

Ocean Acidification as a Priority in the Wider Caribbean Region:

What we each need to know about how to understand, measure, and respond to this threat to food security, tourism, and natural storm resilience

For the **CEPCOP15**



Mark J. Spalding, President, The Ocean Foundation



Ocean chemistry is changing, and **what is needed** is regional monitoring, capacity building, and transfer of technology to understand regional conditions and concerns, including shellfish, conch, spiny lobster, and coral reefs.

Ocean acidification poses a significant threat to the marine resources, food security, economic activities, and thus the jobs that depend upon them within the **Wider Caribbean Region**.



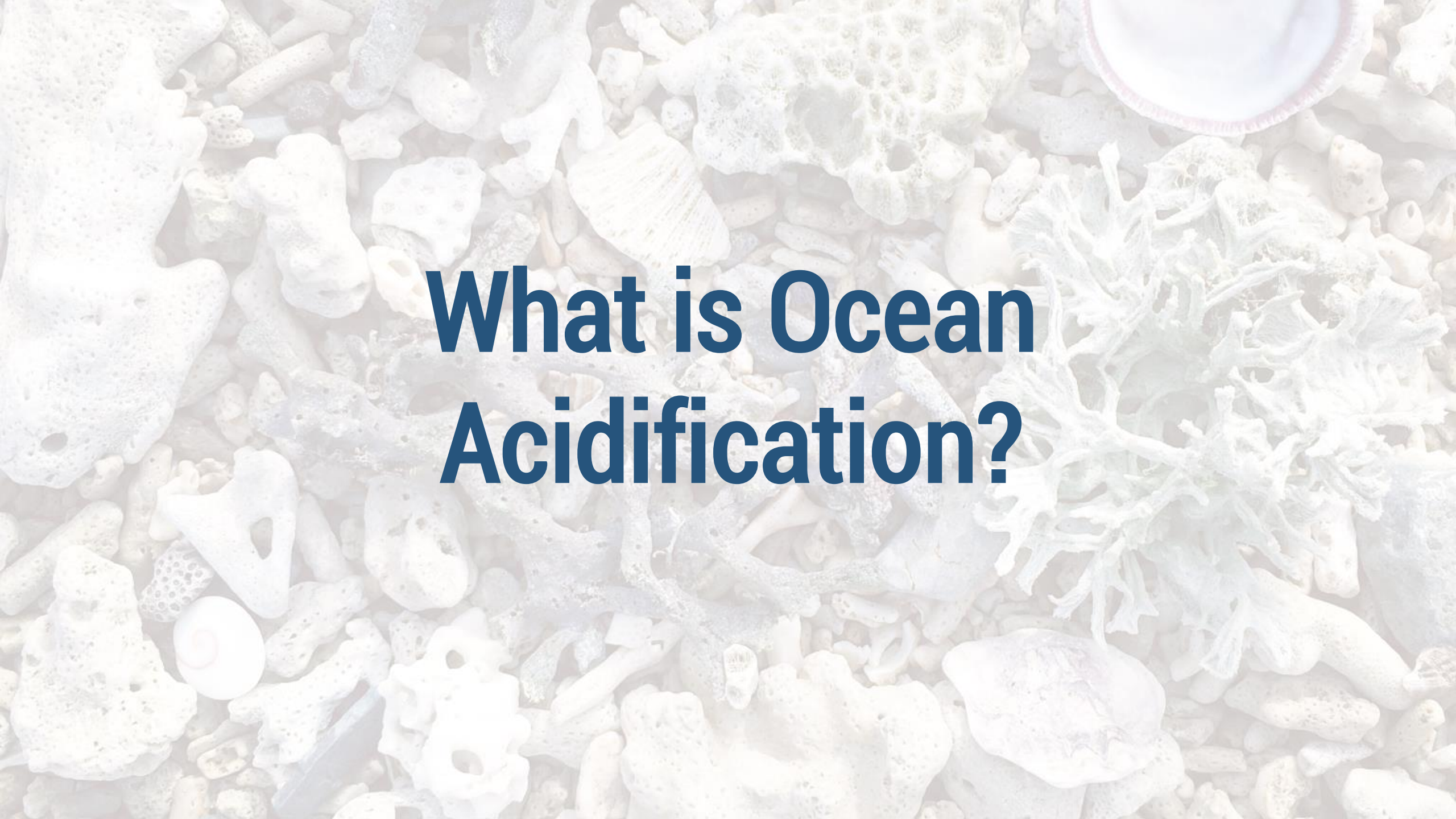
What is The Ocean Foundation?

- The Ocean Foundation (TOF) is the only community foundation for the ocean
- Our mission is to support, strengthen, and promote those organizations dedicated to reversing the trend of destruction of ocean environments around the world

TOF's International Ocean Acidification Initiative

- Founded in 2003 to help vulnerable human communities [understand](#) changes in ocean chemistry, [monitor](#) the changes in their waters, [assess](#) the risks to their social and economic health, and [address](#) the effects with good policy based on strong science



A close-up photograph of a beach covered in bleached coral and shells. The coral is white and porous, and the shells are also white and fragmented. The background is a soft, out-of-focus view of the ocean and sky. The text "What is Ocean Acidification?" is overlaid in the center in a bold, dark blue font.

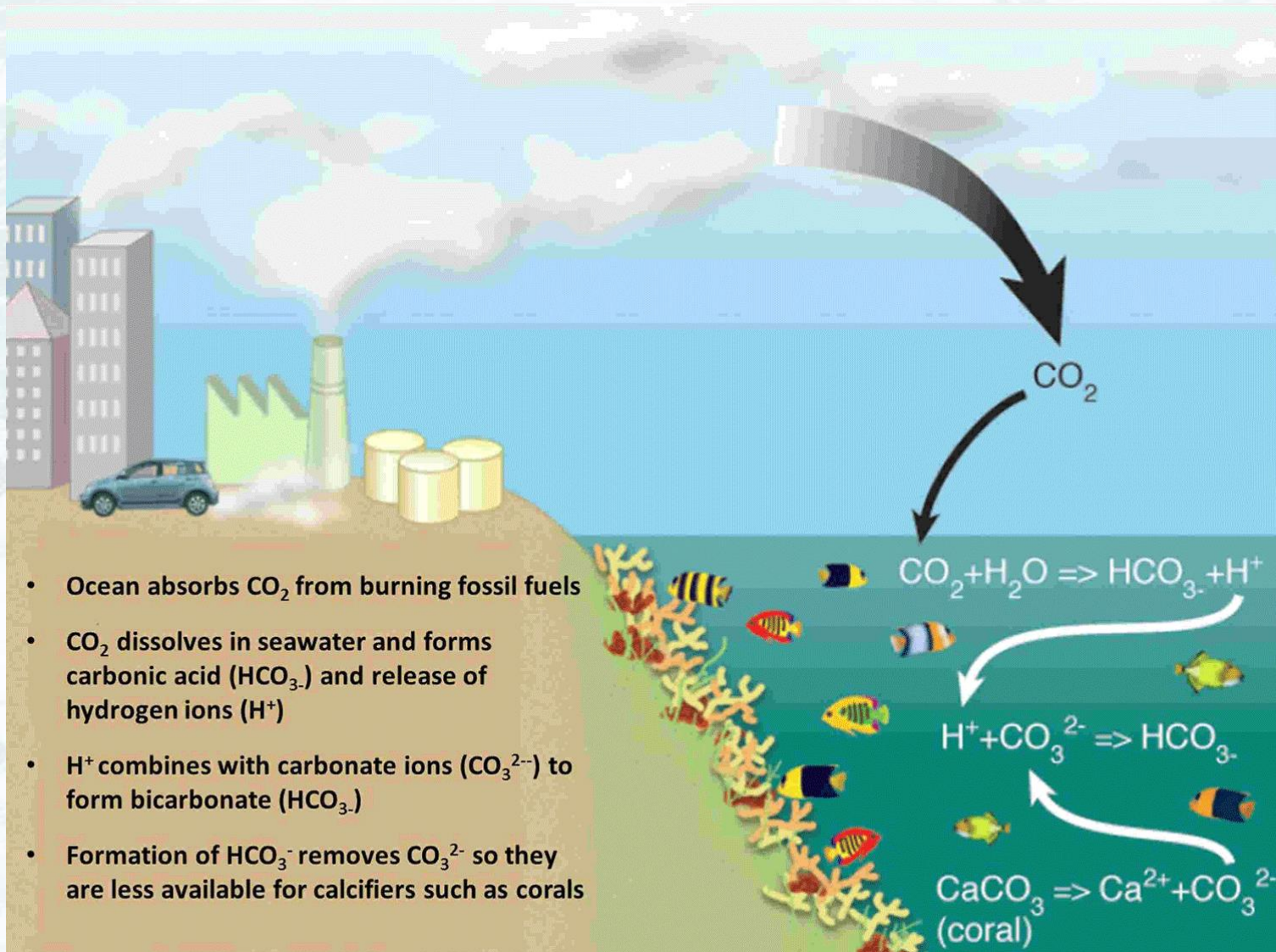
What is Ocean Acidification?

Summary of OA Science

- Well documented, **progressive increase in the acidity** of the ocean
- Acidity increases as the pH decreases
- OA is also changing seawater carbonate chemistry. The concentrations of dissolved CO_2 , hydrogen ions, and bicarbonate ions are increasing, and the concentration of carbonate ions is decreasing



We Are Changing Ocean Chemistry



- The ocean absorbs **approximately 1/3 of the CO_2** emitted into the atmosphere → more CO_2 in the atmosphere, more CO_2 in the ocean
- There is nothing in the **historical record** that equals our current rate of change in pH of the ocean
- Like climate change, caused primarily by **carbon emissions** and **variable across space and time**



Lack of Predictability

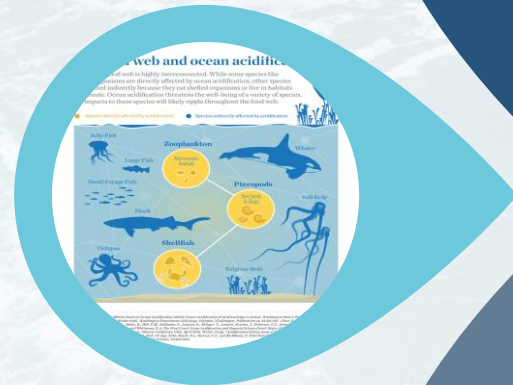
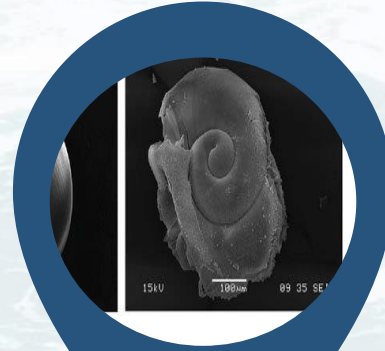
- OA (like rising sea levels, increased sea surface temperatures, increases in pollutants, and other physical disruptions) impacts ecosystems in a **dynamic** and **non-linear** way
- OA changes **daily** and **seasonally**
- Each marine organism and habitat structure will react to the varying impacts of OA differently, leading to some “winners” and some “losers”
- These different reactions will change both **community and ecosystem structure** in **unpredictable** ways



Ecosystem and Species Impacts

Direct Mortality

E.g. due to net dissolution or inability to form feeding parts in shellfish



Food Web Impacts

Loss of key links in the food web

Loss of Function, Fitness, or Quality

E.g. sensory disruptions, change in protein composition of species, change in reproduction



Loss of Biodiversity

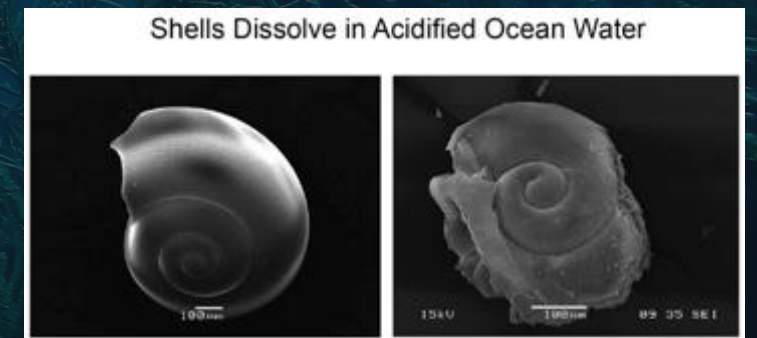
Unstable or new ecosystem regimes



Marine Food Chain

- OA affects the very base of the food chain: the krill and pteropods that bigger fish feed on that, in turn, allow them to grow big enough for human consumption.
- Studies estimate that by 2050, pteropods may be unable to form their **calcium carbonate shells**.¹
- Eradicating the base of the food chain will have rippling effects throughout the food webs that depend on them.

¹Orr, J. C., et al. (2005). Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature*, 437: 681-686.

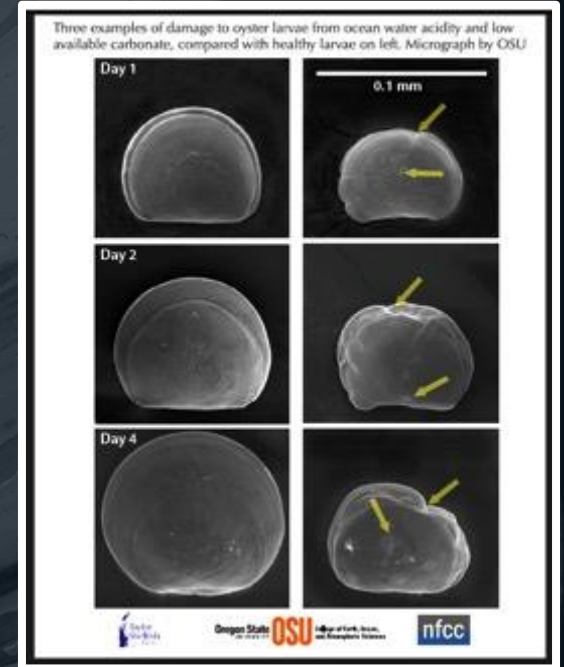


Healthy pteropod shell (left) and degraded pteropod shell due to OA (right). Source: NOAA



Mollusks

- Mollusk: soft-bodied animals that typically have external shells, including oysters, mussels, clams, and crustaceans.
- Mollusks and crustaceans show **negative responses** to acidification at various life stages.
- Scientists at James Cook University found that significant **mortality in juvenile giant clams** occurred at projected pH levels for 2050 & 2100.
- Scientists at Stony Brook University found that the larvae of bay scallops and hard clams **grow best at pre-industrial pH levels**, while their shells corrode at projected pH levels for 2100.¹
- In the Pacific Northwest, oyster larvae **death** has been **linked to** the **upwelling** of acidic water.²
- Mollusks and crustaceans comprise **22.8%** and **9.7%** of the global marine catch, respectively, representing **\$15.857 billion** and **\$30.864 billion**.³



Three examples of damage to oyster larvae from ocean water acidity and low available carbonate, compared with healthy larvae on left. Micrograph by OSU.

¹Talmage, S. C. and C. J. Gobler. 2009. The effects of elevated carbon dioxide concentrations on the metamorphosis, size, and survival of larval hard clams (*Mercenaria mercenaria*), bay scallops (*Argopecten irradians*), and Eastern oysters (*Crassostrea virginica*). *Association for the Sciences of Limnology and Oceanography*. 54(6), 2072-2080. doi:10.4319/lo.2009.54.6.2072

²Grossman, E. (2011). *Northwest Oyster Die-offs Show Ocean Acidification Has Arrived*. Yale 360.

³*The State of World Fisheries and Aquaculture: Opportunities and Challenges*. Rome: Food and Agriculture Organization of the United Nations, 2014. Print.



Jellyfish

- Decreased ocean pH has been **tenuously** linked with increased jellyfish numbers, but it is unclear if a more acidic ocean is the direct cause.¹
- Regardless, it appears that OA **does not harm** jellyfish reproduction or development as it does for many other marine organisms.²
- Being a key predator in pelagic systems, jellyfish affect the abundance of zooplankton, fish larvae and eggs (**affecting fish population recruitment**).

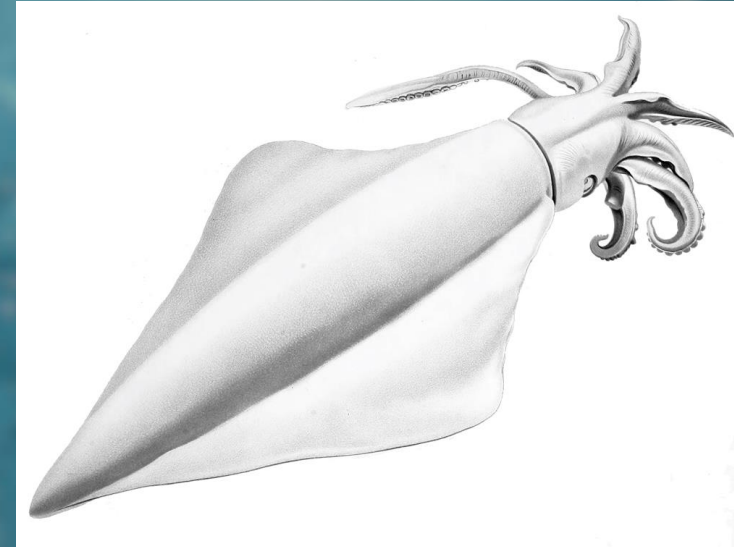
¹Attrill, M.J. et al. 2007. Climate-related increases in jellyfish frequency suggest a more gelatinous future for the North Sea. *Limnol. Oceanogr.* 52, 480-485.

²Winanas, A. K., and J. E. Purcell (2010). Effects of pH on asexual reproduction and statolith formation of the scyphozoan, *Aurelia labiata*. *Hydrobiologia*, 645:39-52.



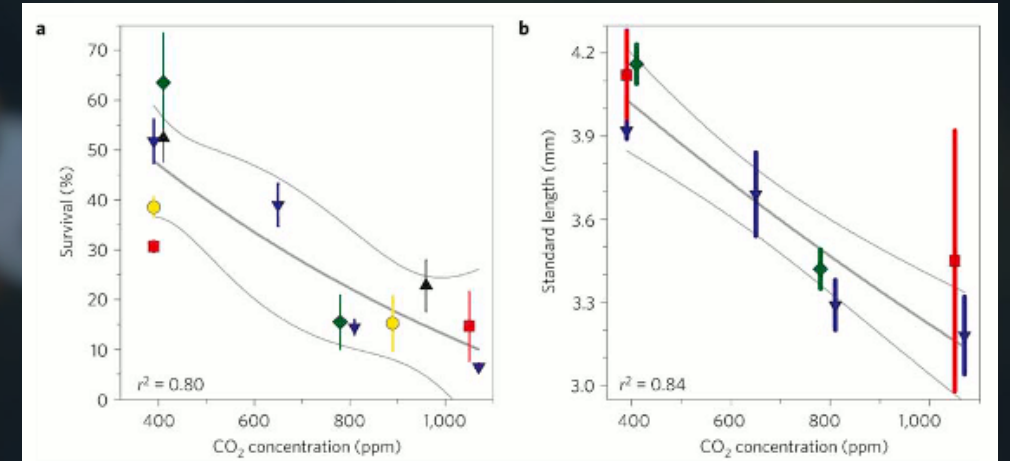
Squid

- Squid use a form of high-energy jet propulsion that requires them to consume large amounts of oxygen.
- Increased ocean acidity may inhibit squid's ability to transport such large amounts of oxygen, **impeding their hunting and survival behaviors**.
- A loss of squid would **affect the commercial species** that feed on it (tuna and swordfish) and would hurt the squid fisheries in the Gulf of California.
- Squid are a large **food source for many toothed whale species**: Sperm whales eat an estimated 220 billion pounds of squid per year.



Fish Biology

- Studies with clownfish larvae raised in a lab show that they lose their ability to both **sniff out predators** and **find their way home** when ocean pH drops below 7.8.¹
- Similar studies show fish may have **orientation problems** due to variable otolith growth rates caused by OA.²
- Multiple studies show that **decreased pH may be fatal** to several fish species at various stages of their life cycle.³



Increased mortality (a) and shortened length (b) of fish larvae (inland silverside) with rising CO₂. Each color and shape represents a different experiment. Points represent means ± 1 standard deviation. Source: Baumann (2011).

¹Munday, P. L. et al. 2009. Ocean acidification impairs olfactory discrimination and homing ability of a marine fish. *Proceedings of the National Academies of Sciences*. 106(6): 1848-1852. doi:10.1072/pnas.0809996106

²Checkley, D.M. et al. 2009. Elevated CO₂ enhances otolith growth in young fish. *Science*. 324, 1683.

³Baumann, H. et al. 2011. Reduced early life growth and survival in a fish in direct response to increased carbon dioxide. *Nature Climate Change*. 2:38-41. doi:10.1038/nclimate1291

³Frommel, A. Y. et al. 2011. Severe tissue damage in Atlantic cod larvae under increasing ocean acidification. *Nature Climate Change*. 2: 42-46. doi:10.1038/nclimate1324



Coral Reefs (As Fish Habitat)

- In a 2011 study of coral reefs off Papua New Guinea, scientists found that **when pH dropped to 7.8**, reef **diversity declined** by as much as **40%**.¹
- One study estimates that reef-building corals and calcifying macroalgae will **calcify up to 50% less** relative to pre-industrial rates by the middle of this century.²
- A loss of reef building organisms **threatens** both the geological and biological **identities** of coral reef ecosystems.

¹Fabricius, K. E. et al. 2011. Losers and winners in coral reefs acclimatized to elevated carbon dioxide concentrations. *Nature Climate Change*. 1, 165-169. doi:10.1038/nclimate1122

²Kleypas, J.A., and C. Langdon. 2006. Coral reefs and changing seawater chemistry. 73-110 in *Coral Reefs and Climate Change: Science and Management*. J.T. Phinney, W. Skirving, J. Kleypas, and O. Hoegh-Guldberg, eds, American Geophysical Union, Washington, DC.



Seagrasses (and Fisheries)

- Certain habitats and species of seagrass might “benefit” from increased CO² concentrations in seawater.
- Seagrasses sequester carbon dioxide and may now be able to thrive in areas beyond their historic range.
- However, many juvenile animals that live in seagrass habitat will be negatively affected.

Photo Credit: Heather Dine, NOAA



The background of the slide is a close-up photograph of a coral reef that has been severely bleached. The coral appears as a dense field of white, porous, and skeletal fragments, with very little of its natural color remaining. The texture is highly irregular and porous. In the upper right corner, a small portion of a white, circular object with a pinkish-red border is visible, possibly a piece of coral or a shell. The overall lighting is bright, highlighting the stark whiteness of the bleached coral.

Social and Economic Impacts of Ocean Acidification

Social & Economic Activities at Greatest Risk

- “Small scale fisheries and mariculture...;
- Poorer communities and social groups dependent on subsistence fisheries, with potential gender inequalities;
- Economies reliant on aquaculture or threatened ecosystems, such as coral reefs;
- Poorly diversified local economies.”



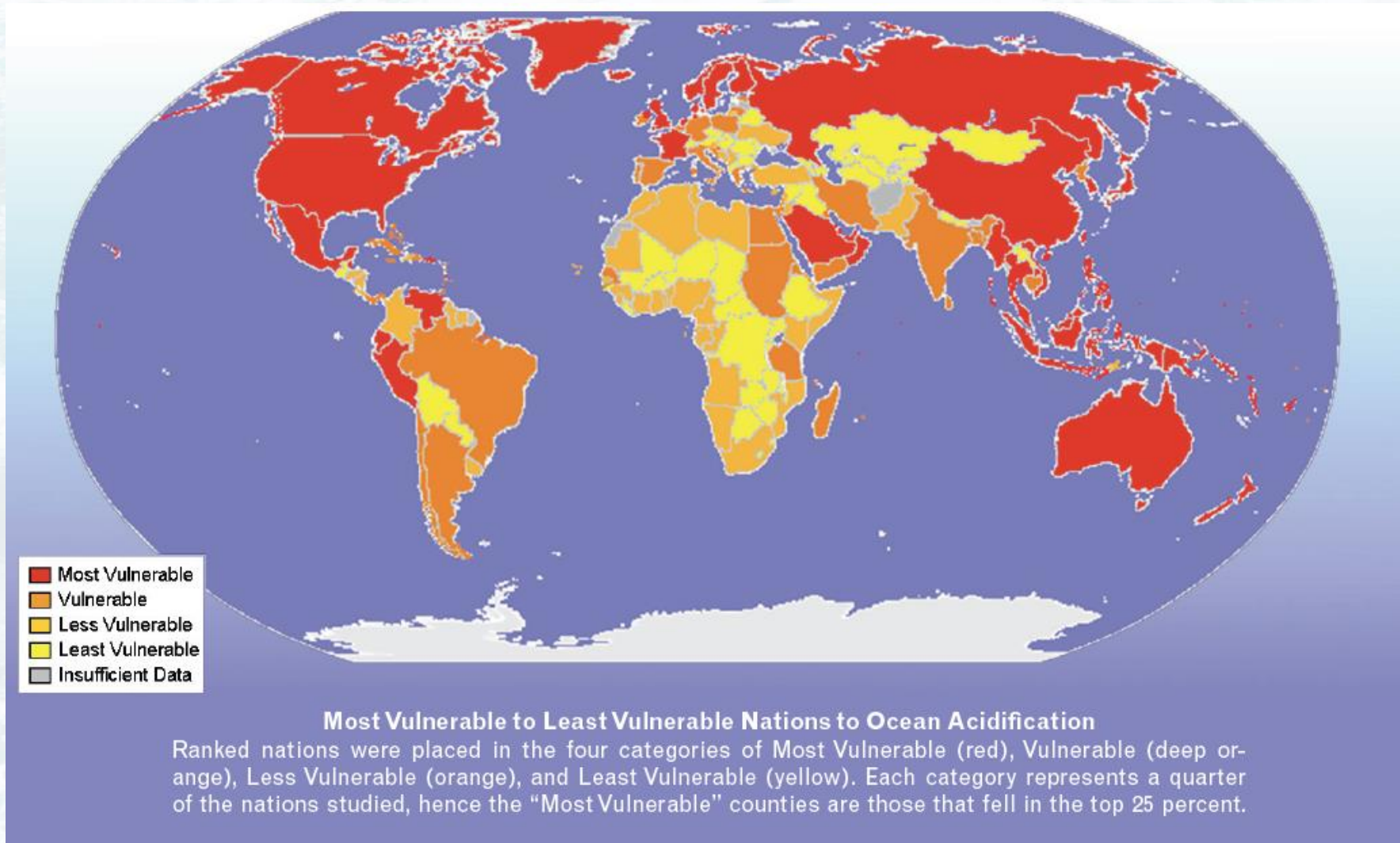


What's at Risk?

- Ecosystem integrity
- Fisheries
- Food security
- Trade and commerce
- Tourism and infrastructure
- And many more activities...



More than a third of the world's population will be strongly affected by acidification



Social and Economic Impacts

Direct Harvest

Shellfish harvesters, fishers, pearl farmers



Ecosystem Services

Physical protection, tourism income, cultural value



Food and International Security

Provision of protein, stability through stable food supplies



Business and Community Services

Services and infrastructure built on or made possible by the industry



What's at Risk?

Seafood Jobs, Income, and Tax Revenue



Ocean acidification threatens **the prosperity of all nations** that catch, farm or eat fish, or depend on coral reefs for food

- **Food Security Disruption**
 - Need for more imports
 - Forced Migration (refugees)
 - Community Life Disrupted (political instability)
- **Job Loss and Loss of Revenue**
(commercial fishing, artisanal, and aquaculture)





What's at Risk?

Tourism and Infrastructure



Ocean acidification threatens the health of all nations that depend on coral reefs for tourism or storm protection

- **Decline** of coral reef health & marine life that attract tourists
- **Reduced profits, tax revenue, and employment** in tourism industry
- **Damage** to tourist and community infrastructure due to loss of storm protection from reefs
- **Loss** of ocean-based cultural heritage and community benefits



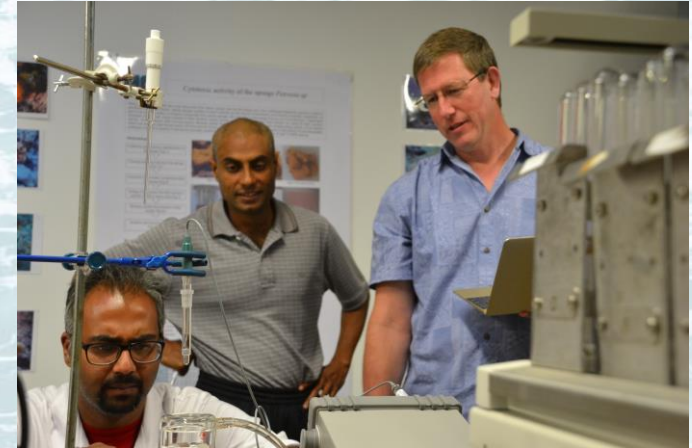
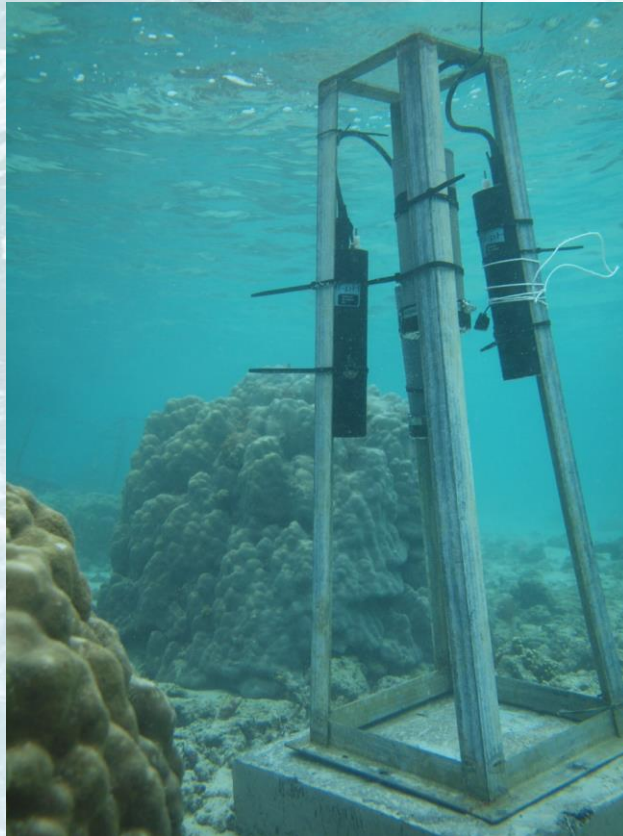
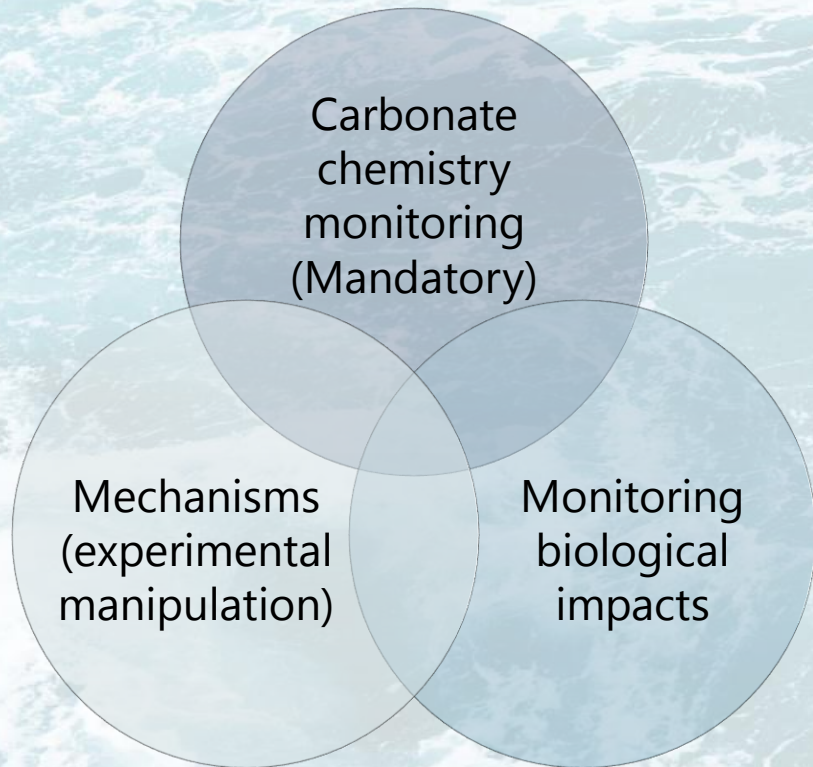
The background of the slide is a close-up photograph of various coral reef fragments, including sponges and branching corals, scattered on a light-colored surface. In the top right corner, a portion of a white plate with a red rim is visible. The text is overlaid on this background.

SOLUTIONS: Building Science Capacity

Why Monitor?



An Accessible Kit to Collect Weather-Quality Data (GOA-ON in a Box)



Approaches to Adaptation

Modifying the Growing Environment

Creating hatcheries or growing facilities for vulnerable species

Manipulating water chemistry based on species vulnerability

Management Strategies

Continuous monitoring and forecasting in production regions

Selective siting of farms or other production facilities

Fisheries management that takes into account species vulnerability

Alternative Livelihoods and Financing

Diversification of jobs in regions with high dependence on vulnerable species

Alternative financing or insurance mechanisms (e.g. reef insurance)



Approaches to Mitigation

Reduction of Global Carbon Inputs

Transition away from fossil fuels at global scale

Reduction of Local Carbon Inputs

Regulation and reduction of nutrient inputs

Sequestration Through Blue Carbon

Local and global mitigation through mangrove, seagrass, or saltmarsh protection/restoration



The background of the slide is a close-up photograph of a coral reef. It features a variety of coral species, including branching corals, brain corals, and other porous structures, all in shades of white and light beige. In the upper right corner, a portion of a white, smooth shell with a pinkish-red rim is visible. The overall scene is brightly lit, creating a clean and natural aesthetic.

Governance and Building Legislative Capacity

The Goal of Governance and Action

Promote More Resilient Coastal Communities

Protecting and defending coastal habitats, thus enhancing food security, improving resiliency, and protecting local economies

Bringing together scientists, business leaders, coastal and fisheries planners, as well as key decision-makers to enable cross-sector collaboration towards

adaptation
Utilizing existing frameworks and meeting international commitments, such as UN SDG 14.3



Legislative Approaches

Approaches can include adoption of policies:

Requiring **adaptation**, such as adoption of early warning systems, hatchery intake valve controls, adding alkaline materials to buffer water

Requiring **mitigation**, such as actions that restore and protect blue carbon habitats; that address runoff and other land-based pollutants; and that otherwise enhance natural infrastructure to increase ecological and economic resilience for the communities

Providing funding for long term, continuous **monitoring** or observations of ocean chemistry change

Providing funding for scientific **research** study of the impacts of ocean chemistry change

Removing barriers to research, such as reducing duties on imported monitoring equipment

We are in initial discussions to implement a second round of trainings with key decision-makers from Fiji and the Republic of Marshall Islands. Participants will include actual decision-makers who have the authority to develop and advance important policy approaches for these two nations.



Governance Strategies

Incentivize development of adaptation strategies for aquaculture and fisheries

Bring ocean acidification considerations into the core of aquaculture and fisheries management decision processes

Consolidate and build on international cooperation

Reduce greenhouse gas emissions (even local emissions reductions make a difference)

Reduce local sources of acidification, if present and feasible (e.g. nutrient run off)

Reduce other (multiple and cumulating) stressors / threats to the marine environment to enhance overall ecosystem resilience

Restore coastal and ocean carbon sinks

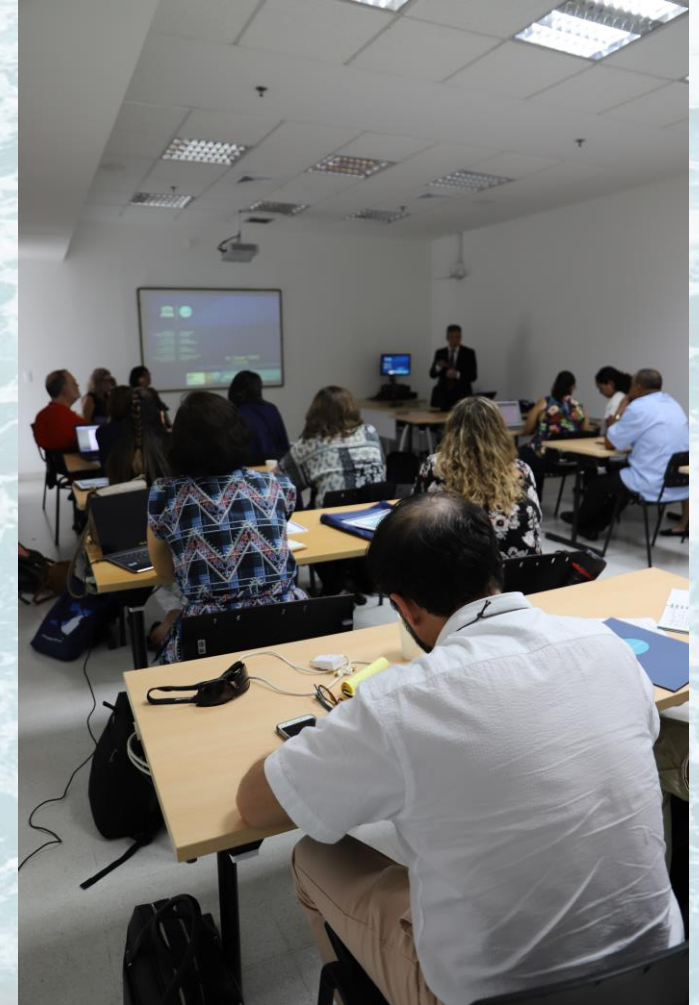
Recognize ocean acidification as a root cause of current and potential food insecurity that could lead to food refuge migration and related security issues

Sufficient international planning and financing for adaptation with increased capacity building in vulnerable countries



Collecting and Sharing a Toolkit

- TOF created a toolkit for policy-makers designed to foster legislative and regulatory responses to ocean acidification including scientific research, monitoring, adaptation, and mitigation strategies (TOF OA Policy Toolkit).
 - Best practices and a comprehensive collection of examples of legislative approaches to date.
 - Fact sheets and international actions for context etc.
 - Draft adaptable templates for various elements of ocean acidification and blue carbon legislation
- At each TOF training, the toolkit is shared with region-specific examples of policies that could best fit their individual countries based on significant research and direct outreach to the participants.



The background of the slide is a close-up photograph of a coral reef that has been severely bleached. The coral appears as a dense field of white, porous, and skeletal structures, indicating a loss of their natural color and vitality. The lighting is bright, highlighting the intricate textures and shapes of the bleached coral.

Collaborating to Address Ocean Acidification

SDG 14: Life Below Water



SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Target	Indicator
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations

- SDG Target Indicator 14.3.1 was recently upgraded from Tier III to Tier II, meaning the “Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.” The custodian agency for this indicator is IOC-UNESCO.
- The Ocean Foundation's International Ocean Acidification Initiative, with partners such as GOA-ON and IOC-UNESCO, directly supports the ability of countries to meet this commitment.



Deliverable	Achievement to Date
<p>Capacity building through the training of 120 scientists in ocean acidification monitoring techniques through six regional training workshops (two in South America, one in the Arctic, one in the Caribbean, one in Africa, and one in the Pacific Islands). Scientists who receive training will be eligible to receive all equipment and materials needed to collect high-quality ocean chemistry data.</p>	<ul style="list-style-type: none"> • 6 regional trainings held • Over 100 scientists trained • One new regional monitoring hub formed
<p>Increased monitoring capabilities through the development and delivery of 12 GOA-ON in a Box Kits.</p>	<ul style="list-style-type: none"> • 17 kits delivered to 16 countries
<p>Increased international collaboration and research through support for the Pier-2-Peer mentorship program, regional convening calls, five four-week internships for junior-level scientists per year, for a total of 12 internships and 18 travel opportunities.</p>	<ul style="list-style-type: none"> • 9 Pier-2-Peer scholarships awarded • 4 travel grants awarded
<p>Increased global policy and mitigation efforts through international and domestic stakeholder engagement, communication to policy makers, and support for drafting legislation (including one policy convening meeting per year, five international policy stakeholder trips, and five domestic policy stakeholder trips, for a total of three policy convenings, 15 international policy stakeholder trips and 15 domestic policy stakeholder trips).</p>	<ul style="list-style-type: none"> • 2 regional policy trainings • 1 national policy training • 1 regional resolution introduced • Over 50 policymakers trained • 1 policy toolkit developed

International

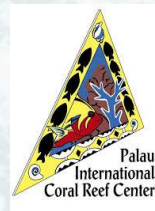
- We worked with Mexico to insert OA into UNEA 4, we will be likely to succeed for UNEA 5
- Forthcoming Commonwealth Secretariat Background Document on Ocean Acidification

Wider Caribbean Region

- OA was named as a topic of regional concern at the UNESCO IOCaribe meeting in Aruba in May 2019



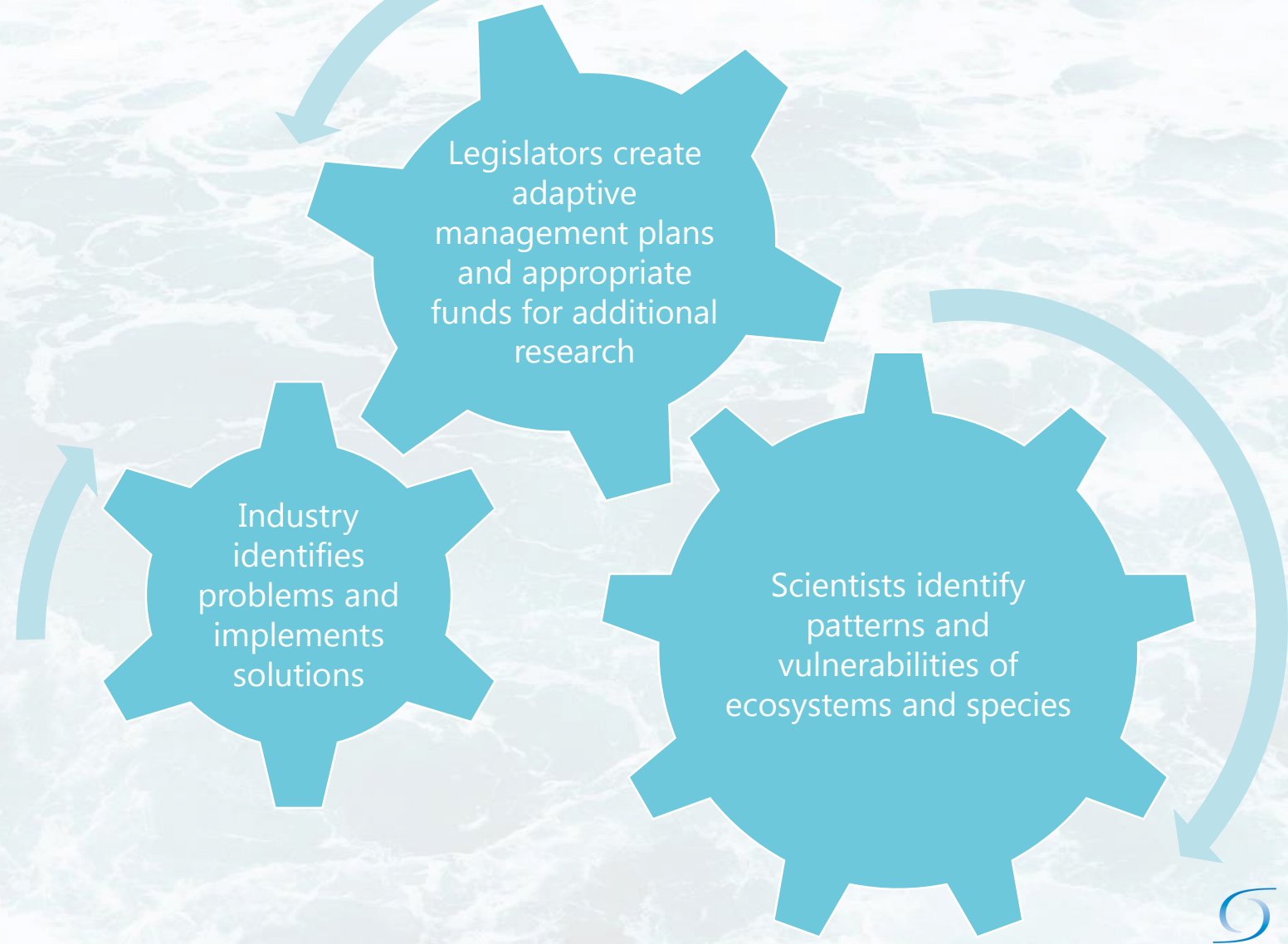
Our work is made possible by our partners



The background of the slide is a top-down view of a beach covered in various types of coral and seashells. The coral pieces are mostly white and light grey, with some darker, more intricate branching structures. The shells are small and scattered throughout. The overall scene is bright and natural. The word "CONCLUSION" is centered in a bold, dark blue font.

CONCLUSION

Bridging the Gap: Collaboration as Key to Success



How We Can Help

- TOF's IOAI could support regional capacity development by replicating its cost-effective and efficient delivery of training and technical assistance
- TOF can provide one-on-one coaching from the experts who have drafted and successfully passed OA legislation
- TOF is working to establish a network of national centers of excellence on ocean acidification monitoring, mitigation, and adaptation



STAC to SPAW to CEPCOP15

- December 2018, TOF attended the Eighth Meeting of the Scientific and Technical Advisory Committee (STAC) to the Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region (the SPAW Protocol) and presented the following recommendations (and included in the Decision of SPAW COP10 without amendment on Monday, June 3rd):
 - **Recognize ocean acidification** as regional topic of common concern to be acknowledged by the SPAW Protocol.
 - Partner with The Ocean Foundation to **implement ocean acidification monitoring and mitigation** projects in key marine ecosystems.
 - Seek **joint collaboration** for proposals to expand funding opportunities.



Thus, as recommended by the STAC, The Ocean Foundation is ready to:

- Work with CEP and address **ocean acidification as a regional topic of common concern**
- Integrate and **strengthen the region's Blue Economy** by supporting adaptation, mitigation, and conservation through ecosystem-based management
- Implement strategies that predict, prevent, and reduce climate disruption effects on coastal communities and Blue Economies through adaptation and mitigation addressing harmful algal (macro and micro) blooms, ocean acidification, ocean warming, sea level rise, storm intensity, and other related phenomena
- Pilot coastal and nearshore restoration and protection as adaptation and mitigation strategies for climate disruption and for reduction of these other and cumulative stressors





THE OCEAN FOUNDATION

Thank You

Mark J. Spalding, President
mbspalding@oceanfdn.org

Alexis Valauri-Orton, Program Manager
avalauriorton@oceanfdn.org

The Ocean Foundation | 1320 19th Street NW, 5th Floor | Washington, DC 20036 | www.oceanfdn.org

