THE SASAKAWA PEACE FOUNDATION

THE OCEAN POLICY RESEARCH INSTITUTE

INTERNATIONAL CONFERENCE

"IMPACTS OF GLOBAL WARMING AND OCEAN ACIDIFICATION ON MARINE ECOSYSTEMS AND NECESSARY POLICY MEASURES"

Toward the establishment of a network in the west Pacific region

Thursday 19th – Friday 20th January, 2017

The Ocean Policy Research Institute,
Sasakawa Peace Foundation

INTERNATIONAL CONFERENCE

"IMPACTS OF GLOBAL WARMING AND OCEAN ACIDIFICATION ON MARINE ECOSYSTEMS AND NECESSARY POLICY MEASURES"

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Date: Thursday 19th – Friday 20th January, 2017
Venue: The Sasakawa Peace Foundation Building, Tokyo, Japan

Background:

The greenhouse gases emitted by our society not only cause global warming, but also increase the levels of carbon dioxide in our oceans, leading to their acidification. Global warming as well as ocean acidification are issues of increasing global importance, and have been mentioned in the United Nations Conference on Sustainable Development (Rio+20) outcome document in 2012 as well as the Sustainable Development Goals adopted in September 2015. However, despite the increased global focus on the issue, the response to ocean acidification in Japan's surrounding waters as well as the west Pacific region has been lacking.

In order to increase awareness on the issue, OPRI-SPF is hosting the international conference "Impacts of Global Warming and Ocean Acidification on Marine Ecosystems and Necessary Policy Measures – Toward the establishment of a network in the west Pacific region –." The conference aims to increase understanding of the current situation in the west Pacific region, identify issues, and formulate relevant policies, in the hopes of creating a network of ocean acidification experts in the region.

Thursday 19th January (10:00 – 17:00)	
10:00 – 10:30	Opening Ceremony Opening Remarks **Hiroshi Terashima** President, Ocean Policy Research Institute, Sasakawa Peace Foundation (OPRI-SPF) Introductory Speech **Yoshihisa Shirayama** Executive Director, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
10:30 – 12:30	Keynote Speech "Research and Policy Trends on Ocean Acidification around the World" **David Osborn** Director, Environment Laboratories, Department of Nuclear Sciences and Applications, International Atomic Energy Agency
	Keynote Speech "Ocean Acidification: An Increasingly Important Issue on Global and Local Scales for Governments and Society" **Carol Turley** Senior Scientist, Plymouth Marine Laboratory
	Keynote Speech "Towards Building an Ocean Acidification Network" **Jan Newton** Senior Principal Oceanographer, Affiliate Assistant Professor, Oceanography, University of Washington
12:30– 13:30	Lunch Break

Session 1 : Current Trends and Issues on the North-West Pacific Oceans including the Bering Sea	
13:30 – 15:30	Session 1-1 “The Status of Ocean Acidification in the Subtropical Pacific Region” **Chen-Tung Arthur Chen** Professor, Department of Oceanography, National Sun Yat-sen University
	Session 1-2 “Progress of Ocean Acidification in the western North Pacific” **Masao Ishii** Head of 3rd Laboratory, Oceanography and Geochemistry Research Department, Meteorological Research Institute, Japan Meteorological Agency
	Session 1-3 “Ocean Acidification Studies in the Seas around Japan” **Tsuneo Ono** Chief Scientist, Japan Fisheries Research and Education Agency (FRA)
	Session 1-4 “Ocean Acidification and its Effects on Pacific Island States” **Tommy S. Moore** Pacific Islands Global Ocean Observing System Officer, Secretariat of the Pacific Regional Environment Programme (SPREP)
15:30 – 15:45	Coffee Break
Session 1 (cont.)	
15:45 – 16:55	Session 1-5 Discussion : “Issues in the West Pacific Region” Moderator Speech **Yukihiro Nojiri** Professor, Department of Earth and Environmental Sciences, Hirosaki University Panel Discussion
16:55 – 17:00	Wrap-up for the Day
17:30 –	Reception
Friday 20th January (9:30 – 17:00)	
Session 2 : Response and Policy	
9:30 – 11:00	Session 2-1 “Social Regional Impacts of Ocean Acidification in Japan” **Masahiko Fujii** Associate Professor, Faculty of Environmental Earth Science, Graduate School of Environmental Science, Hokkaido University
	Session 2-2 “Mitigation Options - CCS and the Marine Environment” **Jun Kita** Supervisory Researcher, Marine Ecology Research Institute
	Session 2-3 “Ocean Acidification: Another Reason to Act” **Tetsuji Ida** Senior Staff Reporter, Kyodo News
11:00 – 11:15	Coffee Break

Session 2 (cont.)	
11:15 – 12:15	Session 2-4 Discussion : “Measures for Converting Response into Policy” Moderator Speech: **Joji Morishita** Professor, Tokyo University of Marine Science and Technology Panel Discussion
12:15 – 13:15	Lunch Break
Session 3 : Towards Establishing a Network	
13:15 – 15:15	Session 3-1 “Synthesis of Information on North Pacific Ocean Acidification Studies by the North Pacific Marine Science Organization (PICES) ” **Tsuneo Ono** Chief Scientist, Japan Fisheries Research and Education Agency (FRA)
	Session 3-2 “Coastal Temperature & OA Monitoring Strategy for the USP Region – Present Status and Future Plans” **Antoine de Ramon N’Yeurt** Marine Biologist and Algal Taxonomist Lecturer, University of the South Pacific (USP)
	Session 3-3 “Studies on the Effects of Warming and Ocean Acidification to Coral Reef Organisms at the Tropical Biosphere Research Center, University of the Ryukyus” **Kazuhiko Sakai** Professor, Ryukyu University
	Session 3-4 “Future Earth / SIMSEA and MARINE Crisis Watch & Action” **Toshio Yamagata** Director, Application Laboratory, JAMSTEC
15:15 – 15:30	Coffee Break
Session 3 (cont.)	
15:30 – 16:55	Session 3-5 Discussion : “Towards Networking in the West Pacific Region” Moderator: **Yoshihisa Shirayama** ● Data Integration ● Monitoring Strategies ● Technological Support ● MARINE Crisis Watch (Information Sharing Platform) ● Raising Public Awareness Wrap-up of the conference
16:55 – 17:00	Closing Ceremony

【Contact】
The Ocean Policy Research Institute, Sasakawa Peace Foundation
Mr. Tomohiko Tsunoda, Ms. Nobuko Nakamura
Tel. 03-5157-5237

Keynote Speech

“Research and Policy Trends on Ocean Acidification around the World”

David Osborn
Director,
Environment Laboratories,
Department of Nuclear Sciences and Applications,
International Atomic Energy Agency

・1991-1995	Seaman Officer, Royal Australian Navy
・1996-2001	Senior Policy Officer, Australian Government’s Department of Environment and Heritage
・2001-2005	Programme Officer, United Nations Environment Programme
・2005-2007	Director, Coastal Policy and Water Quality, Australian Government’s Department of Environment and Heritage
・2007-2008	Director, Community Partnerships, Great Barrier Reef Marine Park Authority
・2008-2012	Coordinator, UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
・2013-present	Director, Environment Laboratories, International Atomic Energy Agency

Mr David Osborn joined the International Atomic Energy Agency as Director, Environment Laboratories, in Monaco in January 2013. Formerly with the United Nations Environment Programme (UNEP) in Nairobi and The Hague, he was Coordinator of the 1995 Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities and Coordinator of UNEP’s Ecosystem Management Programme. A national of Australia with qualifications in both environmental science and environmental law, his interests and career have focussed extensively on the link between robust science and good governance. He has held director posts at the Great Barrier Reef Marine Park Authority and the Australian Government’s Department of the Environment and Water Resources, and has served as an Advisor to the Australian Government Minister for the Environment. He was formerly an officer in the Royal Australian Navy.

IAEA

Ocean Acidification International Coordination Centre

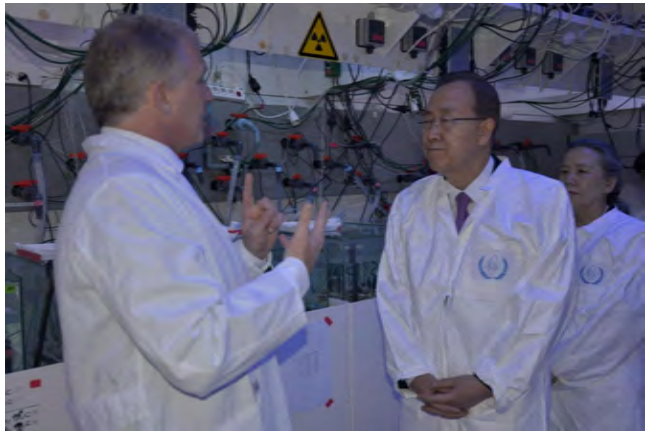
OA-ICC

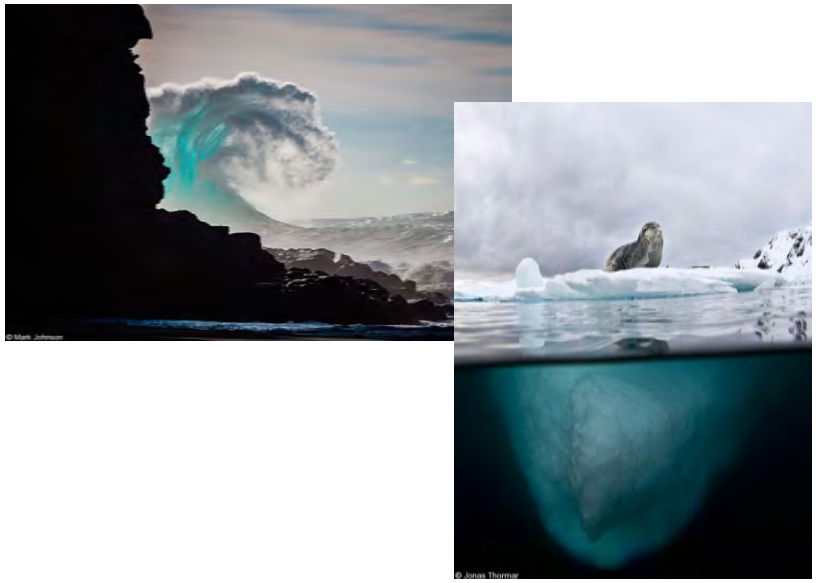
Research and Policy Trends on Ocean Acidification Around the World

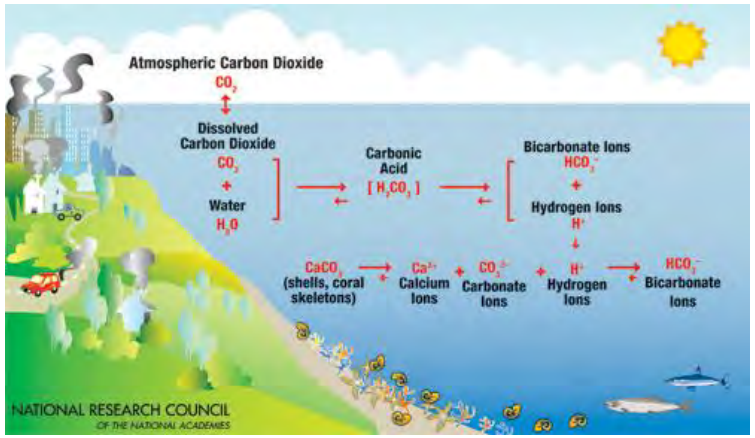
David Osborn
Director
IAEA Environment Laboratories
International Atomic Energy Agency
Principality of Monaco

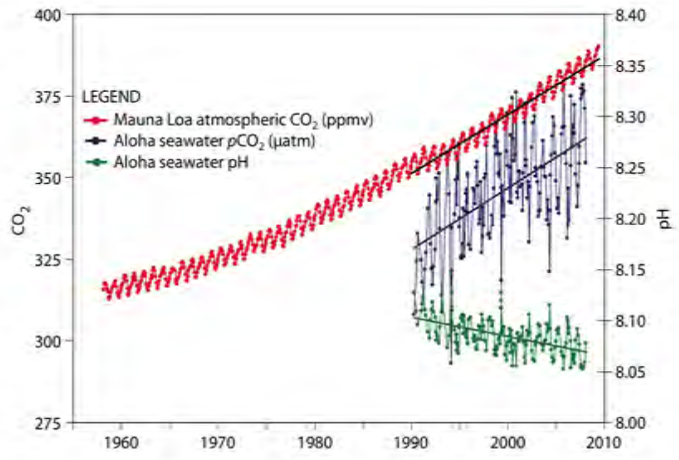
oaicc@iaea.org
www.iaea.org/ocean-acidification
http://news-oceanacidification-icc.org/

Science-Policy Interface









Source: Feely, R.A., S.C. Doney and S.R. Cooley (2009), 'Ocean acidification: present conditions and future changes in a high-CO2 world', *Oceanography*, 22 (4), 36–47.

Shells exposed to corrosive ocean conditions expected by 2100

Movie: Brad Seibel, University of Rhode Island

Day 1 **Day 2** **Day 16**

Image: Victoria Fabry, California State University San Marcos

IAEA Environment Laboratories

To address the BIG challenges, we must start SMALL!

Marine Laboratories, Monaco

Terrestrial Laboratories, Austria

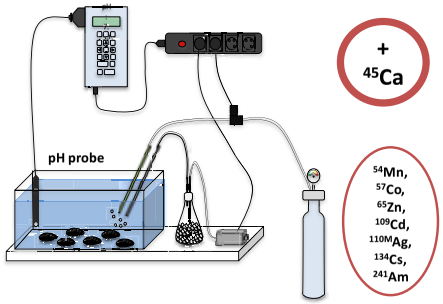
We produce Reference Products

… we also conduct research

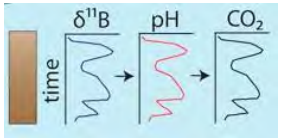
… and we train scientists.

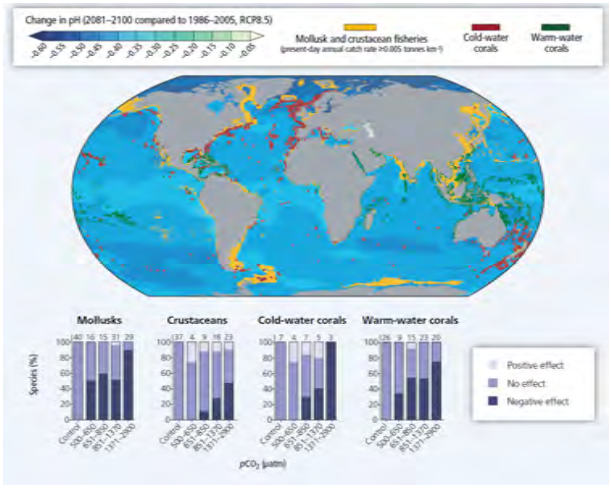
Isotopes are powerful tools to study climate-related changes and ocean acidification

Use of radiotracers to study impact of OA on biological processes, e.g. calcification



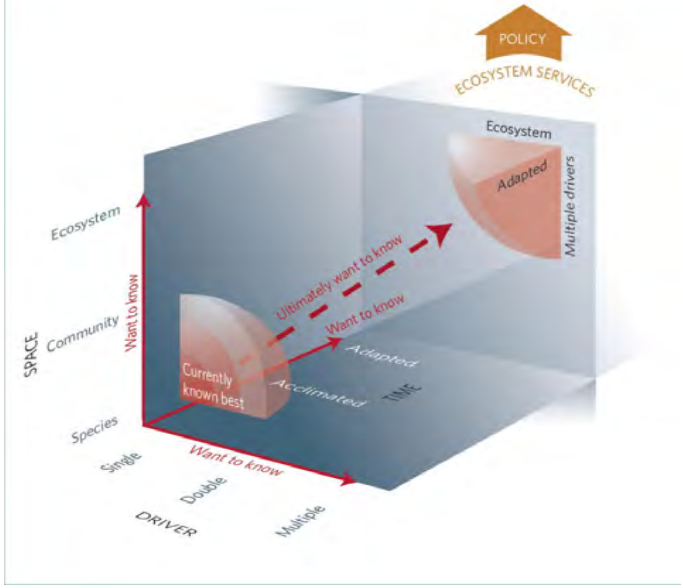
Boron isotopes - paleo-pH proxy





Source: IPCC (2014)

Note: Bottom panel shows impacts of ocean acidification on molluscs, crustaceans and corals, based on a meta-analysis of peer-reviewed articles; negative impacts increase with increasing levels of pCO_2; top numbers show the number of species studied

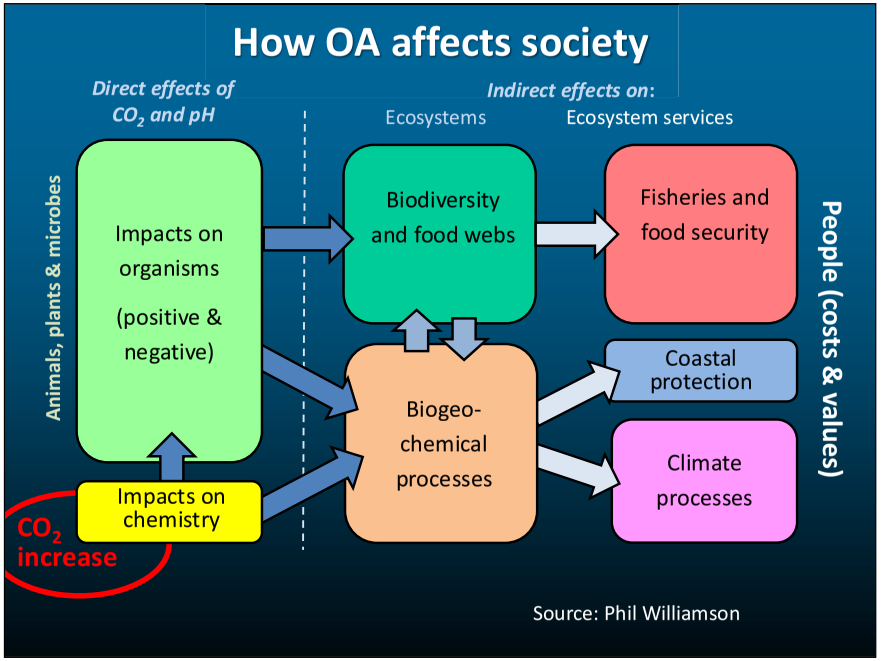


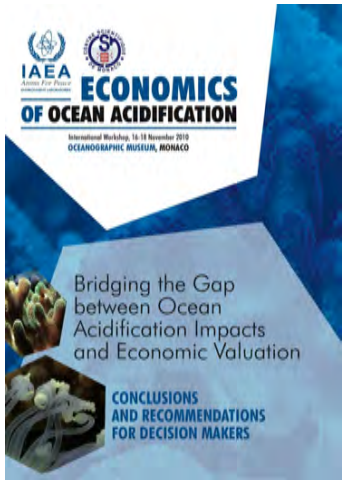
Riebesell and Gattuso (2015)

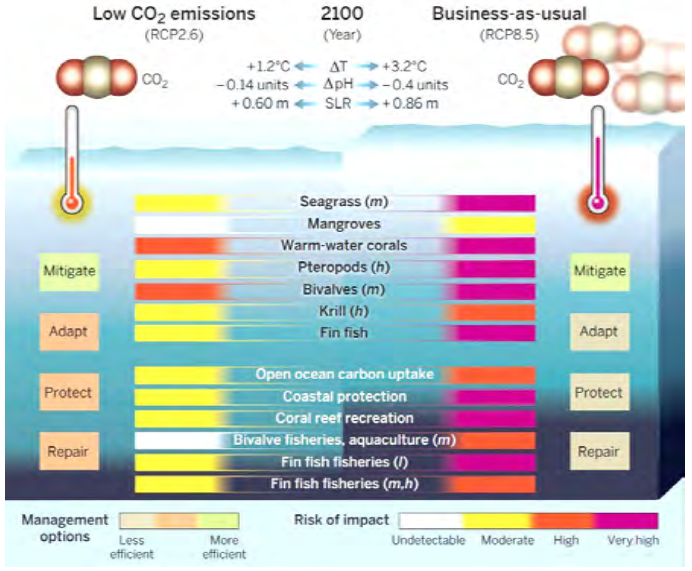
We are only just beginning to comprehend the scale and significance of ocean acidification, and it will have major implications for coastal and marine industry.

GOA-ON

Global Ocean Acidification Observing Network

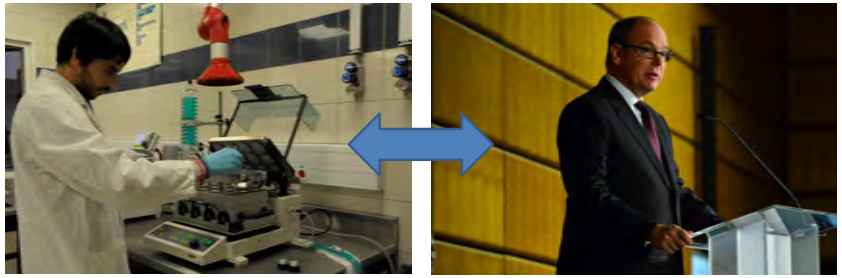






Gattuso et al, 2015

Bridge the Gap



Our Ocean Conferences

"And while the pH of ocean water may vary slightly from one place to another, rising levels of ocean acidification threaten ocean ecology everywhere. Along with the atmosphere, our ocean is the greatest of all of our shared assets. "

Secretary John Kerry

Multilateral Policy Platforms

- UNFCCC
- IPCC
- CBD
- UNGA
- Rio+20 and SDGs

RIO+20
the future we want

Rio+20 outcome document, paragraph 166:

"We call for support to initiatives that address ocean acidification and the impacts of climate change on marine and coastal ecosystems and resources. In this regard, ***we reiterate the need to work collectively to prevent further ocean acidification****, as well as* ***enhance the resilience of marine ecosystems*** *and of the communities whose livelihoods depend on them, and to* ***support marine scientific research, monitoring and observation*** *of ocean acidification and particularly vulnerable ecosystems, including through* ***enhanced international cooperation in this regard****."*

Is there a Silver Bullet?

IAEA Ocean Acidification International Coordination Centre OA-ICC

OA-ICC key online resources

OA-ICC web site
iaea.org/ocean-acidification

OA-ICC news stream
news-oceanacidification-icc.org

OA-ICC data compilation
http://tinyurl.com/oaicc-data

OA-ICC bibliographic database
http://tinyurl.com/oaicc-biblio

Keynote Speech

"Ocean Acidification: An Increasingly Important Issue on Global and Local Scales for Governments and Society"

Carol Turley
Senior Scientist,
Plymouth Marine Laboratory

Dr Carol Turley's research has been centred on the ocean's biogeochemical cycles looking at habitats from shallow and deep-sea sediments, estuaries, frontal systems to large enclosed waters.

In the last 10 years she became interested in ocean acidification and was a member of The Royal Society Working Group on ocean acidification and a Lead Author on the 2007 Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report on Climate Change and a Review Editor for the 5th IPCC Assessment Report.

She was/is a member of the Executive Board of the EU funded European Project on Ocean Acidification (EPOCA), the EU funded Mediterranean Sea Acidification in a Changing Climate (MedSeA) project and is the Knowledge Exchange Coordinator for the UK Ocean Acidification (UKOA) Research Programme funded by NERC, Defra and DECC.

She is a member of the SOLAS-IMBER Ocean Acidification Working Group, chairs the Advisory Board for the Ocean Acidification-International Coordination Centre at the IAEA, Monaco and is a founding member of the international Ocean Acidification Reference User Group.

She is a member of the international Science Advisory Boards for the German and US national ocean acidification programmes.

She has contributed to stakeholder or policy targeted publications with MCCIP, WMO, The World Bank, UNEP, IUCN, IAEA and IOC-UNESCO.

She has giving evidence to the UNFCCC SBSTA in Bonn and since 2009 presented at side-events at the annual UN Conferences on Climate Change in culminating in the latest one in Paris in 2015 (COP21), at the Earth Summit Rio+20 in 2012, at the UN in New York in 2013 and the Convention on Biological Diversity COP in S. Korea in 2014.

She spoke at the Ocean Acidification Panel, giving the science presentation at the Our Ocean Summit at the US State Department in 2014 attended by Heads of State from 80 countries.

She briefs a wide range of interested global stakeholders including UK Government departments, Ministers and Chief Scientists on the latest science of ocean acidification, warming and deoxygenation and has presented in the Houses of Parliament and European Parliament.

She has published and presented on a wide range of topics within the field of ocean acidification, ranging from its cause, chemistry, impacts and the potential social, economic and political consequences.

She has over 130 peer reviewed publications and has been an invited speaker at numerous international conferences.

She received an OBE for services to science in the 2011 New Year's Honours List.

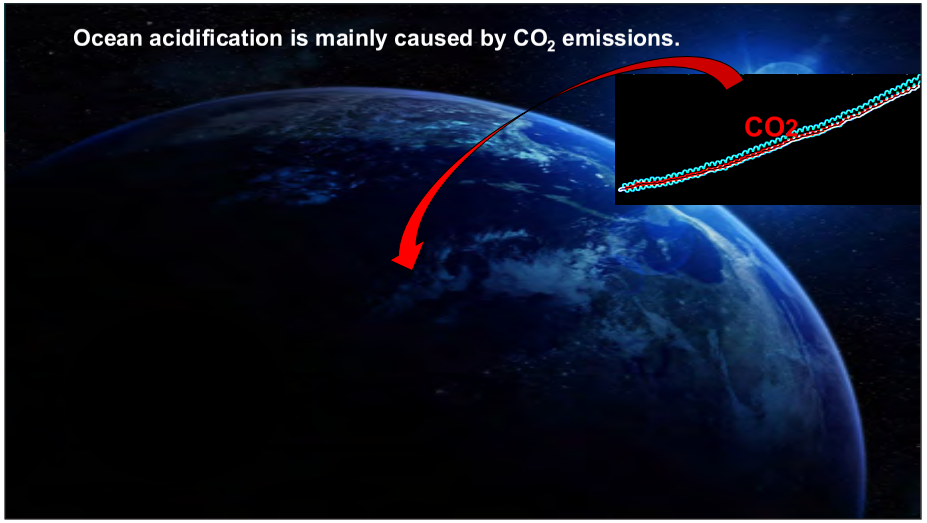
PML | Plymouth Marine Laboratory

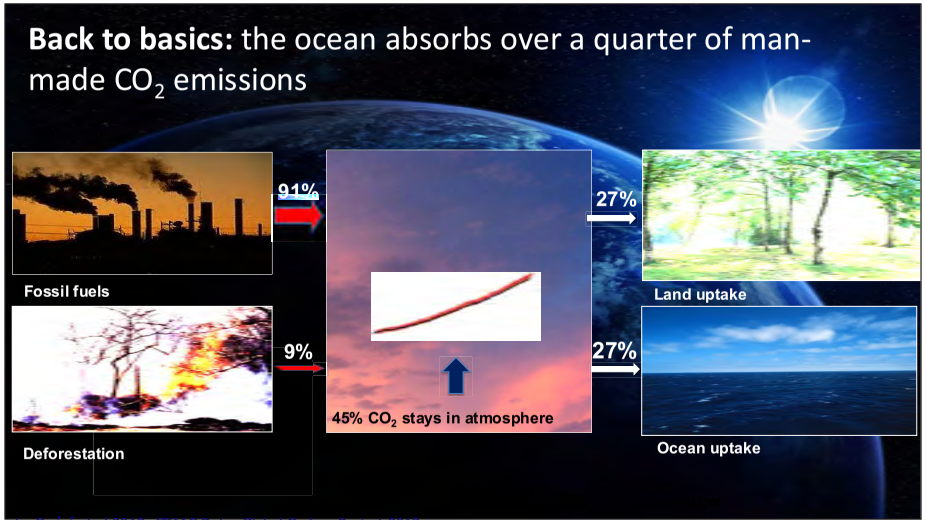
Listen to the ocean

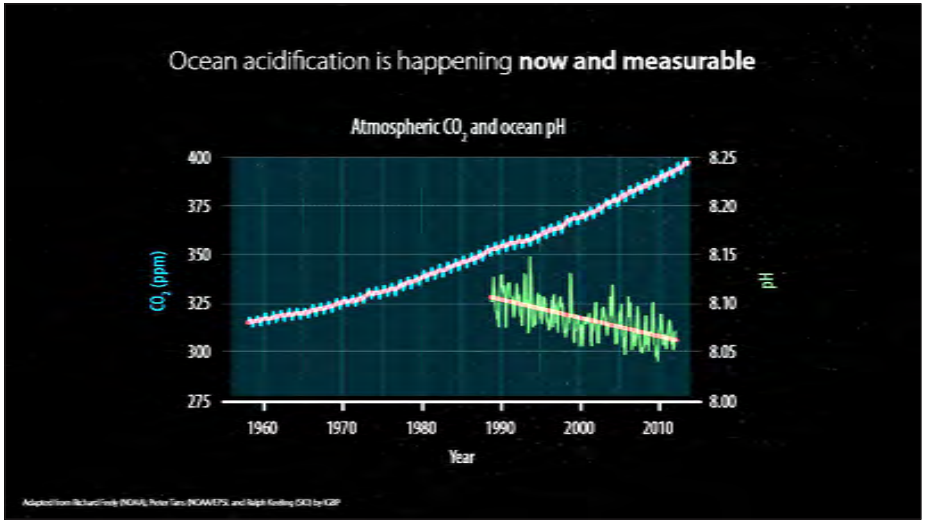
Ocean acidification: an increasingly important issue on global to local scales for governments and society

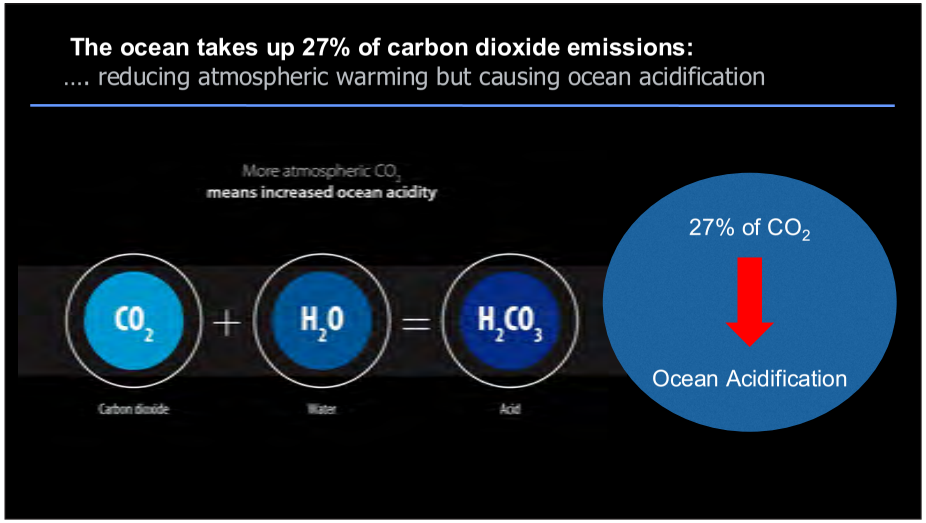
Dr Carol Turley, OBE

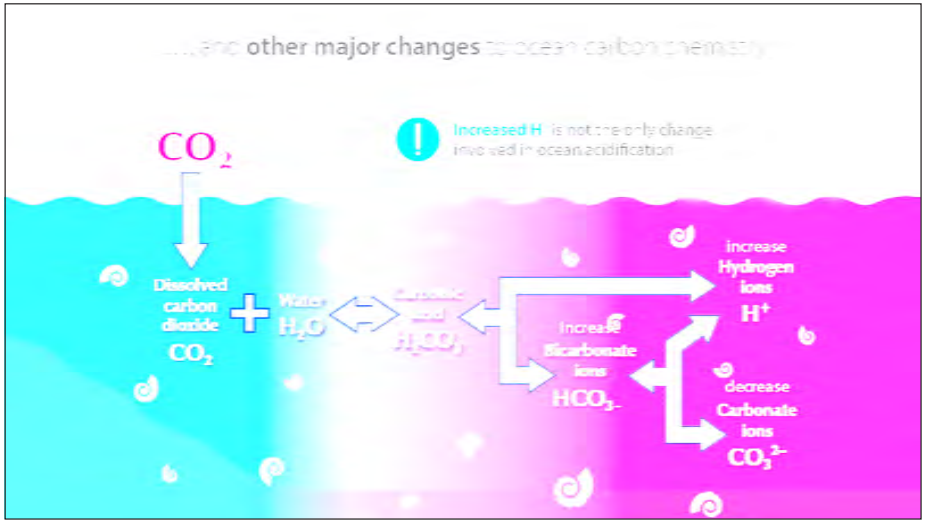
Impacts of global warming and ocean acidification on marine ecosystems and necessary policy measures, 19-20 January 2017, Tokyo

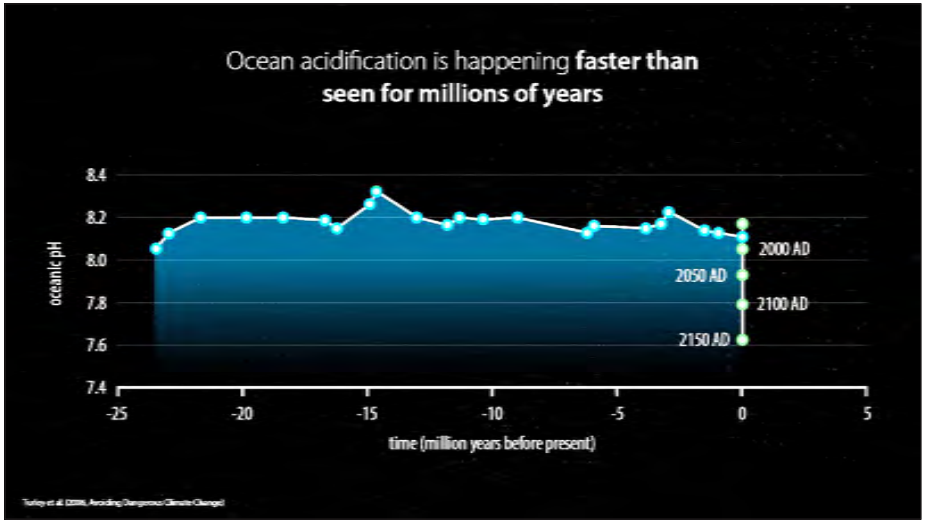


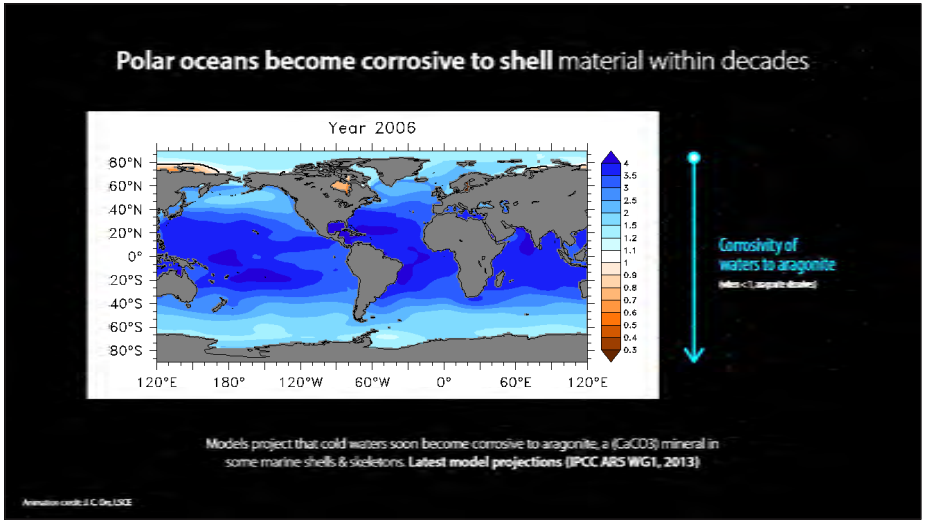




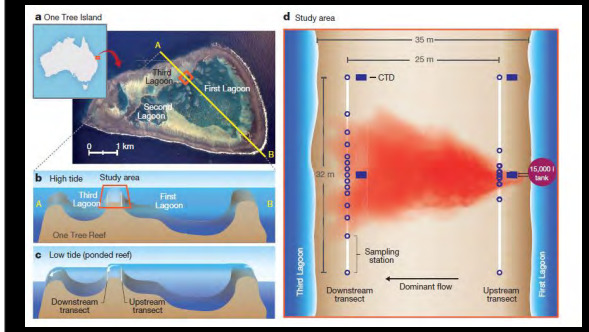

The ocean takes up 27% of carbon dioxide emissions:
.... reducing atmospheric warming but causing ocean acidification
More atmospheric CO_2 means increased ocean acidity
CO_2
H_2O
H_2CO_3
Carbon dioxide
Water
Acid
27% of CO_2
Ocean Acidification

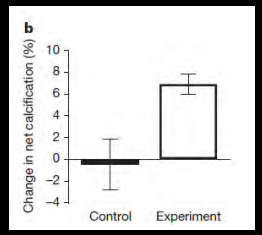

CO_2
Increased H+ is not the only change involved in ocean acidification
Dissolved carbon dioxide
CO_2
Water
H_2O
increase Hydrogen ions
H^+
increase Bicarbonate ions
HCO_3^-
decrease Carbonate ions
CO_3^{2-}


Ocean acidification is happening faster than seen for millions of years
oceanic pH
8.4
8.2
8.0
7.8
7.6
7.4
2000 AD
2050 AD
2100 AD
2150 AD
-25
-20
-15
-10
-5
0
5
time (million years before present)

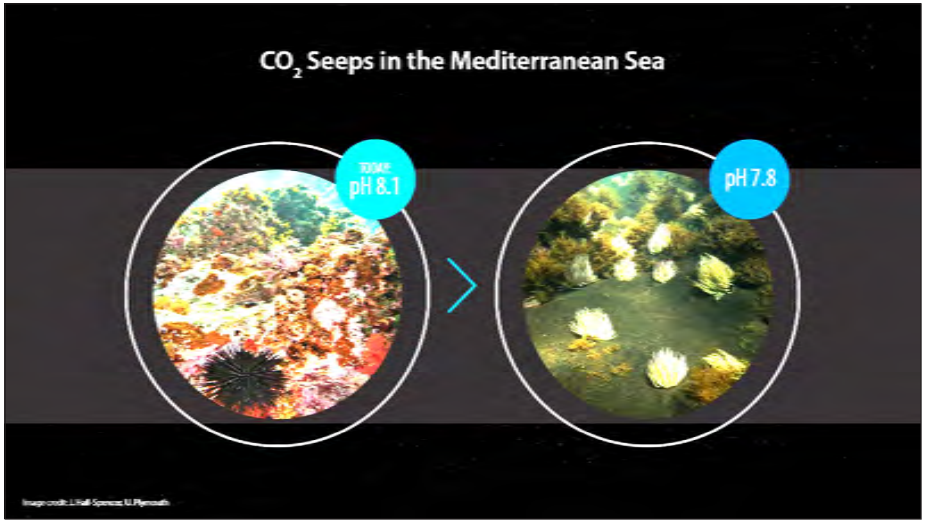

Polar oceans become corrosive to shell material within decades
Year 2006
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S
120°E
180°
120°W
60°W
0°
60°E
120°E
Corrosivity of waters to aragonite
Models project that cold waters soon become corrosive to aragonite, a ($CaCO_3$) mineral in some marine shells & skeletons. Latest model projections (IPCC AR5 WG1, 2013)

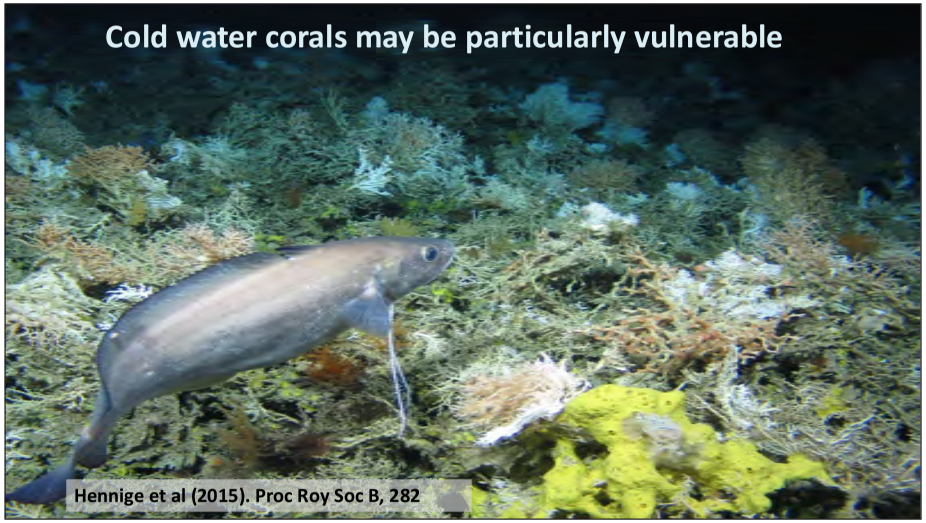
Reversal of ocean acidification enhances net coral reef calcification:
When ocean chemistry is restored to pre-industrial conditions calcification increases by 6.9+/- 0.9% indicating ocean acidification is already impairing reef growth

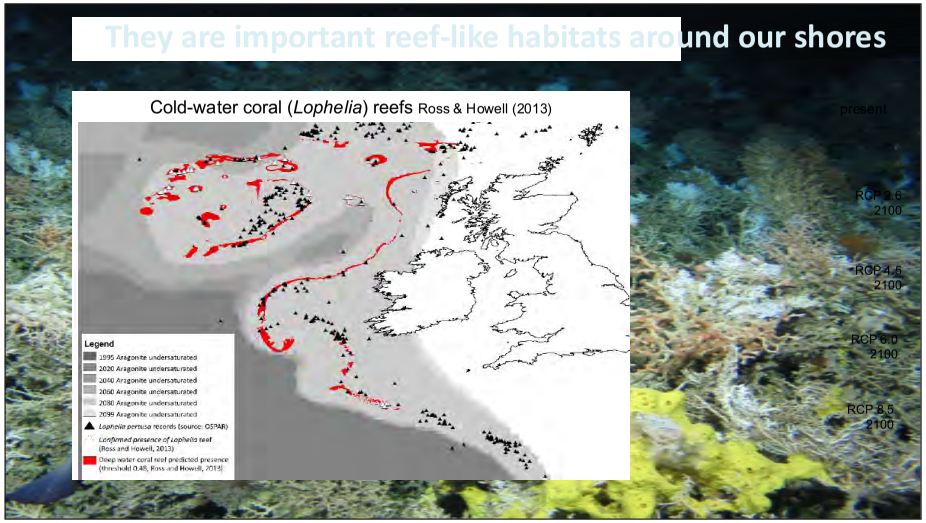


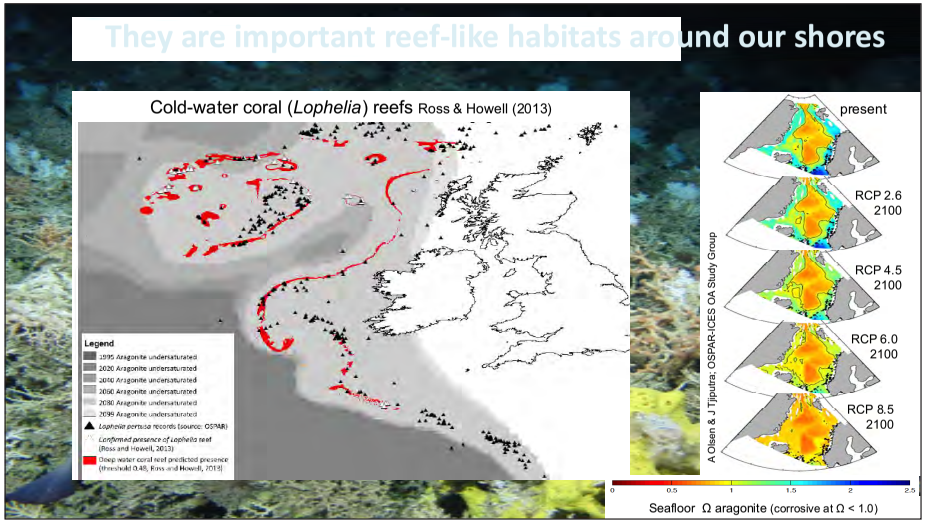


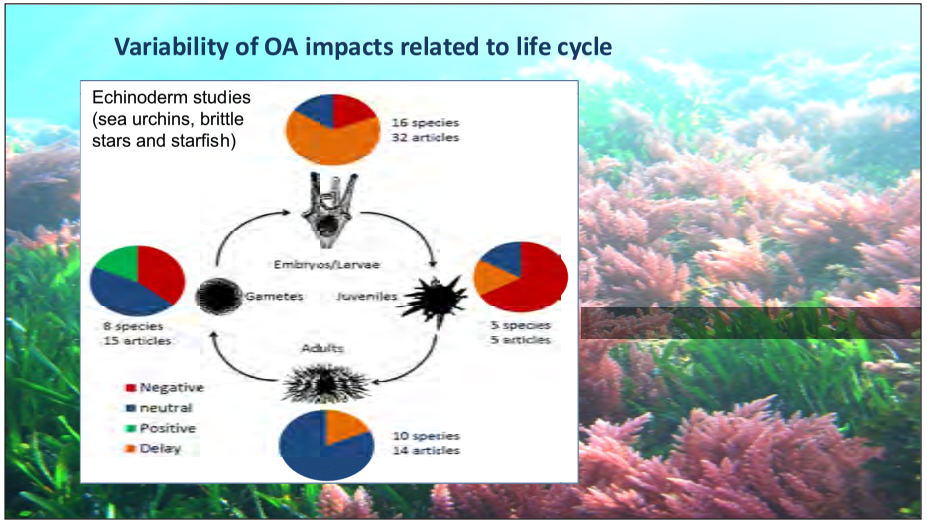
Albright et al. 2016 Nature



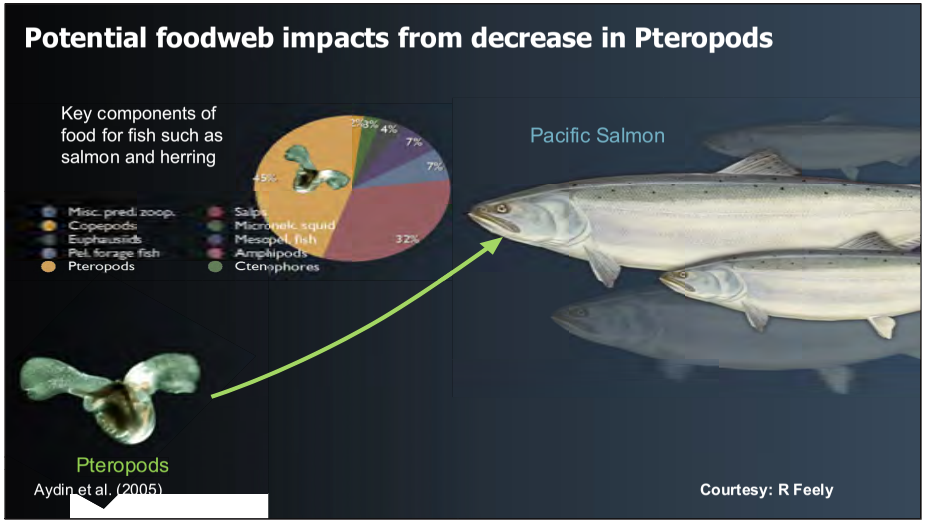





They are important reef-like habitats around our shores
Cold-water coral (Lophelia) reefs Ross & Howell (2013)
present
RCP 2.6 2100
RCP 4.5 2100
RCP 6.0 2100
RCP 8.5 2100
A Olsen & J Tjiputra, OSPAR-ICES OA Study Group
Seafloor Ω aragonite (corrosive at Ω < 1.0)


Variability of OA impacts related to life cycle
Echinoderm studies (sea urchins, brittle stars and starfish)
16 species
32 articles
Embryos/Larvae
Gametes
Juveniles
8 species
15 articles
5 species
5 articles
Adults
10 species
14 articles
Negative
neutral
Positive
Delay

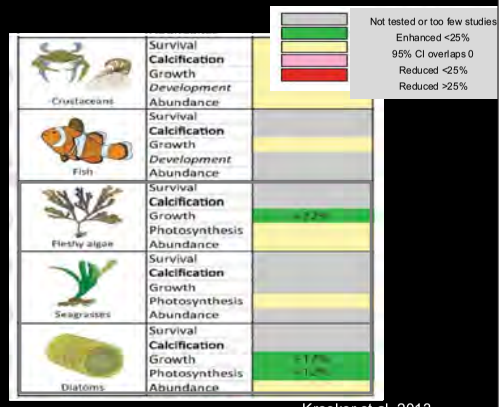

Pteropods shells are already dissolving in the Southern Ocean and off California
Movie: Brad Seibel, University of Rhode Island
100 µm
100 µm
Bednaršek et al. 2012


Potential foodweb impacts from decrease in Pteropods
Key components of food for fish such as salmon and herring
Misc. pred. zoop.
Copepods
Euphausiids
Pel. forage fish
Pteropods
Salps
Micronek. squid
Mesopel. fish
Amphipods
Ctenophores
Pacific Salmon
Pteropods
Aydin et al. (2005)
Courtesy: R Feely

Biological impacts are complex… variability at different levels

Meta-analysis based on single-species studies

Taxa	Response	Mean Effect
Calcifying algae	Survival	
	Calcification	
	Growth	
	Photosynthesis	-28%
	Abundance	-80%
Corals	Survival	
	Calcification	-32%
	Growth	
	Photosynthesis	
	Abundance	-47%
Coccolithophores	Survival	
	Calcification	-23%
	Growth	
	Photosynthesis	
	Abundance	
Molluscs	Survival	-34%
	Calcification	-40%
	Growth	-17%
	Development	-25%
	Abundance	
Echinoderms	Survival	
	Calcification	
	Growth	-10%
	Development	-11%
	Abundance	



Kroeker et al. 2013

And finally - can you can taste the difference?

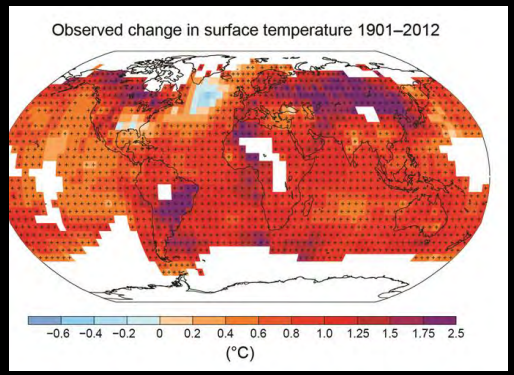
The Swedes can!

In a survey they could taste the difference in their beloved shrimp dish when grown at high CO_2

Dupont et al. 2014

The ocean is absorbing nearly all the heat from global warming:

…..causing it to warm



93% of heat

↓

Ocean warming

IPCC AR5 2014

The ocean receives all the water from melting ice:

…. along with thermal expansion, resulting in sea level rise

100% of water

↓

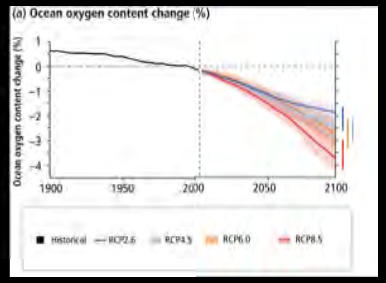
Sea level rise

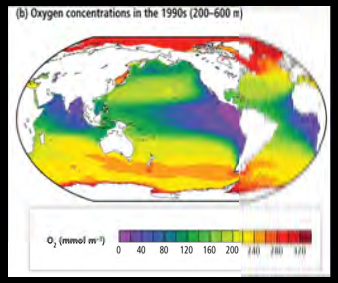
Image credit: UKOA, Sea Surface Consortium

Ocean oxygen concentrations are decreasing:

…due to warming waters increasing stratification

… dead zones with low oxygen will increase





IPCC AR5 2014

Climate scenarios and impacts:

CO_2 emissions	Δ air surface temperature (°C)	
Present day	1.1	
RCP 2.6	1.5	PA Goal
*NDCs: Climate Action Tracker	2.7	NDCs
*NDCs: Climate Interactive	3.5	NDCs
RCP8.5	4.2	BAU

Global mean values in 2090-2099 relative to 1870-1899

*Nationally Determined Contributions

Amended from Magnan et al (2016) Nature Climate Change

Climate scenarios and impacts:

CO_2 emissions	Δ air surface temperature (°C)	Δ sea surface temperature (°C)	
Present day	1.1	0.83	
RCP 2.6	1.5	1.13	PA Goal
NDCs: Climate Action Tracker	2.7	2.03	NDCs
NDCs: Climate Interactive	3.5	2.63	NDCs
RCP8.5	4.2	3.15	BAU

Global mean values in 2090-2099 relative to 1870-1899

*Nationally Determined Contributions

Amended from Magnan et al (2016) Nature Climate Change

Climate scenarios and impacts: Current NDCs are not enough

CO_2 emissions	Δ air surface temperature (°C)	Δ sea surface temperature (°C)	Δ surface ocean pH	
Present day	1.1	0.83	-0.11	
RCP 2.6	1.5	1.13	-0.15	PA Goal
NDCs: Climate Action Tracker	2.7	2.03	-0.26	NDCs
NDCs: Climate Interactive	3.5	2.63	-0.34	NDCs
RCP8.5	4.2	3.15	-0.41	BAU

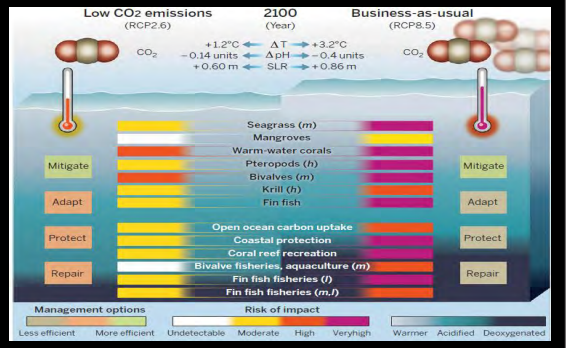
Global mean values in 2090-2099 relative to 1870-1899

*Nationally Determined Contributions

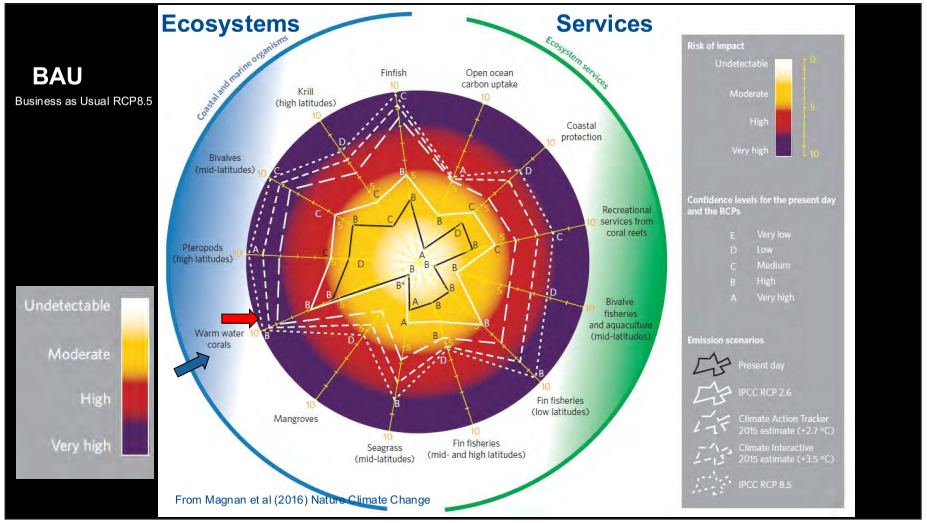
Amended from Magnan et al (2016) Nature Climate Change

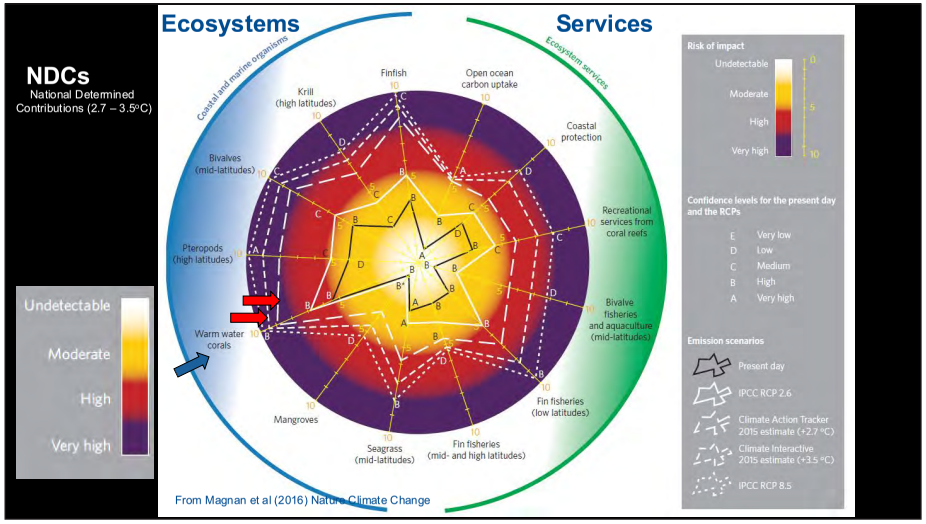
Ocean acidification, warming, oxygen loss and sea level rise are happening at the same time

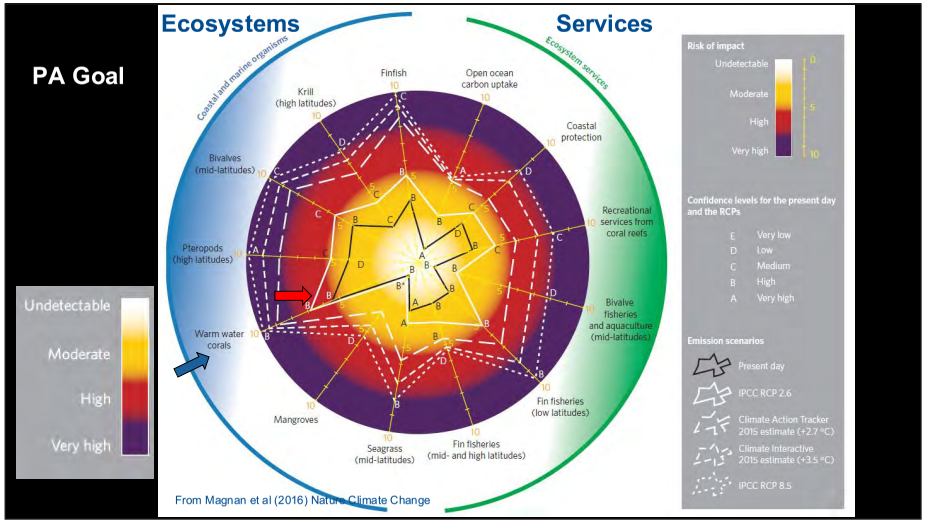
- If we follow a future CO_2 emissions of RCP8.5 the risk to many ecosystems and the goods and services they provide will be very high
- Stringent CO_2 reductions of RCP2.6 would reduce the risk but still be critical for some ecosystems
- Management options decline with higher CO_2

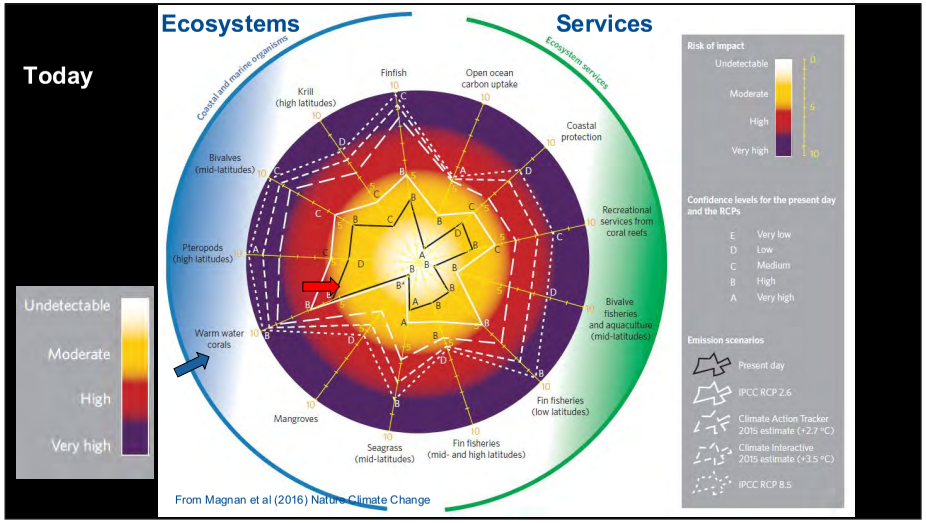


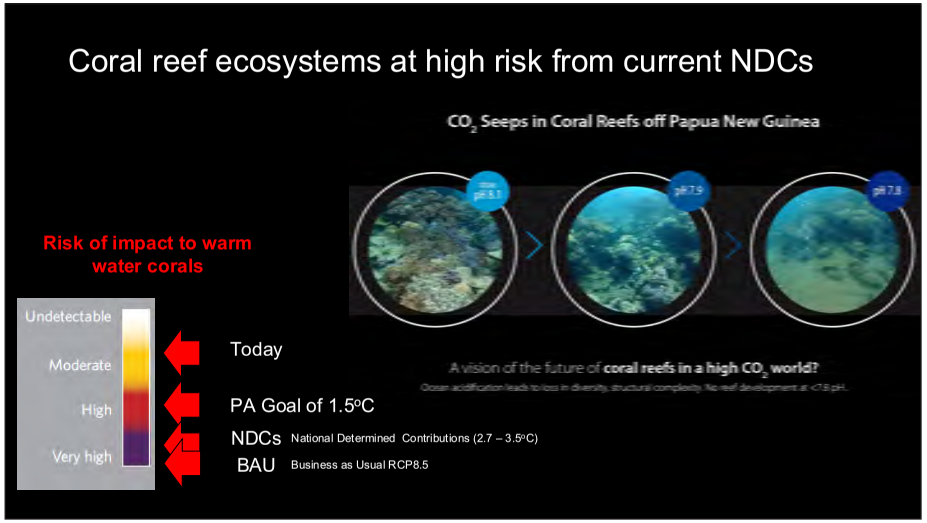
Gattuso et al. *Science* 2015

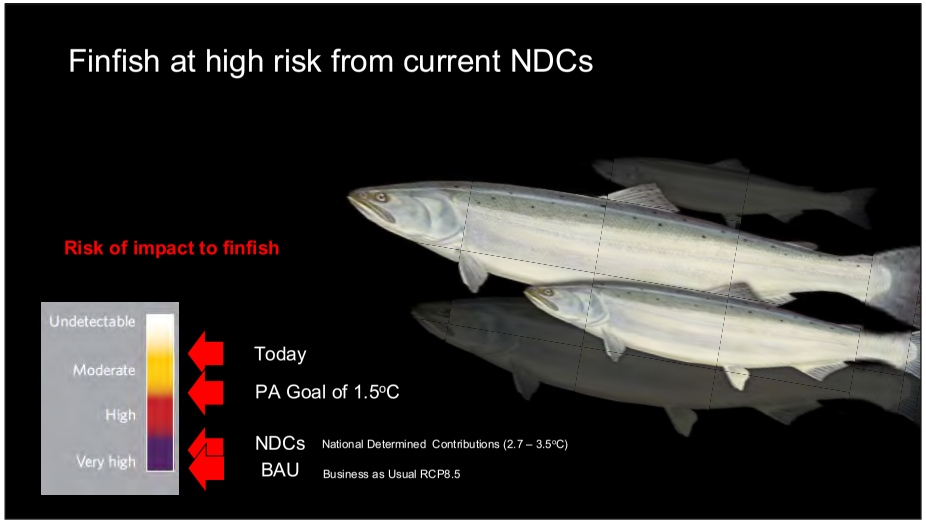







Today
Undetectable
Moderate
High
Very high
Ecosystems
Services
Coastal and marine organisms
Ecosystem services
Finfish
Open ocean carbon uptake
Krill (high latitudes)
Coastal protection
Bivalves (mid-latitudes)
Recreational services from coral reefs
Pteropods (high latitudes)
Bivalve fisheries and aquaculture (mid-latitudes)
Warm water corals
Fin fisheries (low latitudes)
Mangroves
Seagrass (mid-latitudes)
Fin fisheries (mid- and high latitudes)
Risk of impact
Undetectable
Moderate
High
Very high
Confidence levels for the present day and the RCPs
E Very low
D Low
C Medium
B High
A Very high
Emission scenarios
Present day
IPCC RCP 2.6
Climate Action Tracker 2015 estimate (+2.7 °C)
Climate Interactive 2015 estimate (+3.5 °C)
IPCC RCP 8.5
From Magnan et al (2016) Nature Climate Change


Coral reef ecosystems at high risk from current NDCs
CO_2 Seeps in Coral Reefs off Papua New Guinea
Risk of impact to warm water corals
Undetectable
Moderate
High
Very high
Today
PA Goal of 1.5°C
NDCs National Determined Contributions (2.7 – 3.5°C)
BAU Business as Usual RCP8.5
A vision of the future of coral reefs in a high CO_2 world?


Finfish at high risk from current NDCs
Risk of impact to finfish
Undetectable
Moderate
High
Very high
Today
PA Goal of 1.5°C
NDCs National Determined Contributions (2.7 – 3.5°C)
BAU Business as Usual RCP8.5


Societal Impacts
Impacts will be strongest in coastal communities relying on marine productivity and coastal protection
Many of these are highly vulnerable and less able to adapt

Science conclusion:

Current *NDCs are not enough to avoid high risks of impacts to ocean ecosystems and the goods and services they provide.

We need to build on them urgently – **more ambitious CO_2 emissions reduction**

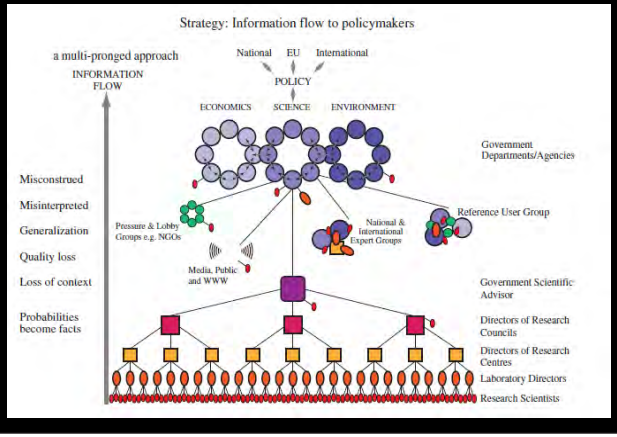
We need global policy action

*Nationally Determined Contributions

We need to bridging the science-policy gap

Use a multi-pronged, multi-level approach

Messages coming from different directions have more impact



Communication is a virus – it needs to spread to have impact

Creating the Science - Policy Link

To get across a globally important message to key policy makers it needs to be based on sound science –

Evidence is key:

Sound Science ⟷ **Evidence** ⟷ **Policy**

Influence & Trust

It's a two-way process:

Listen to the policy questions – they can be very different to the science questions

Reach the influencers: build trust & rapport

- Members of Government
- Government Chief Scientific Advisers
- Government Science & Technology Committees
- Climate change negotiation teams – offer to give briefings

…they influence Government

- Work with journalists – let them know where and when the new science stories emerge– be prepared to give interviews

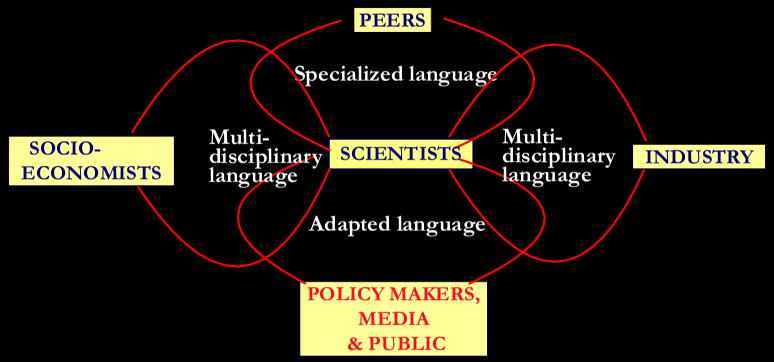
…they influence the public
…who can influence Government
… who make the decisions
… that bring about change

Roger Harrabin, BBC on IPCC findings

Craig Welch and Steve Ringman, Seattle Times

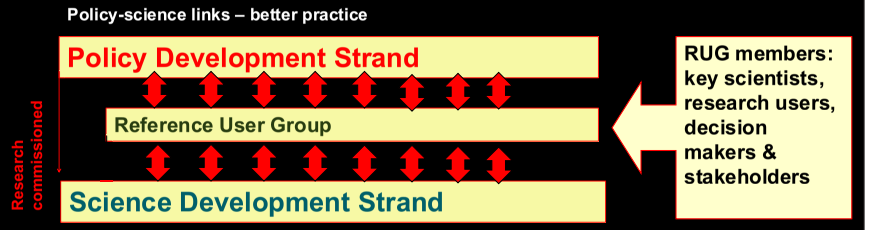
Get our language right

Scientists need to know their audience and adapt their language appropriately



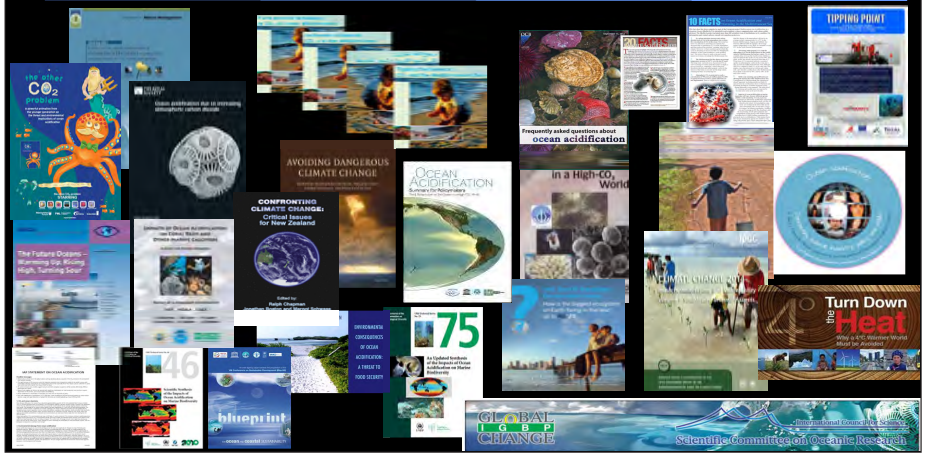
Connect science to stakeholders at the start

The Ocean Acidification Reference User Group (RUG)



Scientists Getting the Message to Stakeholders

– a concerted international effort



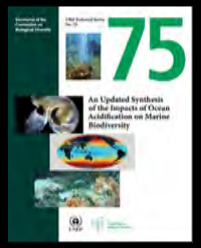
Production of easy to read guides & OpEds

Written by and agreed by experts – a true international collaboration

The New York Times

Acid Test for Marine Life
By JOHN BEDDINGTON and JANE LUBCHENCO JUNE 18, 2012

Contribute to high level evidence-based UN reports



But don't stop there!

Alert policy makers, reporters and media of new science findings: to make sure of wider impact

Engage VIPs! They can reach more than you!

OUR OCEAN
US Department of State

conference website (www.state.gov/ourocean)

2014-2016:
Presidents, Princes, Heads of State, CEO Foundations all talking about ocean stressors, including changing ocean carbonate chemistry!

Reach the next generation ....

Children – The Best Communicators!
The Ridgeway School Animation

Eleven years OA science- policy to the UN

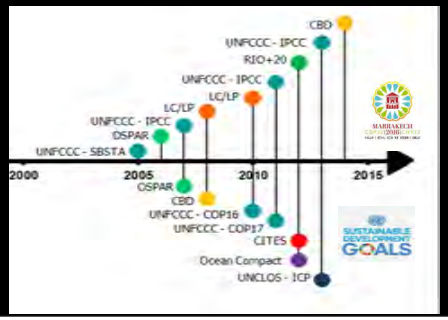
Oceans of talks and panels…….

Concerted and coordinated international effort amongst marine scientists

Exhibition stands in UN area

Engaging delegates, providing scientific knowledge

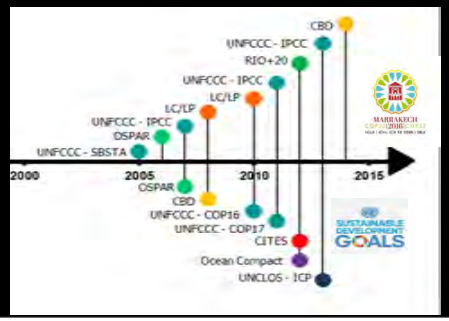
Growing UN interest in ocean acidification



UN's Intergovernmental Panel on Climate Change
Recognised ocean acidification is a CO_2 problem

AR4 in 2007: Ocean acidification mentioned for the first time

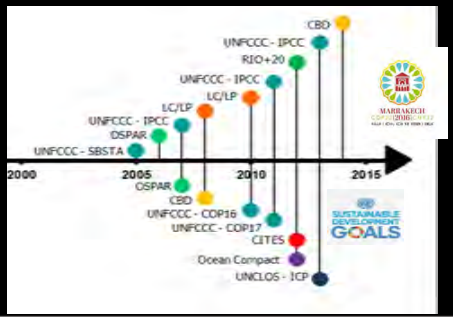
AR5 in 2014: Ocean and ocean acidification received far greater attention



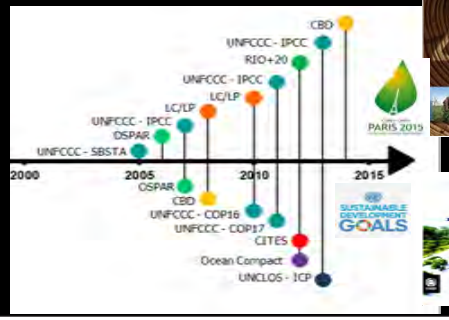
UN Convention on Biological Diversity

2008: CBD's first report on OA

2014: CDB's updated synthesis report



Other UN bodies increasingly aware



The ocean and the UNFCCC – why it should be included

- The ultimate objective of UNFCCC :

  "to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
  [Article 2, UNFCCC Convention]

- The ocean is clearly part of the "climate system" defined by the UNFCCC as:

  "totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions"

- The UNFCCC therefore has responsibility for GHG impacts on the ocean – including ocean acidification!

COP 21: Paris Agreement by 195 national leaders

Surprising, exciting and euphoric!

- Agreed to limited warming to "well below" 2°C
- Pursue efforts to limit to 1.5°C (requires CO_2 removal!)
- Committed to peak GHG emissions asap
- Voluntary commitments limits warming to 2.7-3.7°C
- 5 yr reviews based on new information
- Ocean and its ecosystems recognised and included: "Noting the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity….."

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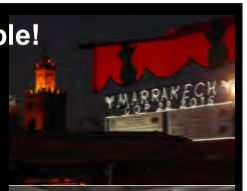
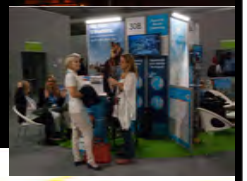
Major role for science!

COP 22, Marrakech 2016: Ocean even more visible!





Numerous ocean side events

Ocean exhibitions

Oceans Day was included within the UN Zone for the first time with an Oceans Action Day

An Eye to the Rapidly Moving Future

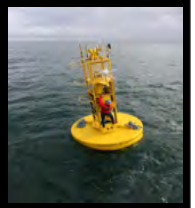
Increased pressure on raising the issue at high level

- G7 Nations' Ocean Initiative
- IPCC SR: Climate, ocean and cryosphere
- IPCC SR: on 1.5°C
- IPCC AR6 cycle starting
- SDG implementation, 5-9 June 2017
- UNFCCC COP23, **Bonn/Fiji**……

Conclusion: Good policy requires good science

Good science – policy requires good communication

Good communication requires understanding and trust by both scientists and policy makers



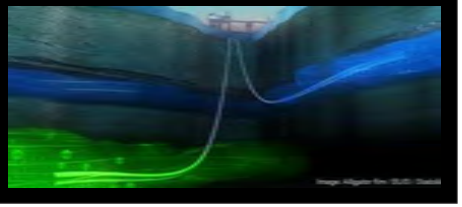
Substantial and sustained investment, accelerated research, and enhanced collaboration at a global scale is required to allow an informed response **by policy makers** to the challenge of mitigation and adaptation

We cannot ignore the largest ecosystem on the planet

Transforming energy, industry, economy and society

A huge and exciting challenge for Mankind full of opportunities

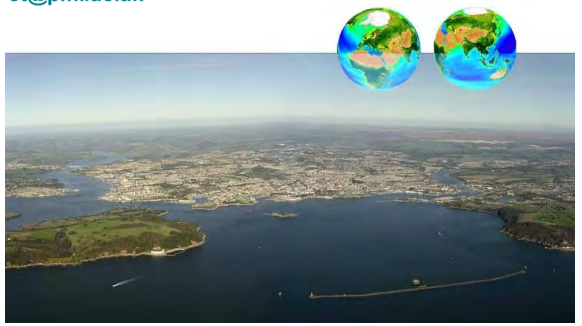
We must rapidly ramp up our reductions of CO_2 emissions and move to a sustainable and low CO_2 emissions energy system



PML | Plymouth Marine Laboratory

Thank you

ct@pml.ac.uk



UK Ocean Acidification Research Programme

BIOACID

IAEA OA-ICC

Keynote Speech

"Towards Building an Ocean Acidification Network"

Jan Newton

Senior Principal Oceanographer, Affiliate Assistant Professor,

Oceanography, University of Washington

PROFESSIONAL AND ACADEMIC CREDENTIALS

University of Washington	Oceanography	Ph.D., 1989
MBARI Postdoctoral Fellow	Oceanography	1989-1991

PROFESSIONAL APPOINTMENTS

Senior Principal Oceanographer, Applied Physics Lab, University of Washington, 2004-present

- *Executive Director,* Northwest Association of Networked Ocean Observing Systems, NANOOS, the PNW Regional Association of U.S. Integrated Ocean Observing System since 2004
- *Co-Director,* Washington Ocean Acidification Center, University of Washington since 2013
- *Instructor,* UW Friday Harbor Laboratories (FHL) since 1991

Affiliate Assistant Professor, University of Washington, School of Marine and Environmental Affairs, 2009-present

Affiliate Assistant Professor, University of Washington, School of Oceanography, 1998-present

Senior Oceanographer, Washington State Department of Ecology, 1994-2004

Senior Research Scientist, Northeastern University, Marine Science Center, 1993-2005

Research Associate, University of Washington, School of Oceanography, 1991-1993

SYNERGISTIC ACTIVITIES

PI for NANOOS: As Executive Director since 2004, my responsibilities include being the PI for our 5-year proposal involving multiple institutions and 19 PIs and $4M/y proposed budgets.

Communication with elected officials: Invited to brief U.S. Senate Committee on Commerce, Science and Transportation, June 2013 on ICOOS and FOARAM Acts; briefed WA State Legislature during 2005-2008 on science needs and research. Governor-appointee to WA Governor's Blue Ribbon Panel on Ocean Acidification; Member of West Coast Ocean Acidification and Hypoxia Science Panel. As Co-Director for the WA OA Center, serve the Marine Resource Advisory Council and support/provide WA Legislature briefings.

Ocean Acidification Observing Networks: Participate in global to local scale ocean acidification observing efforts. Lead author for Requirements and Governance Plan for global-scale OA observing network (GOA-ON). Presented GOA-ON overview at GEO Summit in Geneva, SIDS UNESCO in Samoa, and US State Department Roundtable. Member of GOA-ON Executive Council; co-chaired three GOA-ON workshops (US, UK, Australia) to build GOA-ON effort.

Tribal STEM and experiential education: Work with Northwest Indian College to entrain their students in STEM research and develop peer-to-peer knowledge transfer through shared cruises as part of my UW Friday Harbor Laboratories Research Apprenticeship on the "Pelagic Ecosystem Function." This FHL program is designed to mentor undergraduate apprentices in ecosystem-wide research, cutting across traditional research lines and using discovery methods of research.

Regional applied research: As WA OA Center Co-Director, coordinate academic, state, federal, tribal and industry researchers to monitor and forecast OA and assess its biological effects. As NANOOS Director, lead development and application of operational coastal observations to user-driven products. As former Hood Canal Dissolved Oxygen Program PI, coordinated hypoxia research, citizen science, and public education, and worked with two tribes to include HCDOP science into their programs, mentoring tribal members/scientists; was featured at 2007-2010 UW Tribal Summits. Member Puget Sound Partnership Science Panel.

Towards building an Ocean Acidification Network

Jan Newton
Principal Oceanographer
NANOOS Executive Director
Washington Ocean Acidification Center co-Director
GOA-ON Executive Council
University of Washington

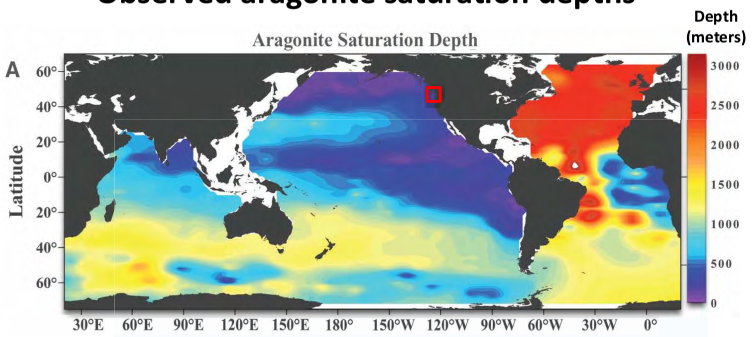
coenv.uw.edu/oacenter www.nanoos.org ioos.noaa.gov www.goa-on.org

Outline

- The Pacific Northwest, upwelling, OA, and oysters
- The Washington Blue Ribbon Panel and its results
- The Washington Ocean Acidification Center and NOAA research
- West Coast shellfish grower and science collaborations: IPACOA
- The Global Ocean Acidification Observing Network (GOA-ON)

The Pacific Northwest US, upwelling, OA, and oysters

Observed aragonite saturation depths



- Natural processes make North Pacific water very rich in CO_2: the US Pacific coast is closer to the aragonite threshold than US Atlantic coast.
- The aragonite saturation depth is getting shallower by 1–2 meters per year.

Feely et al. (2004)

Seasonal upwelling brings high CO_2, low pH water to surface

Summer: Upwelling

Winter: Downwelling

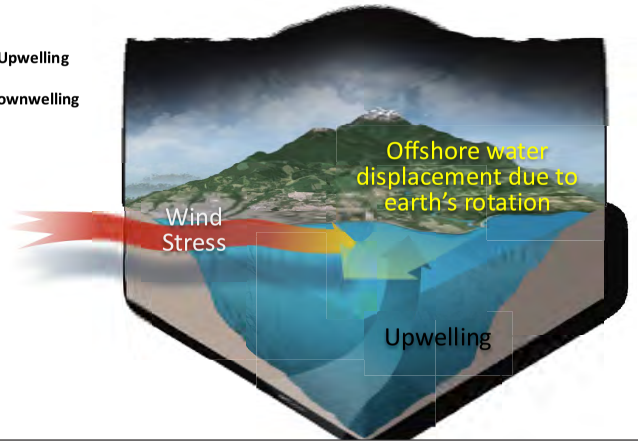
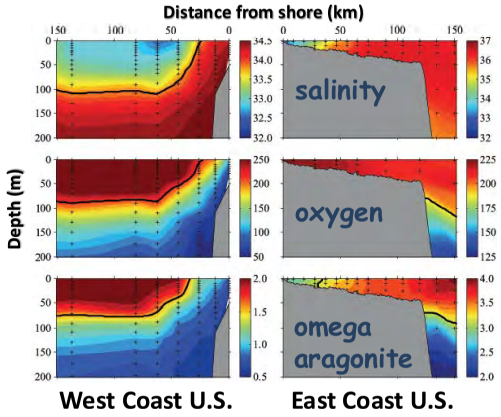


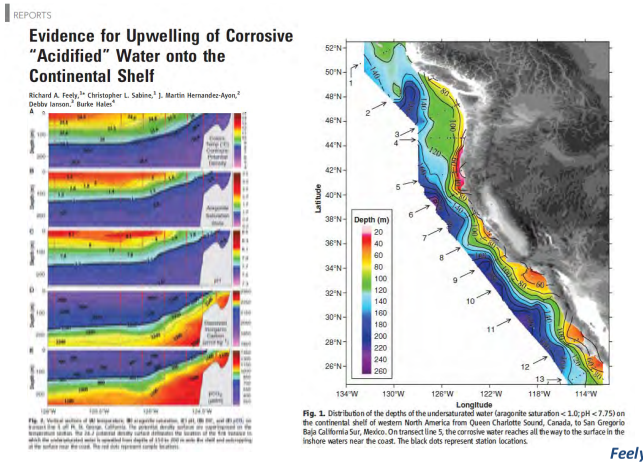
Image: NOAA PMEL

Pacific Coast affected by upwelling



Jiang et al. (2010)

Pacific Coast conditions



REPORTS

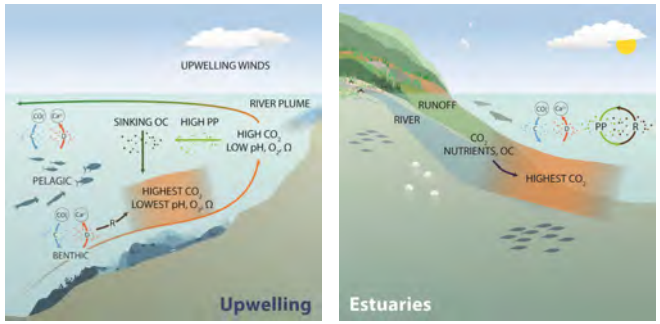
Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf

Richard A. Feely,* Christopher L. Sabine, Joanie M. Hernandez-Ayon, Debby Ianson, Burke Hales

Fig. 1. Distribution of the depths of the undersaturated water (aragonite saturation < 1.0; pH < 7.75) on the continental shelf of western North America from Queen Charlotte Sound, Canada, to San Gregorio Baja California Sur, Mexico. On transect line 5, the corrosive water reaches all the way to the surface in the inshore waters near the coast. The black dots represent station locations.

Feely et al. (2008)

California Current System ecosystem types



Alin et al., Oceanography, 2015

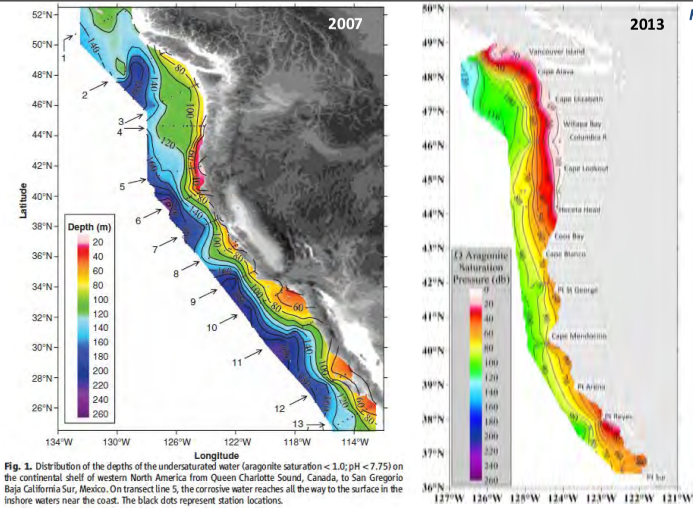


Fig. 1. Distribution of the depths of the undersaturated water (aragonite saturation < 1.0; pH < 7.75) on the continental shelf of western North America from Queen Charlotte Sound, Canada, to San Gregorio Baja California Sur, Mexico. On transect line 5, the corrosive water reaches all the way to the surface in the inshore waters near the coast. The black dots represent station locations.

Feely et al. (2008; 2016)

9

Pacific Coast oysters

Oysters in deep trouble: Is Pacific Ocean's chemistry killing sea life?

Oyster larvae have been dying by the billions. Scientists suspect it's a sign that carbon dioxide is dramatically affecting the ocean — and if they're right, it could push Washington into the center of the debate about the future of the seas.

By Craig Welch
Seattle Times environment reporter

WILLAPA BAY, Pacific County —

The collapse began rather unspectacularly.

In 2005, when most of the millions of Pacific oysters in this tree-lined estuary failed to reproduce, Washington's shellfish growers largely shrugged it off.

In a region that provides one-sixth of the nation's oysters — the epicenter of the West Coast's $111 million oyster industry — everyone knows nature can be fickle.

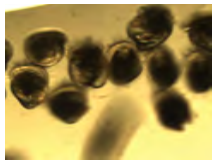
PREV 1 of 6 NEXT

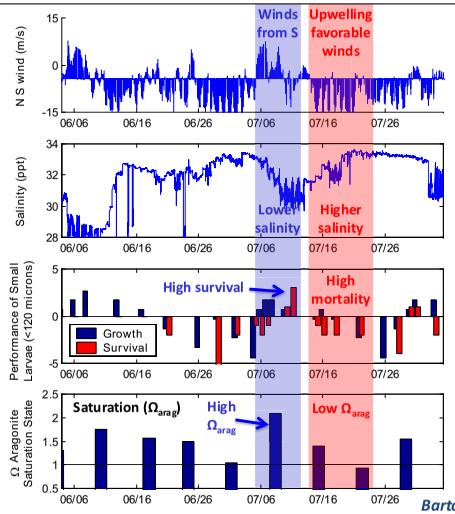
enlarge STEVE RINGMAN / THE SEATTLE TIMES

Seattle Times

Coastal upwelling and oyster larvae

Upwelling linked to high oyster larvae mortality events

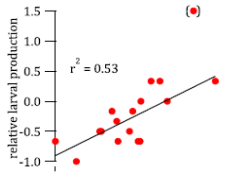




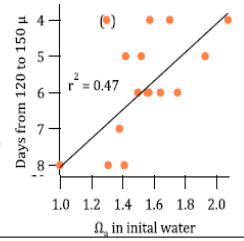
Barton et al., 2012

Oysters in Netart's Bay, OR

Larval production is lower with lower omega$_{arg}$



Larval growth in feeding stage slower with lower omega$_{arg}$

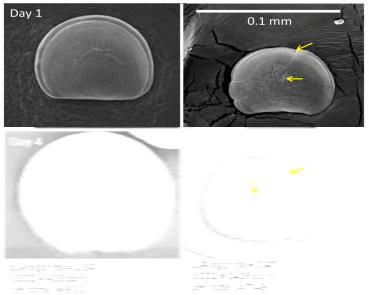


Barton et al., 2012

What we know…

→ Rising atmospheric CO_2 changes ocean chemistry and negatively impacts shelled organisms.

→ Pacific Northwest shellfish are sensitive to reduced calcium carbonate-saturation state within the current range of conditions.



Pacific oyster larvae spawned in favorable (left) and unfavorable (right) seawater conditions

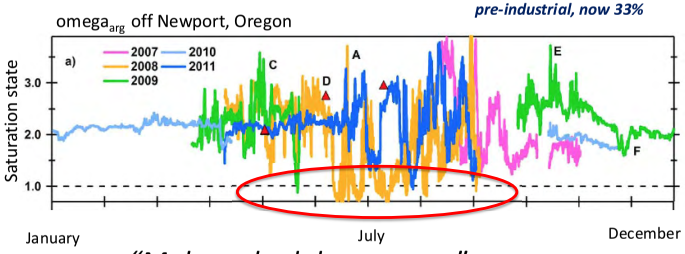
Figure source: E. Brunner and G. Waldbusser, Oregon State University

What we know…

→ Natural and anthropogenic contributions are additive.

→ Anthropogenic contributions to ocean acidification are detectable and have increased the frequency, intensity, and duration of harmful conditions.

Crossed threshold 11% in pre-industrial, now 33%



"Makes a bad day worse…"

Harris et al. 2013

Pacific Northwest waters are particularly vulnerable to ocean acidification

Ocean acidification effects are appearing in the Pacific Northwest decades *sooner* than anticipated.

...regional factors can exacerbate acidification caused by global CO_2 emissions:

Coastal upwelling of CO_2-rich waters

Runoff of nutrients and organic carbon from land-based activities

Decay of organic matter in subsurface waters

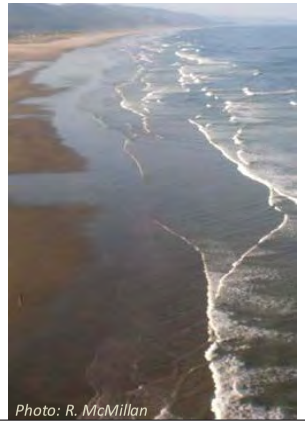
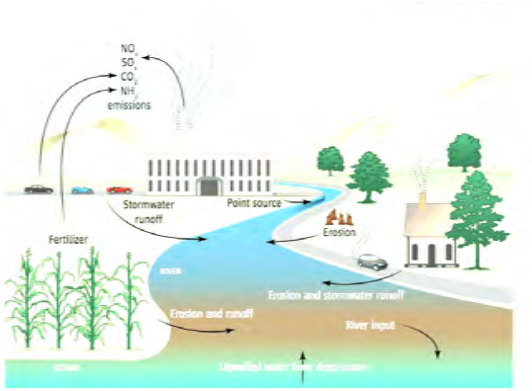


Photo: R. McMillan

Are local stressors contributing too?



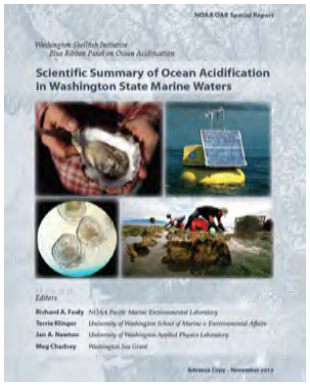
Kelly et al., 2011

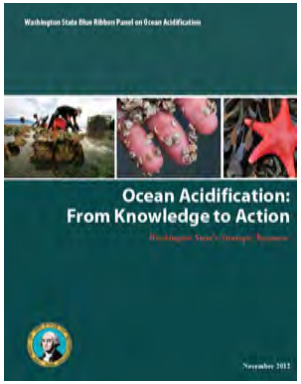
The Washington Blue Ribbon Panel and its results

Bill Dewey
Taylor Shellfish

WA Governor
Christine Gregoire

Washington State Blue Ribbon Panel





http://www.ecy.wa.gov/water/marine/oceanacidification.html

What's at Stake for Washington's Economy?

The most productive commercial shellfish industry on the West Coast

- Washington's shellfish industry generates $270 million annually, and directly and indirectly supports 3,200 jobs.
- Annual sales of farmed shellfish from Washington account for almost 85% of U.S. West Coast sales (including Alaska).

Source: Washington Blue Ribbon Panel on OA; Photos: Benjamin Drummond (left and right); Bryan Penttila (center)

What's at Stake for Washington's Economy?



Valuable wild and recreational fisheries

- Impacts to marine food webs could affect Washington's seafood industry, which generates over 42,000 jobs in Washington and contributes at least $1.7 billion to gross state product.
- Recreational oyster and clam harvesters contribute more than $27 million annually to coastal economies.

Source: Washington Blue Ribbon Panel on OA; Photos (left to right): Washington Association of Conservation Districts, US Dept. Agriculture, City of Seattle

What's at Stake for Washington's Tribes?



Continued identity and cultural survival of Washington's coastal tribes

- Washington tribes depend upon shellfish for food, income, and connection to their cultural heritage.

Source: Washington Blue Ribbon Panel on OA; Photos: Northwest Indian Fisheries Commission

2012: Washington State Blue Ribbon Panel on Ocean Acidification

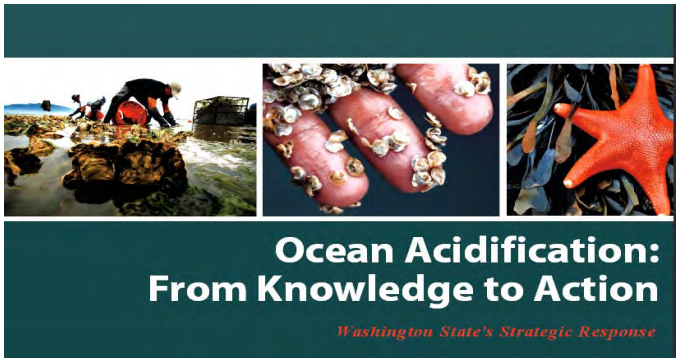
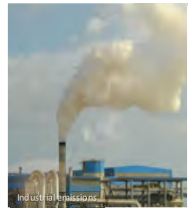


Image: Blue Ribbon Panel Report, 2012

WA Blue Ribbon Panel Recommendations

42 recommendations, including 18 *Key Early Actions*, that will:

1. **Address the root cause of acidification by reducing CO_2 emissions;**



Photos: Oran Viriyincy (top); www.TheEnvironmentalBlog.org (bottom)

WA Blue Ribbon Panel Recommendations

42 recommendations, including 18 *Key Early Actions*, that will:

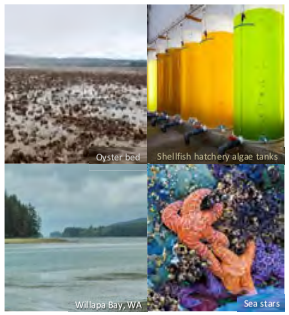
1. Address the root cause of acidification by reducing CO_2 emissions;
2. **Reduce local land-based pollutants that worsen acidification**;

Photos: Wash Dept. of Ecology (top); Kate Boicourt (bottom right); Suvi Geary (bottom left)

WA Blue Ribbon Panel Recommendations

42 recommendations, including 18 *Key Early Actions*, that will:

1. Address the root cause of acidification by reducing CO_2 emissions;
2. Reduce local land-based pollutants that worsen acidification;
3. **Foster adaptation and remediation to protect the shellfish industry and marine ecosystems**;



Photos: Benjamin Drummond (top); Bern Harrison (lower right); Jim Culp (lower left)

WA Blue Ribbon Panel Recommendations

42 recommendations, including 18 *Key Early Actions*, that will:

4. **Increase research and monitoring of acidification in state waters**;

Photos (clockwise from upper left): Wendi Ruef; Michael J. Bok; John Payne, POST Project; Northwest Indian Fisheries Commission

WA Blue Ribbon Panel Recommendations

42 recommendations, including 18 *Key Early Actions*, that will:

4. Increase research and monitoring of acidification in state waters;
5. **Inform, educate, and engage the public, stakeholders, and decision makers in responding to ocean acidification; and**

Photos: Jefferson Co. Marine Resource Committee (top); Center for Microbial Oceanography—Research and Education (bottom); Matt Chadsey (inset)

WA Blue Ribbon Panel Recommendations

42 recommendations, including 18 *Key Early Actions*, that will:

4. Increase research and monitoring of acidification in state waters;
5. Inform, educate, and engage the public, stakeholders, and decision makers in responding to ocean acidification; and
6. **Maintain a sustainable and coordinated focus on ocean acidification.**

Photo: Washington Secretary of State

Washington state Legislative Actions

Established the **Marine Resource Advisory Council**

Established the **Washington Ocean Acidification Center** at the University of Washington

Directed Center to implement actions from **Blue Ribbon Panel recommendations**

Photo: D. Bennett

The Washington Ocean Acidification Center and NOAA research

Washington Ocean Acidification Center

At the
University of Washington
College of the Environment

Dr. Terrie Klinger
Dr. Jan Newton
Co-Directors

- Accelerates and coordinates research and monitoring
- Leverages resources and networks, regional scientists, agencies, industry and institutions
- Provides input to regional assessments, connecting science, management, and policy

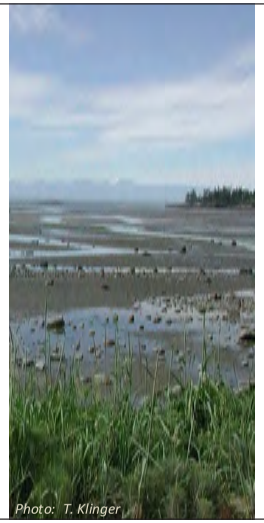


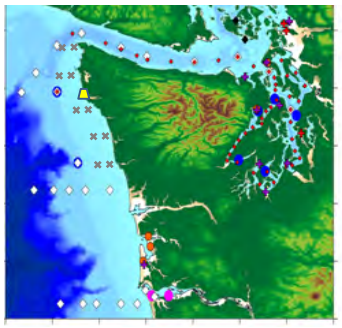
Photo: T. Klinger

Washington Ocean Acidification Center: implementing key Blue Ribbon Panel recommendations

Coordinate and synthesize science to:

1. ***Assess water conditions and what's driving ocean acidification***
   - Monitoring (both in natural environment and at shellfish hatcheries)
2. ***Provide forecasts to facilitate adaptation***
   - Forecast modeling
3. ***Assess how species respond***
   - Biological experiments
4. ***Inform aquaculture practices***
   - Shellfish culture adaptation

1. Assess Washington's waters



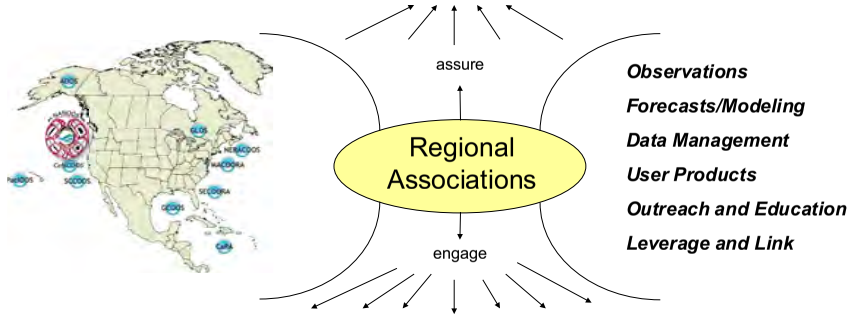
Map: Greeley; Photos: Vander Giessen & USA Today

Strategies:

- Both **chemistry** (DIC, TA) and **biology** measurements
- **Temporal** trends (buoys) & **spatial** coverage (surveys)
- **Leverages** existing networks

IOOS Integrated Ocean Observing System

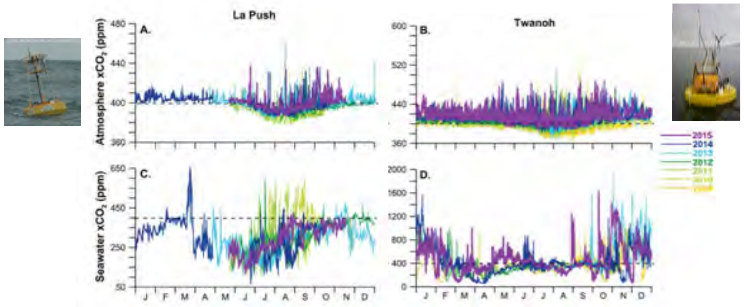
CONSISTENT NATIONAL CAPABILITY



DIVERSE LOCAL STAKEHOLDERS

OUTER COAST vs. PUGET SOUND

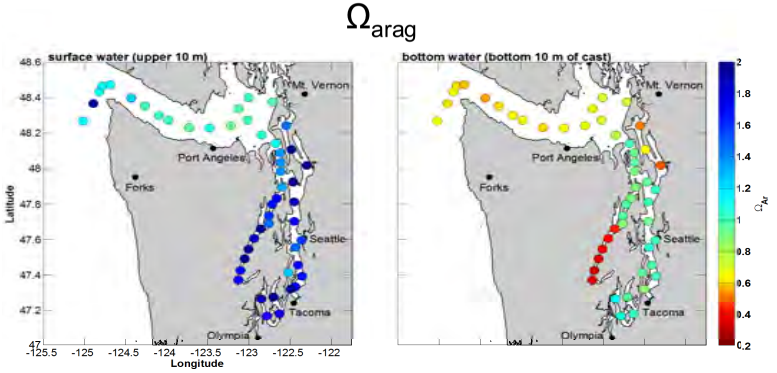
UW-NANOOS buoys w NOAA and WOAC sensors



"Atmospheric measurements at Hood Canal moorings reflect xCO_2 values that are enriched and rising faster than both coastal moorings and globally averaged marine surface air xCO_2."

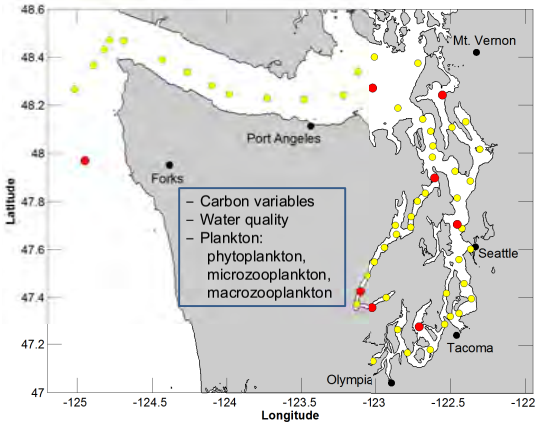
Simone Alin, 2016

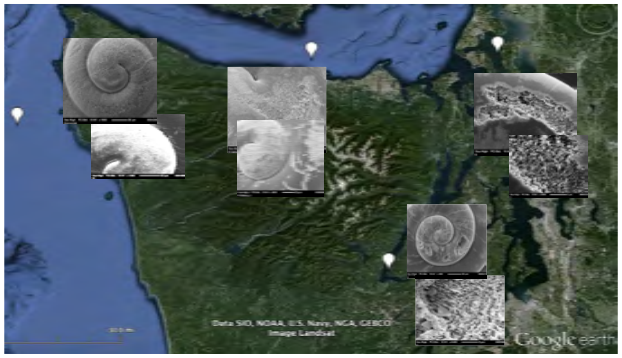
Washington water chemistry



Based on Feely et al., 2010

Integrated Monitoring Stations

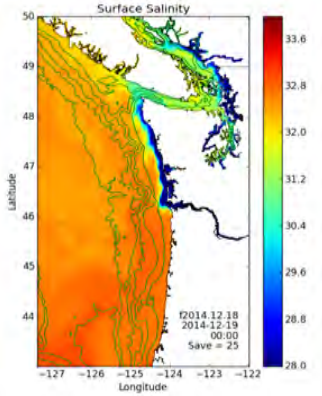




- Strong correlation between intensity of OA and pteropod shell dissolution
- Areas most affected by dissolution are Hood Canal > Whidbey Basin > Strait of Juan de Fuca > outer coast
- Temporally, progression of increased dissolution from spring to fall

Photos: Johnson & Bednarsek, UW

2. Provide forecasts to facilitate adaptation



Model output: MacCready, Banas, Siedlecki

The LiveOcean Daily Forecast Model

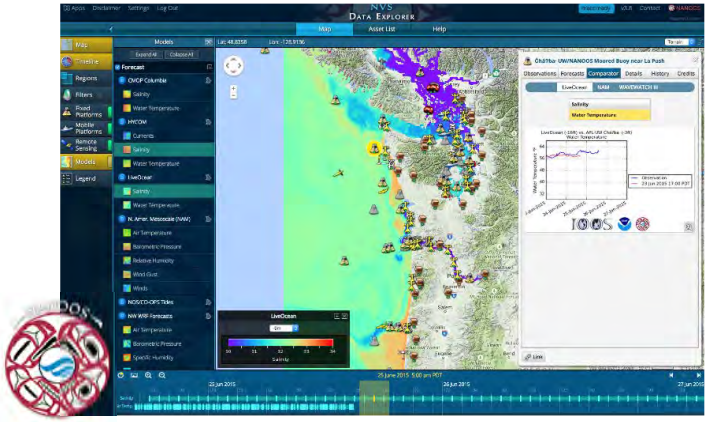
Near-term predictions of ocean acidification in Washington waters

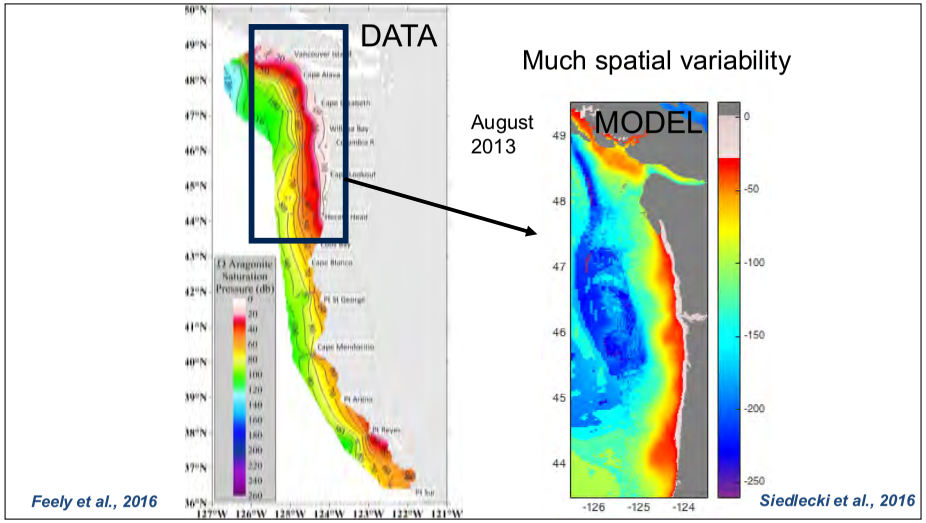
- Parker MacCready
- Samantha Siedlecki
- Ryan McCabe
- Neil Banas

University of Washington & Univ. of Strathclyde

UW Coastal Modeling Group

3-Day forecast appears daily on NANOOS NVS





3. Biological experiments

Exposure to higher levels of CO_2 caused

- Delayed development in crab
- Reduced survival in krill

Photos: McElhany, Keister

4. Shellfish cultivation

Hatcheries serve as working laboratories

- Monitoring **data integrated** with WOAC monitoring network
- Assessing **adaptation** strategies for cultivation

Support: WOAC, PCSGA, and growers

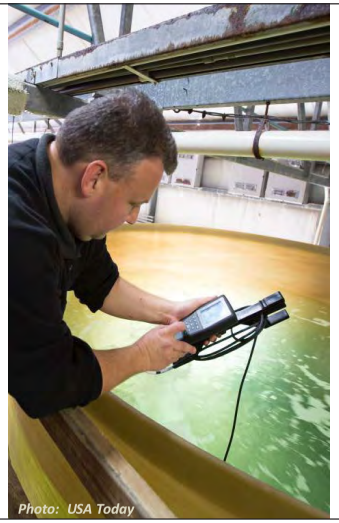
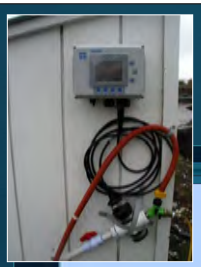


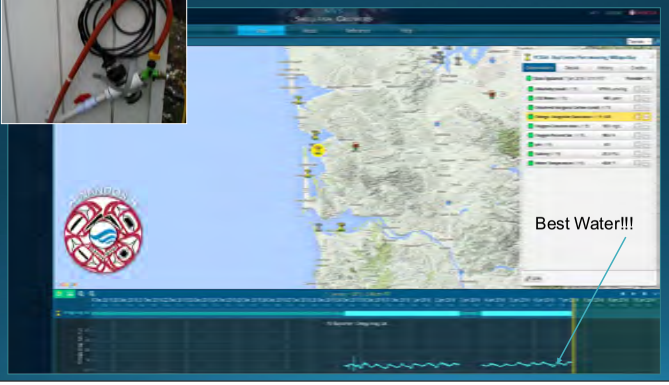
Photo: USA Today

Real Time Data

Slide: Andy Suhrbier Pacific Shellfish Inst.

www.nanoos.org & www.ipacoa.org





Hatchery Modifications

Slide: Andy Suhrbier Pacific Shellfish Inst.

- **Basic:**
  - Choose best water
  - Clean systems
- **Moderate:**
  - Monitor pH and buffer water
    - Sodium Carbonate
- **Advanced:**
  - Monitor Ω aragonite continuously and buffer
  - Long term multi-parameter sampling

West Coast shellfish grower and science collaborations: IPACOA


NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

'Like putting headlights on a car'

Pacific oysters gain from IOOS® data

Promoting

About six years ago, production at some Pacific Northwest oyster hatcheries began declining at an alarming rate, posing severe economic impact and challenging a way of life held by shellfish growers for more than 130 years.

By 2008, the oyster harvest at Whiskey Creek, a major Oregon supplier to the majority of West Coast oyster farmers, plummeted 80 percent. At about the same time, corrosive, acidified seawater was hitting the shores of the Pacific.

Something had to be done. Oyster production accounts for more than $84 million of the West Coast shellfish industry, which supports more than 3,000 jobs.

"When you see oyster shells dissolving in water, there's a compelling need to know why," says Bill Dewey of Taylor Shellfish Farms in Washington state.

Thanks to a $500,000 federal investment in monitoring coastal seawater strengthened by data and observational information from the U.S. Integrated Ocean Observing System (IOOS®) and the NOAA Ocean Acidification Program, oyster hatcheries on the verge of collapse just a few years ago are again major contributors to the $111 million West Coast shellfish industry.

IOOS is a NOAA-led interagency and regional effort aimed at "knowing" — that

"Putting an IOOS buoy in the water is like putting headlights on a car. It lets us see changing water conditions in real time," says Mark Wiegardt, co-owner of Whiskey Creek Shellfish Hatchery.

IOOS = U.S. Integrated Ocean Observing System

NANOOS = Northwest Association of Networked Ocean Observing Systems

Lines of defense for adaptation

Real-time observations at the hatchery or growing sites

Real-time observations at the adjacent estuary, sea, or ocean

Regional forecasts on days to weeks scale (weather)

Forecasts at months to years scale (seasonal to interannual)

Communicated !!

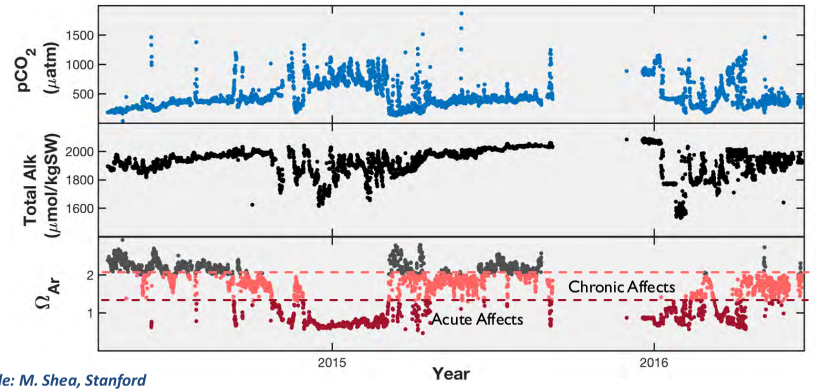
Burke-o-lator System

Burke Hales, Oregon State University

- Continuous pCO_2/TCO_2
- Real-time data display

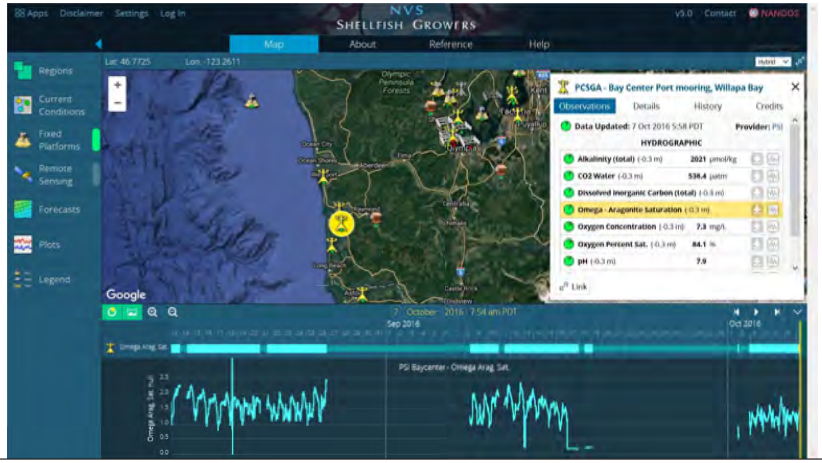
Credit: Meghan Shea

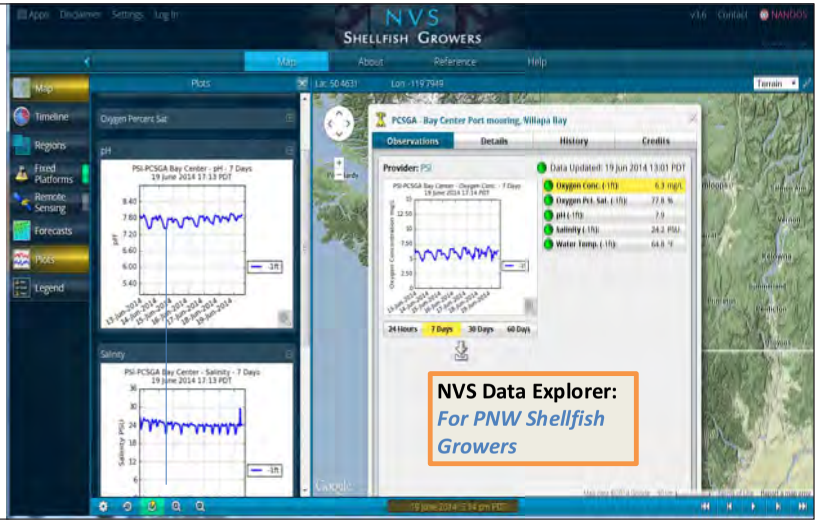
Taylor Shellfish Hatchery, WA
Burke-o-lator data



Slide: M. Shea, Stanford

NANOOS web portal: www.nanoos.org





Monitoring OA for growing shellfish is more than a pH sensor … need to understand aragonite saturation state

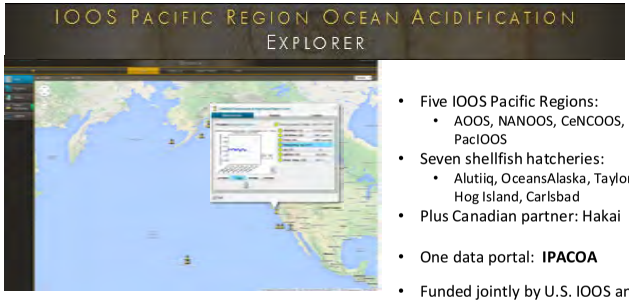
Burke-o-lator *ACDC*

We learned from growers that their **ideal monitoring technology** is:
"…a bullet proof sensor that delivers pH, aragonite saturation, T, and S. **Similar** to the system we have in place now **but lighter and not so crashy**"

Alan Barton, Pacific Coast Shellfish Growers Association monitoring lead

Science-Grower Partnerships

IPACOA: *IOOS Pacific Region Ocean Acidification data portal*

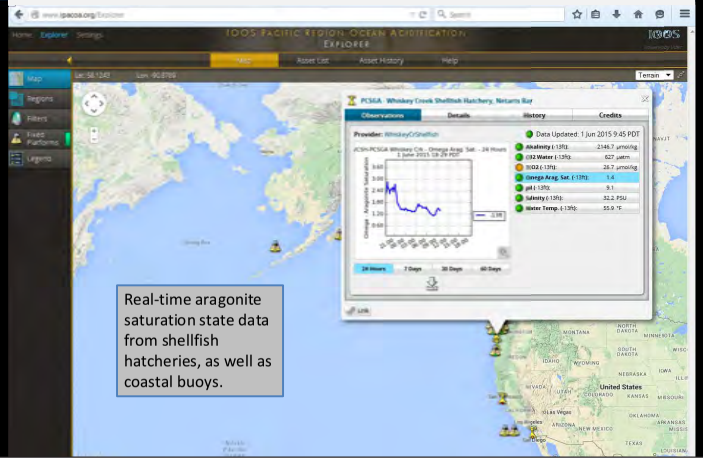


- Five IOOS Pacific Regions:
  - AOOS, NANOOS, CeNCOOS, SCCOOS, and PacIOOS
- Seven shellfish hatcheries:
  - Alutiiq, OceansAlaska, Taylor, Whiskey Creek, Hog Island, Carlsbad
- Plus Canadian partner: Hakai
- One data portal: **IPACOA**
- Funded jointly by U.S. IOOS and NOAA OAP to enhance OA monitoring in shellfish hatcheries

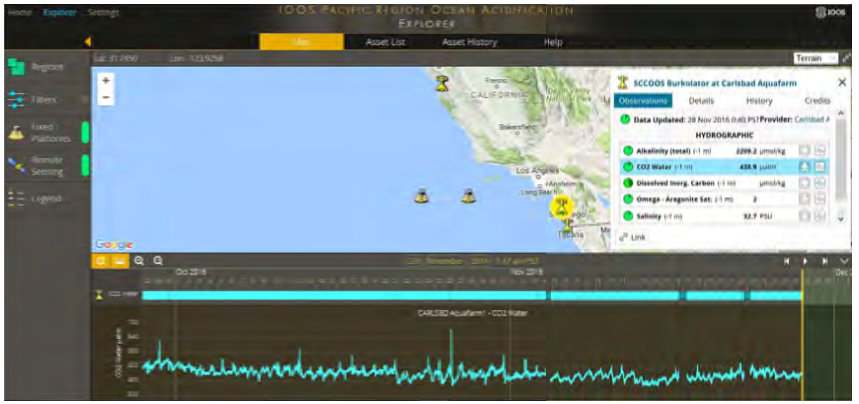
Allows access to real-time data and information links; eventually links to manuals, FAQ, etc. in order to facilitate a 'community of practice' for monitoring.

www.ipacoa.org

IOOS Pacific Region Ocean Acidification Data Portal



Carlsbad Aquafarm, CA: Oct-Nov 2016



Alutiiq Hatchery, AK: Oct-Nov 2016

The Global Ocean Acidification Observing Network (GOA-ON)

GOA-ON
Global Ocean Acidification Observing Network

The Global Ocean Acidification Observing Network

What is GOA-ON?

The **Global Ocean Acidification Observing Network** (GOA-ON) is a **international partnership** to:

1. **Document the status and progress of ocean acidification** in open-ocean, coastal, estuarine, and coral reef environments,
2. **Understand the impacts of ocean acidification on diverse marine ecosystems and societies**, and
3. **Support forecasts of ocean acidification conditions.**

www.goa-on.org