.5 billion metric tons every year, enough to fill a coal train long enough to encircle the equator 13 times.

The consequences of disrupting what has been a relatively stable ocean environment for tens of millions of years are beginning to show. As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating conditions that eat away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs, plants and much more are at risk, especially since, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each stressor is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. This year the first nationwide study of the vulnerability of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of hotspots: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Acidity also is apparent off the Alaskan coast, which accounts for nearly 60 percent of the U.S. commercial fish catch and supports more than 100,000 jobs.

There are concerns in the Mediterranean Sea and in waters around the UK and Germany. In the UK... [more *from UK*] Ocean acidification is weakening coral structures in the Great Barrier Reef, and threatening native fisheries in the Patagonian waters of southern Chile. The most dramatic change is already occurring in the Arctic where water can be corrosive enough to dissolve nearby shelled creatures.

There is urgency to substantially reducing carbon dioxide emissions. A recent NOAA study found that, over the past 15 years, the rate of global warming has been as fast or faster than seen during the latter half of the 20<sup>th</sup> century. There has been no downward trend in our high CO<sub>2</sub> world and both of our nations have called for unprecedented actions to reduce emissions. Tackling ocean acidification is a steep challenge. But it's also a dynamic opportunity to inspire profound advances in our understanding of the ocean. In July, an enterprising team from a small farm in Montana won the X-Prize for developing breakthrough technologies to measure ocean acidity. To better understand the sea's response to CO<sub>2</sub>, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

Smart investments in monitoring and observing are critical to building resilience and hedging risk. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential.

continued

We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals. The new 30-nation network still has gaps in global coverage, and more nations are needed to fill them. To understand the sea, we must first observe it. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. Locally to globally, we are all the stakeholders.

###

Authors:

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Contacts:

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001 202 482 4858  
011 292 349 6310 cell

Jayne Phenton – UK  
[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)  
011 44 20 7238 6600

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Mark Green](#)  
**Subject:** rush question  
**Date:** Thursday, October 01, 2015 3:57:52 PM

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*In Maine, clam farmers can no longer fill their buckets to the top because shells on the bottom will shatter from the weight.*

Hi Mark,

Way back you helped with an OA question. I am now rushing with an op-ed for Rick Spinrad (due 8 am tomorrow in Europe) and want to again fact-check.

Many thanks and hope all is well.

Madelyn Appelbaum/NOAA

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [GREGORY, Joe](#)  
Cc: [Louise Loftus](#); [APPEL, Rebecca](#)  
Subject: Thank you  
Date: Thursday, October 15, 2015 10:11:50 AM

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Joe, many, many thanks. I also appreciate the work of Louise and Rebecca.

Ian uses this title so wonder if that edit can be made?

Ian Boyd is the chief scientific adviser to the **UK** government's Department of Environment, Food and Rural Affairs.

Best wishes and continuing success,  
Madelyn

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Mark Green](#)  
**Subject:** thank you  
**Date:** Thursday, October 01, 2015 4:45:13 PM

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And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification by enhancing the uptake of carbon dioxide from the atmosphere.

**From:** [Madelyn Appelbaum - NOAA Federal](#)  
**To:** [Chris Sabine - NOAA Federal](#)  
**Subject:** with edits  
**Date:** Thursday, August 06, 2015 12:45:26 PM  
**Attachments:** [NOAA UK oped 8 6 15.docx](#)

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adjusted a tad...so a one more "last" round

## **In a High CO<sub>2</sub> World, Ocean Hotspots Tell a Disturbing Story**

In waters around the world, ocean hotspots are beginning to tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, threatening the chemical balance of our ocean and coastal waters and their fragile, finite marine life. Over the past 200 years, the sea has absorbed more than 150 billion metric tons of carbon from human activities. It's now absorbing more than 2.5 billion metric tons every year, enough to fill a coal train long enough to encircle the equator 13 times.

The consequences of disrupting what has been a relatively stable ocean environment for tens of millions of years are beginning to show. As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating conditions that eat away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs, plants and much more are at risk, especially since, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each stressor is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. This year the first nationwide study of the vulnerability of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of hotspots: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Acidity also is apparent off the Alaskan coast, which accounts for nearly 60 percent of the U.S. commercial fish catch and supports more than 100,000 jobs.

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There is urgency to substantially reducing carbon dioxide emissions. A recent NOAA study found that, over the past 15 years, the rate of global warming has been as fast or faster than seen during the latter half of the 20<sup>th</sup> century. There has been no downward trend in our high CO<sub>2</sub> world and both of our nations have called for unprecedented actions to reduce emissions. Tackling ocean acidification is a steep challenge. But it's also a dynamic opportunity to inspire profound advances in our understanding of the ocean. In July, an enterprising team from a small farm in Montana won the X-Prize for developing breakthrough technologies to measure ocean acidity. To better understand the sea's response to CO<sub>2</sub>, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

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continued

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###

Authors:

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Contacts:

Madelyn Appelbaum – US  
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Jayne Phenton – UK  
[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)  
011 44 20 7238 6600

From: [Madelyn Appelbaum - NOAA Federal](#)  
To: [Boyd, Ian \(Defra\)](#)  
Cc: [Carol Turley](#); [Phillip Williamson](#); [jayne.phenton@gmail.com](mailto:jayne.phenton@gmail.com)  
Subject: your acidification op-ed  
Date: Wednesday, October 14, 2015 1:12:38 PM

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Dear Professor Boyd:

Unless there is an unexpected hold-up, your acidification op-ed will appear in tomorrow's International New York Times and online at NYTimes.com. I am delighted it will finally be published!.

Many thanks to you and Carol and Phil, and to Jayne for non-stop assistance almost every day over the past two months. I am extremely grateful to all of you.

Best wishes,  
Madelyn

From: [Loftus, Louise](#)  
To: [madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)  
Cc: [Joe GREGORY](#)  
Subject: your oped in NYT >> request  
Date: Wednesday, October 14, 2015 10:27:05 AM  
Attachments: [spirad.draft.docx](#)

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Hello,

I'm one of the web editors for the opinion section. I was talking to Joe today about the possibility of including before/after images of coral or areas of the sea bed that show the impact that acidification has had.

Does your organization have images that illustrate this that we could use on [nytimes.com](http://nytimes.com) (your piece will have an illustration in print, this is for online only).

If so, please do send along with information on how these should be captioned and credited.

For it to be possible I'd need to receive the images sometime today. Sorry for the short notice and if it's not possible then not to worry, if it is possible -- great!

Thanks,

Louise

Louise Loftus  
Staff Editor, International Opinion  
The New York Times

18 Museum Street, London WC1A 1JN, United Kingdom

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Wed, Oct 14, 2015 at 2:47 PM  
Subject: spinrad draft  
To: Louise Loftus <[lloftus@nytimes.com](mailto:lloftus@nytimes.com)>

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
[202 482 4858](tel:2024824858)  
[202 340 6310](tel:2023406310) cell

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## In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

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## In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters **IS CHANGING AND A GROWING THREAT TO MARINE ECOSYSTEMS**. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 nations. This network

is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

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Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Date: Fri, Oct 2, 2015 at 1:29 AM

Subject: Re: Rush question

To: Shallin Busch <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)>

Thanks and someday, when you have nothing else to do, please explain these distinctions to me!

Sent from my iPhone

> On Oct 1, 2015, at 11:31 PM, Shallin Busch <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)> wrote:

>

> Hi Madelyn-

>

> Increasing acidity is fine. Thanks for checking.

>

> Shallin

>

> Sent from my iPhone

>

>> On Oct 1, 2015, at 6:30 PM, Madelyn Appelbaum - NOAA Federal  
>> <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

>>

>> Shallin,

>> Is "increasing acidity" at start of par 3 incorrect? If this was

>> flagged, I missed it. Just finally relaxed and then this concern hit.

>> Thanks for more help,

>> Madelyn

>>

>> Sent from my iPhone

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Date: Mon, Sep 28, 2015 at 1:19 PM

Subject: Re: article on ocean acidification for the NYT

To: Shallin Busch - NOAA Federal <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)>

Cc: Libby Jewett - NOAA Federal <[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)>, Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>

Thanks and, as with Chris's suggestion, I agree with you. An initial version was more along the lines you're suggesting, but we agreed to partner with the UK where the tone was changed. I am stuck with co-authorship and also making this publishable so trying hard to simultaneously pull this off on several levels. I appreciate your edits -- and algal bloom example is precisely the concrete kind of example the editor is looking for. Thank you!

Madelyn

On Mon, Sep 28, 2015 at 4:06 PM, Shallin Busch - NOAA Federal

<[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)> wrote:

Hi Madelyn-

Thanks for letting me chime in on this piece. Below, I've added my comments to Chris's. My two general impressions are the following:

- 1) This article is mostly gloom and doom, which research has shown that people don't respond to well. In fact, people just stop reading gloom and doom environmental stories. It could be good to highlight ways we can and are dealing with OA now and that we have an opportunity to prevent the major predicted impacts of OA by stopping carbon emissions before larger chemistry changes happen. I've given a couple examples of how to bring up these concepts in my comments below.
- 2) I think it is really important to resist the NYT editor's impulse to say that OA is wreaking all sorts of havoc RIGHT NOW, because for ecological systems, we don't yet have the evidence to say that. OA is a problem today because it is changing ocean chemistry so quickly. The vast majority of the biological impacts of OA will only occur under projected future chemistry conditions. Also, the study of the biological impacts of OA is so young that we don't have any data sets that show a direct effect of OA on population health or trajectory.

Please let me know if you want more help with this!

Best,  
Shallin

CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

Shallin's comments:

In response to Chris's comments, we are unsure of the implications of the pteropod shell dissolution observed in Nina's work on pteropod populations. It could be that some pteropods have always had some dissolution, and we are seeing an amplification of a natural process. It could also be that behavioral responses to ocean conditions can protect most pteropods from exposure to undersaturation waters, but we don't have data to evaluate that hypothesis yet. What I'm more comfortable with saying in terms of pteropods is that we have observed their sensitivity to changes in carbonate chemistry, and project that continued ocean acidification will likely harm pteropod populations. I'm not at all comfortable with making any extrapolations between pteropod and salmon (or other fish, bird, whale) populations, as, again, we do not have the data to support them and, in fact, field data suggests that many salmon and fish will be just fine without pteropods. They have highly flexible diets, and pteropods are not reliable prey in all years. Yes, salmon and other fish eat a lot of pteropods when they are abundant, but they don't suffer when the pteropod populations are low.

I like Chris's example of Washington State shellfish hatcheries moving to Hawaii because ocean conditions are better there, now that OA is a problem in the Pacific Northwest. I also like the idea of extrapolating this out: For example, we know that the Pacific Northwest is a hot spot for OA now and an example of what global oceans might be like in the future. So, with that in mind, Pacific Northwest marine industries can move to safer grounds now, but that won't be possible in the future, as ocean acidification progresses around the globe.

I also think that mentioning the potential impacts of OA on harmful algal blooms could be good in this piece. Laboratory research has shown that many harmful algal species produce more toxins and bloom more readily in acidified conditions. If the response of these species in the wild is the same in the laboratory, the response of harmful algal bloom species to ocean acidification could cause problems for marine ecosystems, as harmful algal blooms can sicken and sometime kill fish marine mammals and can sicken people who consume shellfish contaminated by the harmful algae.

Chris's comments:

We have seen shells dissolving off of live pteropods in the Southern Ocean and in the upwelling areas off the west coast of the US which certainly impacts their abundance. Pteropods are an important food source for juvenile salmon, but I am not aware of any quantitative impact on salmon recruitment specifically related to ocean acidification impacts on pteropods. We have many of the pieces so I would feel comfortable making a qualitative statement about the potential impacts. We have demonstrated that the near collapse of the shellfish industry in the Pacific Northwest was caused by ocean acidification. This has undoubtedly increased prices, but I would have to look into how much if you need a number. I also know that at least one shellfish grower has moved their operations from Washington State to Hawaii because the ocean acidification effects are less dramatic there. Ocean acidification does not make people ill, so that angle will not work.

AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/

Shallin's comments:

In fact, production in the Washington oyster industry is higher now than at the start of the crisis because the oyster industry has made changes to its hatcheries in response to OA events. Again, I like the idea of showing an example of successful adaptation to OA (e.g., that Pac NW oyster hatcheries have made changes to their protocols in response to OA events that have boosted hatchery production), and then talking about how these fixes will only work for so long (e.g., the shellfish industry is reliant on healthy coastal ecosystems to grow shellfish to market size and can't control conditions in the wild to protect their crops. OA threatens to change these ecosystems, potentially threatening the shellfish industry again.).

Just as an FYI, we can't yet attribute any large patterns in shellfish yield to OA.

Chris's comments:

The shellfish story has been well documented in scientific papers as well as the media, but we can tell it again if you like. I thought this article was intended to be more broad reaching than this.

IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

Shallin's comments:

I'm not sure that I agree with Chris's statement about the impact of OA on the Great Barrier Reef, "but underlying all of those factors is the fact that the corals are so stressed from ocean acidification that they can't recover from those other impacts the way they used to be able to recover." Given my knowledge of the literature, OA is more of a future problem than a problem right now for the Great Barrier Reef. I think it is important to resist the NYT editor's impulse to say that OA is wreaking all sorts of havoc RIGHT NOW, because for ecological systems, we don't yet have the evidence to say that.

Chris's comments:

Ocean acidification is stronger in the high latitude oceans than the lower latitudes because of basic chemistry (can explain if needed). Ocean acidification typically manifests itself as an additional stress on calcifying organisms (and other organisms to some degree). Typically it isn't ocean acidification

itself that directly kills the organism, but it makes the organism more susceptible to other factors (e.g. predation, disease, bleaching). Coral reefs, of course, are found in the low latitudes but they are among the most susceptible to ocean acidification. For example, there has been a 50% reduction in coral cover on the Great Barrier Reef off Australia over the last 30 years. This has been primarily attributed to crown of thorns starfish, cyclones and coral bleaching, but underlying all of those factors is the fact that the corals are so stressed from ocean acidification that they can't recover from those other impacts the way they used to be able to recover. Ocean acidification does not result in dead fish washing up on the shore and it doesn't give swimmers skin rashes.

TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED.

Shallin's comments:

Again, I agree with Chris that the focus here is on ecosystems and communities, not specific fish species. It might be good to mention that some species will be harmed by OA, some will benefit, and some won't respond at all! It is this mix of sensitivities that will likely reorder ecosystems, changing the ecosystem services on which we now rely (fisheries, coastal protection, recreation etc).

I found this sentence a bit challenging, as it was both too general and too specific: "Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities." It might be good to change it to something like, "OA may affect some fish populations directly via their sensitivity to changes in marine chemistry, and may also affect fish populations by reordering ecosystems, changing availability of preferring prey and habitat."

Chris's comments:

You already talk about the oysters...the point of this paragraph is that there are impacts on entire marine ecosystems that will have cascading effects. By the time we see those cascading effects it will be too late to do anything about it.

ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

Shallin's comments:

I like Chris's idea of mentioning that nutrient pollution can exacerbate OA. A nice thing about mentioning this is that local jurisdictions have some control over nutrient pollution, which can give them a way to mitigate some causes of OA in their local waters. While OA is a global problem, local actions, informed by monitoring and other research, can do a lot to protect marine ecosystem for the global drivers of climate change and OA.

Chris's comments:

I am not exactly sure what they are asking here. There are many factors of human activity that increase the CO<sub>2</sub> content of the ocean and consequently ocean acidification. These are the same factors that are well discussed in terms of climate change so I don't know that they need to be rehashed here. Plastics do not increase ocean acidification, but they do provide one more stressor on the system that contributes to the overall degradation of the marine environment. We do see a strong connection between coastal eutrophication and acidification. Human activities that add nutrients to the coastal waters causing algal blooms that then die and decompose, will result in hypoxia (low oxygen levels) and ocean acidification (high CO<sub>2</sub> levels) in coastal waters.

---

Shallin Busch, PhD  
Ocean Acidification Program and Northwest Fisheries Science Center  
National Oceanic and Atmospheric Administration  
2725 Montlake Blvd., E  
Seattle, WA 98112

tel: [206 860 6782](tel:2068606782)  
fax: [206 860 3335](tel:2068603335)

On Mon, Sep 28, 2015 at 10:41 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Thanks, Chris. I will work with your info and what comes from the UK, along with what Shallin and Libby may wish to plug in and send back for your review, then on to Rick. The initial version that you were so helpful with is actually much closer to what the editor is looking for but, given that he thinks this is close and, after much angst, the UK has signed-off on this one, I am hesitant to step back too much, although I concur with your suggestion.

Thank you!

Madelyn

On Mon, Sep 28, 2015 at 1:18 PM, Chris Sabine - NOAA Federal  
<[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)> wrote:

Hi Madelyn,

My brief, "off the top of my head" responses are given below. If Rick wants to pursue this, then we can work to wordsmith a properly crafted formal response.

CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING? WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN

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We have seen shells dissolving off of live pteropods in the Southern Ocean and in the upwelling areas off the west coast of the US which certainly impacts their abundance. Pteropods are an important food source for juvenile salmon, but I am not aware of any quantitative impact on salmon recruitment specifically related to ocean acidification impacts on pteropods. We have many of the pieces so I would feel comfortable making a qualitative statement about the potential impacts. We have demonstrated that the near collapse of the shellfish industry in the pacific northwest was caused by ocean acidification. This has undoubtedly increased prices, but I would have to look into how much if you need a number. I also know that at least one shellfish grower has moved their operations from Washington State to Hawaii because the ocean acidification effects are less dramatic there. Ocean acidification does not make people ill, so that angle will not work.

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Ocean acidification is stronger in the high latitude oceans than the lower latitudes because of basic chemistry (can explain if needed). Ocean acidification typically manifests itself as an additional stress on calcifying organisms (and other organisms to some degree). Typically it isn't ocean acidification itself that directly kills the organism, but it makes the organism more susceptible to other factors (e.g. predation, disease, bleaching). Coral reefs, of course, are found in the low latitudes but they are among the most susceptible to ocean acidification. For example, there has been a 50% reduction in coral cover on the Great Barrier Reef off Australia over the last 30 years. This has been primarily attributed to crown of thorns starfish, cyclones and coral bleaching, but underlying all of those factors is the fact that the corals are so stressed from ocean acidification that they can't recover from those other impacts the way they used to be able to recover. Ocean acidification does not result in dead fish washing up on the shore and it doesn't give swimmers skin rashes.

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ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

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I think it would be useful to take a step back and think about the overall point of this article. What is it that you are really trying to say? How is your message new or different and why now? I think if we can clearly answer those questions, the OpEd will be better received. I hope this is helpful.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: [\(206\) 526-6800](tel:(206)526-6800)  
fax: [\(206\) 526-4576](tel:(206)526-4576)  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Mon, Sep 28, 2015 at 9:02 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi Chris,  
Given your terrific help to this point...  
Perhaps you can respond to questions, too?  
Thank you,  
Madelyn

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Mon, Sep 28, 2015 at 11:55 AM  
Subject: Fwd: article on ocean acidification for the NYT  
To: Rick Spinrad - NOAA Federal <[Rick.Spinrad@noaa.gov](mailto:Rick.Spinrad@noaa.gov)>

Hi Rick,  
Didn't get anywhere in NY, but went to the international bureau in Paris where I know the staff.  
Asap, can you please send bullets in response to questions and I'll work them in along with the UK's responses  
Will send full op-ed back to you before resubmitting  
Many thanks,  
Madelyn

----- Forwarded message -----

From: **GREGORY, Joe** <[jgregory@nytimes.com](mailto:jgregory@nytimes.com)>  
Date: Mon, Sep 28, 2015 at 11:19 AM  
Subject: article on ocean acidifation for the NYT  
To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov) Madelyn Appelbaum  
[202 482 4858](tel:2024824858)  
[202 340 6310](tel:2023406310) cell

Dear Madelyn Appelbaum,

Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans? Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.

I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,

Best Wishes,

Joe Gregory, INYT Opinion Pages

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL

## FISH

Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP -- ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/ Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED. Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

ARE OTHER FACTORS INVOLVED -- INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

----- Forwarded message -----

From: **Shallin Busch - NOAA Federal** <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)>

Date: Wed, Sep 30, 2015 at 8:13 AM

Subject: Re: op-ed question

To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Hi Madelyn-

Unfortunately, I can't provide this information to you because it doesn't exist. As I said in my last email, currently there are NO areas of the world that are severely degraded because of OA or even areas that we know are definitely affected by OA right now. If you want to use this type of language, you could write about the CO2 vent sites in Italy or Polynesia as examples of things to come.

Sorry that I can't be more helpful on this!

Shallin

-----  
Shallin Busch, PhD

Ocean Acidification Program and Northwest Fisheries Science Center

National Oceanic and Atmospheric Administration

2725 Montlake Blvd., E

Seattle, WA 98112

tel: [206 860 6782](tel:2068606782)  
fax: [206 860 3335](tel:2068603335)

On Wed, Sep 30, 2015 at 8:02 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Hi Shallin,  
am weaving all edits from you and Chris and UK together  
I think we're in good shape, except for this query...  
editor is looking for a strong picture (have used Pacific NW elsewhere) with graphic detail -  
-  
think you can send a few bullets about a region beyond US, or point me to already  
developed content?  
I am also about to go through Earthzine text  
many thanks  
Madelyn

CAN YOU GIVE A STRONG, CLEAR IMAGE TO HELP US VISUALIZE WHAT IS  
HAPPENING? WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE  
GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT  
HAS BEEN SEVERELY DEGRADED.

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Date: Mon, Sep 28, 2015 at 1:56 PM

Subject: Re: op-ed question

To: Shallin Busch - NOAA Federal <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)>

thank you very much

I'm sure you would have made it more precise but think you would have liked the initial version better

On Mon, Sep 28, 2015 at 4:29 PM, Shallin Busch - NOAA Federal

<[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)> wrote:

Hi Madelyn-

Yes, this text looks fine. Thanks for checking:)

Shallin

-----  
Shallin Busch, PhD  
Ocean Acidification Program and Northwest Fisheries Science Center  
National Oceanic and Atmospheric Administration  
2725 Montlake Blvd., E  
Seattle, WA 98112

tel: [206 860 6782](tel:2068606782)

fax: [206 860 3335](tel:2068603335)

On Mon, Sep 28, 2015 at 1:27 PM, Madelyn Appelbaum - NOAA Federal

<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

Shallin, this was in the initial version that the UK drained. Do you have a concern about reference to pteropods? If not, I am going to plug it back in.

Thanks again for your always quick, careful help.

Madelyn

We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other

commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals.

----- Forwarded message -----

From: **Shallin Busch - NOAA Federal** <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)>

Date: Thu, Oct 1, 2015 at 12:05 PM

Subject: Re: next (last??) round

To: Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>

Cc: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>, Libby Jewett - NOAA Federal <[libby.jewett@noaa.gov](mailto:libby.jewett@noaa.gov)>

Hi Madelyn-

My edits to the recent version of the op-ed are attached.

Good luck!

Shallin

-----  
Shallin Busch, PhD

Ocean Acidification Program and Northwest Fisheries Science Center

National Oceanic and Atmospheric Administration

2725 Montlake Blvd., E

Seattle, WA 98112

tel: [206 860 6782](tel:2068606782)

fax: [206 860 3335](tel:2068603335)

On Thu, Oct 1, 2015 at 9:08 AM, Madelyn Appelbaum - NOAA Federal <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:

sorry...and thanks

On Thu, Oct 1, 2015 at 12:05 PM, Shallin Busch - NOAA Federal <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)> wrote:

Hi Madelyn-

Nothing is attached to this email.

Shallin

-----  
Shallin Busch, PhD

Ocean Acidification Program and Northwest Fisheries Science Center

National Oceanic and Atmospheric Administration

2725 Montlake Blvd., E

Seattle, WA 98112

tel: [206 860 6782](tel:2068606782)  
fax: [206 860 3335](tel:2068603335)

On Thu, Oct 1, 2015 at 8:56 AM, Madelyn Appelbaum - NOAA Federal  
<[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)> wrote:  
Shallin, a slightly updated version.

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Thu, Oct 1, 2015 at 11:38 AM  
Subject: Fwd: next (last??) round  
To: Shallin Busch - NOAA Federal <[shallin.busch@noaa.gov](mailto:shallin.busch@noaa.gov)>

Shallin,  
Chris is working on attached now... didn't plan to bug you again with this.  
A slew of UK scientists has already signed off on the attached and, for the most part, so  
has Rick, who is expecting this asap today.  
Did check info Great Barrier Reef info and found it valid.  
Many thanks,  
Madelyn

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <[madelyn.appelbaum@noaa.gov](mailto:madelyn.appelbaum@noaa.gov)>  
Date: Wed, Sep 30, 2015 at 10:57 PM  
Subject: next (last??) round  
To: Chris Sabine - NOAA Federal <[chris.sabine@noaa.gov](mailto:chris.sabine@noaa.gov)>

Chris,  
thanks yet again...  
we are close, really close, but still not quite there yet  
editor wants more about implications in a given area (quick stories) than we have so  
please see "red" on attached -- there are a couple of questions  
have been online, trying to fill in some of these but can't find precisely what I think is  
needed  
if you know of a great example that's not in op-ed, please plug it in, if international  
I actually think this is too US for an international paper but editor seems fine with the  
balance  
I am also sending this to UK with the hope we can give it to Rick by tomorrow night  
and to paper over the weekend since Chile conference is about to start  
  
it's now about 150 words too many, but I can eliminate most by tightening once content  
is down  
if needed, what do you think of cutting Xprize first; other stressors 2nd?  
  
if you plug in a fresh example, we could pull out Great Barrier, since that's been so  
highly publicized



## In a High CO2 World, Dangerous Waters Ahead

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train so long that it would enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon that is going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce, and build their shells and skeletons. About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs, by decreasing the output of shellfish hatcheries. Under the acidified seawater conditions experienced by hatcheries in the region, baby oysters were unable to properly build their protective shells, so died. [clearer, simpler explanation re baby oysters? however nuanced, anything at all re "look" of water to comply with editor's request?? The baby oysters do not have the energy reserves to build their protective shells so they die.] In Maine, a clam farmer reported that he could no longer fill his bucket to the top because shells on the bottom would shatter from the weight. Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in more acidic/acidified waters. A similar response in the wild could harm people who eating contaminated shellfish and sicken, even kill, marine mammals.

Comment [SB1]: We can't use this phrase as it implies that seawater is acidic, which it is not.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution, including from plastics, is pervasive; and, in general, we over-exploit the resources of the ocean. Each stressor is cause for concern, but all of them affecting the oceans at one time are cause for alarm. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean, and in the cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, due to a variety of stresses, the number of living corals covering the Great Barrier Reef has been cut in half, which has implications for biodiversity, marine resources, and coastal protection. [consequences?] Dramatic change is also apparent in the Arctic-Antarctic where the frigid waters can hold so much carbon dioxide that nearby shelled creatures living in them can dissolve in the corrosive conditions, potentially causing disruptions in marine food webs. [consequences?] Clear pictures of the changes in such remote-most ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

Comment [SB2]: Did the UK people fact check this? I haven't seen data on this.

Comment [SB3]: There has been no work to date on pteropod condition in the Arctic, only in the Antarctic.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of Nemo when the coral clownfish is studied in an acidified environment. He can't smell his predators when they are near and engages in risky behavior, making him more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes changes their food supply. Ocean acidification has the potential to reorganize entire food webs, by changing the abundance and types of predators and prey, like phytoplankton and zooplankton. A line or 2 about food web... plankton dying, in simple text Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic plants and animals that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

Comment [SB4]: Again, the water isn't actually acidic.

Comment [SB5]: We don't know if they will adapt.

Comment [SB6]: This is a strong statement that I'm not really comfortable with.

To understand where the acute challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising CO2 and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt their industry to new ocean conditions. [reword — something about avoiding more near collapses? current periodic ocean acidification events.] And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

will be tightened by about 150 words prior to submission

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Mon, Aug 3, 2015 at 6:34 AM

Subject: Please review asap

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

Hi Chris,

Here's a draft, which no doubt still needs streamlining, but please see what you think.

It's already a bit too long but, at this point, my main concern is accuracy and that priority pts are covered. Once you vet, I'll move op-ed forward here, then on to the UK.

Here's older article:

[http://www.nytimes.com/2012/06/19/opinion/acid-test-for-oceans-and-marine-life.html?\\_r=0](http://www.nytimes.com/2012/06/19/opinion/acid-test-for-oceans-and-marine-life.html?_r=0)

Many, many thanks. I appreciate your help and apologize for the rush review. This took longer than I expected to develop.

Best wishes,

Madelyn

202 482 4858

202 340 6310 cell



**OA Rick & Ian Boyd 8 3 15.docx**

20K

In waters around the world, hotspots are emerging that tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, which is threatening the fundamental chemical balance of our ocean and coastal waters. The sea has absorbed CO<sub>2</sub> from human activities since the start of the Industrial Revolution. But every year since, the sea has absorbed two billion more metric tons of CO<sub>2</sub>. That adds up to 11 million freight cars filled with coal, a number that would encircle earth 14 times.

As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating an environment that eats away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs and many other organisms are at risk, especially since we know that, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each of these stressors is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, jobs, local to global economies, and the goods and services required by society are immense. For the first time this year, a nationwide study revealed where the \$1 billion U.S. shellfish industry and coastal communities are most vulnerable, and the list is daunting: Long Island Sound, Narragansett Bay, Chesapeake Bay, the Gulf of Mexico, Pacific Northwest, and areas of Maine and Massachusetts. Acidity is already apparent off the Alaskan coast, which accounts for about 50 percent OF the U.S. commercial catch and supports more than 100,000 jobs.

Acidity is evident in the Mediterranean Sea and in waters around the UK and Germany. In the UK... *[more to come from UK]* Ocean acidification is weakening coral structures in the Great Barrier Reef, and threatening native fisheries in the Patagonian waters of southern Chile. New research indicates that, within 15 years, acidity in Arctic waters could impede the ability of animals to build shells, with ramifications through the marine ecosystem.

*Chris, references to Mediterranean, UK, Germany drawn from a report from scientific measurement stations...for UK and Germany, ok to state "waters around.."*

*Are these the best examples to cite? More new research to mention?*

Clearly, emissions must be cut substantially, which is why the UK aims to halve emissions by 2025, and cut them by 80 percent by 2050. In the U.S., President Obama's climate change agenda includes an unprecedented 32 percent cut in emissions from power plants by 2030 and a 50 percent cut from federal agencies over the next decade. Tackling ocean acidification is a steep challenge, but also a dynamic opportunity to deter profound changes in ocean ecosystem structures and functions. Just last month [July], an enterprising team (from a small farm in Montana!) claimed *both* top X-Prizes for developing breakthrough technology to measure acidity. If we are to better understand the sea's response to CO<sub>2</sub> overload, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

Smart investments in monitoring and observing are critical to building resilience and hedging risk. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential.

For this reason, we are pleased that representatives of our two nations co-chair the emerging Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this new network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the new network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other animals that have no shell. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals. The Global Ocean Acidification Observing network launched with 30 nations. To fill serious gaps in global coverage, it's important that more nations come aboard. When it comes to building ready, responsive and resilient communities, and ensuring the economic vitality of our planet, the stakes are high. And in a high CO<sub>2</sub> world, everyone is a stakeholder.

###

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Wed, Aug 5, 2015 at 7:44 AM

Subject: CORRECT "final" to this pt

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

Thanks again, Chris.

Rick may get back with questions.

Best wishes,

Madelyn



**NOAA UK oped 8 5 15.docx**

22K

## **In a High CO<sub>2</sub> World, Ocean Hotspots Tell a Disturbing Story**

In waters around the world, ocean hotspots are beginning to tell a disturbing story. Just like a sponge, the ocean is absorbing increasing amounts of carbon dioxide from the atmosphere, threatening the chemical balance of our ocean and coastal waters and their fragile, finite marine life. Over the past 200 years, the sea has absorbed more than 150 billion metric tons of carbon from human activities. It's now absorbing more than 2.5 billion metric tons every year, enough to fill a coal train long enough to encircle the equator 13 times.

The consequences of disrupting what has been a relatively stable ocean environment for tens of millions of years are beginning to show. As an acidic gas, carbon dioxide becomes corrosive when dissolved in water, creating conditions that eat away at the minerals much of our marine life relies on to build protective shells and skeletons. Oysters, clams, lobsters, shrimp, coral reefs, plants and much more are at risk, especially since, along with increasing acidity, the oceans are warming and the oxygen critical to marine life is decreasing. Each stressor is a problem. But all three hitting our oceans at one time is cause for alarm. The implications for food security, economies, jobs, and vital consumer goods and services are immense. This year the first nationwide study of the vulnerability of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a daunting list of hotspots: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects shellfish production. Acidity also is apparent off the Alaskan coast, which accounts for nearly 60 percent of the U.S. commercial fish catch and supports more than 100,000 jobs.

There are concerns in the Mediterranean Sea and in waters around the UK and Germany. In the UK... *[coming from UK]* Ocean acidification is weakening coral structures in the Great Barrier Reef, and threatening native fisheries in the Patagonian waters of southern Chile. The most dramatic change is already occurring in the Arctic where water can be corrosive enough to dissolve nearby shelled creatures.

There is urgency to substantially reducing carbon dioxide emissions. A recent NOAA study found that, over the past 15 years, the rate of global warming has been as fast or faster than seen during the latter half of the 20<sup>th</sup> century. There has been no downward trend in our high CO<sub>2</sub> world and both of our nations have called for unprecedented actions to reduce emissions. Tackling ocean acidification is a steep challenge. But it's also a dynamic opportunity to inspire profound advances in our understanding of the ocean. In July, an enterprising team from a small farm in Montana won the X-Prize for developing breakthrough technologies to measure ocean acidity. To better understand the sea's response to CO<sub>2</sub>, and develop the know-how to protect lives, livelihoods, communities and economies against the consequences, we need more such breakthroughs generated by public-private partnerships.

Smart investments in monitoring and observing are critical to building resilience and hedging risk. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential.

continued

We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network. Designed for robust forecasting capabilities, this network will assess not only the international picture but the intrinsic links of global, regional and community conditions. Integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets, the network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals. The new 30-nation network still has gaps in global coverage, and more nations are needed to fill them. To understand the sea, we must first observe it. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. Locally to globally, we are all the stakeholders.

###

Authors:

Dr. Richard W. Spinrad, Chief Scientist  
National Oceanic and Atmospheric Administration  
United States

Professor Ian Boyd, Chief Scientific Adviser  
Department of Environment, Food and Rural Affairs  
United Kingdom

Contacts:

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[Madelyn.Appelbaum@noaa.gov](mailto:Madelyn.Appelbaum@noaa.gov)  
001 202 482 4858  
011 292 349 6310 cell

Jayne Phenton – UK  
[Jayne.Phenton@defra.gsi.gov.uk](mailto:Jayne.Phenton@defra.gsi.gov.uk)  
011 44 20 7238 6600

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Wed, Sep 30, 2015 at 5:22 PM

Subject: Re: PLEASE SEE JUST THIS ONE

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

thanks very much

Sent from my iPhone

On Sep 30, 2015, at 7:54 PM, Chris Sabine - NOAA Federal <chris.sabine@noaa.gov> wrote:

Madelyn,

Attached are my suggestions. I hope this helps.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Wed, Sep 30, 2015 at 2:49 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

ok...yet another round  
it needs to be cut, but not worried about that now  
"red" is new text

anything you might do to spice it up, greatly appreciated!  
editor wants "pictures"

once you clear content, I'll work through it again tonight and try to cut about 265 words before sending to Rick -- am hoping to get it to UK tomorrow and to paper by Mon am at latest

what would you cut??

how about one high resolution visual? pteropods?

many thanks

Madelyn

<op-ed working\_cls.docx>

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Wed, Sep 30, 2015 at 6:01 PM

Subject: Re: PLEASE SEE JUST THIS ONE

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

thank you

I really do like your edits -- always do!

line in par 2 about baby oysters could be simplified and fleshed out a bit but will work well

Sent from my iPhone

On Sep 30, 2015, at 8:58 PM, Chris Sabine - NOAA Federal <chris.sabine@noaa.gov> wrote:

Yes, I will be in.

Sent from my iPhone

On Sep 30, 2015, at 5:45 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

yep, really helpful  
will you be in tomorrow??  
thanks again

On Wed, Sep 30, 2015 at 7:54 PM, Chris Sabine - NOAA Federal <chris.sabine@noaa.gov> wrote:

Madelyn,

Attached are my suggestions. I hope this helps.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115

ph: (206) 526-6800  
fax: (206) 526-4576  
web: www.pmel.noaa.gov

On Wed, Sep 30, 2015 at 2:49 PM, Madelyn Appelbaum - NOAA Federal  
<madelyn.appelbaum@noaa.gov> wrote:

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it needs to be cut, but not worried about that now  
"red" is new text

anything you might do to spice it up, greatly appreciated!  
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once you clear content, I'll work through it again tonight and try to cut about 265  
words before sending to Rick – am hoping to get it to UK tomorrow and to paper  
by Mon am at latest

what would you cut??

how about one high resolution visual? pteropods?

many thanks  
Madelyn

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Wed, Oct 7, 2015 at 8:30 PM

Subject: Re: next round...

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

of course, every one of your edits is extremely helpful  
making changes now and sending off  
thanks, Chris

On Wed, Oct 7, 2015 at 10:58 PM, Chris Sabine - NOAA Federal <chris.sabine@noaa.gov> wrote:  
Madelyn,

A very nice article. I really liked it. Attached are some thoughts that you are free to take or discard as you see fit.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Wed, Oct 7, 2015 at 2:16 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

ah...the freedom to just write whatever I want...  
please see what you think  
and, THANKS for yet more

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Thu, Oct 15, 2015 at 7:28 AM

Subject: OA op-ed...thank you!

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>, Libby Jewett - NOAA Federal <libby.jewett@noaa.gov>, Ciaran Clayton - NOAA Federal <ciaran.clayton@noaa.gov>, Pieter Tans - NOAA Federal <pieter.tans@noaa.gov>, Jan Newton <newton@apl.uw.edu>, Shallin Busch - NOAA Federal <shallin.busch@noaa.gov>, Jennifer Mintz - NOAA Federal <jennifer.bennett@noaa.gov>, Richard Feely - NOAA Federal <Richard.A.Feely@noaa.gov>, Brady Phillips - NOAA Federal <brady.phillips@noaa.gov>  
Cc: Rick Spinrad - NOAA Federal <Rick.Spinrad@noaa.gov>

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

Thanks everyone. Rick's op-ed with his UK colleague finally landed today (sorry about the title).

Tomorrow it appears in print in the International NY Times.

Chris and each of you were extremely helpful and patient through mega rounds of questions and edits, and I am very grateful. So lucky to be working with you!

Best wishes,  
Madelyn

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Mon, Aug 3, 2015 at 10:30 AM

Subject: Re: PS

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Okay, I am working on this now...

Chris

Christopher L. Sabine, PhD.

Director, Pacific Marine Environmental Laboratory

7600 Sand Point Way NE

Seattle, WA 98115

ph: (206) 526-6800

fax: (206) 526-4576

web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Mon, Aug 3, 2015 at 9:50 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

Chris,

Unfortunately, I can't repeat oyster hatchery story used in 2012, but hope there's another way, in a few words, to plug IOOS in? Perhaps in assets referenced with GOA-ON?

Thanks again for your review,

Madelyn

Sent from my iPhone

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Tue, Aug 4, 2015 at 4:26 PM

Subject: Re: ready to go?

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Hi Madelyn,

I think the op-ed looks good to me. Your two additional changes listed below are also fine. The only thing to note is the version I have has some odd wording/formatting problems in the very last sentences of the article. I'm not sure what that is about....

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Tue, Aug 4, 2015 at 3:22 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:  
just checking that these additional edits are ok...

... enough to fill a coal train long enough to encircle the equator 13 times.

The most dramatic change is already occurring in the Arctic where water can be corrosive enough to dissolve nearby shelled creatures.

thanks, Chris

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Tue, Aug 4, 2015 at 4:11 PM

Subject: ready to go?

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

Chris, am still grappling with an ending but otherwise *think* this is ready for go, Ok?

Thank you!

Madelyn

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Wed, Aug 5, 2015 at 9:20 AM

Subject: Re: CORRECT "final" to this pt

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Madelyn,

I'm glad I could help and happy to address any questions or concerns Rick may have.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Wed, Aug 5, 2015 at 7:44 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

Thanks again, Chris.  
Rick may get back with questions.  
Best wishes,  
Madelyn

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Aug 6, 2015 at 8:03 AM

Subject: Re: Rick's edits

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Hi Madelyn,

I am just into work now. I will work on this first thing....

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Aug 6, 2015 at 7:06 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:  
Chris, whatever you think best but it seems both additions could seamlessly work at the end of this par?

Smart investments in monitoring and observing are critical to building resilience and hedging risk. Resilience reduces the costs of uncertainty and supports renewed vitality and recovery with fewer negative impacts. We can't manage what we can't measure, and observations are requisite to providing the environmental information that underpins sound policy and approaches to building community resilience. While a global phenomenon, ocean acidification manifests itself differently in different waters. Some organisms may also defy increasing acidity and be able to adapt. To forecast ocean and coastal conditions and understand implications all along the food chain, observations are essential. [Without them, we would not have the forecasting capability to predict hotspots in many regions. However, there is still a crucial need to measure regions such as Antarctica where...]

we also need the capability to predict at [scales-- simple language], enabling, for example, daily adjustments to water intake at shellfish farms which can determine whether an industry thrives or [crashes] and to long-term planning for ocean-based infrastructure so pivotal to...]

or please ditch and address his edits differently

thanks, Chris

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Thu, Aug 6, 2015 at 9:21 AM

Subject: Rick's edits

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

Good morning, Chris.

Rick really likes the op-ed, and I explained how indispensable you've been in developing it.

He's asked for just a few edits, most of which I can handle, but perhaps you can flesh out these 2 and plug them into the op-ed, or I can do that once I have the right substance to work with?

Started fleshing them out myself, then realized you'd change the text anyway so sending to you upfront

and this truly is the last round, pre-UK...honest

thanks yet again!

Madelyn

We should emphasize that we know about these hot spots because we've been able to measure in these hot spots, but there are many areas of the ocean where we don't have measurements, like parts of the Antarctic where it's critical to measure because...

I'd like to include something about being able to predict at multiple spatial and temporal scales (stated more eloquently than that, of course), because the applications of such predictive products include uses from daily adjustments for water-intake at shellfish farms, to long-term planning for ocean-based infrastructure such as...

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Aug 6, 2015 at 10:37 AM

Subject: Re: with edits

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Madelyn,

I am fine with all the proposed changes, but can we change "Southern Ocean in Antarctica" to "Southern Ocean around Antarctica"? Antarctica is the continent so technically the ocean is around Antarctica not in it. Otherwise it looks great.

Chris

Christopher L. Sabine, PhD.

Director, Pacific Marine Environmental Laboratory

7600 Sand Point Way NE

Seattle, WA 98115

ph: (206) 526-6800

fax: (206) 526-4576

web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Aug 6, 2015 at 9:45 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:  
adjusted a tad...so a one more "last" round

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Mon, Aug 24, 2015 at 7:11 AM

Subject: Re: op-ed

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Okay, thanks for the update.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Mon, Aug 24, 2015 at 7:11 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

Hi Chris,  
Still on hold for UK response...  
Will get back as soon as something lands

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Fri, Aug 28, 2015 at 11:59 AM

Subject: Re: correct copy to review...thank you!

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Hi Madelyn,

My only potential scientific concern is with the red sentence in paragraph two. Carbon dioxide is an acidic gas, so I am okay with that. My concern is over the statement that "carbon dioxide becomes corrosive when dissolved in water". My first concern is corrosive to what? It may be corrosive to carbonate shells, but not to metal for example. The statement is unclear. Also, it is also true that if you dissolved CO<sub>2</sub> in pure water it would be corrosive to carbonate, but seawater is well buffered so you must dissolve a lot of CO<sub>2</sub> in the ocean to make it corrosive. This may be a subtlety, but I think it is important. What if you said:

Because carbon dioxide is an acidic gas, it can make seawater corrosive to carbonate shells; eating away at the minerals much of our marine life relies on to build protective shells and skeletons.

I have two other stylistic comments. First, the last sentence in that same paragraph (Fish are also under threat.) seems tacked on and unsupported. This needs another sentence to support it. Second, the last sentence seems to be hanging and doesn't clearly tie into the previous text all by itself.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Fri, Aug 28, 2015 at 11:22 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>  
Date: Wed, Sep 30, 2015 at 12:18 PM  
Subject: Re: article amends from this end!  
To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Madelyn,

I have asked everyone I can reach and nobody is aware of a study that suggests that Nemo's hearing would be impaired by ocean acidification. I did find one article on the web that suggested the opposite. I am aware of studies indicating that Nemo would lose sense of smell or ability to detect predators and therefore would be more likely to be eaten. Perhaps you can ask the UK people to check on that sentence.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Wed, Sep 30, 2015 at 5:09 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

Hi Chris,

I am working through all comments today and will send draft for your (again!) review. Sorry for so many rounds. Here's what landed from the UK...

Madelyn

Sent from my iPhone

Begin forwarded message:

**From:** Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>  
**Date:** September 30, 2015 at 8:06:16 AM EDT  
**To:** Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>  
**Subject:** Fwd: article amends from this end!

Sent from my iPhone

Begin forwarded message:

**From:** "Phenton, Jayne (DEFRA)" <Jayne.Phenton@defra.gsi.gov.uk>  
**Date:** September 30, 2015 at 5:41:03 AM EDT  
**To:** "Madelyn Appelbaum - NOAA Federal (madelyn.appelbaum@noaa.gov)"  
<madelyn.appelbaum@noaa.gov>  
**Subject:** article amends from this end!

Hi Madelyn

The team have added some examples (Nemo the clown fish a particularly good one I think!) and a few thoughts. This is not a clean copy – I've left their comments in because I thought it might be helpful for you to see the reasoning, but if a tidy copy would be better, let me know and I can do that straight away.

Let me know what you think. By the by, I was thinking we should offer this to a national broadsheet here – be great for a comment piece on the Guardian website I think. Let me know if you have any thoughts – I don't it would matter if it had already appeared in the NY Times although of course we would acknowledge that.

Hope all well there.

Best wishes

Jayne

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
Nobel House | 17 Smith Square | London SW1P 3JR

Department for Environment, Food and Rural Affairs (Defra)

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----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Wed, Sep 30, 2015 at 4:54 PM

Subject: Re: PLEASE SEE JUST THIS ONE

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Madelyn,

Attached are my suggestions. I hope this helps.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Wed, Sep 30, 2015 at 2:49 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

ok...yet another round  
it needs to be cut, but not worried about that now  
"red" is new text

anything you might do to spice it up, greatly appreciated!  
editor wants "pictures"

once you clear content, I'll work through it again tonight and try to cut about 265 words before sending to Rick --  
am hoping to get it to UK tomorrow and to paper by Mon am at latest

what would you cut??

how about one high resolution visual? pteropods?

many thanks  
Madelyn



op-ed working\_cls.docx

24K

## In a High CO<sub>2</sub> World, Dangerous Waters Ahead

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon that is going into the ocean, but it dissolves in the seawater as carbonic acid, and is now changing the water's chemistry at a rate faster rate than has occurred seen for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish, and corals and other marine organisms to grow, reproduce, and build their shells and skeletons. About 10 years ago, the U.S. Pacific Northwest oyster industry nearly collapsed when acidified ocean water reached coastal areas, threatening a \$230 million coastal economy and 3,000 jobs. Shells became so thin, larvae couldn't grow. The baby oysters do not have the energy reserves to build their protective shells so they die. In Maine, a clam farmer reported that he could no longer fill his bucket to the top because shells on the bottom would shatter from the weight. Marine industries may choose to move are already considering moving to safer waters that have seen less dramatic changes, but that will become less likely only delay the impacts as ocean acidification emerges around the globe.

Human health is a major concern. Laboratory research shows that many harmful algal species produce more toxins and bloom more readily in acidified conditions. A similar response in the wild could seriously harm people consuming shellfish contaminated by the harmful algae and even kill marine mammals.

Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is cause for concern, but all of them hitting our oceans at one time are cause for alarm. For both the developing and developed world, the implications for food security, economies and vital goods and services are immense.

Recently, the first nationwide study of the \$1 billion U.S. shellfish industry revealed a considerable list of vulnerable areas. In addition to the Pacific Northwest, they include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean, and in the cold-water coral reefs found in the deeper waters off Scotland and Norway. In the past three decades, the number of living corals covering coral cover on the Great Barrier Reef has diminished by 30 percent been cut in half. [what does this look like?] Dramatic change is also apparent in the Arctic where the frigid waters can hold so much carbon dioxide that nearby shelled creatures will dissolve in the be corrosive enough to dissolve nearby shelled creatures conditions. The waters of the north don't have the chemicals to buffer acidification. They originate from melting ice, and this clean water is exposed to a carbon dioxide-filled

**Comment [CS1]:** I think you could lose this paragraph if you need to cut words. It seems a bit out of place and isn't referred to anywhere else in the article.

atmosphere. Clear pictures of the changes in such remote ocean regions are sparse. To better prepare for understanding these and other hotspots, more regions must be studied.

We still cannot predict exactly how ocean acidification will affect the interactions and connections between the many different marine organisms around the world, but we do know that its consequences will be profound. Laboratory studies already point to the unnatural behavior Nemo, the coral clownfish, displays when placed in an acidic environment, making him more likely to be eaten by a predator. We don't fully understand how fish, like salmon, will adapt as ocean acidification affects their food supply. Fish around the world are likely to be affected by food-web changes since some microscopic plankton are likely to die out. [Chris, please simplify—a lot] Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic species plants and animals that occur can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

To understand where the acute challenges lie, we need better ocean measuring capability, linked with better-improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets. The network will enable scientists to study more species. We don't yet know, for example, what acidification means for salmon and other commercially important fish. But we do know that, in some areas, ocean acidification is already dissolving the shells of important food sources for these animals.

Comment [CS2]: This seems redundant and out of place here.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration.  
Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 7:48 AM

Subject: Re: next (last??) round

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Hi Madelyn,

I am just into the office...I will work on the article first thing.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 6:59 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

so modestly, I really like it – thanks to you

UK likes it, too, so as soon as you fill in, I will send it to Rick, who is in NY with a train ride ahead!

with oyster text, can you please add a few descriptive words re water? is there any way to visually make a point or two?

slight color change? cloudy? anything, however nuanced?

also will call later – wait until you hear the latest request!

we (sorry for the assumption) will be writing for royalty

On Wed, Sep 30, 2015 at 10:57 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

Chris,

thanks yet again...

we are close, really close, but still not quite there yet

editor wants more about implications in a given area (quick stories) than we have so please see "red" on attached – there are a couple of questions

have been online, trying to fill in some of these but can't find precisely what I think is needed

if you know of a great example that's not in op-ed, please plug it in, if international

I actually think this is too US for an international paper but editor seems fine with the balance  
I am also sending this to UK with the hope we can give it to Rick by tomorrow night and to paper over the weekend since Chile conference is about to start

it's now about 150 words too many, but I can eliminate most by tightening once content is down  
if needed, what do you think of cutting Xprize first; other stressors 2nd?

if you plug in a fresh example, we could pull out Great Barrier, since that's been so highly publicized

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>  
Date: Thu, Oct 1, 2015 at 8:16 AM  
Subject: Re: UK (Carol Turley's) very mild edits  
To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

I'm on it...

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 8:16 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:  
Chris, please see only #2 and #4 -- attached just landed  
Re #7, we might put emerging ocean acidification, or perhaps you can suggest a more interesting way.

not concerned about other edits, and neither is Ian

thank you

----- Forwarded message -----

From: **Phenton, Jayne (DEFRA)** <Jayne.Phenton@defra.gsi.gov.uk>  
Date: Thu, Oct 1, 2015 at 11:03 AM  
Subject: Carol's edits  
To: "Madelyn Appelbaum - NOAA Federal (madelyn.appelbaum@noaa.gov)"  
<madelyn.appelbaum@noaa.gov>

Hi Madelyn

So sorry to have to dash – I should be back at my desk in about an hour if you want to speak, otherwise I'm sure this is all fine.

Thanks again – always lovely to speak with you.

Best wishes

Jayne

Jayne Phenton | Senior Communications Officer  
News and External Communications  
Department for Environment, Food and Rural Affairs  
Direct line: 0207 238 6600 | Out of hours: 0345 051 8486  
Nobel House | 17 Smith Square | London SW1P 3JR

Department for Environment, Food and Rural Affairs (Defra)

This email and any attachments is intended for the named recipient only. If you have received it in error you have no authority to use, disclose, store or copy any of its contents and you should destroy it and inform the sender. Whilst this email and associated attachments will have been checked for known viruses whilst within Defra systems we can accept no responsibility once it has left our systems. Communications on Defra's computer systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 9:42 AM

Subject: Re: baby oysters?

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3, 000 jobs. Ocean currents pushed acidified water into coastal areas, making it too difficult for baby oysters to build their protective shells that help them settle into their oyster beds. Without their shells, the baby oysters drift with the tides until they die. In Maine, a clam farmer...

Christopher L. Sabine, PhD.

Director, Pacific Marine Environmental Laboratory

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Seattle, WA 98115

ph: (206) 526-6800

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web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 9:33 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:  
depleting instead of draining?

----- Forwarded message -----

From: **Madelyn Appelbaum - NOAA Federal** <madelyn.appelbaum@noaa.gov>

Date: Thu, Oct 1, 2015 at 12:31 PM

Subject: baby oysters?

To: Chris Sabine - NOAA Federal <chris.sabine@noaa.gov>

Ocean currents pushed acidified water into coastal areas, [draining] the energy baby oysters require to build protective shells and causing leaving them to float in coastal waters until they died.

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 9:51 AM

Subject: Re: edits

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

It is not that the ocean acidification is depleting their energy reserves, but that they do not have the energy reserves to fight against the changing chemistry.

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 9:47 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

would this be ok? I think the energy drain is important, if we can keep it in, since editor is pushing for details

Ocean currents pushed acidified water into coastal areas, depleting the energy baby oysters require to build protective shells. Without their shells, they drift with the tides until they die.

Already oyster hatcheries on the West Coast of the United States are using technology [[ocean observing buoys?](#)] to adapt to ocean acidification and monitor water quality so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification. [[line or 2 re how?](#)]

thanks, Chris

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>  
Date: Thu, Oct 1, 2015 at 10:05 AM  
Subject: Re: article on ocean acidifation for the NYT  
To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

How about the attached?

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: www.pmel.noaa.gov

On Thu, Oct 1, 2015 at 10:03 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

this is terrific!  
after you sign off, I will immediately send to Rick  
goal will be to get this to paper by tomorrow am in Paris

----- Forwarded message -----

From: **GREGORY, Joe** <jgregory@nytimes.com>  
Date: Thu, Oct 1, 2015 at 12:42 PM  
Subject: Re: article on ocean acidifation for the NYT  
To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Madelyn, do you have a sense yet of when the authors might refile their op-ed?  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

On Mon, Sep 28, 2015 at 5:42 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

we will definitely beef it up  
many thanks  
Madelyn

Sent from my iPhone

> On Sep 28, 2015, at 11:19 AM, GREGORY, Joe <jgregory@nytimes.com> wrote:

>

> madelyn.appelbaum@noaa.gov Madelyn Appelbaum

> 202 482 4858

> 202 340 6310 cell

>

>

> Dear Madelyn Appelbaum,

>

> Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?

> Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.

> I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,

> Best Wishes,

> Joe Gregory, INYT Opinion Pages

>

>

> Richard W. Spinrad

> Ian Boyd

>

>

> Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

>

> We can't see this massive amount of carbon that's going into the ocean, but it dissolves in the seawater as carbonic acid and is now changing the water's chemistry at a faster rate than has occurred for millions of years. Known as ocean acidification, this process creates conditions which erode the minerals much of our marine life rely on, making it difficult for shellfish and corals to grow, reproduce, and build their shells and skeletons. CAN YOU GIVE A STRONG, CLEAR IMAGE HERE TO HELP US VISUALIZE WHAT IS HAPPENING?

> WHAT REGIONS ARE PARTICULARLY AFFECTED. IT WOULD BE GOOD, FOR EXAMPLE, IF YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

> Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

>

> Recently, the first nationwide study of the \$1 billion U.S. shellfish industry and the coastal communities that depend on it revealed a considerable list of vulnerable areas: Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, areas off Maine and Massachusetts, and the Pacific Northwest where acidification already affects commercial shellfish production. AGAIN, A STRONG EXAMPLE WOULD HELP – ARE OYSTER FARMS OFF ANY PARTICULAR COAST EXPERIENCE NOTABLE DECLINE IN YIELDS?/ Ocean acidification also threatens Alaskan fisheries, which account for nearly 60 percent of the United States commercial fish catch and supports more than 100,000 jobs.

>

> Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE

IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

> Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

>

> We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED. Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

>

> To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

> ARE OTHER FACTORS INVOLVED – INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

> Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

> When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

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> Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

>

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that is going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce, and build their shells and skeletons. About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs. clearer, simpler explanation of what happened?—TOcean currents pushed acidified water into coastal areas, making it too difficult for baby oysters to use their limited energy reserves to build their protective shells that help them settle into their oyster beds. Without their shells, the baby oysters drift with the tides until they die. ~~he baby oysters do not have the energy reserves to build their protective shells so they die.~~ In Maine, a clam farmer reported that he could no longer fill his bucket to the top because shells on the bottom would shatter from the weight. Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster ~~ok to put "faster"~~ instead of "more readily?" in with ocean acidification-acidified conditions. A similar response in the wild could harm people eating contaminated shellfish.

Formatted: Underline, Font color: Red

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is cause for concern, but all of them affecting the oceans at one time are cause for alarm. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean, and in the cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. ~~[consequences?]~~ Dramatic change is also apparent in the Arctic where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions impacting food sources for fish, birds, marine mammals, and even indigenous peoples. ~~[consequences?]~~ Clear pictures of the changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We still cannot predict exactly how ocean acidification will affect the interactions and connections between the many different marine organisms around the world, but we do know that the consequences will be profound. Research already points to the unnatural behavior of Nemo when the coral clownfish is studied in an acidic environment. He ~~xx and xx~~ wanders farther away from his

protective anemone, making him more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply. Some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish eat so there may be cascading impacts of ocean acidification on the fish that we still do not fully understand. A line or 2 about food web...plankton dying, in simple text — Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic plants and animals life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the acute challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are working with scientists to use technology to monitor water quality and adapt to ocean acidification so baby oysters can survive. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to [simplify? current periodic ocean acidification events.] And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification by enhancing the uptake of carbon dioxide from the atmosphere.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 10:20 AM

Subject: Re: article on ocean acidification for the NYT

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Of course you can send it to me again...I am around and happy to help. I am also in the middle of doing all my performance reviews. Not fun.

Chris

Christopher L. Sabine, PhD.

Director, Pacific Marine Environmental Laboratory

7600 Sand Point Way NE

Seattle, WA 98115

ph: (206) 526-6800

fax: (206) 526-4576

web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 10:18 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

perfect -- thank you, thank you

can I please send final to you before it goes to Rick?

have my performance review from 1:30 - 2:30 (bummer!) and will send to you soon after

On Thu, Oct 1, 2015 at 1:05 PM, Chris Sabine - NOAA Federal <chris.sabine@noaa.gov> wrote:

How about the attached?

Chris

Christopher L. Sabine, PhD.

Director, Pacific Marine Environmental Laboratory

7600 Sand Point Way NE

Seattle, WA 98115

ph: (206) 526-6800

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On Thu, Oct 1, 2015 at 10:03 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

this is terrific!  
after you sign off, I will immediately send to Rick  
goal will be to get this to paper by tomorrow am in Paris

----- Forwarded message -----

From: **GREGORY, Joe** <jgregory@nytimes.com>  
Date: Thu, Oct 1, 2015 at 12:42 PM  
Subject: Re: article on ocean acidification for the NYT  
To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Madelyn, do you have a sense yet of when the authors might refile their op-ed?  
Best Wishes,  
Joe Gregory, INYT Opinion Pages

On Mon, Sep 28, 2015 at 5:42 PM, Madelyn Appelbaum - NOAA Federal  
<madelyn.appelbaum@noaa.gov> wrote:

we will definitely beef it up  
many thanks  
Madelyn

Sent from my iPhone

> On Sep 28, 2015, at 11:19 AM, GREGORY, Joe <jgregory@nytimes.com> wrote:

>  
> madelyn.appelbaum@noaa.gov  
> Madelyn Appelbaum  
> 202 482 4858  
> 202 340 6310 cell

>  
>  
> Dear Madelyn Appelbaum,

>  
> Thank you for sending this to us. It's very interesting, but in order to work for us it needs to be geared more toward the general reader. Can the authors give us more specific, descriptive images about how acidification has already affected the oceans?

> Is the situation akin to the acid rain phenomenon that hit North America? What can be done to counteract the problem.

> I've included some questions IN CAPITAL LETTERS in the body of the text. If they can provide strong descriptive images of what is happening I think the piece has a good chance,

> Best Wishes,  
> Joe Gregory, INYT Opinion Pages

>  
>  
> Richard W. Spinrad  
> Ian Boyd

>  
> Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their fragile, finite marine life are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. That's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

>  
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YOU COULD DESCRIBE AN AREA OF THE SEAS THAT HAS BEEN SEVERELY DEGRADED. IS ACIDIFICATION MANIFESTING ITSELF IN INCREASED DISEASE IN MARINE LIFE, OR ILLNESS IN PEOPLE WHO EAT DEGRADED SEAFOOD? WHAT EXACTLY HAS HAPPENED TO THE AFFECTED FISHERIES? IS THIS DRIVING UP THE COST OF SHELL FISH

> Along with this increasing acidity are other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; and in general we over-exploit the resources of the ocean. All of these stressors affecting our oceans at one time are a problem. The implications for food supplies, economies, jobs and vital consumer goods and services are immense, not just for some of the most vulnerable communities in the developing world but for developed countries, too.

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>

> Ocean acidification is weakening coral structures, not only in the Great Barrier Reef and the Caribbean but in the cold-water coral reefs found in deeper waters off Scotland and Norway. IS THE SITUATION WORSE IN NORTH SEAS. HOW DOES THIS MANIFEST ITSELF, HOW HAS IT AFFECTED THE APPEARANCE OF THE REEFS? DEAD FISH WASHING UP ON SHORE? IS ACIDIFICATION SUCH THAT IT WOULD AFFECT SWIMMERS, SKIN RASHES FOR EXAMPLE?

> Some of the most dramatic changes are in polar seas where acidified seawater is already dissolving the shells of sea butterflies, the small marine snails that are an important food for salmon, whales and seabirds. In coming decades, the Southern Ocean and Arctic Ocean will become increasingly hostile to shell-producing animals and plants, even if the rate of future ocean acidification is slowed.

>

> We cannot yet predict exactly how ocean acidification will affect the many different marine organisms around the world, but we do know that it will have a profound effect on the structure of marine ecosystems. TO MAKE YOUR POINT, IF YOU CAN DISCUSS EVEN ONE SPECIES OF FISH OR MARINE LIFE THAT HAS ALREADY BEEN AFFECTED. Fish around the world may be affected by food-web changes as sea life in their coral reef habitats are impacted or changes in the water chemistry affect fish's sensory capabilities. It will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and safely store pollutants, including future emissions of carbon.

>

> To understand where the challenges lie, we need better ocean measuring capability, linked with better modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect community, regional and global economies. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

> ARE OTHER FACTORS INVOLVED – INCREASED DUMPING OF PLASTICS AND OTHER REFUSE IN THE OCEAN?

> Both of our nations recognize that rising carbon dioxide in the atmosphere and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for the robust forecasting required. There are gaps in global coverage, but the network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt to current periodic ocean acidification events.

> When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidity at our own peril, and that of future generations.

>

> Richard W. Spinrad is the chief scientist of the U.S, National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs  
>

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 11:50 AM

Subject: Re: question

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

I suggest:

Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater.

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 11:45 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic life that can be found in every drop of seawater.

Chris, should this revert to plants and animals? multitudes of microscopic life?  
"lives" doesn't work

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 12:28 PM

Subject: Re: another question

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

I have added my comments to her comments in the attached. I would leave the Arctic statement as it is, but there are a couple of other changes in wording that I agree with.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 12:25 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

Dramatic change is also apparent in the Antarctic where the frigid waters can hold so much carbon dioxide that shelled creatures can dissolve in the corrosive conditions.

[SB1]There has been no work to date on pteropod condition in the Arctic, only in the Antarctic.

should I change from Arctic to Antarctic? or are both correct?

thanks

## In a High CO2 World, Dangerous Waters Ahead

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters and their marine treasures are under growing threat. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train so long that it would encircle the equator 13 times every year.

We can't see this massive amount of carbon that is going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce, and build their shells and skeletons. About 10 years ago, ocean acidification nearly collapsed the \$230 million U.S. Pacific Northwest oyster industry and its 3,000 jobs, by decreasing the output of shellfish hatcheries. Under the acidified seawater conditions experienced by hatcheries in the region, baby oysters were unable to properly build their protective shells, so died. [clearer, simpler explanation re baby oysters? however nuanced, anything at all re "look" of water to comply with editor's request??] The baby oysters do not have the energy reserves to build their protective shells so they die. In Maine, a clam farmer reported that he could no longer fill his bucket to the top because shells on the bottom would shatter from the weight. Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in more acidic waters. A similar response in the wild could harm people who eating contaminated shellfish and sicken, even kill, marine mammals.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution, including from plastics, is pervasive; and, in general, we over-exploit the resources of the ocean. Each stressor is cause for concern, but all of them affecting the oceans at one time are cause for alarm. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean, and in the cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, due to a variety of stresses, the number of living corals covering the Great Barrier Reef has been cut in half, which has implications for biodiversity, marine resources, and coastal protection. [consequences?] Dramatic change is also apparent in the Arctic Antarctic where the frigid waters can hold so much carbon dioxide that nearby-shelled creatures living in them can dissolve in the corrosive conditions, potentially causing disruptions in marine food webs. [consequences?] Clear pictures of the changes in such remote-most ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

**Comment [SB1]:** We can't use this phrase as it implies that seawater is acidic, which it is not.

**Comment [CS2]:** This is tricky since any short hand can be misread to imply waters are acidic. I actually prefer Shallin's wording but it is your call.

**Comment [SB3]:** Did the UK people fact check this? I haven't seen data on this.

**Comment [CS4]:** I don't know, but I assume they fact checked this so I would leave it in.

**Comment [SB5]:** There has been no work to date on pteropod condition in the Arctic, only in the Antarctic.

**Comment [CS6]:** You can leave this as arctic because we are not specifically calling out pteropods. We know the waters are undersaturated so any carbonate organism will dissolve.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of Nemo when the coral clownfish is studied in an acidified environment. He can't smell his predators when they are nearxx and engages in risky behaviorxx, making him more vulnerable to predationers. We have yet to learn how salmon and other commercially important fish will adapt respond as acidification erodes changes their food supply. Ocean acidification has the potential to reorganize entire food webs, by changing the abundance and types of predators and prey, like phytoplankton and zooplankton. ~~A line or 2 about food-web... plankton dying, in simple text~~ Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the thousands of microscopic plants and animals that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

**Comment [SB7]:** Again, the water isn't actually acidic.

**Comment [CS8]:** Acidified is better

**Comment [SB9]:** We don't know if they will adapt.

**Comment [CS10]:** This is your call. They will have to either adapt or go extinct. I feel that adapt is fairly safe here.

**Comment [SB11]:** This is a strong statement that I'm not really comfortable with.

**Comment [CS12]:** It is a strong statement, but I feel it is okay. We know for a fact that it will affect the ocean's ability to store future carbon emissions so you are good on the last half. I also think it is fairly safe to say it will affect seafood supplies but you already have some weasel words built in so I would not change anything.

To understand where the acute challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. A recent study by the U.S. National Oceanic and Atmospheric Administration showed that the rate of carbon emissions is rising as fast as ever, accelerating the ocean acidification process.

Both of our nations recognize that rising CO2 and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations lead the pioneering Global Ocean Acidification Observing Network, a collaboration already involving 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from gliders, hydrographic surveys, volunteer observing ships and many more assets.

The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt X-Prize for ocean health by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the West Coast of the United States are using monitoring technology to adapt ~~their industry to new ocean conditions. o [reword -- something about avoiding more near-collapse? current periodic ocean acidification events.]~~ And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that exacerbates acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of rising ocean acidification at our own peril, and that of future generations.

Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser of Britain's Department of Environment, Food and Rural Affairs

will be tightened by about 150 words prior to submission

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 2:11 PM

Subject: Re: a solution??

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Hi Madelyn,

You can either leave the original statement or go with the statement you propose below. either one works.

Chris

PS my previous explanation was not intended for the article, but explaining my thought process so Mark could see why I said what I did if you wanted to pass it along to him. I am fine with your statement below if that makes Mark more comfortable.

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 2:02 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

And while ocean acidification is a global concern, inroads in Maine and elsewhere are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

do we need the rest? ... by enhancing the uptake of carbon dioxide from the atmosphere.

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 3:09 PM

Subject: Re: clam buckets

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

I agree that it is not as strong because anything could have caused the disappearance. I am not familiar with any of those specific stories so I leave that to you to decide.

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 3:03 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:  
have been trying really hard to connect with head of Maine Clammers but can't get through on any line

unless I hear back, will plug this line in instead – it's stronger but, I think, less appealing but Mark vouches for it – that bucket line is 10 years old and references just one person

In Maine, entire populations of soft-shell clams and blue mussels have almost entirely disappeared from coastal waters.

cheers  
m

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 1, 2015 at 6:37 PM

Subject: Re: Help!

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

My pleasure. I am getting way too many thank yous from you. ;-)

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 6:34 PM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:  
thank you!

Sent from my iPhone

On Oct 1, 2015, at 9:33 PM, Chris Sabine - NOAA Federal <chris.sabine@noaa.gov> wrote:

Hi Madelyn,

It is way too late for you to be still working on this.

I don't think it is a big deal, but I suppose to be consistent we should say "Increasing acidification is..."

Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
web: [www.pmel.noaa.gov](http://www.pmel.noaa.gov)

On Thu, Oct 1, 2015 at 6:19 PM, Madelyn Appelbaum - NOAA Federal  
<madelyn.appelbaum@noaa.gov> wrote:

Chris, this just hit...

Is "increasing acidity" at opening of 3rd par incorrect?

if anyone flagged it, I missed it

thanks

Sent from my iPhone

----- Forwarded message -----

From: **Mark Eakin** <mark.eakin@noaa.gov>  
Date: Wed, Oct 14, 2015 at 10:22 AM  
Subject: Re: your oped in NYT >> request  
To: Madelyn Appelbaum <madelyn.appelbaum@noaa.gov>  
Cc: Chris Sabine <chris.sabine@noaa.gov>

The best I can think of are:

- 1) photomicrographs showing the lack of carbonate infilling inside of corals in an area of low CO<sub>2</sub> and high CO<sub>2</sub> (attached but not very exciting)
- 2) photos of communities of corals inside areas influenced by a CO<sub>2</sub> vent and outside of the vent area (you can get from Ian Enochs at AOML).

Sorry, Madelyn, OA is a slow impact on corals that typically isn't highly photogenic, unlike bleaching.

Cheers,  
Mark

---

C. Mark Eakin, Ph.D.  
Coordinator, NOAA Coral Reef Watch  
National Oceanic and Atmospheric Administration  
Center for Satellite Applications and Research  
Satellite Oceanography & Climate Division  
e-mail: mark.eakin@noaa.gov  
url: coralreefwatch.noaa.gov

NOAA Center for Weather and Climate Prediction (NCWCP)  
5830 University Research Ct., E/RA32  
College Park, MD 20740  
Office: (301) 683-3320 Fax: (301) 683-3301  
Mobile: (301) 502-8608 SOCD Office: (301) 683-3300

"Maybe the biggest subsidy of them all is being able to belch and burn in the trash dump of the sky without paying any tipping fee."

Bob Inglis, Six Term Congressman (R-SC)  
October 3, 2014

On Oct 14, 2015, at 10:35 AM, Madelyn Appelbaum - NOAA Federal  
<madelyn.appelbaum@noaa.gov> wrote:

Hi and any chance for a before/after corals image reflecting injury from ocean acidification?  
This is for NY Times and needed quickly.  
Thank you.  
Madelyn

----- Forwarded message -----  
From: **Loftus, Louise** <lloftus@nytimes.com>  
Date: Wed, Oct 14, 2015 at 10:27 AM  
Subject: your oped in NYT >> request  
To: madelyn.appelbaum@noaa.gov  
Cc: Joe GREGORY <jgregory@nytimes.com>

Hello,

I'm one of the web editors for the opinion section. I was talking to Joe today about the possibility of including before/after images of coral or areas of the sea bed that show the impact that acidification has had.

Does your organization have images that illustrate this that we could use on nytimes.com (your piece will have an illustration in print, this is for online only).

If so, please do send along with information on how these should be captioned and credited.

For it to be possible I'd need to receive the images sometime today. Sorry for the short notice and if it's not possible then not to worry, if it is possible -- great!

Thanks,

Louise

Louise Loftus  
Staff Editor, International Opinion  
The New York Times

18 Museum Street, London WC1A 1JN, United Kingdom

----- Forwarded message -----  
From: **GREGORY, Joe** <jgregory@nytimes.com>  
Date: Wed, Oct 14, 2015 at 2:47 PM  
Subject: spinrad draft  
To: Louise Loftus <lloftus@nytimes.com>

madelyn.appelbaum@noaa.gov Madelyn Appelbaum  
202 482 4858  
202 340 6310 cell

Contact: Madelyn Appelbaum/NOAA

+1 202 482 4858 office  
+1 202 340 6310 cell

## In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

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202 340 6310 cell

Contact: Madelyn Appelbaum/NOAA  
+1 202 482 4858 office  
+1 202 340 6310 cell

## In a High CO2 World, Dangerous Waters Ahead

Richard W. Spinrad  
Ian Boyd

Ocean and coastal waters around the world are beginning to tell a disturbing story. The seas, like a sponge, are absorbing increasing amounts of carbon dioxide from the atmosphere, so much so that the chemical balance of our oceans and coastal waters IS CHANGING AND A GROWING THREAT TO MARINE ECOSYSTEMS. Over the past 200 years, the world's seas have absorbed more than 150 billion metric tons of carbon from human activities. Currently, that's a worldwide average of 15 pounds per person a week, enough to fill a coal train long enough to encircle the equator 13 times every year.

We can't see this massive amount of carbon dioxide that's going into the ocean, but it dissolves in seawater as carbonic acid, changing the water's chemistry at a rate faster than seen for millions of years. Known as ocean acidification, this process makes it difficult for shellfish, corals and other marine organisms to grow, reproduce and build their shells and skeletons.

About 10 years ago, ocean acidification nearly collapsed the annual \$117 million West Coast shellfish industry, which supports more than 3,000 jobs. Ocean currents pushed acidified water into coastal areas, making it difficult for baby oysters to use their limited energy to build protective shells. In effect, the crop was nearly destroyed.

Human health, too, is a major concern. In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken, even kill, fish and marine mammals such as sea lions.

Increasing acidity is hitting our waters along with other stressors. The ocean is warming; in many places the oxygen critical to marine life is decreasing; pollution from plastics and other materials is pervasive; and in general we over-exploit the resources of the ocean. Each stressor is a problem, but all of them affecting the oceans at one time is cause for great concern. For both the developing and developed world, the implications for food security, economies at all levels, and vital goods and service are immense.

This year, the first nationwide study showing the vulnerability of the \$1 billion U.S. shellfish industry to ocean acidification revealed a considerable list of at-risk areas. In addition to the Pacific Northwest, these areas include Long Island Sound, Narragansett Bay, Chesapeake Bay, Gulf of Mexico, and areas off Maine and Massachusetts. Already at risk are Alaska's fisheries, which account for nearly 60 percent of the United States commercial fish catch and support more than 100,000 jobs.

Ocean acidification is weakening coral structures in the Caribbean and in cold-water coral reefs found in the deep waters off Scotland and Norway. In the past three decades, the number of living corals covering the Great Barrier Reef has been cut in half, reducing critical habitat for fish and the resilience of the entire reef system. Dramatic change is also apparent in the Arctic, where the frigid waters can hold so much carbon dioxide that nearby shelled creatures can dissolve in the corrosive conditions, affecting food sources for indigenous people, fish, birds, and marine mammals. Clear pictures of the magnitude of changes in such remote ocean regions are sparse. To better understand these and other hotspots, more regions must be studied.

We cannot yet predict exactly how ocean acidification will affect connections among the world's many different marine organisms, but we do know the consequences will be profound. Research already points to the unnatural behavior of coral clownfish in an acidified environment. These fish wander farther from away from their natural protection, making them more vulnerable to predators. We have yet to learn how salmon and other commercially important fish will adapt as acidification erodes their food supply, especially since some of the most vulnerable species are the small, simple life forms that juvenile salmon and other fish depend on. There may be cascading impacts that we don't yet fully understand. Ocean acidification won't make seawater dangerous for swimming, but it will upset the balance among the multitudes of microscopic life that can be found in every drop of seawater. Such changes will almost certainly affect future supplies of seafood, and the ocean's future ability to take up and store pollutants, including future emissions of carbon.

To understand where the challenges lie, we need better ocean measuring capability, linked with improved modeling of marine ecological systems. Smart investments in monitoring and observing are critical to building resilience and hedging risks that can directly affect economies at all levels. There is urgency to such investments. The U.S. National Oceanic and Atmospheric Administration conducts round-the-clock monitoring of global CO<sub>2</sub>. The rate of increase has never been higher than during the past three years, accelerating the ocean acidification process.

Both of our nations recognize that rising CO<sub>2</sub> and the production of other greenhouse gases have widespread consequences and have called for strong action to reduce carbon emissions. We are pleased that representatives of our two nations help lead the pioneering Global Ocean Acidification Observing Network, a collaboration of scientists from 30 nations. This network is based on the premise that we can't manage what we don't measure. It's designed to provide the basis for robust forecasting by integrating existing observations from unmanned vehicles, research vessels, volunteer observing ships and many more assets.

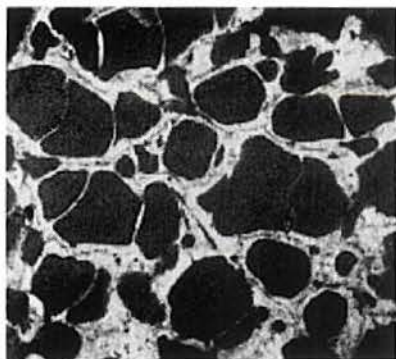
The new network will build on the success of the American and British teams that recently came in first and second in the Wendy Schmidt Ocean Health XPRIZE by developing affordable, accurate sensor technology. Such technology will help coastal countries around the world obtain the environmental information required to underpin sound policy and build community and global resilience. Already oyster hatcheries on the U.S. West Coast are working with scientists to monitor water quality and adapt to ocean acidification so baby oysters can survive. And while ocean acidification is a global concern, inroads are occurring at the local scale, encouraging control, for example, of nutrient pollution that can exacerbate acidification.

When it comes to the health of the sea, we are all stakeholders. The ocean is a harbinger of our own well-being and the resilience and economic viability of our planet. We ignore the risks of ocean acidification at our own peril, and that of future generations.

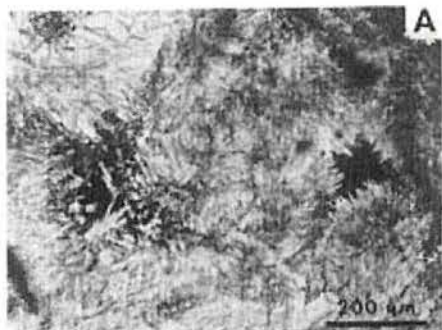
Richard W. Spinrad is the chief scientist of the U.S. National Oceanic and Atmospheric Administration. Ian Boyd is the chief scientific adviser to the UK GOVERNMENT'S Department of Environment, Food and Rural Affairs

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4 attachments



**Panama.png**  
1026K



**Florida.png**  
982K

 **PastedGraphic-2.pdf**  
477K

 **PastedGraphic-3.pdf**  
477K

----- Forwarded message -----

From: **Chris Sabine - NOAA Federal** <chris.sabine@noaa.gov>

Date: Thu, Oct 15, 2015 at 7:54 AM

Subject: Re: OA op-ed...thank you!

To: Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov>

Cc: Libby Jewett - NOAA Federal <libby.jewett@noaa.gov>, Ciaran Clayton - NOAA Federal <ciaran.clayton@noaa.gov>, Pieter Tans - NOAA Federal <pieter.tans@noaa.gov>, Jan Newton <newton@apl.uw.edu>, Shallin Busch - NOAA Federal <shallin.busch@noaa.gov>, Jennifer Mintz - NOAA Federal <jennifer.bennett@noaa.gov>, Richard Feely - NOAA Federal <Richard.A.Feely@noaa.gov>, Brady Phillips - NOAA Federal <brady.phillips@noaa.gov>, Rick Spinrad - NOAA Federal <Rick.Spinrad@noaa.gov>

Hi Madelyn,

The title is quite inflammatory and the graphic the Times created doesn't help, but I know that was not under your control. I think you did a fantastic job with the text and I know all the late hours and frustrating exchanges you had to go through to get this done. Congratulations on getting this published.

Cheers,  
Chris

Christopher L. Sabine, PhD.  
Director, Pacific Marine Environmental Laboratory  
7600 Sand Point Way NE  
Seattle, WA 98115  
ph: (206) 526-6800  
fax: (206) 526-4576  
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On Thu, Oct 15, 2015 at 7:28 AM, Madelyn Appelbaum - NOAA Federal <madelyn.appelbaum@noaa.gov> wrote:

[http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?\\_r=0](http://www.nytimes.com/2015/10/16/opinion/our-deadened-carbon-soaked-seas.html?_r=0)

Thanks everyone. Rick's op-ed with his UK colleague finally landed today (sorry about the title).

Tomorrow it appears in print in the International NY Times.

Chris and each of you were extremely helpful and patient through mega rounds of questions and edits, and I am very grateful. So lucky to be working with you!

Best wishes,  
Madelyn