MEOPAR
EXPERT FORUM

OCEAN ACIDIFICATION

FEBRUARY 18 - 19, 2015
VICTORIA CONFERENCE CENTRE

MEOPAR

MARINE ENVIRONMENTAL OBSERVATION
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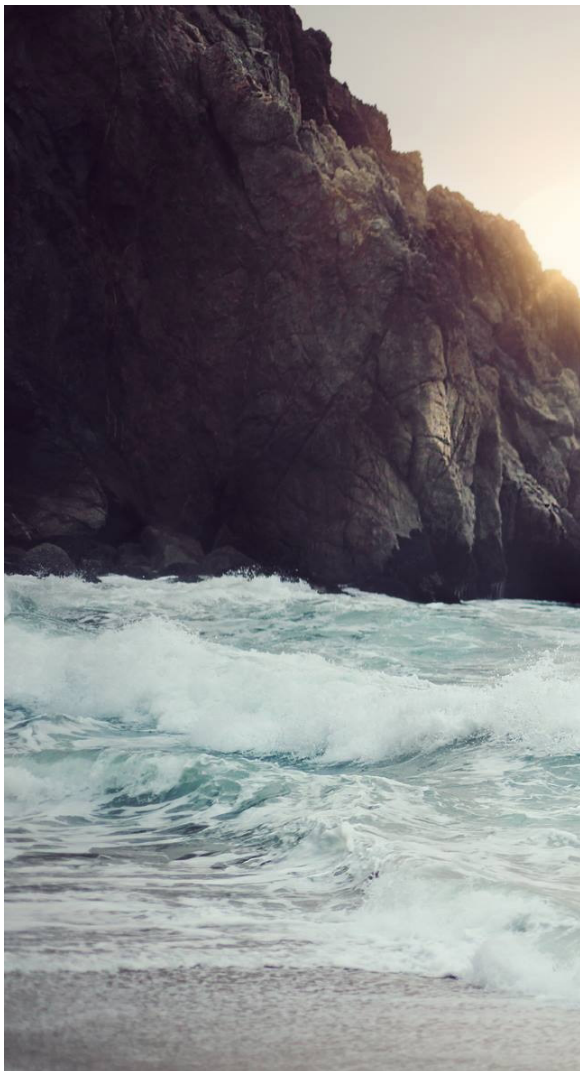

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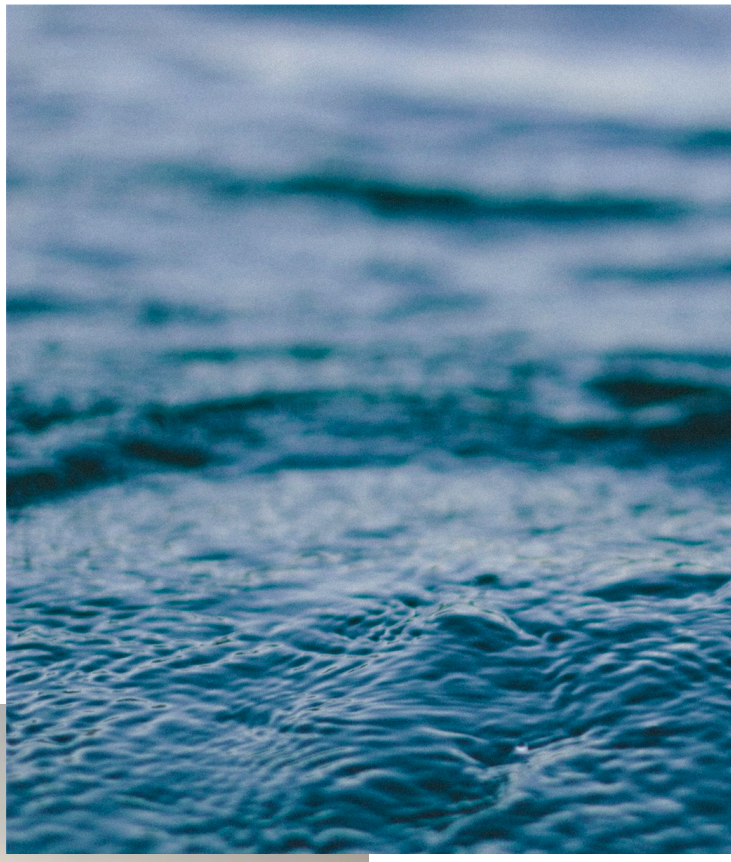
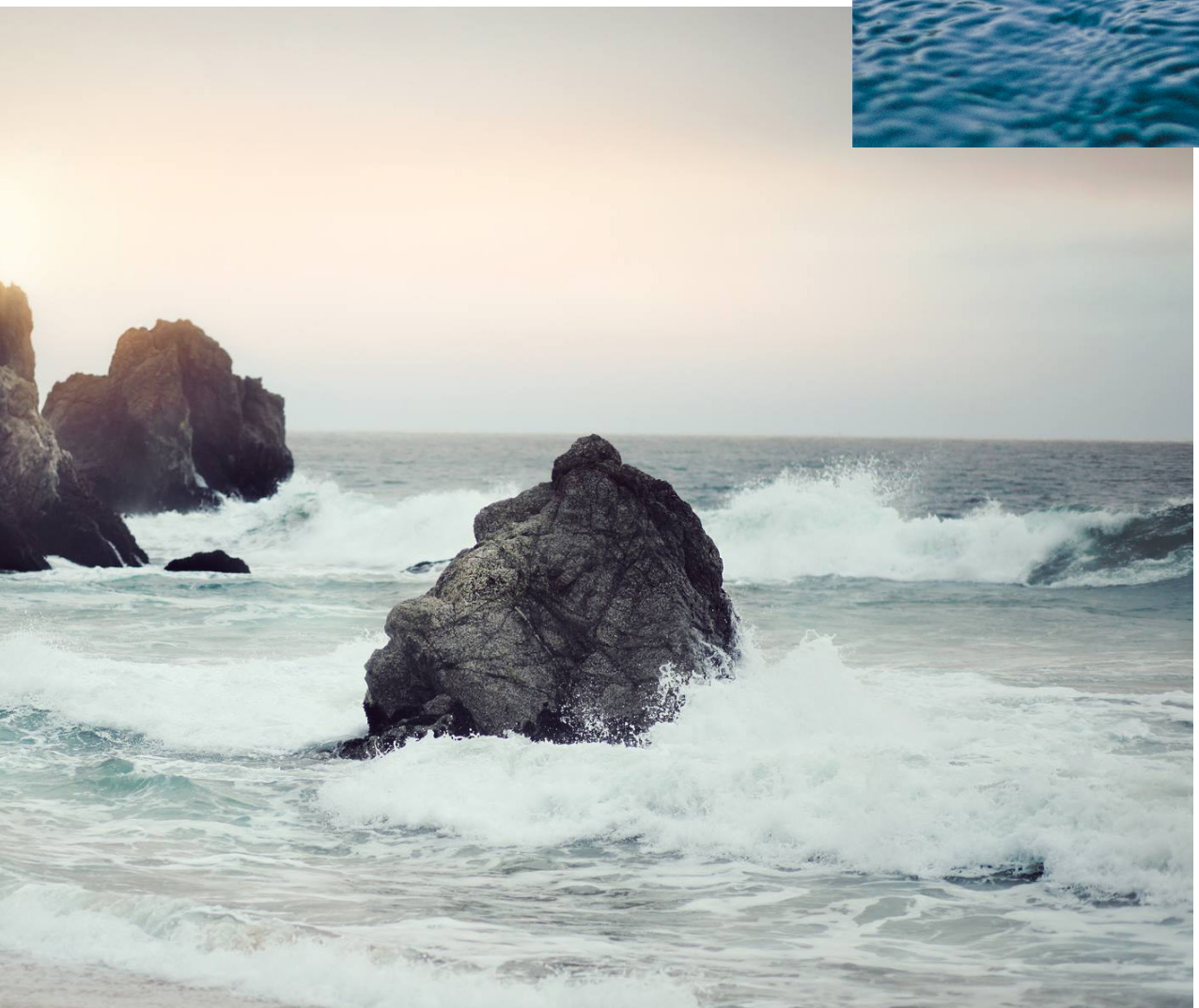




GREETINGS FROM THE BOARD

On behalf of the Board of Directors of the Marine Environmental Observation Prediction and Response Network (MEOPAR), I welcome you to the Ocean Acidification Expert Forum.

The Expert Forum format has been designed by MEOPAR as a means to bring Canadian and international experts together for the illumination, evaluation and communication of emerging and new risks in the marine environment to a wide audience. We are pleased to host our first Expert Forum on the important subject of ocean acidification.

Ocean acidification is a complex issue that affects industries and environments worldwide. This Expert Forum is an important tool to begin creating a Canadian network to help coordinate Canadian effort to address the impacts of ocean acidification. The program that has been developed for you this week provides the opportunity to review research and practices currently taking place elsewhere in the world and to then apply those practices in the form of a white paper.

I would like to thank all of the guest speakers, attendees and the University of Victoria for your support. MEOPAR looks forward to working with you at this Expert Forum and in the future.

Robert Walker
Chair, MEOPAR Board of Directors

CONTEXT

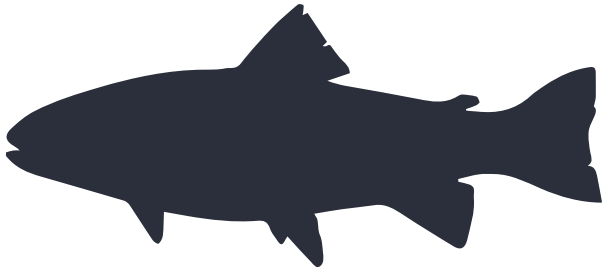
Several research projects already focus on ocean acidification in Canada, ranging from chemistry to biology, modelling, socio-economic impacts and policy. However, there is **no national coordinated effort for ocean acidification research**. This expert forum will initiate a coordinated research approach for Canada that will address the future issues of ocean acidification in our waters.

The objectives of this expert forum are to:

1. Review **international ocean acidification research and policy**, and its relevance to Canada's situation.
2. **Identify and prioritize ocean acidification research needs**, in terms of experimental research, monitoring and policy.
3. Establish **the way forward for a Canadian effort** to address and respond to the impacts of ocean acidification.
4. **Produce a white paper** to guide research efforts across multiple sectors, within Canada and internationally.

Ocean acidification is a decrease in the ocean's pH level. The oceans are a "carbon sink" where carbon dioxide (CO_2) dissolves and reacts in the surface water to form carbonic acid. **Increased global CO_2 emissions** have led to higher levels of carbonic acid, thereby decreasing the overall pH of the oceans. In the past 200 years, the surface ocean pH has decreased by 0.1 pH units. If current emissions persist, by 2100 the surface ocean pH is predicted to drop by ***triple the rate of the last 200 years***. To a chemist, this pH change may seem small. To a marine organism, which may have adapted to extremely stable ocean pH conditions of the past, the change is large and unprecedented for the last 20 million years.

Ocean acidification is a global issue, however polar oceans are more vulnerable due to the high solubility of CO_2, reduced chemical buffering, and the dissolution potential of calcium carbonate in cold waters. Calcium carbonate is the key building block that comprises the hard shells of lobsters, scallops, mussels, crab and many other shellfish species. Increased levels of carbonic acid in the ocean are corrosive to calcium carbonate shells and present a **real threat to the Canadian shellfish industry**. In addition, ocean acidification also threatens other organisms in the shellfish's ecosystem.



WEDNESDAY, FEBRUARY 18TH

7:30 a.m.	Registration and breakfast
8:30 a.m.	Welcome and purpose - Dr. Doug Wallace, MEOPAR
8:45 a.m.	Ocean Acidification Steering Committee - Dr. Kenneth Denman, University of Victoria

Ocean Acidification Global Issues

9:00 a.m.	Dr. Kenneth Denman, University of Victoria
9:20 a.m.	Dr. Jan Newton, University of Washington, USA
9:40 a.m.	Audience contribution and panel discussion
10:15 a.m.	Coffee break

Ocean Acidification: Fisheries and Aquaculture Perspective

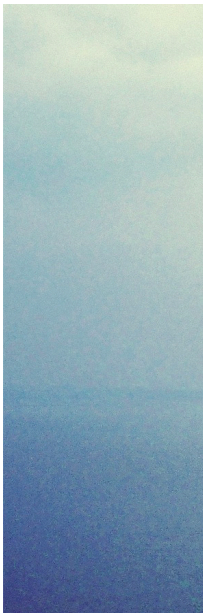
10:45 a.m.	Dr. Benoit Eudeline, Taylor Shellfish, USA
11:05 a.m.	Ms. Catherine J. Boyd, Clearwater Seafoods, NS
11:25 a.m.	Audience contribution and panel discussion
12:00 p.m.	Lunch

Ocean Acidification and the Arctic

1:00 p.m.	Dr. Nadja Steiner, DFO - Institute of Ocean Sciences, BC
1:20 p.m.	Dr. Helen Findlay, Plymouth Marine Laboratory, UK
1:40 p.m.	Audience contribution and panel discussion
2:15 p.m.	Coffee break

Experimental Research

2:45 p.m.	Dr. Jean-Pierre Gattuso, Centre National de la Recherche Scientifique, France
3:05 p.m.	Dr. Sonya Dyhrman, Columbia University, USA
3:25 p.m.	Audience contribution and panel discussion
4:00 p.m.	Poster introductions
5:00 p.m.	Wrap-up
6:30 p.m.	Bus leaves hotel reception for offsite reception/poster session
6:50 p.m.	Offsite reception/poster session
8:30 p.m.	Bus leaves for hotel



THURSDAY, FEBRUARY 19TH

7:30 a.m.	Breakfast
8:30 a.m.	Plenary recap

Ocean Acidification Monitoring

9:00 a.m.	Dr. Pierre Pepin, DFO, NL
9:20 a.m.	Dr. Simone Alin, Pacific Marine Environmental Laboratory, USA
9:40 a.m.	Audience contribution and panel discussion
10:15 a.m.	Coffee break

Ocean Acidification Policy

10:45 a.m.	Dr. Kathryn Mengerink, Environmental Law Institute, USA
11:05 a.m.	Dr. Sarah Cooley, Ocean Conservancy (remotely), USA
11:25 a.m.	Audience contribution and panel discussion
12:00 p.m.	Lunch

The Way Forward

1:00 p.m.	Breakouts
2:30 p.m.	Coffee break
3:00 p.m.	Plenary
3:30 p.m.	Writing breakouts
4:30 p.m.	Reports from breakouts
5:00 p.m.	Wrap-up

OCEAN ACIDIFICATION - GLOBAL ISSUES

Dr. Kenneth Denman

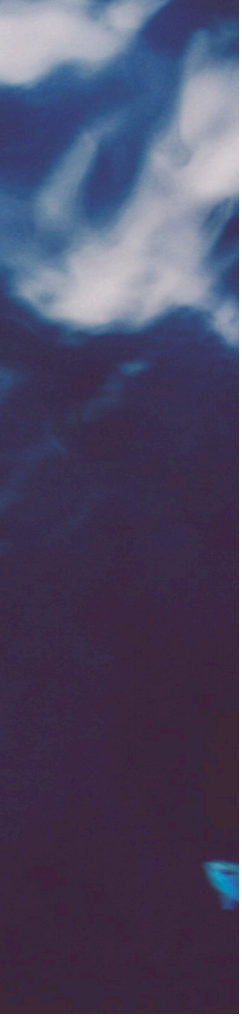
is Adjunct Professor in the School of Earth and Ocean Sciences at the University of Victoria. Most recently he was Chief Scientist with Ocean Networks Canada. Until 2010 he was Senior Scientist with Fisheries and Oceans Canada (DFO), seconded since 2000 to Environment Canada's Canadian Centre for Climate Modelling and Analysis (CCCma).

Dr. Denman's research interests include current and future impacts of climate change, including ocean acidification, on marine ecosystems and fish populations. He was a Coordinating Lead Author of the Second and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC). Dr. Denman has been awarded the President's Prize of the Canadian Meteorological and Oceanographic Society, the T.R. Parsons Medal for excellence in ocean science, the Wooster Award from the North Pacific Marine Sciences Organization (PICES), and in 2014 the Hutchinson Medal of the UK Institute of Chemical Engineers for a multi-authored paper on ocean iron fertilization and geoengineering. He received a PhD in ocean physics from the University of British Columbia, and is an elected Fellow of the Royal Society of Canada.

Dr. Jan Newton

is a Senior Principal Oceanographer with the Applied Physics Laboratory of the University of Washington (UW) and affiliate faculty with the UW School of Oceanography and the School of Marine and Environmental Affairs, both in the UW College of the Environment. She was appointed to the Washington Blue Ribbon Panel on Ocean Acidification by the Washington state governor and is the Co-Director of the Washington Ocean Acidification Center at the University of Washington.

She is the Executive Director of the Northwest Association of Networked Ocean Observing Systems (NANOOS), the US IOOS Regional Association of the Pacific Northwest. Jan is a biological oceanographer who has studied the physical, chemical, and biological dynamics of oceanic and local coastal waters, including the Salish Sea and coastal Washington, to understand effects from climate and humans on water properties. Lately, she has been working with colleagues at UW and NOAA to assess the status of ocean acidification in the waters of the Pacific North West region.



OCEAN ACIDIFICATION – FISHERIES AND AQUACULTURE PERSPECTIVE

Dr. Benoit Eudeline

is the Research and Technology Division Manager for Taylor Shellfish, Inc. He conducts scientific research at the Taylor Shellfish Hatchery, in Dabob Bay, to improve general larvae and seed performance in commercial aquaculture facilities.

His current research focuses on understanding water quality and chemistry changes in Dabob Bay and their impact on shellfish larvae survival. The goal, both through monitoring and bioassays is to assess and understand the relationships between ocean acidification, upwelling and their impact on carbonate chemistry (pH, Aragonite saturation, DIC) and larvae performance in the hatchery.

Thanks to this work and multiple collaborations with Oregon State University, University of Washington and NOAA's PMEL, the hatchery is now equipped with continuous carbonate chemistry monitoring equipment and treatment systems are being designed and implemented to improve water chemistry and larvae performance. Benoit received a Ph.D. in Biology from the University of Rennes (France) in 2004.

Ms. Catherine Boyd

is the Manager of Sustainability and Public Affairs at Clearwater Seafoods. One of North America's largest vertically-integrated seafood companies, Clearwater Seafoods is recognized globally for its wild-caught and premium-quality scallops, lobster, clams, coldwater shrimp and crab. One of Clearwater's 6 key business strategies is to preserve the long term sustainability of resources on land and at sea.

For the last 7 years Catherine has been advancing this strategic objective through her focus on fisheries research and management, sustainability, regulatory compliance, and multi-stakeholder engagement. Catherine sits as a Director to a number of seafood sector industry associations, including the Fisheries Council of Canada and the Lobster Council of Canada and works with scientists, fisheries managers and industry partners to promote sustainable fishing practices. Catherine holds a Masters of Environmental Studies from Dalhousie University.

OCEAN ACIDIFICATION AND THE ARCTIC

Dr. Nadja Steiner

is located at the Institute of Ocean Sciences (IOS), a Fisheries and Oceans Canada (DFO) marine research facility based in Sidney, British Columbia. She is also a research associate at the Canadian Centre for Climate Modelling and Analysis (CCCma) and an adjunct professor at the University of Victoria.

Dr. Steiner works on the development of coupled atmosphere-ocean ecosystem models to study the marine sulphur and carbon cycles in the North Pacific and Arctic. In collaboration with CCCma's Canadian Earth System Modelling group, she is developing parameterizations for Arctic marine ecosystems and evaluates marine ecosystem responses to climate change. She is a contributing author of AMAP's recent and upcoming Arctic Ocean Acidification assessments as well as the AMAP Adaptation Actions for a Changing Arctic (AACA) assessment. She is leading the Arctic trends and projections component of DFO's Aquatic Climate Change Adaptation Services Program and is co-chair of the SCOR-WG 140, Biogeochemical Exchange Processes at Sea-Ice Interfaces (BEPSII).

Dr. Helen Findlay

is a biological oceanographer who uses a combination of experimental, observational and modelling tools to investigate the impacts of climate change and ocean acidification on marine organisms and ecosystem functioning. She has an interest in understanding the biological, physical and chemical interactions within the marine environment, specifically relating to carbon biogeochemical cycling, with a particular focus in Arctic regions.

Helen was the first recipient of the PML Lord Kingsland Fellowship, allowing her to continue her research on ocean acidification in both temperate seas and in the Arctic. She is currently involved in the UK Shelf Seas Biogeochemistry Programme; participating on the cruises to investigate nutrient and carbon biogeochemical cycling in sediments. Helen was involved in the UK Ocean Acidification project, offering advice for setting-up and running long-term CO_2 experiments, and is lead PI on an Arctic project Ocean Acidification in Arctic Fjords. Helen facilitates PML's carbon chemistry research, with an aim to understand short-term variability relating to ocean acidification and climate change.

Helen is also involved in the outreach of marine science to schools and educators, working alongside Digital Explorer and the Royal Geographical Society (with IBG) to promote ocean learning in the classroom.

EXPERIMENTAL RESEARCH

Dr. Sonya Dyhrman

is a tenured Associate Professor of Earth and Environmental Sciences at Columbia University with the Lamont Doherty Earth Observatory.

Dyhrman graduated with high honors in biology from Dartmouth College and received her Ph.D. in marine biology from the Scripps Institution of Oceanography. She did her postdoctoral training at the Woods Hole Oceanographic Institution (WHOI), where she was a tenured member of the scientific staff until 2014. At WHOI she was awarded an Ocean Life Institute Fellowship to support the development of new molecular tools to track the physiology of ocean microbes.

In 2007, she was a Marie Tharp Fellow of the Columbia University Earth Institute working on ocean acidification and more recently was a Sir Allan Sewall Fellow of Australia's Griffith University working on toxin producing cyanobacteria. Last year she was named a SCOPE Investigator by the Simons Foundation, focusing on how key microbes shape open ocean ecosystems.

Dyhrman has also served on the scientific steering committee for the U.S. Ocean Carbon Biogeochemistry Program. Her research leverages molecular tools to study the physiological ecology of cyanobacteria and eukaryotic microalgae and their role in shaping marine ecosystem structure, function, and biogeochemistry.

In addition to her research efforts, Dyhrman has developed ocean science literacy activities for classrooms and the virtual world Whyville, giving more than one million children exposure to ocean literacy standards and the process of scientific discovery.

Dr. Jean-Pierre Gattuso

is a Research Professor at the Centre National de la Recherche Scientifique (CNRS; National Center for Scientific Research, France) and is based at the Laboratoire d'Océanographie de Villefranche, a marine station operated by the Université Pierre-et-Marie Curie (Paris 6) in Southern France.

His research interests are related to: (1) the carbon and carbonate cycles in coastal ecosystems; and (2) the response of marine organisms and ecosystems to global environmental changes. Dr. Gattuso is founding Editor-in-Chief of ''Biogeosciences" and the founding President of the Biogeosciences division of the European Geosciences Union. He is a member of the European Academy of Sciences.

OCEAN ACIDIFICATION MONITORING

Dr. Pierre Pepin

has worked as a Quantitative Ecologist and Oceanographer with Fisheries and Oceans Canada since 1986. His early research focussed on factors that affect growth, mortality, and dispersal of early life stages of fish. However, since the mid-1990s, his research has expanded to address issues dealing with the study of physical, chemical and biological interactions using long-term ocean monitoring observations, as well as investigating the consequences of changes in the spatial organization of ecosystem structure on species interactions and fishery production potential.

He was the national co-chair of the Impact, Vulnerability and Opportunities working team on Aquatic Climate Change Adaptation Services Program. Pierre is one of the lead designers of the Atlantic Zone Monitoring Program, a coordinated oceanographic observing network across DFO's Atlantic research stations, and its current Chair.

Dr. Simone Alin

is an Oceanographer and marine chemist at NOAA's Pacific Marine Environmental Laboratory in Seattle. Her research focuses on coastal carbon cycle processes and ocean acidification, with emphasis on West Coast and Puget Sound ecosystems.

Simone received her B.S. from Stanford University in 1993 in Biological Sciences and a Ph.D. from University of Arizona in 2001 in Geosciences. She held a fellowship from the NOAA Climate and Global Change Postdoctoral Fellowship program to study large lake carbon cycling at the University of Minnesota Duluth's Large Lakes Observatory from 2001–2003. Following this, she studied the carbon cycles of large tropical river systems (Amazon, Mekong) at the University of Washington before commencing her current position at NOAA in 2007. At NOAA, Simone leads the coastal carbon research program of the Marine Carbon Program and is actively involved in national and international efforts to synthesize marine carbon cycle data.

Photo from Fisheries and Oceans Canada

OCEAN ACIDIFICATION POLICY

Dr. Kathryn Mengerink

is the Senior Attorney and Director of the Ocean Program at the Environmental Law Institute (ELI) in Washington, DC. She brings her marine biology and legal expertise to bear on Ocean Program projects. She has led ELI's Ocean Program since founding it in 2006. Under her leadership, the Program has launched law and policy projects related to regional ocean management, fisheries management and enforcement, aquaculture, ocean and coastal restoration, offshore energy development, marine protection, and more.

Her work focuses on supporting healthy oceans by working with communities, scientists, policy-makers, and other stakeholders to improve laws and policies, and their implementation. She regularly convenes and facilitates working groups, panels, and meetings. She has led a number of projects, including evaluating the legal ramifications of, opportunities for, and obstacles to coastal and marine spatial planning; supporting implementation of ocean and coastal ecosystem-based management through rigorous analysis of relevant laws and policies; conducting 23-state assessment of state and local authority for marine protection, supporting the role of subsistence communities in ocean management in the U.S. Arctic; and examining the legal framework for deep ocean stewardship, among others.

Based in San Diego at Scripps Institiution of Oceanograpy (SIO), Dr. Mengerink regularly interacts and engages with the ocean science community. In addition to her role at ELI, she is a Lecturer and Academic Coordinator at SIO, where she teaches ocean law and policy, deep sea policy, and runs a 9-week graduate summer course on marine biodiversity, conservation and global change.

Dr. Mengerink holds a B.S. in Zoology (Texas A&M University), Ph.D. in Marine Biology from SIO (UC San Diego) and a J.D. with a certificate of specialization in environmental law from Boalt Hall, School of Law (UC Berkeley).

Dr. Sarah Cooley

is the Science Outreach Manager in the Ocean Acidification Program at Ocean Conservancy, Washington DC, USA. She conducts scientific research to support the development of sound ocean acidification policy, and she provides input on policies relevant to ocean acidification.
Sarah's research focuses on how global ocean change, primarily ocean acidification, affects marine resource availability, and how that in turn impacts human communities. Previously, Sarah was a research scientist at Woods Hole Oceanographic Institution, where she also completed her postdoctoral studies. She received a Ph.D. from University of Georgia's School of Marine Sciences in 2006, and a B.S. from Haverford College in 1999.

*Dr. Cooley will be presenting remotely

Photo from Fisheries and Oceans Canada

OCEAN ACIDIFICATION GLOSSARY

Calcification – the process by which some calcifying marine organisms (such as shellfish, corals and some plankton) produce solid, usually crystalline, calcium carbonate. Carbonate shells and plates are vulnerable to dissolution when surrounding seawater contains less than a saturating concentration of carbonate ions.

Carbon cycle - the movement of carbon, in various chemical forms, between oceans, land, and air. Human activities, such as the burning of fossil fuels, have caused a major new input of CO_2 into the atmosphere, and the carbon cycle has re-distrubuted much of this "extra" carbon into the oceans and the land biosphere.

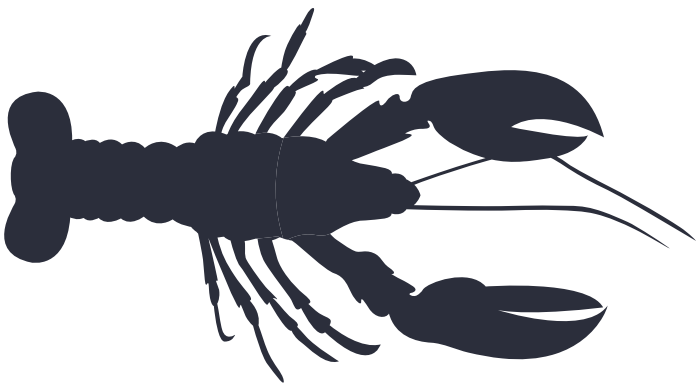
Climate change – a long-term change in weather patterns. It can be natural or human-induced.

Hypoxic zones – sometimes referred to as "dead zones", hypoxic zones are regions of the ocean where levels of dissolved oxygen have dropped below a threshold level, so that metabolism of some organisms is affected. Anoxic zones are regions where all dissolved oxygen has been removed so that, usually, only certain microbial life forms can survive. Hypoxic zones occur naturally, however their extent has grown due to increased nutrient supply arising from human activities.

Ocean acidification – the decrease of ocean pH caused by increased uptake of CO_2 from the atmosphere over the past 200 years. Of the "extra" CO_2 released by the burning of fossil fuels and changes in land vegetation, 40-50% is dissolved in the oceans. The resulting formation of carbonic acid has lowered seawater pH (and increased acidity) on a global scale.

pH buffering – seawater is resistant to changes of pH as a result of "chemical buffering". When acid (H^+) is added to seawater, many of the H^+ ions react with dissolved substances, such as the carbonate ion, so that the overall decrease of pH is limited. However, as more and more acid (e.g. from CO_2) is added, the concentration of seawater carbonate ions is reduced and the ability to "buffer" further pH change is also reduced. Today, the oceans have much lower pH buffering capacity than they did 200 years ago. This means that swings of pH due to natural processes are larger than they were 200 years ago, and the rate of pH change is increasing.

pH level – a measure of the hydrogen ion (H^+) concentration, and therefore of the acidity of a solution. The pH is the negative logarithm of the H^+ concentration, so that a pH of 7 represents a 10X higher concentration of H^+ than a pH of 8. Seawater typically has a pH of around 8, which is mildly alkaline. Addition of CO_2 increases the H^+ concentration, which increases acidity and lowers the pH.



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