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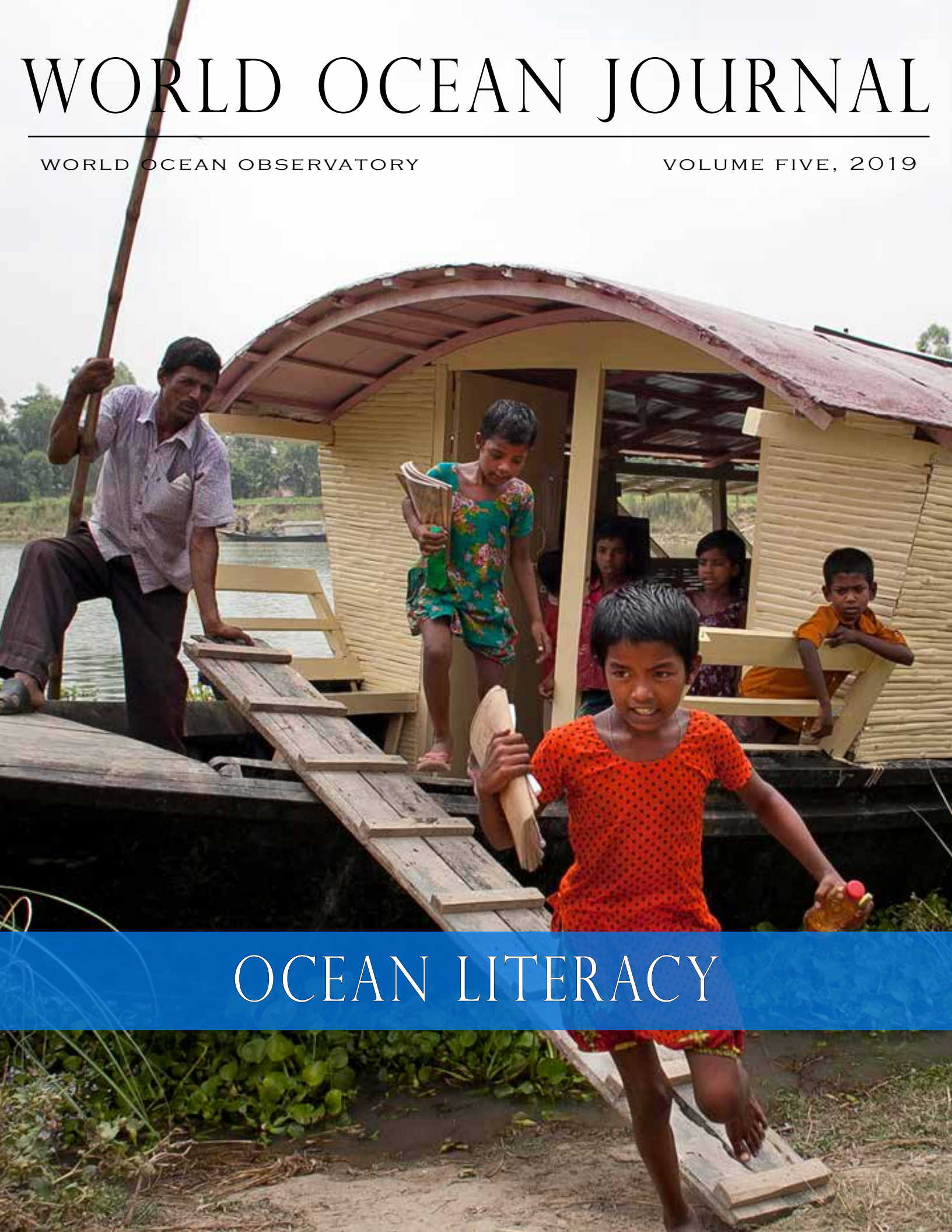

OCEAN LITERACY

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OCEAN LITERACY: EDUCATING & ENGAGING THE NEXT GENERATION OF OCEAN STEWARDS

ON THE COVER

Shidhulai Swanirvar Sangstha, a solar-powered floating school located in Bangladesh

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WORLD OCEAN JOURNAL
is a publication of the World Ocean Observatory. WOJ is a digital magazine on ocean culture and solutions to today's ocean issues. Each volume includes essays, articles, interviews, art, exhibits, and performances profiling the vital impacts of the ocean on our lives. This and future editions focus on a particular theme.

WORLD OCEAN OBSERVATORY
is a major utility for ocean communication as a means to advance public awareness and political will, and is dedicated to providing information and education about the health of the ocean. It is our belief that the sea connects all things.

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CONTACT
director@thew2o.net

OCEAN LITERACY: AN INTRODUCTION

by Peter Neill

We think of ourselves as literate people. We put full value on education, our ability to read and write, to analyze and distill from history as experience, archive, memoir, and material things toward a more complete understanding of where we live, how we live, and what we live for. We are social beings; our stories are narratives of human interactions, among ourselves over time and with Nature as source of substance and sustenance for what we call civilization.

To know is to observe, to organize our observations, and to apply that knowledge as invention, exchange, and communication. This latter is so important. Are we truly knowledgeable if we are unable to communicate what we know? Literacy is functional communication, in the form of words, equations, visualizations, and songs. We are literate when all our senses are applied as sensitive and sensual response to the course of human events.

Key to that response is engagement with the natural world. And the ocean represents 71% of that world in its most literal iteration. We cultivate the surface layers of the land – as agriculture, manufacture, extraction, and settlement. We claim to know a lot about that scape, but not enough to protect it from the consequence of exploitation. As a result, the land approaches exhaustion, not so much a garden as a refuge, not so much a place for abundance as a wasteland for the detritus of our irresponsible consumption. We approach a point when literate people must not tolerate the perpetuation of this situation – the values, structures, and behaviors that clearly inhibit the probability of survival.

This may seem melodramatic, but I don't think so anymore. As we face the consequence of our history, we are faced with choice. What will it take to redress and reverse the vectors of decline? What will it take to address and advance the vectors of change? The odds are high, and long. Literate people, the world over, must now, soon, apply their knowledge, their understanding, and their energy toward plausible scenarios for alternative futures. That future, in our view, depends on the ocean.

The subject of this volume is Ocean Literacy. It offers an anthology of reflections, examples, illustrations, and demonstrations that represent the best responses to the challenges we face. The work we describe here is based on the efforts of a group

of ocean experts and educators to outline a curriculum intended to instill inside and outside formal classrooms a full understanding of what the ocean means for our lives, for all aspects of the wellness and welfare of our selves and our communities. While the focus is on comprehensive ocean science, the curriculum transcends the usual natural resource perimeters of such study to relate the ocean to climate, fresh water, food, energy, health, work, trade, transportation, finance, community development, and cultural traditions. This effort has met with a certain resistance, not necessarily overt, but nonetheless based on the restrictive conventions of the educational systems and formalized standards for teaching and learning in the United States. This is a sad circumstance, the inability to change and offer to ensuing generations the facts and systems that must be sustained if their lives are to equal and surpass the successes of ours.

These perspectives will serve as a framework for a catalogue of the most innovative ideas for our ocean future that we can find and present to you here. Taken together, we hope they will serve as a communication tool for you to share with family, friends and colleagues as we build together a global community of *Citizens of the Ocean* who will serve as agents for change and sustainability of the sea that connects all things.

The essential principles of Ocean Literacy are as follows:

1. The Earth has one big ocean with many features
2. The ocean and life in the ocean shape the features of Earth
3. The ocean is a major influence on weather and climate
4. The ocean made Earth habitable
5. The ocean supports a great diversity of life and ecosystems
6. The ocean and humans are inextricably interconnected
7. The ocean is largely unexplored

Learn more about Ocean Literacy:

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THE OCEAN LITERACY FRAMEWORK

An ocean-oriented approach to teaching science standards

Ocean Literacy: An understanding of the ocean's influence on you and your influence on the ocean

The Ocean Literacy Framework was developed with the intention of providing educators with a roadmap to build coherent, conceptually sound, and engaging experiences for students learning about ocean systems. The building of the Framework (from conception to development and review) took 8 years, from 2002 to 2010, and was reviewed by hundreds of scientists and educators throughout the process.

The Framework is comprised of two consensus documents:
1. Ocean Literacy: The Essential Principles of Ocean Sciences K-12 (also known as the Ocean Literacy Principles); and
2. Ocean Literacy Scope and Sequence for Grades K-12 (also known as the Scope and Sequence)

The Ocean Literacy Principles remain a work in progress. Scientists and educators continue to develop and review the Framework; instructional materials and resource development are ongoing. The Network is valuable and relevant to the scientific community and resources are used to develop university courses, to inform scientists' broader impact activities, and to provide a rationale for grant proposals.

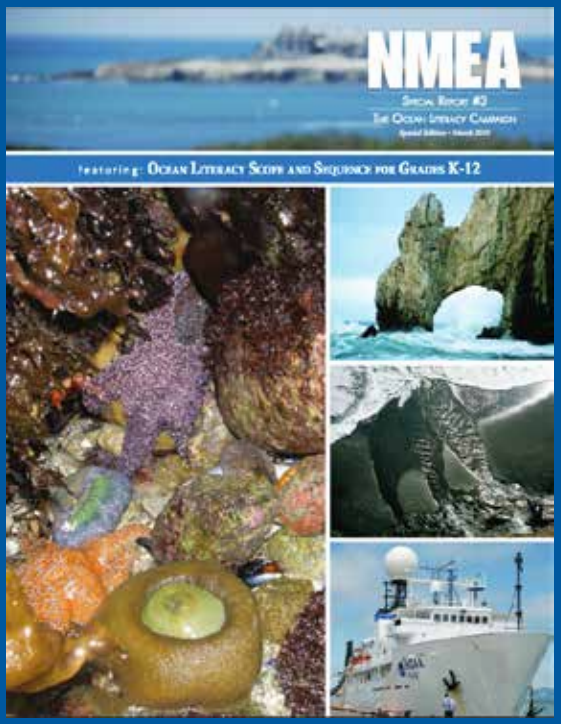
In October of 2004, development of the document that came to be known as *Ocean Literacy: The Essential Principles of Ocean Sciences K-12* formally began with a two-week online process involving over 100 people from the ocean sciences education community. By the end of the two weeks, the community had identified the seven essential principles and 44 fundamental concepts. Small teams of scientists and educators took this draft and fleshed out the ideas through an iterative process of writing and sending out their revisions for review by members of the community. Individuals from the community with a diverse range of perspectives and expertise contributed to developing and reviewing the Ocean Literacy Principles.

The Ocean Literacy Scope and Sequence involved a more extensive progress, with conceptual flow diagrams developed between 2006 and 2008; in 2008 a small working group developed the first drafts. In 2010 the final version of the Scope and Sequence was published in *Current: Journal for Marine Education*.

The Ocean Literacy Framework was developed by many scientists and educators from the ocean sciences education community. Their efforts built on previous work to define ocean literacy, assess what the public knows about the ocean, and redress the lack of ocean-related content in state and national science education standards, instructional materials and assessments. The ocean sciences education community came together to create these documents and ignite a movement within ocean sciences and beyond.

Efforts to develop a consensus position on ocean sciences education began in 2002 and involved committed efforts from the following key individuals and organizations:

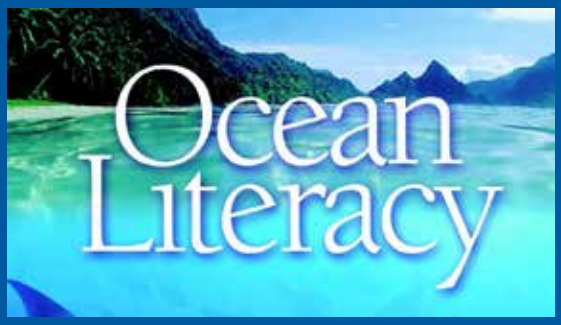
- Bob Chen
- Elizabeth Day-Miller
- Sarah Schoedinger
- Bob Stewart
- Craig Strang
- Sharon Walker
- Association of Zoos & Aquariums
- College of Exploration
- Lawrence Hall of Science
- National Marine Educators Association
- National Geographic Society
- NOAA
- National Sea Grant College Program
- The Ocean Project



NATIONAL MARINE EDUCATORS ASSOCIATION

Read the NMEA Special Report on Ocean Literacy which highlights the work of dozens of agencies and hundreds of individuals who worked together to bring ocean science into the mainstream of both formal and informal education.

http://oceanliteracy.wp2.coexploration.org/ocean-literacy-network/foundations/nmea-special-report/

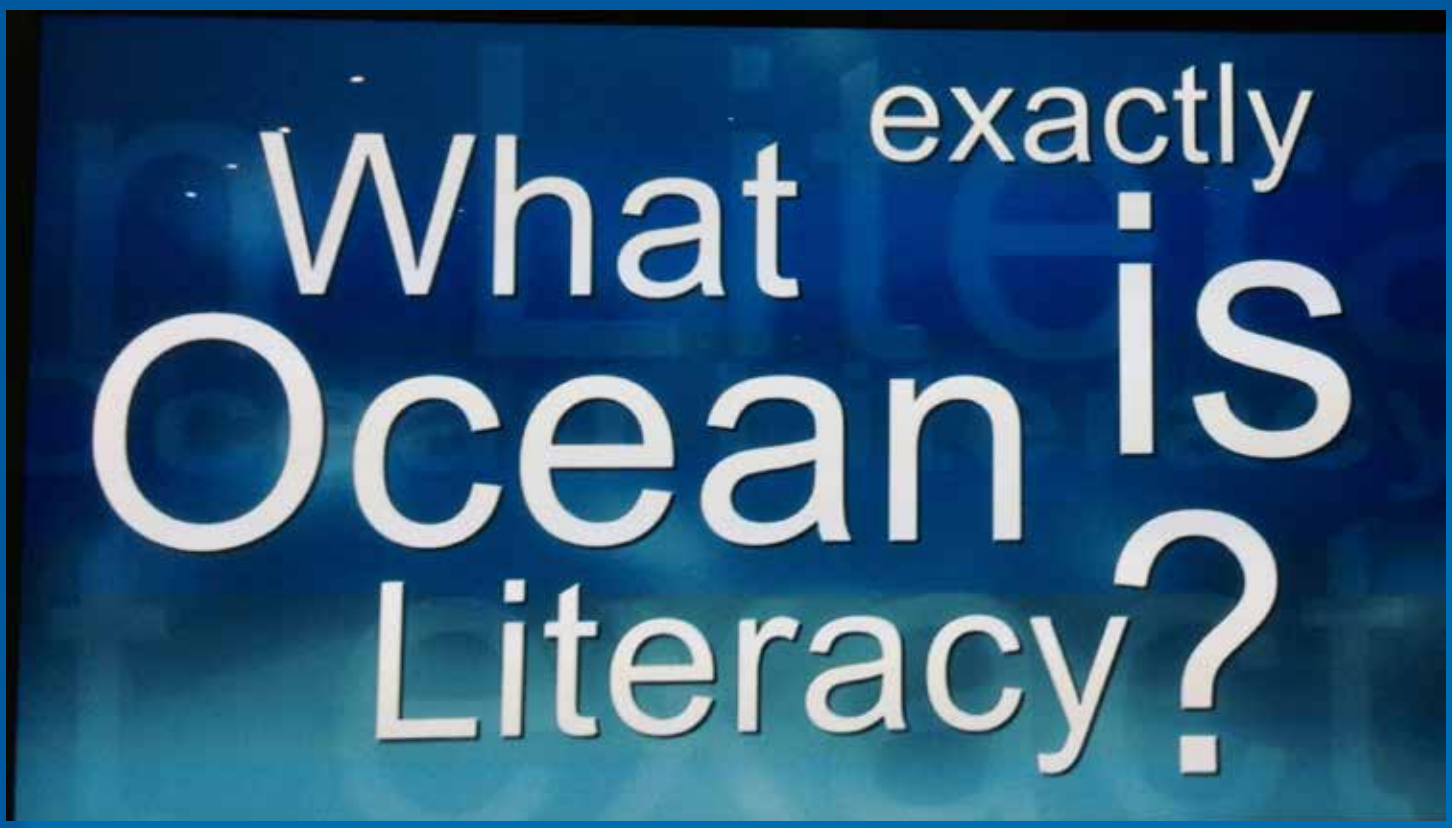


2019 NMEA CONFERENCE
JULY 21-25, DURHAM, NEW HAMPSHIRE

The Gulf of Maine Marine Education Association will host the National Marine Educators Association Annual Conference in July at the University of New Hampshire campus in Durham, NH.

The annual NMEA conference brings together formal and informal marine educators from around the world to promote awareness and education of the global marine environment. The conference draws 300 to 500 professionals from K-12 schools, public aquariums, non-profit NGOs, and government agencies together for four days of learning, sharing, and networking.

Registration available at gommea.org/NMEA2019


What exactly is Ocean Literacy?

A DEFINITION

Ocean literacy is an understanding of the ocean's influence on us—and our influence on the ocean.

An ocean-literate person:

1. understands the Essential Principles and Fundamental Concepts about the functioning of the ocean;
2. can communicate about the ocean in a meaningful way;
3. is able to make informed and responsible decisions regarding the ocean and its resources.

Developed through a community-wide consensus-building process, this definition along with the seven essential principles outlined in this volume build on previous efforts to define ocean literacy, assess what the public knows about the ocean, and redress the lack of ocean-related content in state and national science education standards, instructional materials and assessments.

OCEAN LITERACY: PRINCIPLE 1

1

THE EARTH HAS
ONE BIG OCEAN
WITH MANY FEATURES

In a series of premises defined by educators as fundamental to our understanding of ocean systems is the following:

The Earth has one big ocean with many features

This would seem obvious, but not so fast. There are some assumptions within worth emphasis. First, what is the actual physical relation of ocean to earth? We know that the ocean covers 71% of the earth's surface; that some 97% of the water on earth is salt; that of the remaining 3% that is fresh, two-thirds is frozen, for now, in the polar caps. But what is the mass relationship of ocean to earth? I will spare you the math, but scientists have concluded that the ocean represents just 1/4400th of the total earth's mass, 71% of surface coverage equating to .02% of the planetary total, an astonishing calculation of relative volume. Let me argue here, then, that the relative impact of scale, ocean to land, is a very imbalanced equation between the productive value of the ocean/freshwater continuum and the land. This is more fully exaggerated if you include the reasonable observation that the productive value of the land shows evermore critical warning signs of exhaustion. Each year, we calculate the day when what the land produces can no longer meet the needs and demands of its population, and

each year that day comes earlier, indicating a production deficit that can only be met by increased exploitation of the ocean.

Secondly, the premise asserts that there is only one ocean, not seven seas, but one integrated oceanic system that connects us all, even as we are separated by continents, politics, economic development, and cultural traditions. This, too, appears not so obvious when you understand that our governance, historical exchange, patterns of settlement, and social organization has been almost exclusively land-based. Only with the most recent realization of globalization, that is the interconnectedness of all nations and all peoples, has the world come to understand the unifying reality of the ocean and its undeniable force for the future.

Third, the premise affirms the existence of the ocean's many features: its still unfathomable catalogue of marine life and processes; its measure as integrated global natural system that circulates and exchanges worldwide with calculable impact on weather, agriculture, food production, coastal settlement, security, and other acknowledged natural outcomes, but also in the acceptance of its social connection through economic development, exchange of manufactured and processed goods, financial transfer, worldwide communications, and the increasing force of intellectual property and invention.

So, the simple premise that the Earth has one big ocean with many features reveals a complicated system that has not been fully understood, not been taught in our educational system, or used as a foundation for the organization and re-organization of our policies or our constructive evolution of new concepts and ideas for change, future development, and the demand for sustainability of best practice on land and sea.
To accept this first premise is to accept an entirely new way of knowing the ocean, establishing the extent of its future production and protection, and its inevitable and urgent meaning for continuity, sustainability, equity, justice, and peace in the 21st century.

We can visualize these connections: the re-emphasis of integration over separation in our global depictions; the measurable impacts and predictions of climate change; the depiction of watershed connection is Europe and South America; the ocean conveyor that distributes heat, protein, and persistent pollutants with equal efficiency; the routes of ships engaged in international transport and trade; the shifting population from heartland to coastal concentration; and the many, many more examples of the many features of one big ocean.

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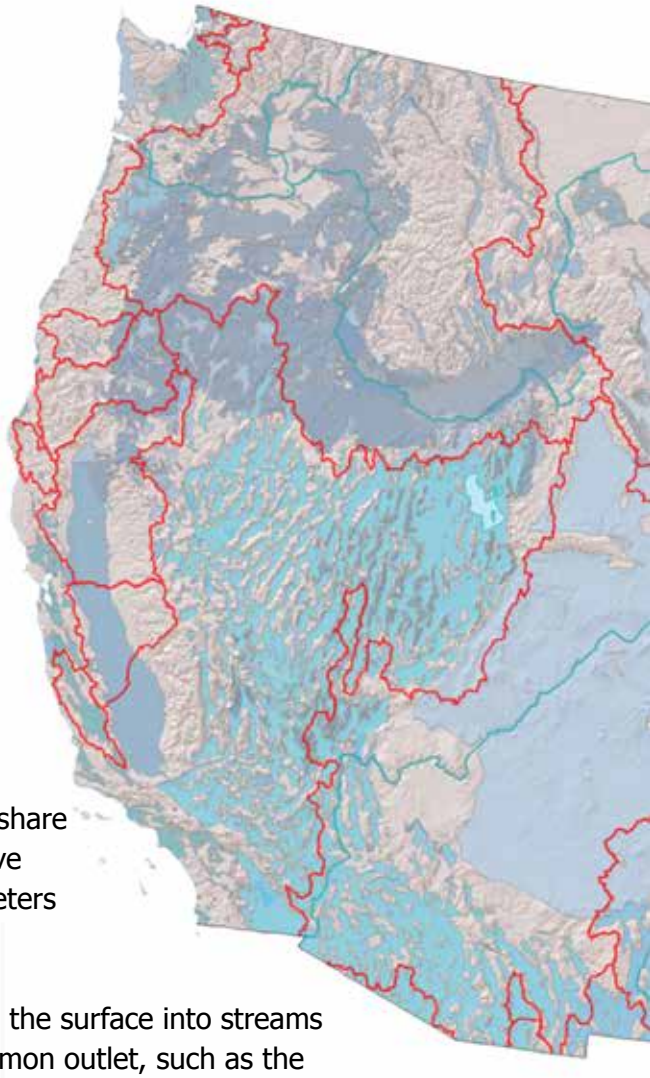
WHERE DOES THE WATER GO?

Decolonial Atlas
Aquifers and Watersheds of the United States

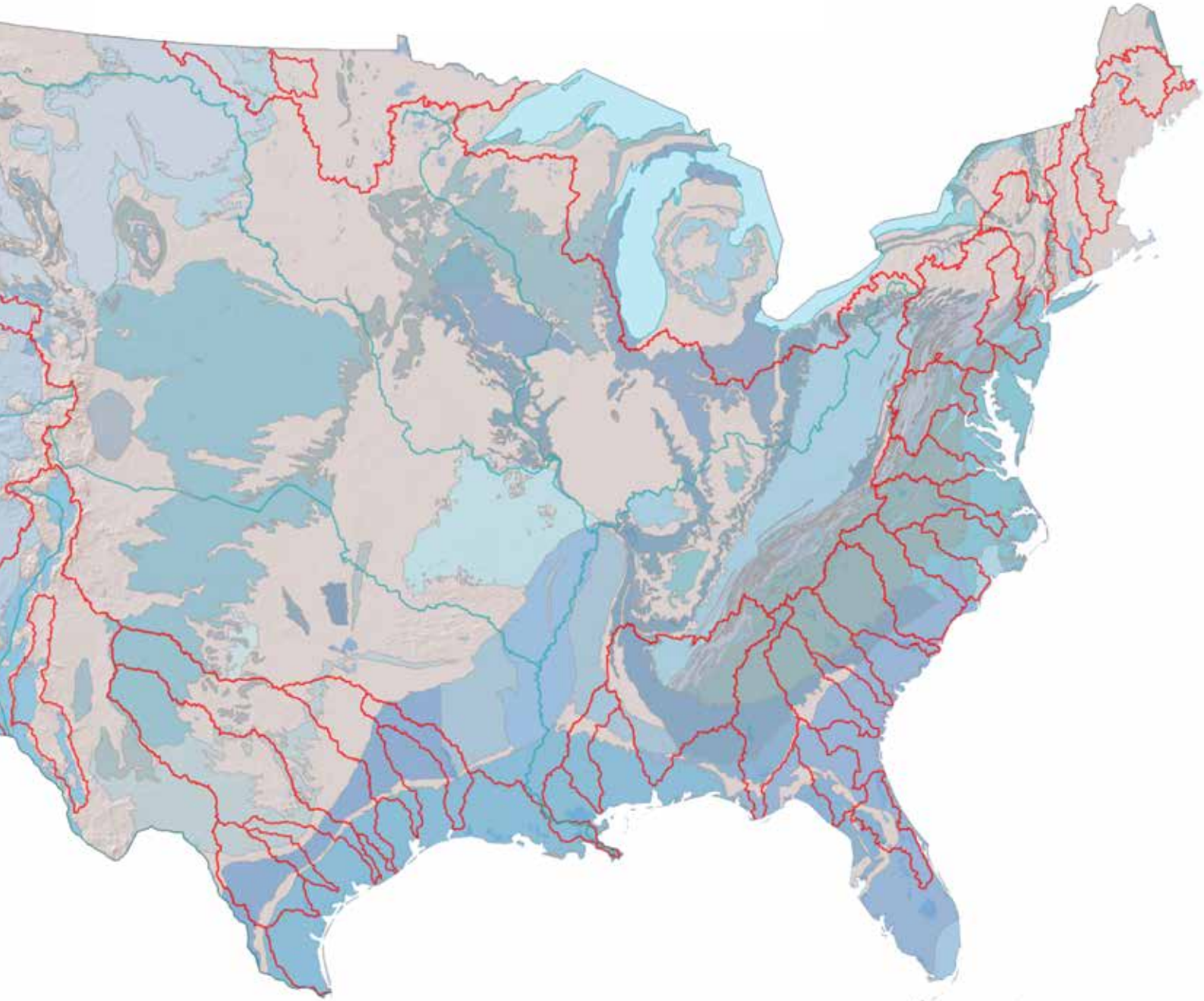
In this map of the United States, watersheds are outlined in red. Aquifers are represented in shades of blue, green, and purple. Major rivers and lakes are also overlaid to show surface water features. Notice the incongruence of the groundwater and surface water systems: surface water will cross over eight different aquifers on its journey from the Ohio River to the Mississippi River Delta and on to the ocean.



(from the Decolonial Atlas)
Water is life. We share the fate of our survival with those whom we share our water. Ultimately, that includes everyone on the planet. We all live downstream, but more directly it is those who live within the parameters of certain local and regional water systems.

When it rains, water generally does one of two things: it flows along the surface into streams which eventually reach the ocean. The area that is drained to a common outlet, such as the mouth of a river, is called a watershed or drainage basin. Alternatively, precipitation seeps into the earth, flowing underground through a permeable rock layer called an aquifer. These networks are naturally-defined areas which are intimately connected. Toxins released upstream contaminate the entire watershed downstream. Likewise, over-extracting groundwater from one part of an aquifer contributes to the decline of the entire aquifer.

Where Does The Water Go? was produced by the Decolonial Atlas' Jordan Engel. World Ocean Journal has permission to reuse this material under the Decolonial Media License 0.1. Drainage basin data came from the Global Runoff Data Centre. Aquifer data came from the United States Geological Survey.



WHEN RIVERS TAKE THE LONG WAY AROUND

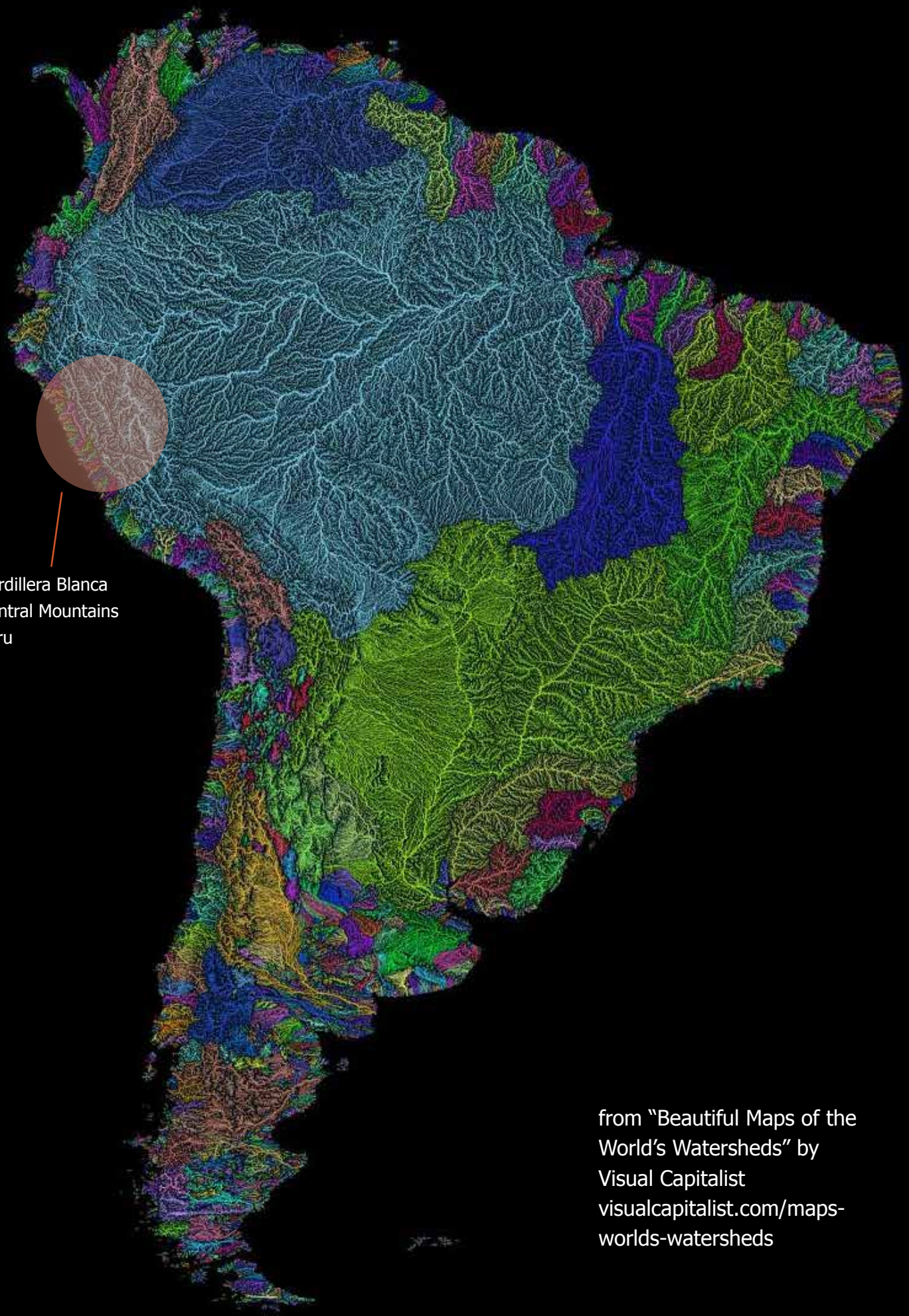
Water takes the most available path of least resistance. Sometimes that most available path can take water from mountains clear across a continent before reaching the ocean.

Take Peru, home of the glacier-packed Cordillera Blanca. As rain and meltwater flows from the peaks of the Andes Mountains, there are two diverging paths to the ocean.

The journey to the Pacific Ocean is a quick one, and there are small rivers at regular intervals along the coast of Peru.

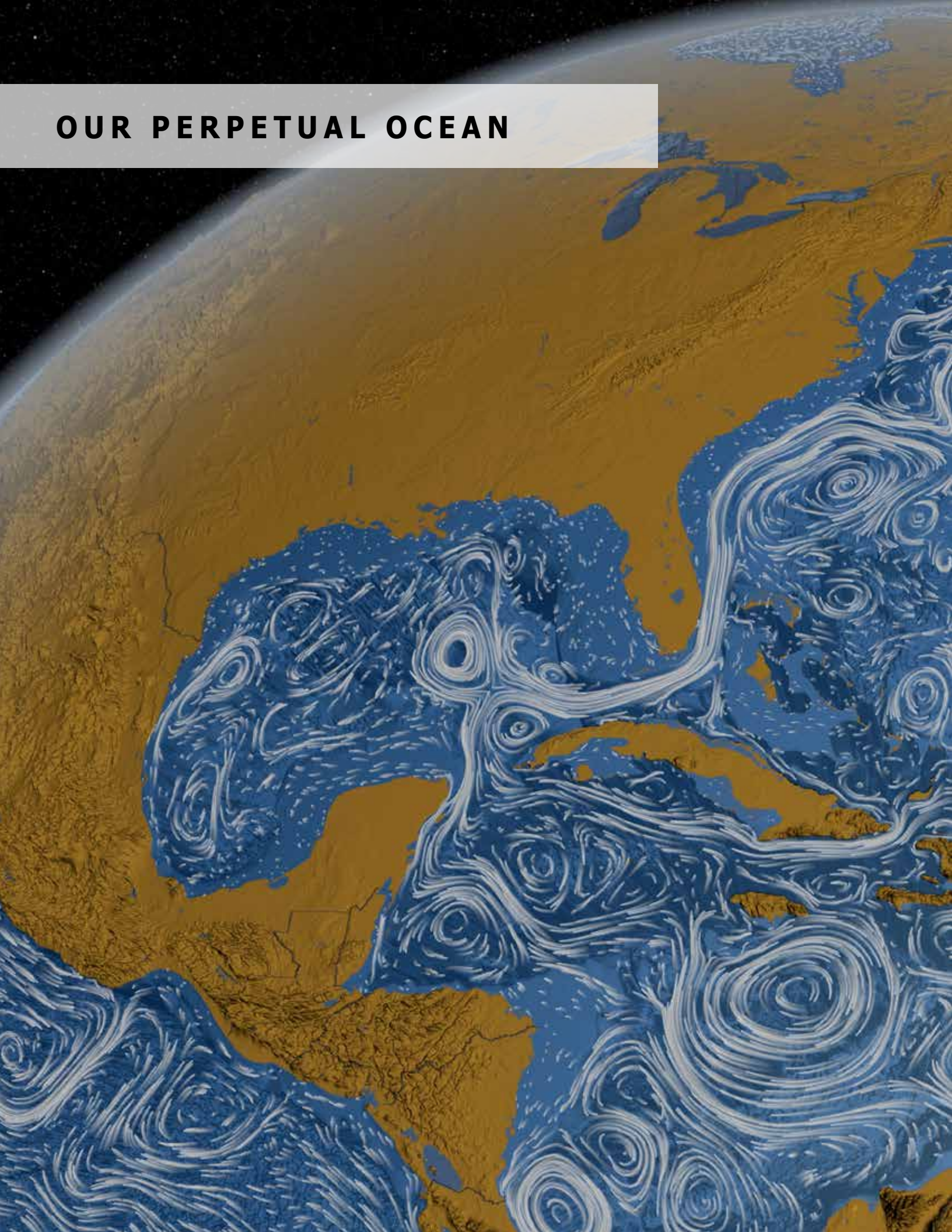
Because trade winds blow east-to-west in that region, most of the water flows down the eastern side of the Andes, the beginning of a journey across the continent. This is demonstrated by the light blue section of the map.

Without the Andes acting as a backstop for rain, the Amazon rainforest would not exist in its current scale and form.



from "Beautiful Maps of the World's Watersheds" by Visual Capitalist
visualcapitalist.com/maps-worlds-watersheds

OUR PERPETUAL OCEAN



This graphic shows ocean surface currents from June 2005 to December 2007 from NASA satellites. Bigger currents like the Gulf Stream in the Atlantic Ocean and the Kuroshio in the Pacific carry warm waters across thousands of miles at speeds greater than four miles (6 km) per hour. Coastal currents like the Agulhas in the Southern Hemisphere move equatorial waters toward Earth's poles and thousands of other ocean currents are confined to particular regions that form slow-moving, circular pools called eddies.

Credit: NASA/SVS

THE EARTH HAS ONE BIG OCEAN WITH MANY FEATURES

a. The ocean is the defining physical feature on planet Earth, covering approximately 70% of the planet's surface.

b. Ocean basins are composed of the seafloor and all of its geological features and vary in size, shape and features. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.

c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation, the Sun, and water density differences. Changes in ocean circulation have a large impact on the climate and cause changes in ecosystems.

d. Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides and is subject to change as sea water expands and contracts when ocean water warms and cools.

e. Most of Earth's water (97%) is in the ocean and seawater has unique properties.

f. The ocean is an integral part of the water cycle and is connected to all of the earth's water reservoirs.

g. The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean.

h. Although the ocean is large, it is finite and resources are limited.

OCEAN LITERACY: PRINCIPLE 2

2

THE OCEAN AND LIFE IN THE OCEAN SHAPES THE FEATURES OF EARTH

The ocean and life in the ocean shapes the features of Earth

Well yes, and in how many ways does this occur? First, there is the geological record of forces above and below the sea that have moved glaciers, shifted tectonic plates, and eroded and augmented the shape of the land, sometimes over eons, sometimes overnight. Wave action and currents are like blades of force that carve and curve the shore, build and un-build the coast, and define landside response by such change, the addition of land, the subtraction of land, the deposits and sediments left behind, and the capacity of the terrestrial environment to support life in all its forms and functions.

Science helps us document this change—cartography, for example, the continuous record by maps and charts of the features of land and sea as they change over time. From the beginning, humans endeavored to answer the question: *where am I, in space and time?* Through memories, documents, explorations and expeditions, and ever-technical and accurate renderings that help us to locate, envision and plan routes from one place to another. In our era of comprehensive observing and collecting of data, this documentary understanding of the features of

earth and ocean has become more complete, detailed, and beautiful.

Another shaping force of the ocean is the associated consequences of environmental change. Land once underwater is revealed; glaciers leave grinding, striated marks on land and rocky shores; the leavings coalesce as resources to be extracted as value; the success and failure of plant life is advanced as food or medicine; and the habitability of places is destroyed into history or enhanced into the future of civilization. Natural resources define watersheds, from mountaintops to streams, lakes and rivers; where rivers meet the shore, safe anchorages are found; safe harbors become ports; ports become centers of settlements; settlements become nodes of production, trade, and international connection. If the ocean is defined as a "hydraulic continuum," from fresh water to saltwater and around again, then it can be claimed to the most direct and impactful shaping force there is.

The ocean shapes our lives every day through the impact of fisheries as a protein harvesting industry, at large and small scale, the world over. We have nations, towns, and villages that have been founded on and sustained for centuries through coastwise and offshore catch in many forms to feed us and promote our well being as individuals and communities. The ocean is also a vast pharmacopoeia, an inventory of literally millions of plants and animals that we know or remain to be discovered. Coral reefs, for example, contain biological and chemical diversity that may hold the cure to diseases beyond imagination, some of which might well be the result of over-population, other unthinking interventions into natural processes, or engendered by activities and other so-called advancements with consequences unforeseen. So much about the ocean remains unknown. So much of what it has provided in the past is at risk. So much of its value as part of the Earth may serve us still through continuing research and scientific analysis as we continue to study and understand.

Finally, the ocean has shaped our cultures and beliefs. We can see the history of fisheries, for example, in the monuments and architecture of coastal towns: stone tablets listing fishermen lost at sea; stories, songs, and poetry describing and remembering sea experience; wharves and buildings that once supported the transfer of fish products from catch to table, from villages to cities, and from there to cities elsewhere inland or for international exchange; captains' houses, votive ships and stained glass scenes in local churches; logs and accounting books; and rituals and beliefs, baptisms and burials, sagas and myths, all shaped by the ocean.

To be literate about the ocean is to be open to and knowledgeable of everything thereby connected.

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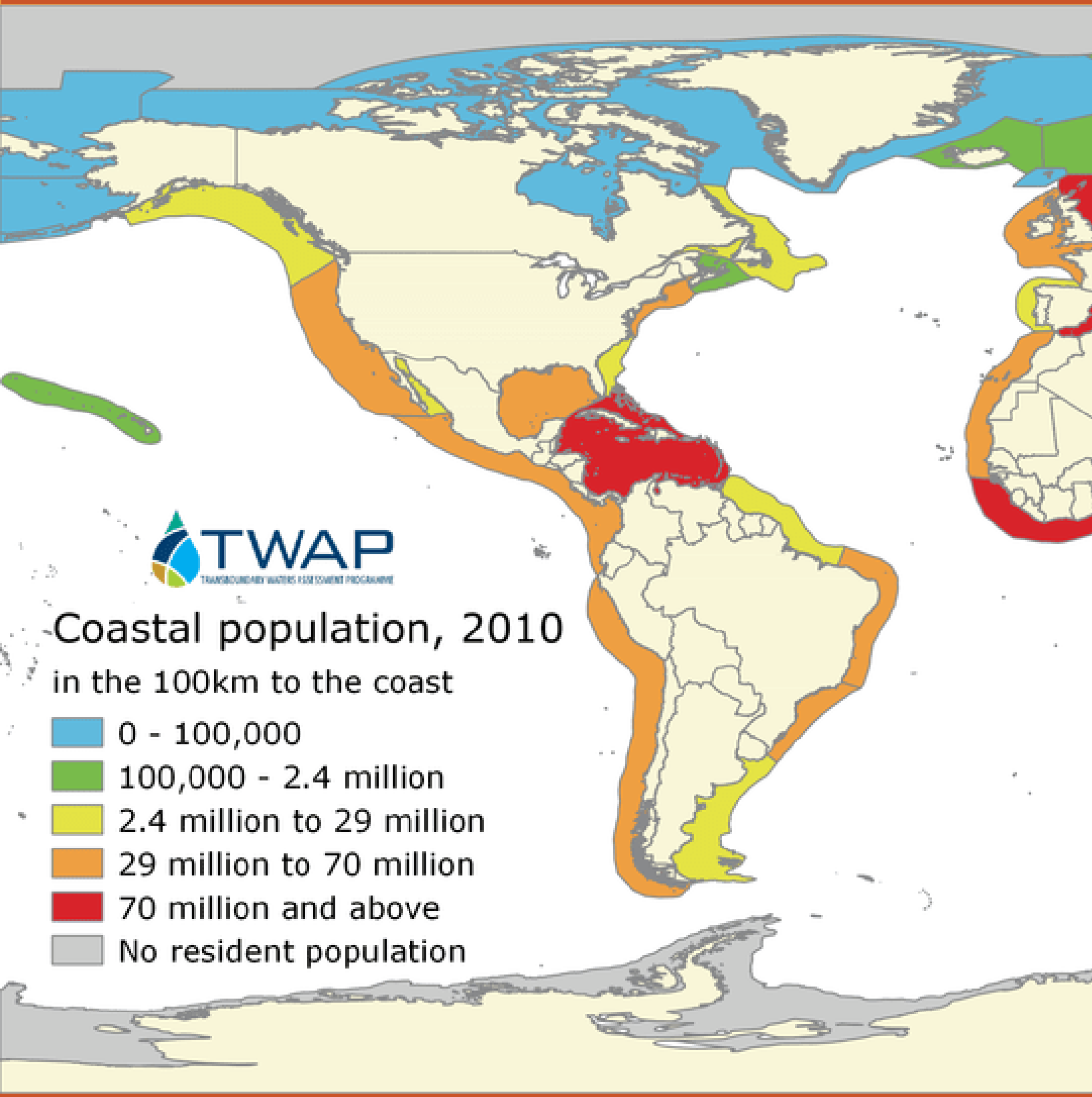
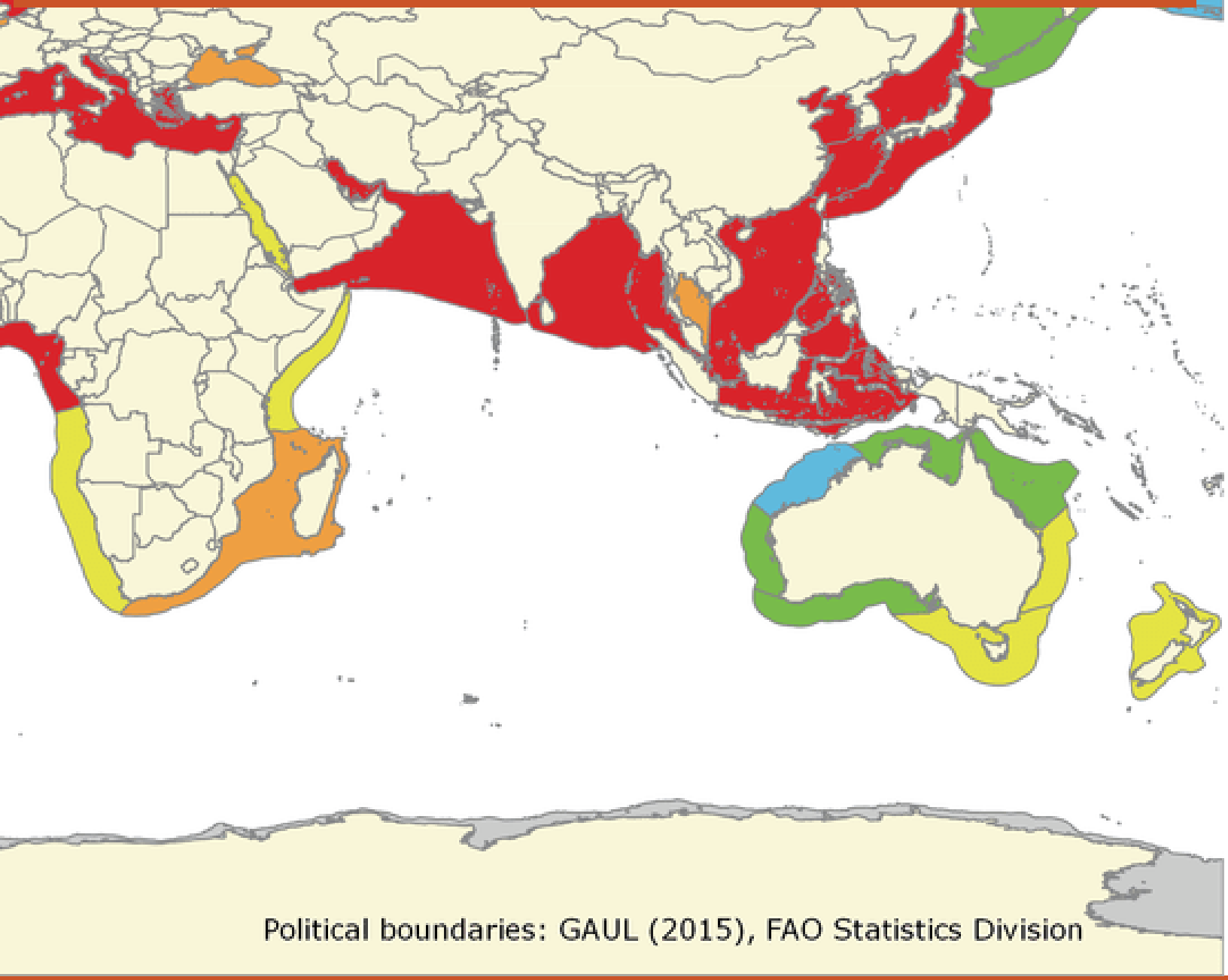
THE COASTAL ZONE: ONE SHARED OCEAN



The most populous coastal zones on the planet include the Bay of Bengal, the South China Sea, the Mediterranean Sea, the Arabia Sea, and the Indonesia Sea. 60% of global populations live in urban coastal areas and that number is expected to rise as more people move toward urban coastal communities. According to the TWAP (Transboundary Waters Assessment Program), coastal populations living around living marine ecosystems make up more than 40% of the global population and more than 20% of coastal residence are considered poor. Large coastal populations in many nations indicate high dependence on living resources as well as a high potential to deplete those resouces at an unsustainable rate.



SAND WARS

Are international protections needed to preserve a valuable resource?

After water, the largest volume of natural material used to support our global growth is sand. According to a special report by UNEP (the United Nations Environmental Program) up to 59 billion tons of aggregated sand and gravel are extracted annually, primarily to enable the production of cement for use in the burgeoning construction industry. A ton of cement requires some 6 to 7 more tons of sand and gravel, enough, according to the report "to build a wall 27 meters high by 27 meters wide around the equator."

China is by far the biggest supplier and the biggest user, about 58% of total supply and demand. To support its recent exponential growth, its use has increased 437.5% in the past two decades. In every nation, every place, every road, and every building, sand, extracted from quarries, riverbeds, and coastal marine areas, is being removed from where it was created by centuries of geological processing, transported to faraway places, transformed into every form of construction, and used as a base element in the growth-driven alchemy of the modern economy. The impact on the environment is enormous, with measurable destructive consequence for biodiversity, land loss, hydrological function, water supply, infrastructure, climate, landscape, and extreme events. These are just a few of the serious outcomes of such massive, localized extraction.

Beach renewal is a use perhaps familiar to us all. But consider the sand required to expand Singapore to provide some 130 square kilometers of land reclaimed from the sea by land fill. Most of that sand came from Indonesia, the rest from Malaysia, Thailand, and Cambodia, impacting and deteriorating those environments and creating political tensions that have forced a negotiated ban. Or consider Dubai and its creation of artificial islands that used some 385 million tons of sand to construct the Palm Jumeriah, the Palm Jebel Ali, and the World Island Project, all in the prospect of need for office and residential space for development of a new modern world city. The Burj Khalifa Tower, at 828 meters arguably the highest building in the world, sits at the center of this development as a hubristic assertion of Dubai's economic nationalism; it was constructed using massive amounts of sand imported not from the Arabian peninsula, but from Australia.

Much of this extraction comes from illegal coastal mining, transported by smugglers, financed by organized crime, and enabled by lack of regulation and bureaucratic corruption. Ironically, in Morocco, a stretch of beach was transformed into a rocky landscape by extraction of all its sand with the intent to build hotels, roads, and tourism-related infrastructure elsewhere dependent on the beauty of the sand beaches there left untouched.

Sand is cheap, often priced only as a measure of its extraction and transportation. Its true cost as a non-renewable resource; its detriment by channel erosion, turbidity, changed pH, and sediment in its surrounding ecosystem; its disturbance of the benthic fauna and lowered water table of fish spawning habitat, feeding patterns, and the livelihood of local fishers; its contribution to emissions through CO_2 release in cement manufacture and dust to the atmospheric conditions locally and regionally; its underpriced and

untaxed value; and its subversion of governance and economic return -- none of these costs are factored into what is actually the true price per grain of sand.

A UNEP survey of relevant policies showed little hope for international protection or oversight of this problem. No international conventions exist to regulate the extraction, use, or traded of land-based sand. The UN International Seabed Authority seems without effect. The UN Convention on the Law of the Sea pertains in part, but many of the primary parties are not signatories of that treaty. Regional agreements do oversee some aspects of such activity in Northeast Atlantic, the Baltic, the Mediterranean, and the Caribbean, and some national and state coastal policies may apply, but that has not addressed the need for international standards, agreement, enforcement, and action to address the larger problem. Consider China's blatant construction of islands in the South China Sea, as a geo-political extension of its economic zone and standing.

Where has all that sand come from? Ask that question and you may be met with an expression of disrespect and disdain:

"Go pound sand."

"Sand Wars" originally appeared as a World Ocean Radio audio broadcast. Find out more at worldoceanobservatory.org/world-ocean-radio.

Chinese dredging vessels in the waters around Mischief Reef in the disputed Spratly Islands. Still shot is from video taken by a U.S. Navy P-8A Poseidon surveillance aircraft (May 2015). REUTERS/U.S. Navy/Handout via Reuters.

OCEAN AND LIFE IN THE OCEAN SHAPE THE FEATURES OF EARTH

a. Many earth materials and geochemical cycles originate in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.

b. Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

c. Erosion occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

d. Sand consists of tiny bits of animals, plants, rocks and minerals. Sand is redistributed by waves and coastal currents seasonally.

e. Tectonic activity, sea level changes, and force of waves influence the physical structure and landforms of the coast.

OCEAN LITERACY: PRINCIPLE 3

3

THE OCEAN IS A MAJOR INFLUENCE ON WEATHER AND CLIMATE

The ocean is a major influence on weather and climate

Which comes first: the influence of weather and climate on the ocean or the influence of the ocean on weather and climate? Both, of course. Secondly, can weather or climate exist independently of each other, whether or not influenced by the ocean? No, they are inextricably inter-related, generally and specifically around the globe. These facts are not very well understood by the public, or, in many cases, by policy-makers, agencies, and politicians who, informed or not, must deal with the short-term consequences and long-term planning decisions that weather, climate, and ocean will demand. One can be blind to the implications of research and the almost universal evidence of science on the reality of changing climate and extreme weather on coastal populations, but one cannot be indifferent to the deaths, financial disaster, and physical disruption of storms, wind, drought, erosion, economic distress, community collapse, and cost of response and re-construction brought about by actual events.

Weather and climate change affect and are affected by the ocean – its physical distribution on earth, its currents, and its temperature.

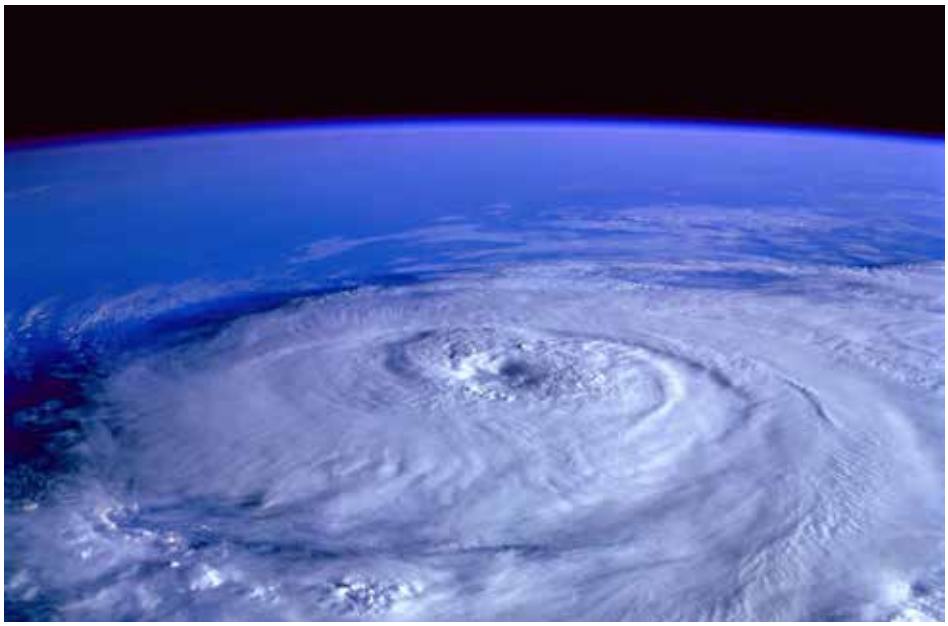
The evaporation of ocean water

into the global water cycle has further implications on conditions far inland with concurrent implications for rainfall, local water supply, watershed management, food production, employment and unemployment, internal distribution of goods, floods, forest fires, erosion, sanitation and public health, and almost every other aspect of human life. Incidents reflecting these factors are prolific, and we are inundated with reports of increased ferocity, frequency, and damage worldwide.

As the ocean covers so much of the earth's surface, it becomes a primary source and force for such phenomena with enormous loss of real property and human life. If climate and related weather change are a function of anthropogenic intervention in the asset value and processes of Nature, then we are the unknowing, knowing cause of our own distress. Knowing this, and failing to respond, transcends paradox to become self-destructive and illiterate.

The ocean is equally affected by climate change and weather. Two results are perhaps the most important: temperature change and acidification. The first determines the growth dynamic for life in the ocean – the incubation, feeding, and durability of marine species of every kind and the availability of that life as protein, medicine, and livelihood. Artisanal and commercial fishing are both a reflection of supply and demand: if demand is increasing through population growth and changing human diet—and supply is consequently limited by over-fishing and compromised habitat—then decreased regeneration and redistribution of the remaining resources are diminished leading possibly to collapse or extinction.

Acidification is the changing pH of the ocean, the measure of acidity and alkalinity that affects the growth and feeding habits, distribution and sustainability of all life in the ocean, whether marine animals or plants. A small change in the ratio can mean a very large change in ocean health, a consequence that is at first invisible, then perversely damaging, then very difficult to mitigate or reverse over time. Research indicates that the changing acidity of the ocean is having real, measurable consequence for the food chain, ocean plants, coral reefs, algae blooms, and many other dangerous adjustments in a heretofore relatively stable environment.



What is the cause? Again, research has shown, and scientists have attempted to argue, that man-made carbon and particulate emissions have deposited in amounts over time to have generated the pH change with all dangers for security and well-being for the future. The Paris Climate Agreement, with all its efforts to modify carbon production, emissions control and alternative energy use is a major step forward, if not perfect, toward an institutional and human response to what is an institutional and human condition.

The ocean speaks louder than treaties or denials. It is a natural voice of reality that must be heard. That is more than influential. That is an inviolate determining factor that lies at the heart of our collective survival—a voice perceived through weather, climate, abundance, resilience, community, and personal benefit, that demands our hearing, understanding, and response.

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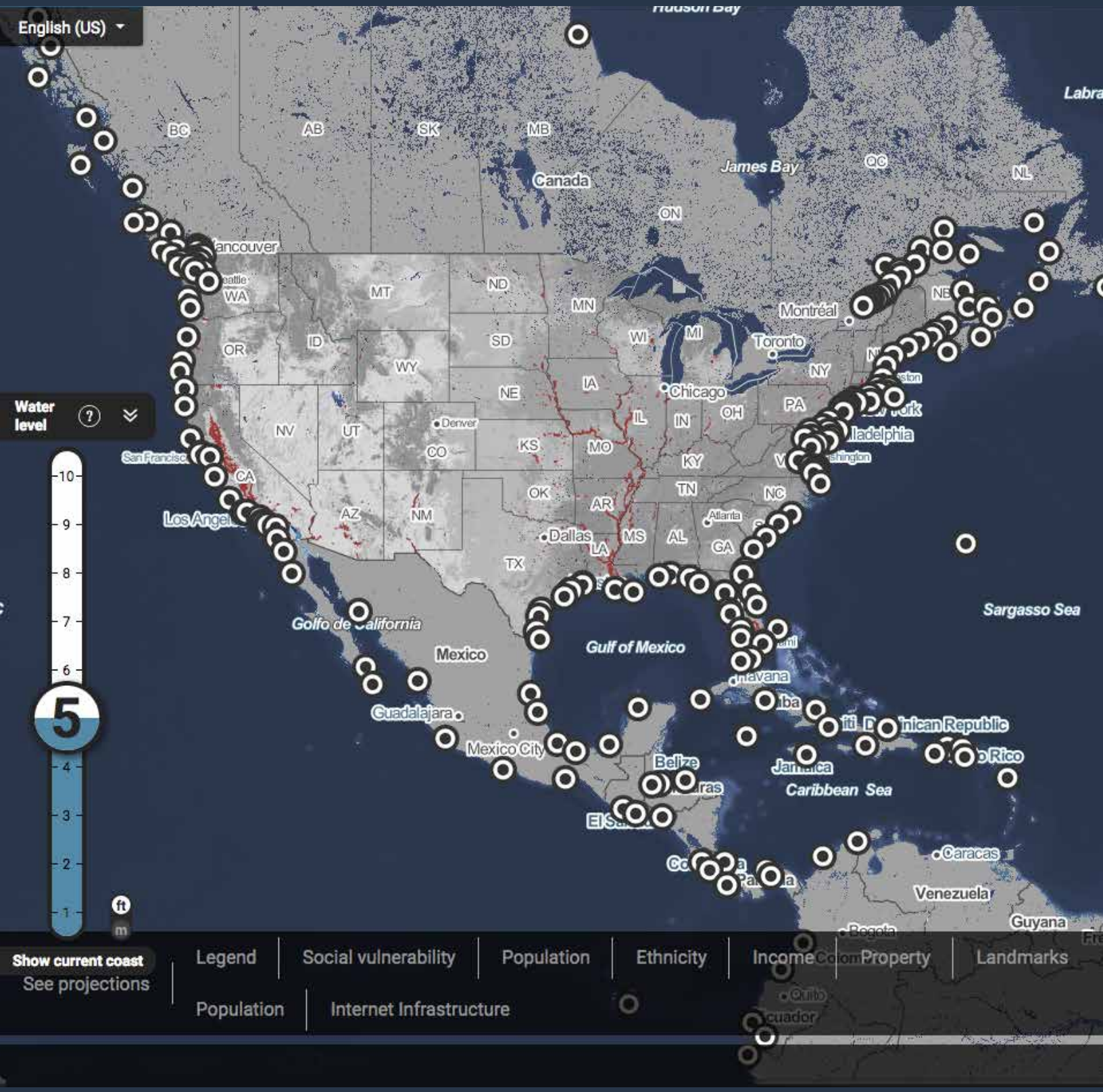
SEA LEVEL RISE

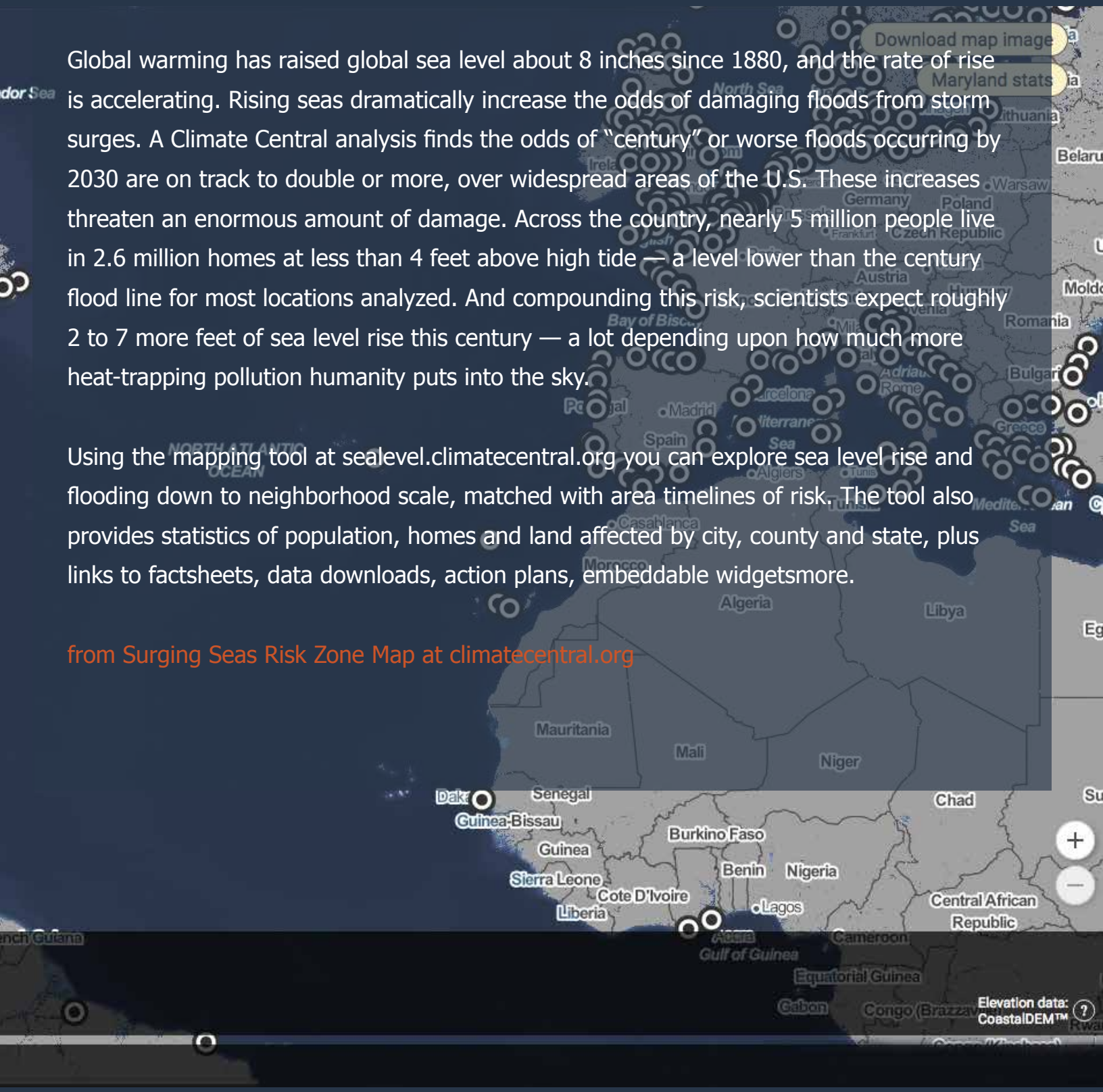


The Facts About Sea Level Rise

Global warming has raised global sea level about 8 inches since 1880, and the rate of rise is accelerating. Rising seas dramatically increase the odds of damaging floods from storm surges. A Climate Central analysis finds the odds of "century" or worse floods occurring by 2030 are on track to double or more, over widespread areas of the U.S. These increases threaten an enormous amount of damage. Across the country, nearly 5 million people live in 2.6 million homes at less than 4 feet above high tide — a level lower than the century flood line for most locations analyzed. And compounding this risk, scientists expect roughly 2 to 7 more feet of sea level rise this century — a lot depending upon how much more heat-trapping pollution humanity puts into the sky.

Using the mapping tool at sealevel.climatecentral.org you can explore sea level rise and flooding down to neighborhood scale, matched with area timelines of risk. The tool also provides statistics of population, homes and land affected by city, county and state, plus links to factsheets, data downloads, action plans, embeddable widgetsmore.

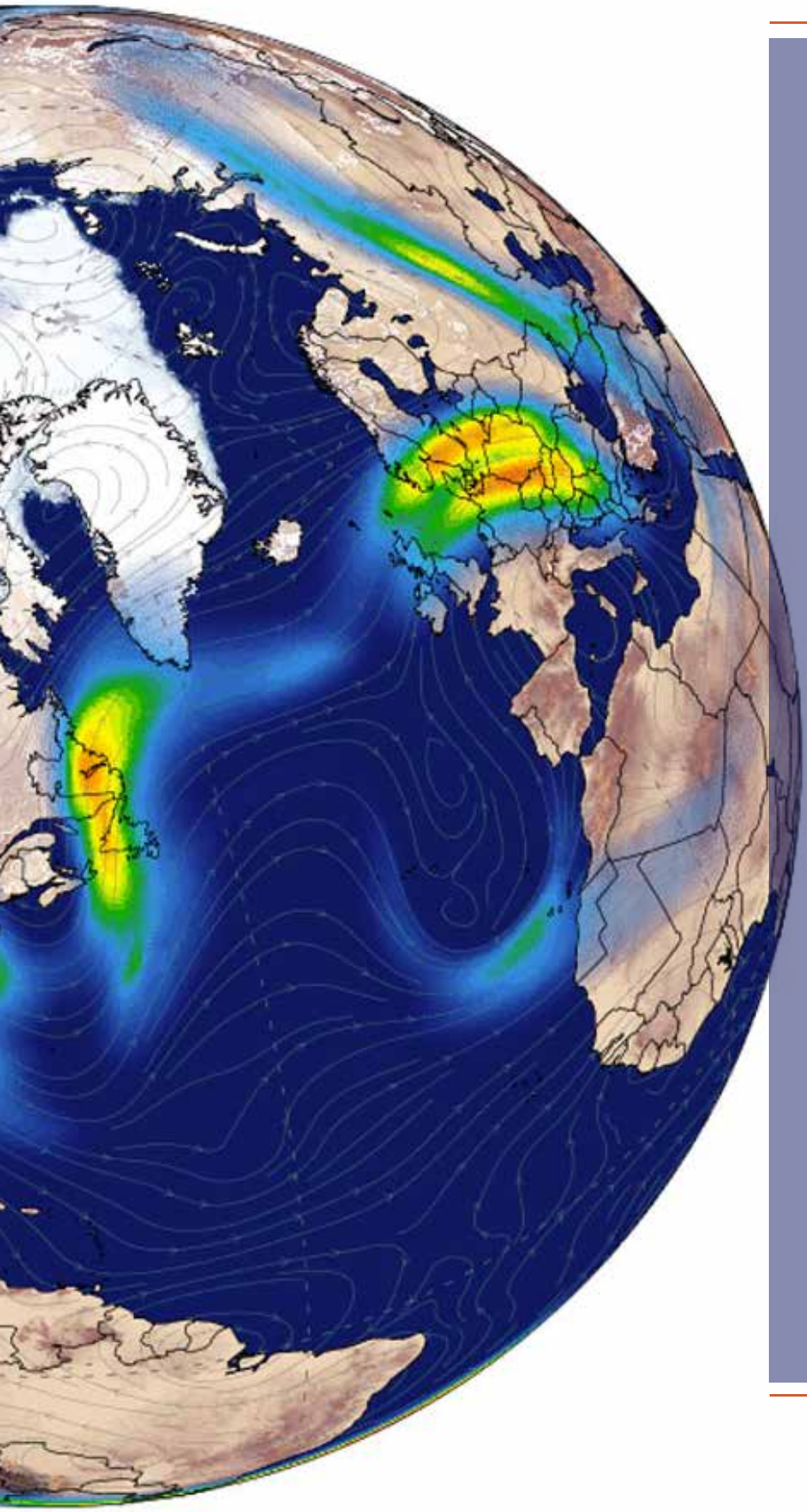
from Surging Seas Risk Zone Map at climatecentral.org



A Visualization from the Climate Change Insti

tute

CLIMATE CHANGE INSTITUTE



Climate Reanalyzer is a platform for visualizing climate and weather data sets. The site is coded and maintained by Dr. Sean Birkel through support from the Climate Change Institute and the School of Earth and Climate Sciences of the University of Maine, and partial support from the National Science Foundation.

On the Climate Reanalyzer you can investigate climate using historical station data, plot maps, export data and use exports in Google Earth.

Climate Reanalyzer also provides access to weather forecast models, allowing you to get 10-day animated forecast maps from global and regional models.

The most visited page on the site is "Today's Summary" which features several weather variables including temperature departure for the current day, relative to a recent climate baseline.

This is a resource as deep and as vast as the ocean itself. To access the Climate Reanalyzer interface visit cci-reanalyzer.org.

1865 THE UNIVERSITY OF MAINE

OCEAN IS A MAJOR INFLUENCE ON WEATHER AND CLIMATE

a. The ocean interaction of oceanic and atmospheric processes controls weather and climate by dominating the Earth's energy, water and carbon systems.

b. The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth. Heat exchange between the ocean and atmosphere drives the water cycle and oceanic and atmospheric circulation.

c. Heat exchange between the ocean and atmosphere can result in dramatic global and regional water phenomena, impacting patterns of rain and drought.

d. Condensation of water that evaporated from warm seas provides the energy for hurricanes and cyclones.

e. The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere.

f. The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon and water.

g. Changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere. These interactions have dramatic physical, chemical, biological, economic, and social consequences.

OCEAN LITERACY: PRINCIPLE 4

4

The ocean made earth habitable

The ocean made the Earth habitable

To frame the discussion, let's accept the following:

The ocean is the cradle of life; the earliest evidence of life is found in the ocean. The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.

Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean. This accumulation of oxygen in Earth's atmosphere was necessary for life to develop and be sustained on land.

The ocean provided and continues to provide water, oxygen, and nutrients, and moderates the climate needed for life to exist on Earth.

These are sweeping assertions that nonetheless confirm the basic conclusions of natural and ocean science over time. But within each, there are key elements that might be emphasized here.

First, consider the scale of life, its extreme complication of diversity and change through the historical record that extends backwards to theories

of the creation of our planet and the events, large and small, that have accelerated, impeded, and expanded the inventory of life. What is most humbling is to realize that, while that number is vast, perhaps an equal number or more remain to be discovered in the vast incubator of today's ocean. The implication of this past and future catalogue is as mysterious and challenging looking forward as it is looking back. Can we ever completely understand the matter and meaning of ocean life? Can we ever avoid the contradiction or extinction of any one species that might matter and mean the most for our future? The humbling reality of this vast and fluid compendium of what is both known and unknown must give us pause, must give us guidance, must give us direction that will accrue to the benefit of all mankind.

Second, consider the ocean as an universal operating system that provides air, water, food, energy, and nurturing conditions for all life, most specifically our own as individuals and social organizations. Consider also the incontrovertible impact on our health, security, and psychological and geo-political stability. Our engagement is total. As with modern tools, machines and computers, we are vulnerable to any single disconnection, any glitch in the system, any break that interrupts or shuts down the process, that leaves us swimming in a different sea of uncertainty, disruption, and fear. To knowingly or accidently produce such a condition is simply unacceptable.

Thus, third, the assumption that the ocean will continue always to provide is dangerous and self-defeating. That we would ignore existing or measurable consequence of inadequate or degrading outcomes is more than hubris; some idea that we know more than there is to know. That, ironically, transcends ignorance. If literacy is functional communication of knowledge, then to perversely pursue an uniformed path away from what the ocean provides is anti-social and fundamentally illiterate.

We must transform and apply our understanding of the ocean to solutions. What are the best practices now in use? What are the new ideas that we must dare to explore? What are the tools of invention by which to focus our energies and resources? What are the values, structures, and behaviors that must be changed to nurture and sustain what is a universal, inexorable system for the sustenance of all forms of life? The ocean is what makes our world, our land, our homes, our communities, and our selves "habitable."

We have neither reason nor right to compromise that, to poison that, or to limit that affirming aspect. We have every reason to study, analyze, and know the ocean, and in turn we are compelled to conserve, sustain and celebrate it as a vital gift.

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THE CRADLE OF LIFE

Shedding life on Earth's first oxygen-breathing life

Life-sustaining oxygen may have existed in primordial oceans long before entering the atmosphere. Oases of oxygen apparently existed for hundreds of millions of years before the gas made its debut in our atmosphere. Research suggests oxygen was present on Earth 300 million years before it spiked in the atmosphere, but at extremely low concentrations that would have left very slight traces in ancient rocks. Instead, the gas may have lurked in oases in the ocean, enough to feed oxygen-loving "aerobic" microbes.

Although life-sustaining oxygen gas currently makes up about a fifth of the air we breathe, very early in Earth's history, it was rare — if not completely absent — in the primeval atmosphere. It was only with the Great Oxidation Event nearly 2.3 billion years ago that this gas, whose molecules are each made of two oxygen atoms, began making a measurable dent in our atmosphere. This "O2" in turn stimulated the evolution of air-breathing life and ultimately the complex organisms that we are familiar with today.

Investigators speculated that microbes like cyanobacteria — so-called "blue-green algae" that live at the ocean surface — evolved the ability to produce oxygen gas via photosynthesis long ago. However, instead of building up in the oceans, much of this oxygen may have at first been rapidly consumed by early aerobic organisms, with the rest being consumed by chemical reactions with iron and sulfide that spewed out of underwater volcanoes. Eventually, however, there was enough oxygen to seep into the atmosphere, initiating the Great Oxidation Event.

Waldbauer, Summons and their colleague Dianne Newman detailed their findings in the August 8, 2011 *Proceedings of the National Academy of Sciences*.

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Life-sustaining oxygen may have existed in primordial oceans long before it entered the atmosphere.

LIVESCIENCE

THE OCEAN MADE THE EARTH HABITABLE

a. Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean. This accumulation of oxygen in the Earth's atmosphere was necessary for life to develop and to be sustained on land.

b. The first life is thought to have started in the ocean. The earliest evidence of life is found in the ocean.

c. The ocean provided and continues to provide water, oxygen and nutrients, and moderates the climate needed for life to exist on Earth.

OCEAN LITERACY: PRINCIPLE 5

Here is another premise on which a new understanding of and curriculum for the ocean can be based:

The ocean supports a great diversity of life and ecosystems

The ocean is an astonishingly fertile place, from micro to macro, at lever level of being. Simultaneously, these infinite bits and pieces are organized into relationships, processes, and amplified systems that are in constant movement – generation and re-generation – life and death and life again – that is dynamic beyond our present knowledge, perhaps our imagination.

How is such a phenomenon to be observed and understood? How can science even begin to access, collect, analyze, and conclude such a vast work and world of seemingly infinite change?

One way to understand the ocean is to enumerate its component parts. And that is precisely what science does today: with a global network of observation stations, buoys, autonomous vehicles, satellites, and research vessels with underwater instruments for exploration and discovery. The old saying that we know more about Mars that we do the ocean is quickly changing. Yes, Mars has its exciting aspects and

intimations, but knowledge of the the ocean as a physical, geological, chemical, and biological space is accelerating exponentially, driven by expanding technology, the power of curiosity and revelation, and a growing sector of the public that wants to see and know what's out there and how it pertains to humankind. In my informal anecdotal poll of career aspirations among the young, Astronaut have been handily replaced by Oceanographer or Marine Scientist – an encouraging sign for the future of ocean exploration.

Another way to understand the ocean is to reduce its vastness to manageable elements such as marine protected areas, whereby large parts of the ocean map are designated for restricted use and safety from extraction and polluting activities at risk. A similar method is the partition of the total fecundity into definable species of flora or fauna that can be studied horizontally across a migration path or food chain or life cycle that relies on the efficiency and economy of specialization. And yet another method is to focus on the whole, not so much as a sum of parts, but rather as an arrangement of connections that run off energy generated from outside or inside the ecosystem, viewed as an entity in and of itself and interacting with other systems of similar composition and scale.

A third way toward understanding is, of course, the amalgam of these two as affected by human responses in the form of utility and additional layers of social interaction as defined by finance, community, and culture. The complexity of the ocean system is further complicated by human applications and interactions, comparably organic, fraught with possibility, fraught with pain.

Human life is but a part of ocean life. An ecosystem relates biological organisms to one another and their physical surroundings, just as it is political entity that seeks to protect its value from all forms of pollution.

Finally, there is a fourth way to understand, by the negative value of the deprivation of diversity and life, activities that consume species to extinction, degrade habitats to dead zones, poison the sustaining cycles of food and food chain, modify or destroy the genetic cycle, and deprive all participants in the ocean world of succeeding parts of its total fertility, its implication for global health, a process of subtraction of value until the other ways of understanding are subverted, compromised, and left for dead. It will take more than a generation of aspiring marine scientists and ocean explorers to protect us from this destructive regress.

So what will it be? A process of addition, or subtraction, in an ocean account book of ecosystems and diversity? Ours to choose. A future that is ours to gain or lose.

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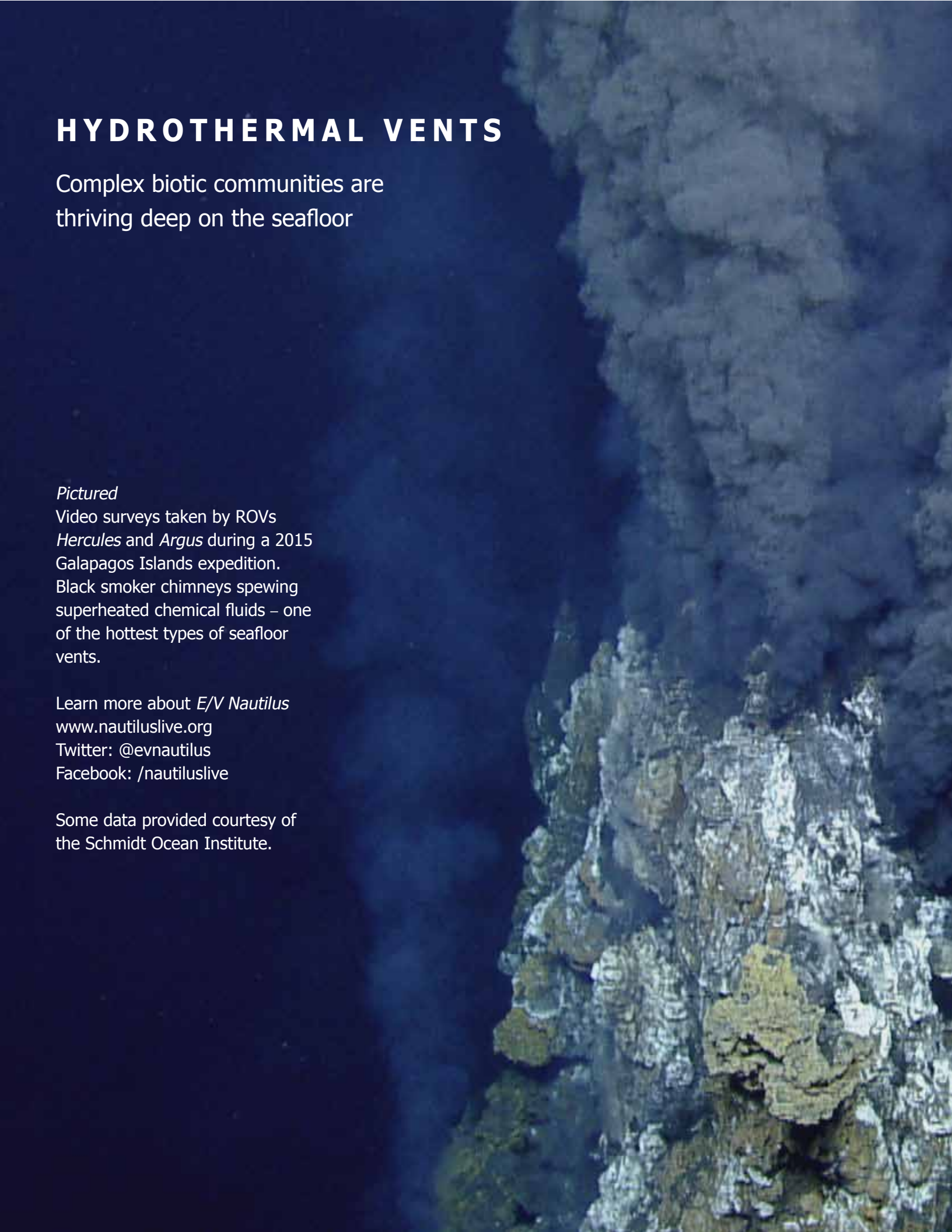
HYDROTHERMAL VENTS

Complex biotic communities are thriving deep on the seafloor



Pictured
Video surveys taken by ROVs *Hercules* and *Argus* during a 2015 Galapagos Islands expedition. Black smoker chimneys spewing superheated chemical fluids – one of the hottest types of seafloor vents.

Learn more about *E/V Nautilus*
www.nautiluslive.org
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Some data provided courtesy of the Schmidt Ocean Institute.

A vast portion of the world ocean seafloor is a flat, muddy abyssal plain. The rest is criss-crossed by deep trenches, rifts, seamounts and mountain ranges. Perhaps the area that fascinates scientists the most are hydrothermal vents, otherwise known as "black smokers" that are home to an astonishing array of sea life that live off the hydrogen sulfide contained in the vent fluids.

According to a report from the WorldWatch Institute, the diversity of life at vent sites may be relatively low, but the abundance of animals is generally quite high. Vent environments are said to support among the highest levels of microbial diversity on the planet.

While autonomous and interactive robotic seafloor mapping systems are allowing us to unlock the mysteries of the deep ocean, there is still much we do not know about these seafloor hydrothermal vent complexes.

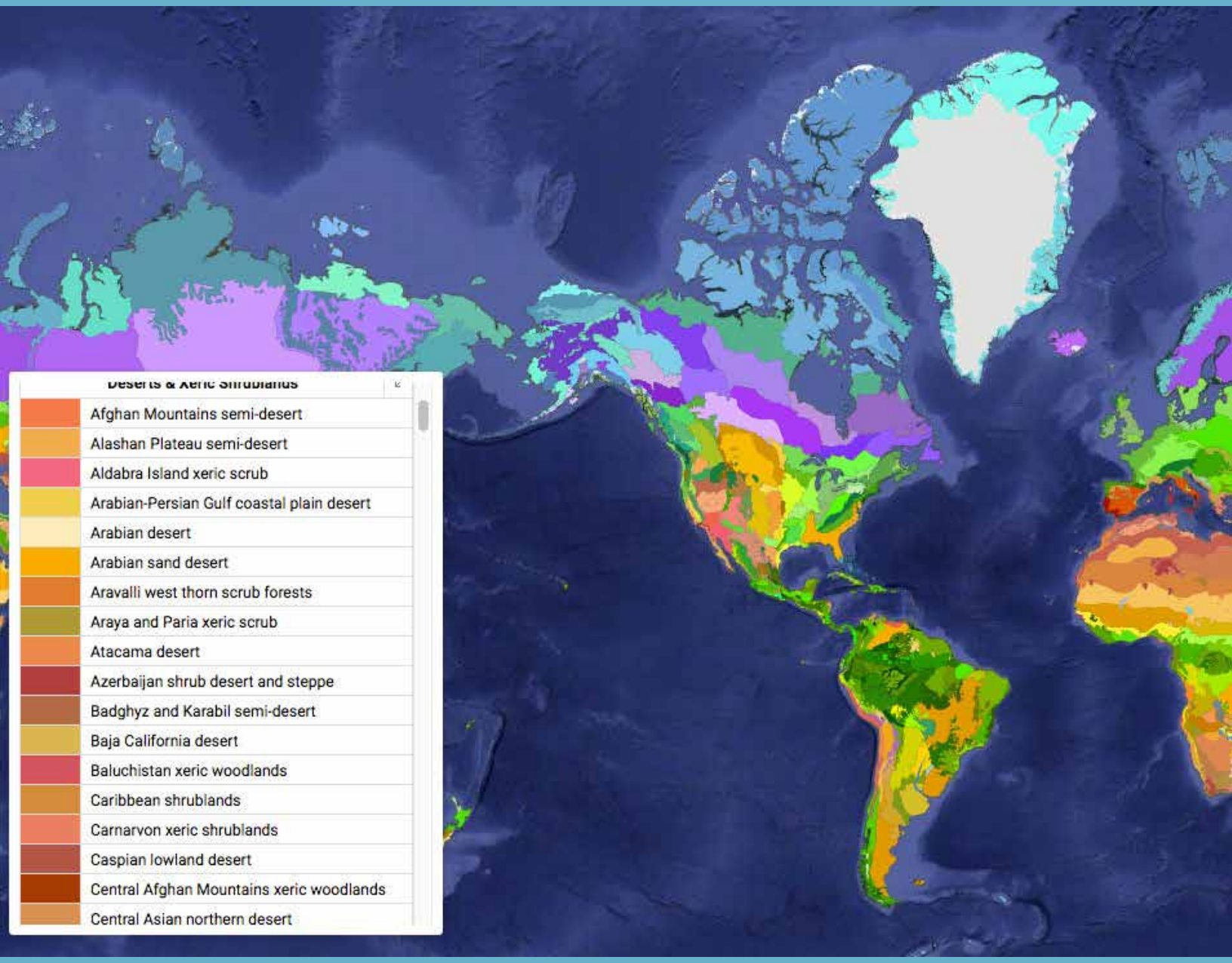
These hot springs on the bottom of the ocean form when a body of magma rises towards the seabed, such as on mid-oceanic ridges or volcanic arcs – the boundaries of oceanic plates. The biological, chemical and geological relationships in these areas are complicated and intricate, intertwined in ways that are not completely understood.

It is still largely unknown how neighboring vents influence each other, as new chimneys form while others shut down, and the ways in which life has to adapt. The big picture of vent systems evades most scientists as humans are as yet unable to experience and fully explore these deep sea environments.

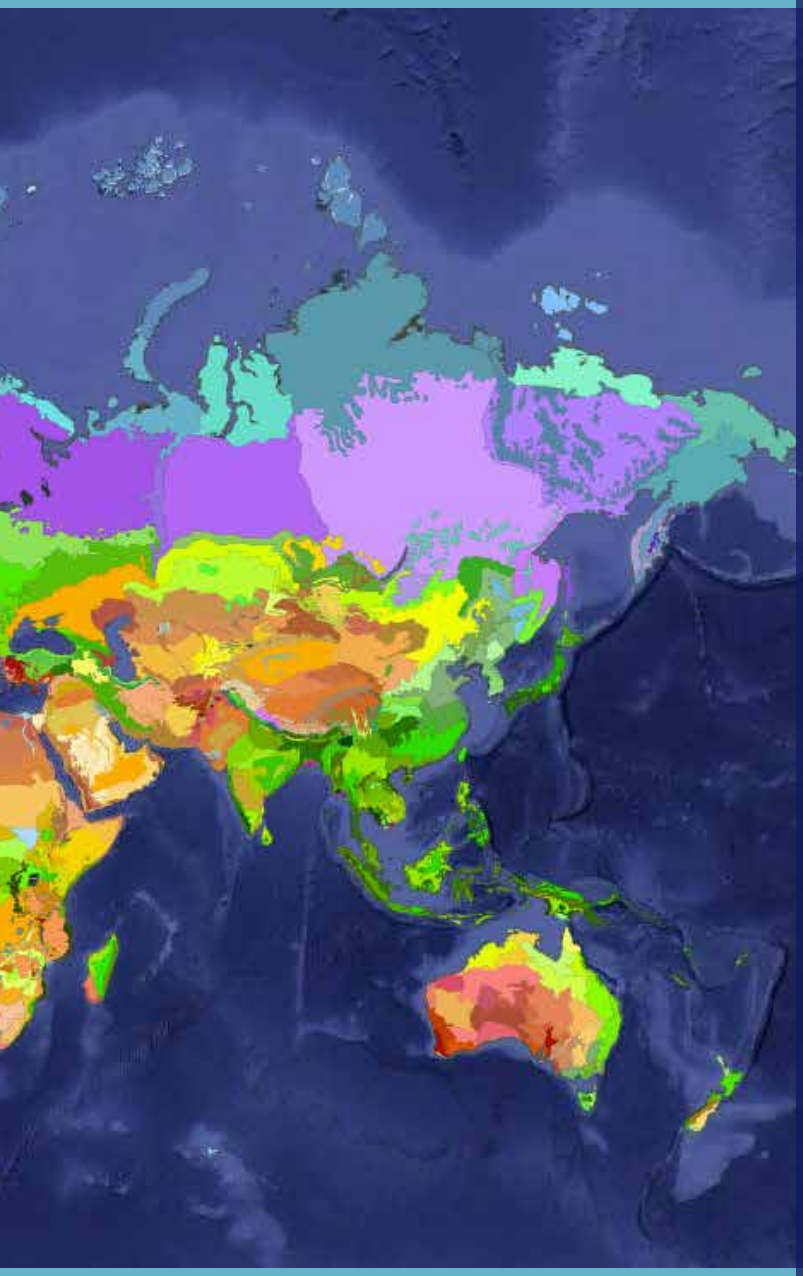
These ecosystems are not immune to human intervention: scientific research, bio-prospecting and seabed mining are among the many conflicts that will likely affect these largely unknown ocean spaces in the future.

WHAT ECOREGION ARE YOU IN?

There are only 846 ecoregions on the planet



BIOSCIENCE
Volume 67, Issue 6, June 2017
Download the "An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm" report at
academic.oup.com/bioscience/article/67/6/534/3102935



The ECOREGIONS 2017 map offers a depiction of the various ecoregions that represent our living planet. Ecoregions are defined as ecosystems of regional extent. On the Ecoregions Resolve interactive map they are color-coded to highlight their distribution and the biological diversity they represent. This new map is based on recent advances in biogeography – the science concerning the distribution of plants and animals. Map data underpins the most recent analysis by ecologists of the effects of global climate change. Ecoregion data can also be used to chart progress toward achieving the goal of *nature needs half:* to protect half of all the land on Earth to save and protect a living terrestrial biosphere.

Use the Ecoregions interactive map at ecoregions2017.appspot.com

Encyclopedia of Life

Global access to knowled

Search EOL ...

Begun in 2007 with the idea of providing a webpage for every species. EOL brings together trusted information from resources across the world such as museums, learned societies, expert scientists, and others into one massive database and a single, easy-to-use online portal at EOL.org.

Founded by E.O. Wilson in 2007, the vision was to create an online encyclopedia for every species on the planet, providing global access to knowledge about life on Earth including articles, photos, maps, data and links. The EOL has grown to include information on nearly 1.4 million species out of the 1.9 million species recognized by science.

In January 2014, to support the needs of the global research community, EOL launched TraitBank™ - a searchable, comprehensive, open digital repository for organism traits, measurements, interactions and other facts for all species. The searchable database contains more than 11 million records related to more than 330 attributes for 1.7 million taxa from more than 50 data sources.

Learn more about the EOL

EOL.org

media.eol.org/traitbank

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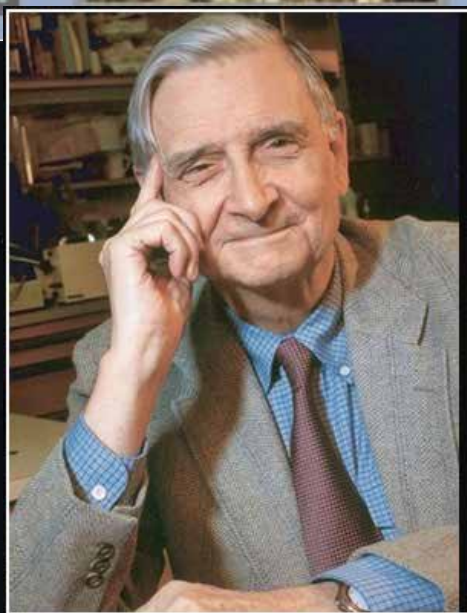

What we need is an electronic encyclopedia of life, with one page for each species. On each page is given everything known about that species.

— E. O. Wilson —

OCEAN SUPPORTS A GREAT DIVERSITY OF LIFE AND ECOSYSTEMS

a. Ocean life ranges in size from the smallest living things (microbes) to the largest animal that has lived on Earth (blue whales.)

b. Most organisms and biomass in the ocean are microbes, the basis of all ocean food webs.

c. Most of the major groups that exist on Earth are found exclusively in the ocean.

d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.

e. The ocean provides a vast living space with diverse and unique ecosystems from the surface through the water column and down to, and below, the seafloor. Most of the living space on Earth is in the ocean.

f. Ocean ecosystems are defined by environmental factors and the community of organisms living there. A few regions of the ocean support the most abundant life on Earth, while most of the ocean does not support much life.

g. There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms.

h. Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast.

i. Estuaries provide important and productive nursery areas for many marine and aquatic species.

OCEAN LITERACY: PRINCIPLE 6

6

The ocean and humans are inextricably interconnected

The ocean and humans are inextricably interconnected

The full extent of this statement is key to any future resolution of today's challenges to the natural health and social value of the ocean. First, there is the affirmation of human presence—action and reaction—in all aspects of the natural world. Denial of the impact, positive or negative, is simply not a fact of life. Second, there is the finality of inextricability, the certainty that there can be no separation one from the other, no compromise of the actuality of connection. Third, there are the implications of the prefix, inter: to be located or existing between, in the midst, as in "inter-grated"; to be reciprocal or carried on between, as in "inter-national"; or to be occurring among, as in "inter-vening." There are linguistic subtleties here that relate to nuance that, when amplified to a global scale, have incontrovertible meaning and significance.

How can we better communicate this connection? For example, most students learn about the water cycle in their earliest science classes. They see and understand the circular inter-action between ocean water, evaporation, circulation in the atmosphere, and condensation into fog or rain or snow far inland that further deposits and flows through run-off, streams, lakes, rivers, to an

extent ending back again in the ocean near or far from each drop's point of origin. It is simple, elegant, easy to explain, and so most students retain it as a fundamental understanding of a natural system.

But what about the human impacts of this circulation? While these may seem obvious, it is surprising how disconnected this knowledge is from understanding of the social consequences of the cycle as essential for our daily lives in the form of drinking water, irrigation, sanitation, manufacture, and so much else. When we claim that the ocean begins at the mountaintop and descends to the abyssal plain, we are amazed at the surprise such a declaration engenders, as if we have redefined the ocean far beyond and in some original way from how it is conventionally understood as a distinctly separate place apart from the land.

Another similar example pertains to our patterns of consumption and exchange. Most people don't understand that almost every thing we make or purchase for our use has its economy and efficiency affected by maritime transportation and trade.

Much of our energy, appliances, electronics, automobiles, processed foods, computers and communications, and even financial products such as currency and trading, are produced somewhere else and exchanged via ships or underwater cables that are, even in port cites such as New York or Shanghai, located away from the concentrated populations that consume these goods and services. When we interrupt this delivery, as a result of market forces, tariffs, regulations, or other economic or political actions, this global network slows or stops with further devastating inhibition of world security and stability. This ocean system is invisible and necessary as a structure for the circulation of goods that unites us in the best of times and separates and alienates us in the worst.

Finally, there are connections of people and ideas. Never have the people of this world been more mobile, moving as business executives, tourists, migrants and refugees seeking opportunity or fleeing tyranny. Never have ideas and innovations been more shared between teachers, students, policy-makers, governors, creators, and curious individuals who find connection though art, language, and invention. We have all become inter-connected citizens of the world through media and information facilitated by the same network of connection that brings us to the admixture of things and people that we call civilization.

We look at a world map and we see the continents as if floating in a unifying ocean. It has been so since the beginning of time.

We are not separated by the ocean; the sea connects all things.

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WE ARE A MARITIME NATION

Connected through and by the sea

"The People's History of the United States" by author and historian Howard Zinn, should be read by everyone regardless of political persuasion. In the book, Zinn provides a provocative and alternative perspective on the story of the United States' history as institutionalized in the text books, a telling argument for taking a second look from a different point of view.

I have always felt that Americans have no real understanding of our history as a maritime nation. The subject is mostly absent from the texts and the specific maritime histories have been most often enumerations of customs house documents, ship voyages, and the odd naval battle. Only recently has that begun to change as historians from other disciplines have discovered the broad impact and richness of maritime endeavor as a core theme in the American narrative.

Let's take two points of view: internal and external. If you look at the topography of our nation, you see a system of watersheds – great lakes connected to rivers and the sea; streams descending from major mountain systems, east and west; and myriad rivers feeding the

James Guy Evans (United States, circa 1810 - 1860), US Ships of the Line *Delaware* and *North Carolina* and Frigates *Brandywine* and *Constellation*. Oil on canvas, New York Historical Society. Anonymously gifted to the Portland Museum of Art.

Mississippi, a central north-south artery that splits the nation. Those waterways were the paths of early exploration and settlement.

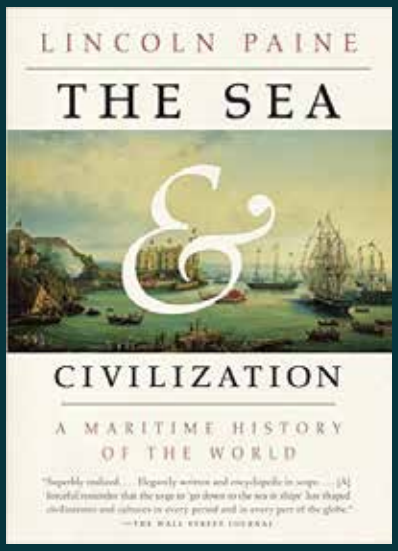
Many of our largest inland cities are located on the confluence of navigable rivers. The Erie Canal, an engineering marvel, linked the heartland to the east coast ports and Europe. Lewis and Clark followed the rivers and streams into the west, through the Rockies to the Pacific. Along these waterways passed the grain, cotton, tobacco, and other agricultural products, the iron and steel and coal and timber, and the manufactured goods, distributed internally, to the eastern ports like New York, Boston, Charleston, and Savannah and around Cape Horn to western ports of San Francisco and Seattle and beyond, as the essence of an emerging American world trade.

The external perspective is also instructive. It reveals that trade as more than export, rather the exchange of goods from Europe and further east, and, most importantly, the imported return, the arrival of immigrants, refugees from religious tyranny, entrepreneurs, and outlaws, who are our forbears by the thousands. We honor our few remaining indigenous people. But the rest of us came from away, from Ireland, Scotland and England, from Scandinavia, from Germany and Italy, from Africa (albeit an involuntary passage), and eventually from all the nations of the world, these diverse ethnicities combining to create the complex nation that we are. Most of these people came by ship across oceans, and, today, perhaps by different vessels, they are still coming.

What Zinn and other historians have recognized is that the principal value exchanged by this process was not just the trade goods and financial accountings, but also the ideas and beliefs, the art, the music, and the literature that are the cultural fabric of our moment. We listen to world music and appreciate world art. We are open to multiple religions and spiritual practice. We fuse food traditions, fashion, fads, medical treatments, exercise, sport, and language. We may have new and different portals now, but the process began long ago when the first sailors left shore in search of something beyond their own experience, beyond their limited horizon.

When I look at things now, I wonder where the sailors are. We have become fearful and oppositional and close-minded. We have become complacent within our horizon and hostile to new people and new ideas.

We need historians like Howard Zinn, and new leaders to show us the way back to the sea, the sea that connects all things.



The Sea and Civilization: A Maritime History of the World
by Lincoln Paine
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A monumental retelling of world history through the lens of the sea, revealing how people first came into contact with one another by the world's waterways--ocean, river, lake and stream--and how goods, languages, religions, and cultures spread across water, bringing together civilizations and defining what makes us most human.

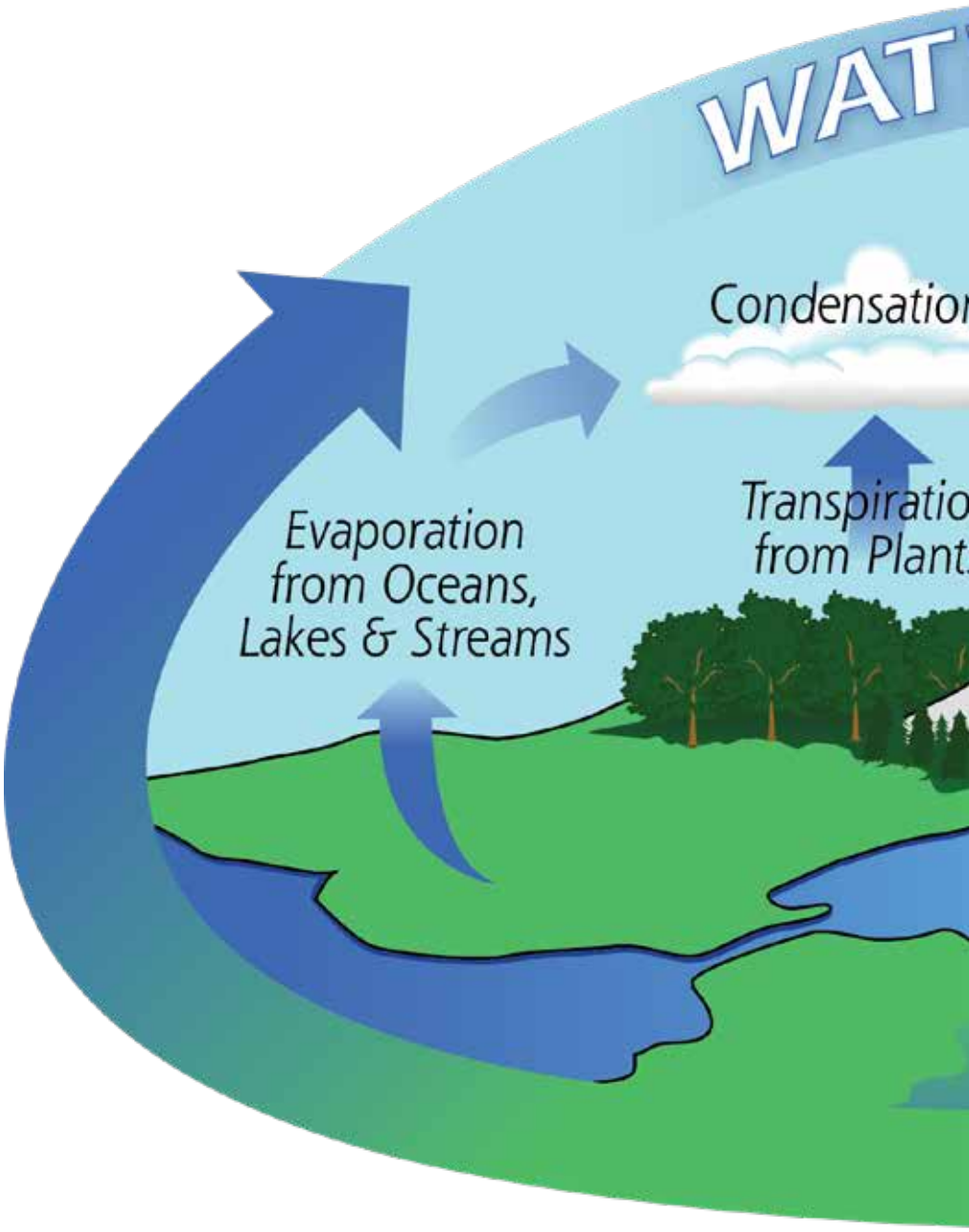
Lincoln Paine's book casts the world in a new light, arguing that the rise and fall of world civilizations can and should be linked to the sea.

THE GLOBAL WATER CYCLE

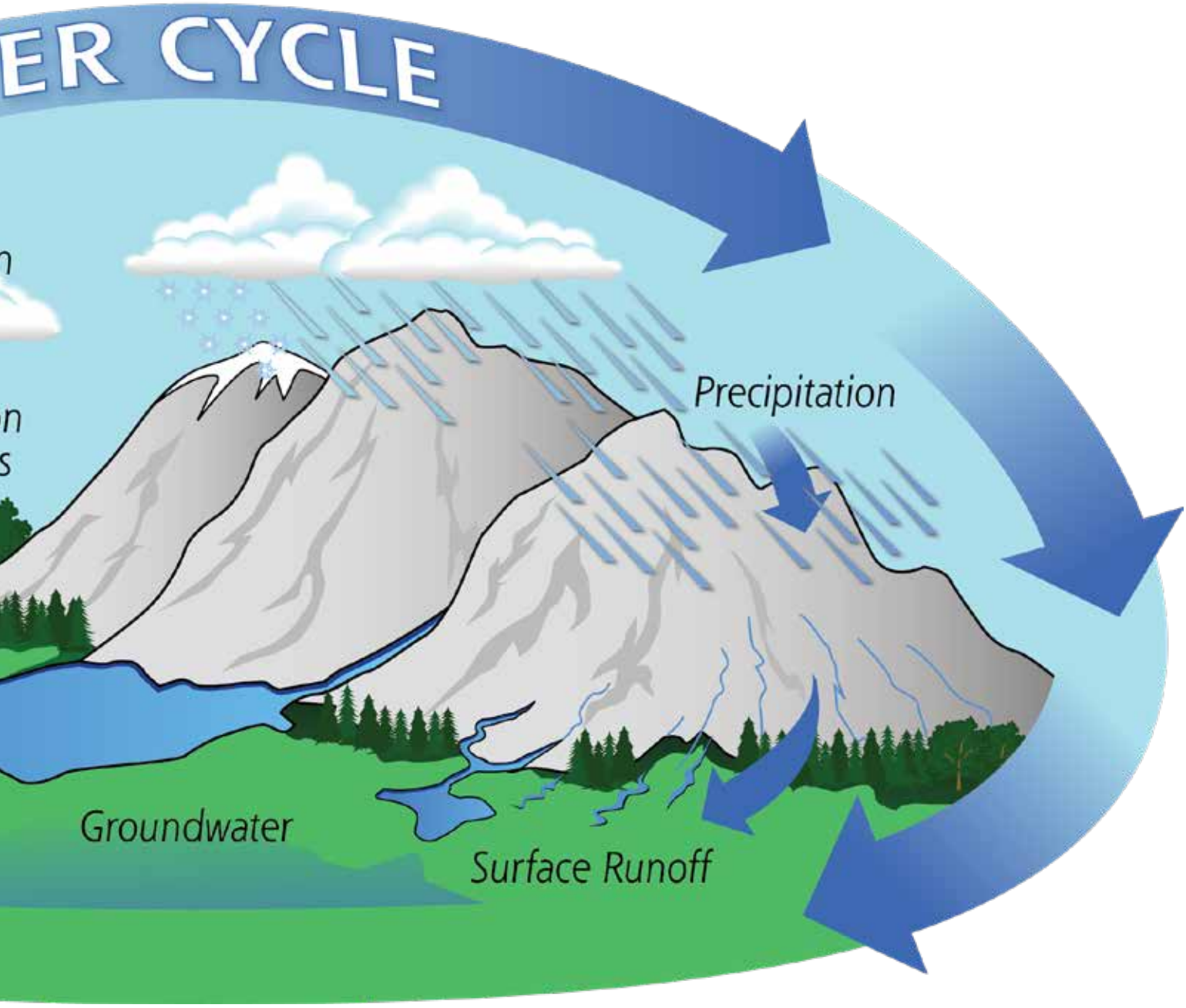
Where does water come from?

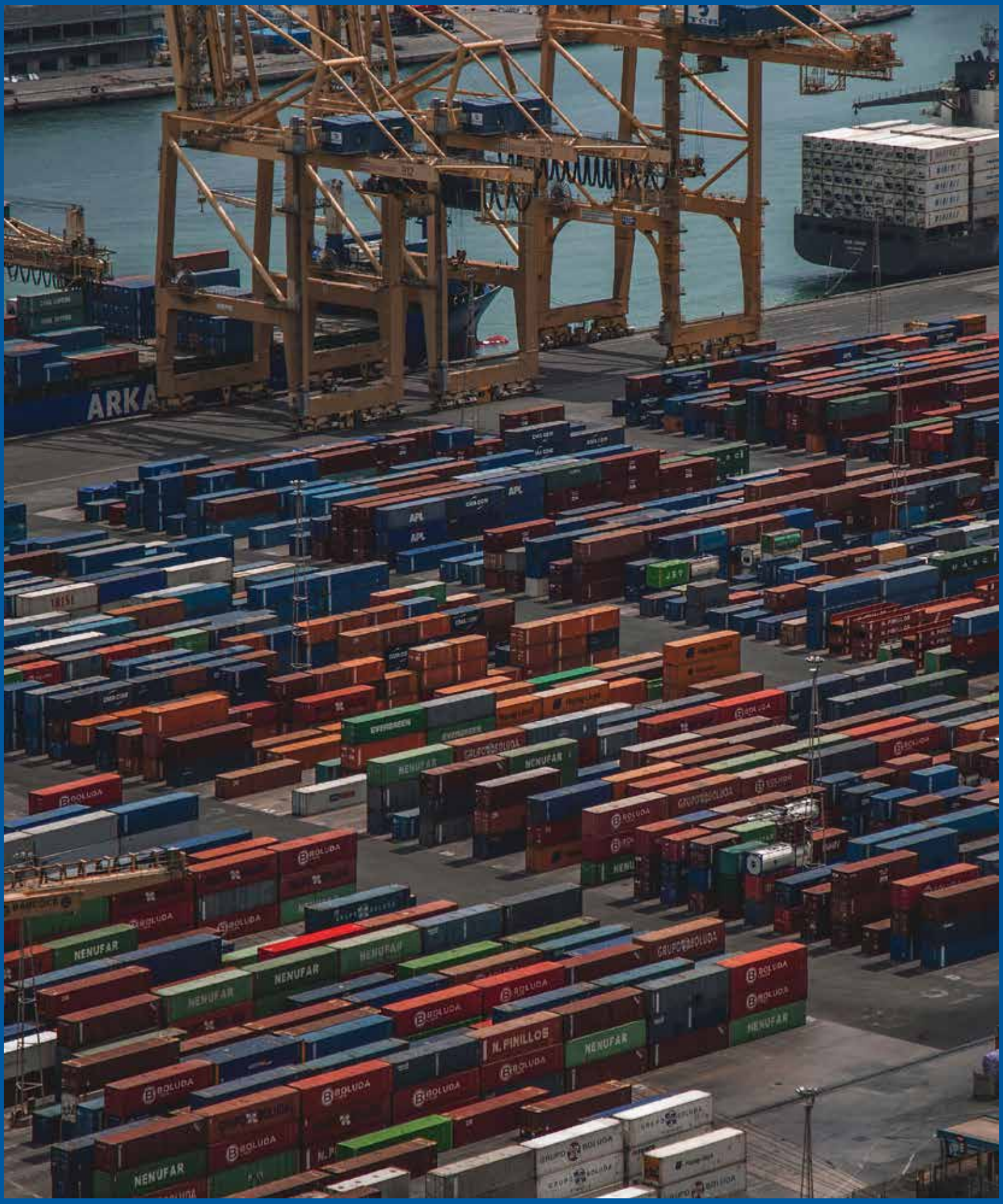
The answer is known from our earliest science lessons, when we are introduced to the water cycle and the global circulation system that is so essential to our well-being. Water evaporates from the ocean reservoir, captured in clouds and fog and rain, from which it descends to become ground water, seeping into the underground aquifer, or surface water distributed by lakes and streams. Some of the water is captured in ice as glaciers and high mountain peaks; some is retained deep in the earth, some perhaps pre-historic in its deposit, for now beyond our eager digging and drilling. And all of the earth's water is finite in volume.

If we think about the water cycle it becomes easy to understand that the ocean, where 97% of that volume of water is contained, is the alpha and omega, the mouth and tail from this circle of sustenance. It becomes easy to see the ocean edge not at the boardwalk or the beach, but rather at the distant snow-capped mountain range with the long, circuitous flow of water down and across the land, until it reaches its ocean origin where the cycle begins again.



Main processes of the water cycle
Credit: NASA


ER CYCLE
Precipitation
Groundwater
Surface Runoff


ARKA
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BOLUDA
GRUPOBOLUDA
N. FINILLOS

THE OCEAN AND HUMANS ARE INEXTRICABLY LINKED

a. The ocean affects every human life. It supplies freshwater and nearly all of the Earth's oxygen. The ocean moderates climate, influences our weather, and affects human health.

b. The ocean provides foods, medicines, and mineral and energy resources.

c. The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

d. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution, changes to ocean chemistry and physical modifications.

e. Changes in ocean temperature and pH due to human activities can affect the survival of some organisms and impact biological diversity.

f. Much of the worlds population lives in coastal areas.

g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean.

OCEAN LITERACY: PRINCIPLE 7

7

The ocean is largely unexplored

The ocean is largely unexplored

No one argues this point with such authority as Edward O. Wilson, university research professor emeritus and an honorary curator of entomology at Harvard, who, in a recent opinion in the *New York Times* entitled "The 8 Million Species We Don't Know," writes, "The most striking fact about the living environment may be how little we know about it. Even the number of living species can be only roughly calculated. A widely accepted estimate by scientists puts the number at about 10 million. In contrast, those formally described, classified and given two-part Latinized names (Homo sapiens for humans, for example) number slightly more than two million. With only about 20 percent of its species known and 80 percent undiscovered, it is fair to call Earth a little-known planet… In the sea and along its shores swarm organisms of the other living world — marine diatoms, crustaceans, ascidians, sea hares, priapulids, coral, loriciferans and on through the still mostly unfilled encyclopedia of life."

To preserve these organisms, Wilson and other conservation scientists propose to keep half the land and half the sea of the planet as wild and protected from human intervention

or activity as possible. Called *The Half-Earth Project*, they argue for conservation of places chosen by three main criteria: 1. areas judged best in number and rareness of species by experienced field biologists; 2. *hot spots*: localities known to support a large number of species of a specific favored group such as birds and trees; and 3. broad-brush areas delineated by geography and vegetation, called eco-regions.

These, applied to the ocean, underscore the efforts by governments and ocean advocates to designate marine protected areas around the world as reserves to protect the natural biodiversity from further destruction human intervention and exploitation.

Associated tactics such a *marine zoning* are corollary to this effort, by additional designation of remaining areas to restrict specific enterprise such as industrial fishing, limited shipping routes, prohibited waste disposal, and all the other activities that occur in the ocean as a result of destructive behaviors on land.

Wilson continues, "In the sea and along its shores swarm organisms of the other living world — marine diatoms, crustaceans, ascidians, sea hares, priapulids, coral, loriciferans and on through the still mostly unfilled encyclopedia of life." And he concludes, "With new information technology and rapid genome mapping now available to us, the discovery of Earth's species can now be sped up exponentially. We can use satellite imagery, species distribution analysis and other novel tools to create a new understanding of what we must do to care for our planet."

So where and how are we looking? Research vessels, fixed observation systems, autonomous vehicle on the surface, in the water column, and on the ocean floor. Ice cores, hydrothermal vents, coral reefs – all these *ocean* places contain evidence of past and present life with enormous implication for future life in the form of news species discoveries, medicines synthesized from marine organisms, mimicry of ocean processes, and more complete knowledge of what surely is the last great wilderness where Nature still exists to support life in all it forms, now and to come.

Ocean literacy comprises principles and awareness that will inform our world. We cannot be truly educated without it, reliant on only half of Earth's supporting assets. We can also learn from what has gone before: the exhaustion of indiscriminate use of the land, the corruption of the air, and the already evident compromise that may delimit the essential value of the freshwater/ocean continuum. To be literate means to know the history and to learn from it; to see the reality and challenges of the present; and to engage in the pursuit of knowledge – in the vast ocean world – on which our future will depend.

Learn more about Ocean Literacy:

oceanliteracy.wp2.coexploration.org
#oceanliteracy | @4Oceanliteracy

MAPPING THE OCEAN FLOOR

The biology behind the origin of life

To know the ocean is to know the biology of the origin of life, the physiology of ourselves, the chemistry of cures and diseases...

The earth is more than 70% covered by water, and otherwise comprising an infusion found in our plants and animals, in our above and below ground waterways, and in our bodies. The ocean cycles and conveys that water and supports life above and below, in the water column, and into the geology, physics, chemistry, and biology of all habitats for all species. How can it be that we know so little about it?

Over the past decades, scientists have become obsessed with observation, enabled by new technologies like satellites and remotely operated underwater vehicles, by fixed installations and structures, buoys and submerged collectors that can capture a constant stream of data, represented on globes and projections then, charts and global positioning devices now. Sonar, a modern technology that can scan through the barriers of turbidity and depth in the ocean, can provide

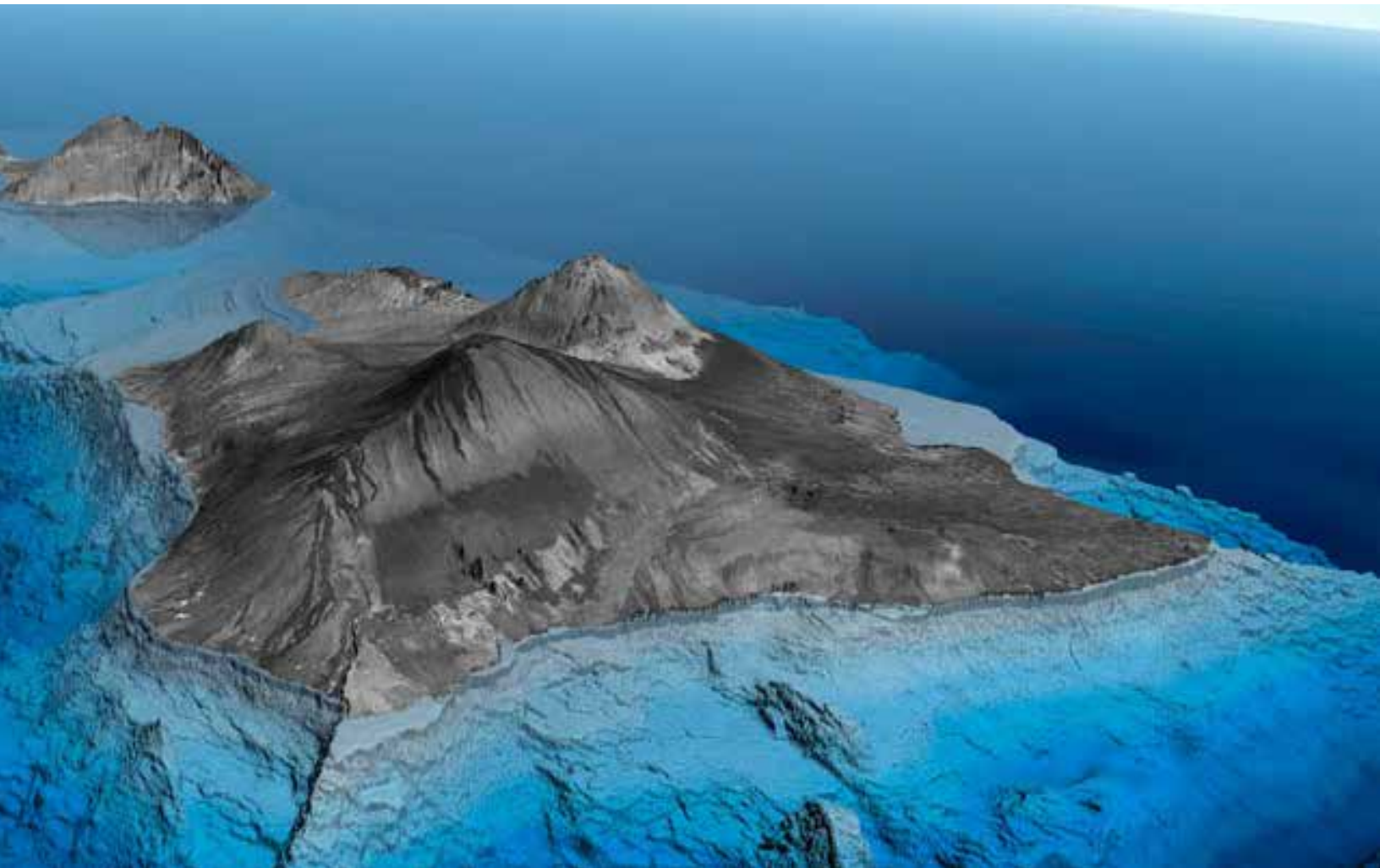
Hawaiian Islands. GEBCO-NF Alumni team. Led by alumni of the Nippon Foundation / GEBCO Ocean Bathymetry training program at the Center for Coastal and Ocean Mapping of University of New Hampshire.

an incredibly detailed, accurate rendering of every nook and cranny of the sea floor, all the places for fish to breed, natural resources to be found, and submarines to hide. There have been numerous independent efforts to coordinate and collect this information—networks of observation stations, programmed satellite monitoring, ships at sea in the trade routes, fishing boats, or research vessels in certain areas in search of specific information – all that have increased our knowledge to be sure, but a true, coordinated, comprehensive effort, planned for methodical survey has been difficult to sustain beyond such piecemeal progress.

Until now.

Financed by major support by the Nippon Foundation, a Japanese ocean research philanthropy, the General Bathymetric Chart of the Oceans (GEBCO), a project based in Monaco, has resolved to complete the full mapping of the world ocean by 2030 by coordinating all existing information, commissioning specific surveys of unexplored areas, and engaging public and private institutions and interests, nations and international associations to combine existing data with related scientific expeditions, shipping itineraries, satellite controlled unmanned vessels, fishing fleets, and underwater drones to record every hidden corner of the sea.

There is always the question: why? Why do we pursue any knowledge really, the world seemingly understood well enough, progress risky, and resultant change uncertain? Oddly, these questions are being asked more often these days, an emerging, disconcerting distrust and dismissal of science that is finding its way into public media, education, and politics. The threat to "defund science" goes against what I would argue is the essential measure of human progress as over time we have inquired and investigated, theorized and experimented to discover answers to questions about how the world works that have advanced our well-being time and time again with no reason to doubt that such beneficial advancement will continue into the future.



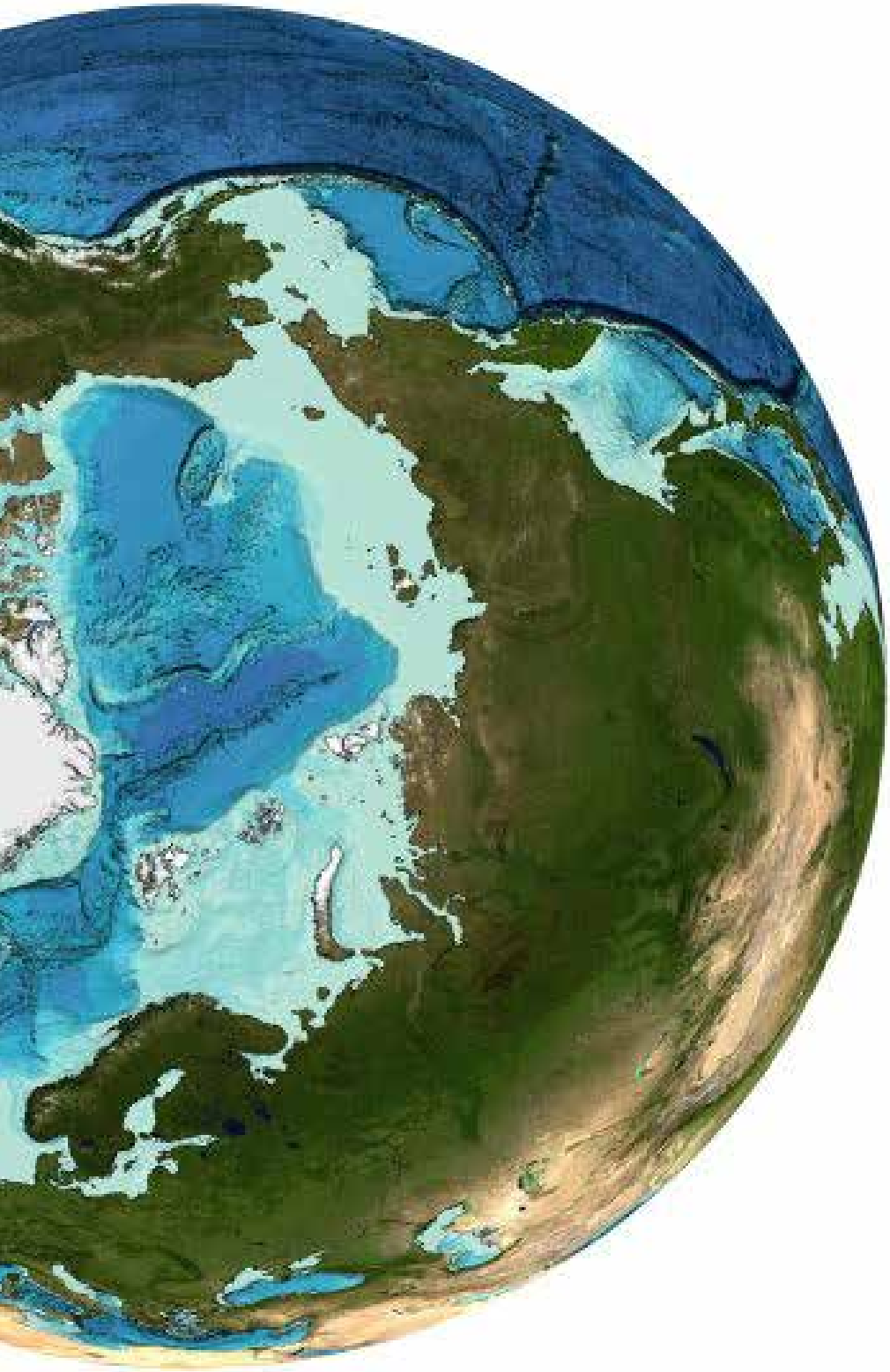
Unless we stop asking the questions, and by so doing not caring to improve our lives and the lives of others, denying human curiosity and the civilizing value of inquiry.

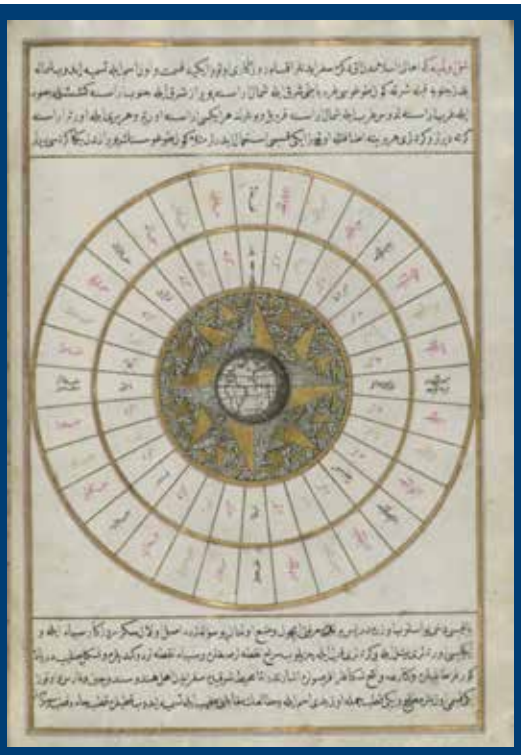
To know the ocean is to know the biology of the origin of life, the physiology of ourselves, the chemistry of cures and diseases, the geology of plate tectonics, volcanoes, and the earth's core and crust, the physics of waves and currents, temperatures, and conditions in the water column that contribute to our food security, economy of our work, and the anthropology of our history and the art of our cultural traditions.

To abandon science and to not know these things is a contradiction of what it means to be educated and engaged for the betterment of all human life.

If we don't know or don't care about the ocean as an integrated and interconnected natural, financial, political, and social system, we are lost. Science is a method and a map to tell us exactly where we are, at least for now, until we know that it is time to ask ourselves again. To navigate successfully, it is always best to have clear soundings.

The General Bathymetric Chart of the Oceans (GEBCO) aims to provide the most authoritative publicly-available bathymetry data sets for the world's oceans. GEBCO operates under the joint auspices of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. You can view an array of 3-D views from the GEBCO 2014 Grid at gebco.net/data_and_products





DAVID RUMSEY MAP COLLECTION

The David Rumsey Historical Map Collection Database has more than 89,000 maps and related images online. The collection includes rare 16th through 21st century maps of the Americas, Europe, Asia, Africa, the Pacific, Arctic, Antarctica, and the maritime world.

The David Rumsey Map Collection focuses on rare 16th through 21st century maps. The collection includes atlases, wall maps, globes, school geographies, pocket maps, books of exploration, maritime charts, and a variety of cartographic materials including pocket, wall, children's, and manuscript maps. Items range in date from about 1550 CE to the present. Maps are available for hi-res download on demand. Visit davidrumsey.com

LEARNING BY DOING: ALTERNATIVE CLASSROOMS

Examples of maritime education around the world teaching beyond the traditional classroom

Teaching and training the next generation of citizens of the ocean

Education is the transfer, formally or informally, of knowledge, skills, and experience from one generation to another. Educators can be academic experts, research scientists, classroom teachers, mentors, or special individuals who accept the responsibility of such exchange for the reward of seeing students of all ages mature and respond through improvement of self, relations with peers and partners, and integration with community.

Here we offer some remarkable examples of programs in the United States and abroad that explore alternatives that are proving effective, successful, and influential in the shifting of didactic structures for teaching and learning toward progressive application in the future. Ocean Literacy itself is a serious step in that direction, offering the broadening of perspective and premise around which we organize and share what we know as a new world context for value, structure, and behavior that is dependent on an healthy ocean.

1 SOUND SCHOOL

NEW HAVEN, CONNECTICUT

Sound School is the first full-time ASTE center to concentrate on the study of aquaculture and marine trades in the state of Connecticut.

Their comprehensive academic program prepares students for a post-secondary life which may include, college, technical school, the military, or entering employment upon graduation. Curriculum includes extensive exposure to on-the-water and water-related activities and coursework such as nautical drafting, marine research, aquaculture production, and vessel handling and safety at sea. New Haven students may opt to study the more traditional vocational agriculture program which includes courses in plant science, animal science, agriculture mechanics, and veterinary science.

Learn more: http://sound.school

2 EXPEDITIONARY LEARNING

IN SCHOOLS IN 30 U.S. STATES

EL Education was born out of a collaboration between The Harvard Graduate School of Education and Outward Bound USA, infusing the philosophy of Outward Bound founder Kurt Hahn. EL Education has a focus on teamwork, courage, and compassion with an active approach to learning. Their mission now, as then, is to create classrooms where teachers can fulfill their highest aspirations and students achieve more than they think possible, becoming active contributors to building a better world. Today there are more than 150 Expeditionary Learning Schools in 30 U.S. states.

Learn more: eleducation.org

3 FLOATING SCHOOLS BRING CLASSROOMS TO STUDENTS

SHIDHULAI SWANIRVAR SANGSTHA

BANGLADESH

Shidhulai Swanivar Sangstha is a not-for-profit that has served over 70,000 children in Bagnladesh by creating 20 free floating schools. Classes are housed in refurbished traditional wooden boats that can be moored in rivers and safe places, unaffected by the water environment, thereby keeping the children involved in consistent learning in facilities that are resilient against natural disasters. The program was started by Mohammed Rezwan who founded the organization with $500. Shidhulai has received support from the Global Fund for Children in the United States, a financial prize from the World Innovation Summit for Education, sponsored by the Qatar Foundation, and a major grant from the Bill and Melinda Gates Foundation that has enabled Rezwan to build more boats, install solar power, and create a floating library.

Learn more: shidhulai.org

BILLION OYSTER PROJECT

Engaging students in a hands-on activity to reconnect New York harbor to the 30 million people living within its vast urban watershed

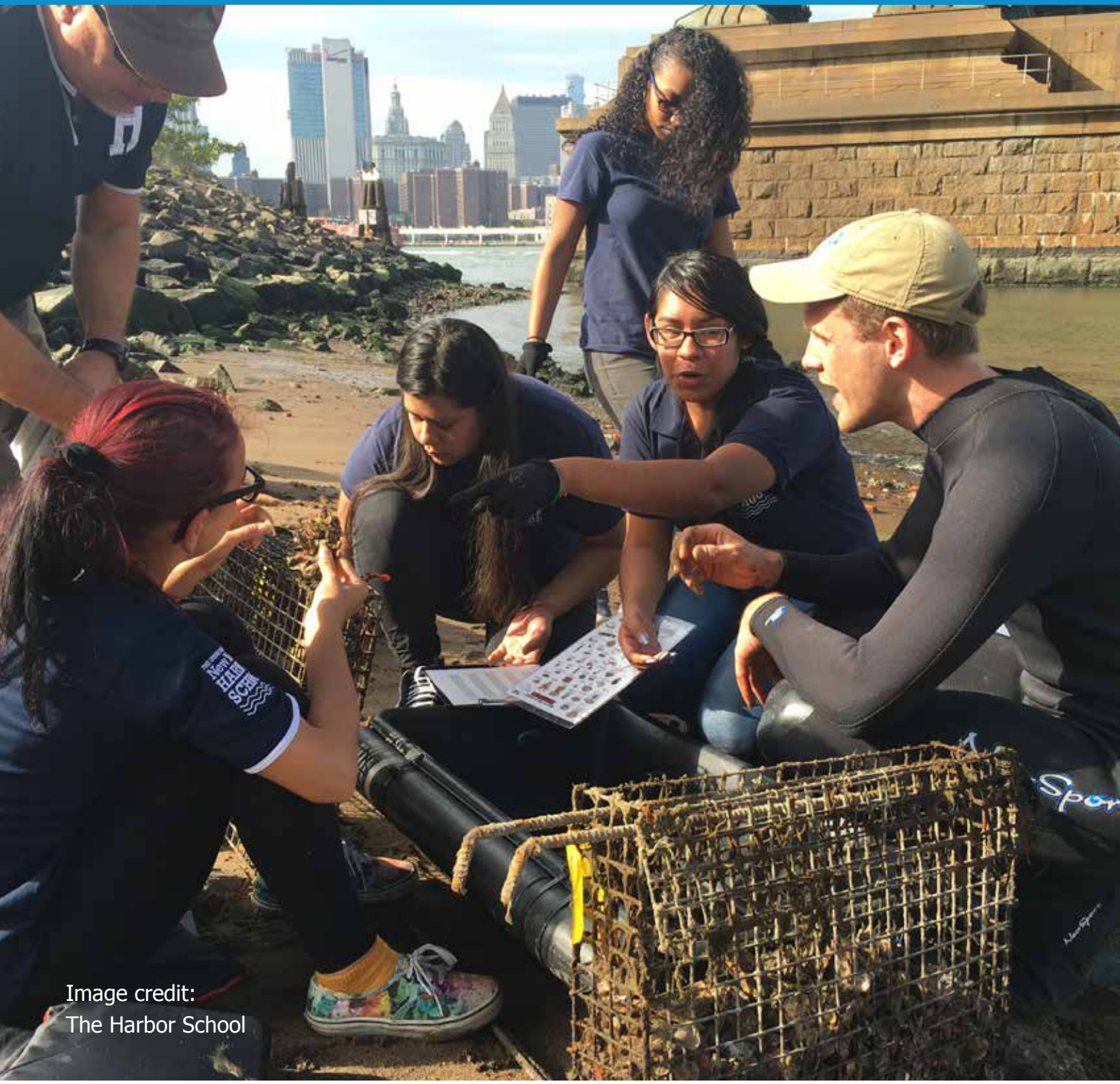


Image credit:
The Harbor School

As a community organization, an educational experiment, and an expression of new sustainability-based values, the Harbor School demonstrates how learning can be effective and useful when coupled with Nature to build better lives for ourselves and better places to live alongshore.

Today, in New York Harbor, an innovative, theme-based high school is organizing its curriculum around maritime history, marine science, and marine vocational skills as a context for teaching and learning that is authentic, experiential, and inspiring. Located on Governor's Island, the former U.S. Coast Guard headquarters in New York Harbor, this educational experiment has grown in size and stature and places its graduates in jobs, often marine-related, as well as college and the maritime academies in the United States and elsewhere.

The Billion Oyster Project is a citizen science ecosystem services initiative coordinated by the Harbor School. The project aims to engage hundreds of thousands of school children during its lifetime in marine restoration-based STEM education programs. To date they have involved more than 3,000 students in an aquaculture study that has the potential to clean up and sustain New York Harbor. The students exploit the new cleanliness of the water and are reviving the defunct oyster populations through the ambitious goal of restoring no less than one billion oysters to the Harbor by 2030.

And so they have begun through aquaculture study, seeding and growing, shell recycling, summer camps, fundraising events, and volunteer efforts. They have planted some 16 million oysters for ecosystem services since the project began in the polluted Gowanus Canal in 2006.

Learn more at www.newyorkharborschool.org

LEARNING BY DOING: SAIL TRAINING

Teaching and learning beyond the traditional classroom

What matters at sea? Safety, knowledge, competence, civility, and concern for self and others. There are values not easily learned in a conventional classroom, nor, once learned, are they easily forgotten.

1 SEA EDUCATION ASSOCIATION

CAPE COD, MASSACHUSETTS

Sea Education Association (SEA) is an internationally recognized leader in undergraduate ocean education. Since 1971, their semester at sea programs have provided students with the tools to become environmentally literate leaders prepared to address the defining issue of the twenty-first century: the human impact on the environment. Accredited through Boston University, SEA offers the leading off-campus environmental studies program focused on the ocean. While academic focus varies, each program is designed to explore a specific ocean-related theme using a cross-disciplinary approach. SEA is based on Cape Cod in the oceanographic research community of Woods Hole, Massachusetts.

Learn more: sea.edu

2 PICTON CASTLE BOSUN SCHOOL

LUNENBERG, NOVA SCOTIA

The Bosun School is designed for people preparing for a career at sea and is available to those with previous experience aboard traditional vessels or who have sailed on ships and vessels of some kind. The purpose of the Picton Castle's Bosun School is to provide an opportunity for young dedicated mariners to advance their skills in a concentrated fashion without the natural demands and distractions of being underway at sea.

Learn more: picton-castle.com/bosun-school

3 ATLANTIC CHALLENGE INTERNATIONAL

GLOBAL CONTESTS OF SEAMANSHIP

Every other year the Atlantic Challenge International Contests of Seamanship take place in a different host country. A friendly contest of seamanship in traditional Bantry Bay gigs, teams from around the world gather to build trust among nations and form a community of youth and adults in the fun practice of traditional maritime skills. An international experiential education organization operating in many nations, Atlantic Challenge programs practice, share, and encourage the rise of the skills of the sea including boat building, sailing, rowing, and seamanship. Its activities bring youth together with the intent of fostering cultural and global understanding. The most recent Atlantic Challenge Contests of Seamanship took place in Antrim in Northern Ireland in 2018.

Learn more: atlanticchallenge.org

LEARNING AT SEA

Building the next generation of ocean stewards through sea experience

image credit:
Woods Hole SEA Semester
Pacific Reef

What happens at sea is authentic rather than circumstantial, real not virtual, active not passive, and demands awareness and response to the demands of the ship, the crew, and the community.

Sail training at sea programs are designed to build the next generation of ocean stewards through sea experience, service and education. Using traditional sailing vessels, organizations provide formal and informal education through onboard programs. Students live and learn together, operate the vessel, engage in accredited educational classes in science and the humanities, take part in meaningful service activity ashore, and experience the sea 24 hours of every day directly, constantly involved in the most dynamic and challenging natural system in the world. Students leave behind their landside conveniences and comforts of home to accept not just rigorous teaching and learning, but also physical and psychological growth described by student after student as transformational.

Tall Ships America programs foster opportunities for intensive personal development and life experiences in order to advance leadership and team-building development and a reverence for the natural world. Sail training teaches the qualities of stewardship, resourcefulness, pride, humility, strength and grace. To learn more about Tall Ships America, visit sailtraining.org.

LEARNING BY DOING: BOATBUILDING

Examples of maritime education around the world teaching beyond the traditional classroom

Teaching and training the next generation of traditional craftspeople

Education is the transfer, formally or informally, of knowledge, skills, and experience from one generation to another. Educators can be academic experts, research scientists, classroom teachers, mentors, or special individuals who accept the responsibility of such exchange for the reward of seeing students of all ages mature and respond through improvement of self, relations with peers and partners, and integration with community.

Here we offer some remarkable examples of programs in the United States and abroad that explore alternatives that are proving effective, successful, and influential in the shifting of structures for teaching and learning toward progressive application in the future. Ocean Literacy itself is a serious step in that direction, offering the broadening of perspective and premise around which we organize and share what we know as a new world context for value, structure, and behavior that is dependent on an healthy ocean.

1 THE APPRENTICESHOP

ROCKLAND, MAINE USA

The Apprenticeshop uses the learning-by-doing model to teach boatbuilding and seamanship to men and women from around the world. Inspired by the philosophy of experiential educator Kurt Hahn and founder Lance Lee's own experiences in education and Outward Bound, The Apprenticeshop began in 1972 within the complex of the Maine Maritime Museum in Bath, Maine. Since its beginning, the structure of The Apprenticeshop is built around craftsmanship, seamanship, and community. Craftsmanship develops as apprentices work alongside the master builder and one another to learn the traditional methods of wooden boatbuilding. Seamanship is practiced throughout the year as apprentices sail vessels built by students at the shop. The Apprenticeshop also offers a twelve-week small boatbuilding program for those who cannot commit to the two-year program.

Learn more: apprenticeshop.org

2 SKOL A MOR

MESQUER, BRITTANY, FRANCE

Twice each year Skol a Mor launches boats built by students into the small Mesquer port on the Brittany coast. From French bateaus to Norwegian faerings, beetle cats to racing sloops, Skol a Mor provides the vocational training and skills required for French students to go on to become not only master builders and carpenters at boat shops around the country, but skilled seamen able to sail and maneuver the boats that they build. The goal of Skol a Mor is to preserve, enhance and transmit all the traditional maritime skills of marine carpenters and maritime heritage.

Learn more: skolarmor.fr

3 ALBAOLA: SEA FACTORY OF THE BASQUES

BAY OF PASAIA (GIPUZKOA)

BASQUE COUNTRY, NORTHERN SPAIN

Albaola is the major traditional boatbuilding center in the Basque Country. Founded by Xavier Agote, the school was born at a time when traditional boatbuilding was near to disappearing in the Basque Country. New materials and techniques put traditional boatbuilding at risk, and the knowledge that was accumulated for centuries was in danger of being lost. The Albaola community believes that traditional boatbuilding is necessary to maintain, reinforce and share local maritime history; thus they built a school to provide students with professional training. The Lance Lee International Boatbuilding School is modeled after The Apprenticeshop and modeled after the learning-by-doing experiential system. Their training program lasts for three years, during which time students have the opportunity to take part in every phase of traditional boat and shipbuilding.

Learn more: albaola.com

LEARNING THE ART OF APPRENTICING

image credit:
The Apprenticeshop
Rockland, Maine

If, along the way, you can make a living by starting to use your hands through learning boatbuilding, you can make anything. The compound curve and the changing bevel of a boat provide the disciplines along the route to the point which you no longer have to worry about whether you can do something.

- Lance Lee, Founder, The Apprenticeshop

Apprenticing is a time-honored tradition that has been practiced through the centuries. As we have demonstrated on the previous pages, there are programs around the world that are committed to continuing this style of education in the 21st century. Learning boatbuilding is a demanding discipline which involves decision-making, care, patience, forethought, and time. The philosophy behind the apprenticing ethos is simple: learning to do anything is best accomplished through direct experience. When an apprentice starts with a mere concept of a boat on the lofting floor and carries it through all the subsequent stages of mold-making, framing, planking, decking, and finish work to a fully rigged boat ready for launching, a great deal of learning happens in a relatively short amount of time. It is a process that not only fosters a high level of craftsmanship, but also sharpens one's problem solving skills and sense of aesthetic proportion and detail.

LEARNING BY DOING: CITIZEN SCIENCE

Innovative citizen initiatives offering real potential for the future of ocean science

Citizen Science supports oceanographic research projects that help expand the understanding of the world's oceans through technological advancements, intelligent observation and analysis, and open sharing of information.

"Citizen Science" is a term used to describe non-specialist research and data collection carried out by private individuals, foundations and organizations utilizing the power of the internet to collaborate around the globe. There are many innovative projects and ways that anyone can collect data and conduct research using sophisticated yet affordable submersible equipment. Interest in citizen science among curious students young and old not only builds awareness of key ocean issues but also promotes greater commitment by the general public to commit to creating positive change for the future of the ocean. Citizen science is vital, imaginative, innovative, and international.

1 MARINE ADVANCED TECHNOLOGY UNDERWATER ROBOTICS COMPETITION

The MATE Center uses underwater robotics to teach science, technology, engineering and math (STEM) to prepare students for technical careers. The annual MATE competition challenges K-12, community college, and university students from all over the world to design and build remotely operated underwater vehicles (ROVs) to tackle missions modeled after scenarios from the ocean workplace. The competition's class structure of beginner, intermediate, and advanced complements the education pipeline by providing students with the opportunity to build upon their skills – and the application of those skills – as they engineer increasingly more complex ROVs for increasingly more complex mission tasks. The new and ever increasing interest in robotics among students young and old suggests real potential for future ocean science.

Learn more: marinetech.org/rov-competition

2 ROSALIA PROJECT

The Rosalia Project is dedicated to connecting people of all ages to their underwater world, to inspire them to be part of the plastic pollution solution by using underwater robots and sonar as well as nets to locate and remove marine debris. Rosalia Project is committed to accurate data collection and working with sailors, fishermen, boaters, concerned citizens, schools, municipalities and more to clean up and progress solutions to the marine debris crisis. Their programs include underwater trash-hunting with ROVs, presentations, STEM-based activities for grades 3 through 12, coastal cleanups and research projects throughout North America.

Learn more: rozaliaproject.org

3 SURFRIDER FOUNDATION

Among its many citizen science initiatives, Surfider has a chapter-run program called the Blue Water Task Force, a water testing program designed specifically to fill in the data gaps left by agency programs to help with resource allocation in areas with the biggest concerns for public health risk. The Blue Water Task Force citizen science program tests approximately 25 surf spots and streams that discharge onto popular recreation sites. The program continues to work with states to improve public notification about chronically polluted sites and to direct available resources appropriately.

Learn more: surfrider.org

LEARNING BY DOING: MARITIME FESTIVALS

Celebrations around the world teach us about our maritime heritage and connect us to each other and to the sea

Maritime festivals are more than a gathering of boats and sailing ships. They celebrate traditions and remind us of the ways the sea connects people and ideas on and across the water, linking our hearts and minds through the ocean.

Maritime festivals offer the best celebrations of living maritime heritage and offer educational opportunities for those wanting to learn about our deep connections to seafaring and sea life. Festivals are numerous, colorful, and are typically not interpreted as vehicles for educational outreach. Maritime festivals are, in fact, among the best celebrations of living heritage. They are phenomenal learning by doing events by the participants and the tens of thousands of people who come to see, to experience, and to learn.

1 DOUARNENEZ TEMPS FÊTE AND BREST INTERNATIONAL FRANCE

credit: brittanytourism.com

The Brittany coast in the far west of France is home to numerous celebrations of maritime culture. Brest and Douarnenez offer some of the best French sailing grounds in Europe and are teeming with traditional sailing and rowing vessels during these two summer gatherings. Fête Brest offers a gathering for boat enthusiasts, tall ships, and is a celebration of maritime culture.

With its history of sardine fishing, Douarnanez is considered one of the most beautiful bays in Europe. Their Temps Fête Festival gathers traditional sailing ships to the Pointe du Finistère and is the highlight of Brittany's maritime festival season.

Learn more: festival-douarnenez.com/fr *and* france-voyage.com/events/brest-international-maritime-festival

2 SEMAINE DU GOLF GOLFE DU MORBIHAN

FRANCE

A festival of more than one thousand traditional and classic boats, the Gulf of Morbihan Maritime Festival is a bi-annual "sea party" of epic proportion. Festival goers can get out on the water or enjoy a parade of sail from the seashore. La Semaine du Golfe Du Morbihan celebrates Brittany (in the north of France) culture, music, food, boating and marine traditions. Morbihan Gulf is one of Brittany's most beautiful and inspiring seaports in France.

Learn more: tallshipsnetwork.com/events/semaine-du-golfe-2019

3 WORLD OCEANS DAY

GLOBAL

credit: aquarium by the bay, san francisco

Every June 8th we celebrate World Oceans Day, a date designated by the United Nations to recognize our relationship with the ocean through global connection. Around the world, through the World Ocean Network, Thte Ocean Project, and many other organizations with ocean interests, events take place to highlight the value of ocean resources. There are maritime festivals, beach cleanups, school projects and environmental presentations around the world: in Africa, Asia, Europe and the Americas.

What was once a small bright idea is now an international event that focuses world interest on the ocean and its benefits for all of mankind.

Learn more: worldoceansday.org

THE OCEAN IS LARGELY UNEXPLORED

a. The ocean is the largest unexplored place on Earth—less than 5% of it has been explored.

b. Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes.

c. Over the last 50 years, use of ocean resources has increased significantly, the future sustainability of ocean resources depends on our understanding of those resources and their potential.

d. New technologies, sensors and tools are expanding our ability to explore the ocean system. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

e. Use of mathematical models is an essential part of the ocean systems. Models help us understand the complexity of the ocean and of its interaction with Earth's interior, atmosphere, climate and land masses.

f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators and illustrators. And these interactions foster new ideas and new perspectives for inquiries.

OCEAN LITERACY:
A Conclusion

A vital living natural system demands a vital living educational system to explain the vital living social implications of its value, as addition to our well being at every level. What has interested me about the discussion is the increasing revelation of scale. Conventionally we approach education through data: the facts of history and science, the explication of philosophical ideas and works of art. We explore the record of inquiry and discovery as a map of knowledge that can be measured, parsed, interpreted, and understood. The ocean has been presented through the disciplines of geology, biology, physics, and engineering – more a didactic construct of many tiny functional parts than a dynamic flow of movements and processes, of discoveries and their consequences. When we speak of the ocean as a global connector, we can also describe it as the historical routes of trade and migration, and by so doing amplify its substance as a system of exchange of goods, people, and ideas. Thus, we have started small and ended large and that extent reveals a scale of awareness that may have surprised many, certainly challenged the existing methods for teaching and learning about the ocean.

Another provocation possible is the suggestion that we completely change the order of approach. That is, move from large to small, start at the largest possible human implication, relationship, and consequence and move

downward in increments to reach the structure of the component parts. Here are two examples:

1.
What if we were to begin our lesson with a powerful, relevant, essential experience of which every student would already be aware? Let's start with salt. We salt our eggs, our French fries, the many dishes we love, and we have an inherent visceral knowledge of its meaning through taste. What is salt? Where does salt come from? How is it made? By whom? What is it made of? What elements and by what process? How do we know this? What is the scientific process to get us to this understanding? In this reversed passage, from large to small, we have moved from the known to the unknown, to be explored and learned in smaller and smaller detail, with perhaps a more immediate and deeper meaning.

There is such an ocean curriculum in Africa that is organized in just this way, and, incidentally, all the illustrations incorporate African figures and context to underscore the immediate relation and relevance to the students and their surroundings.

2.
What is we do not present the ocean simply as a natural system at all? At the World Ocean Observatory, we have changed the definition of the ocean from a natural system apart to an integrated global process that begins at the mountaintop and descends to the abyssal plain, transcends the established focus on marine species and habitat, and relates the ocean to climate, fresh water, food, energy, health, trade, transportation, science, research, finance, planning, policy, governance, international relations, community and regional development, and cultural traditions. This is a transformation assumption that upsets the educational order, confronts existing structures, and assumes alternative behaviors to be successful. Traditional curricula must therefore be re-examined, singular disciplines must meld into multi-disciplinary content and team teaching, and other subjects, including civics, history, and art be allowed to inform the lesson plans and activities. Technology has a key role to play as a means to research, manage data, communicate results, and share knowledge of the ocean as a determining force in the educational process.

So, what is ocean literacy?

The literate Citizen of the Ocean understands the pervasive influence of all things ocean on all things human, the full range of its contribution to our health and welfare worldwide, and the imperative to conserve that understanding and give back for the benefit of all mankind.

Learn more about Ocean Literacy:
oceanliteracy.wp2.coexploration.org
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THE 8 MILLION SPECIES WE DON'T KNOW

by Edward O. Wilson

The only way to reverse an extinction crisis is through a conservation moonshot

We have to enlarge the area of Earth devoted to the natural world enough to save the variety of life within it…

The history of conservation is a story of many victories in a losing war. Having served on the boards of global conservation organizations for more than 30 years, I know very well the sweat, tears and even blood shed by those who dedicate their lives to saving species. Their efforts have led to major achievements, but they have been only partly successful.

The extinction of species by human activity continues to accelerate, fast enough to eliminate more than half of all species by the end of this century. Unless humanity is suicidal (which, granted, is a possibility), we will solve the problem of climate change. Yes, the problem is enormous, but we have both the knowledge and the resources to do this and require only the will.

The worldwide extinction of species and natural ecosystems, however, is not reversible. Once species are gone, they are gone forever. Even if the climate is stabilized, the extinction of species will remove Earth's foundational, billion-year-old environmental support system. A growing number of researchers, myself included, believe that the only way to reverse the extinction crisis is through a conservation moonshot: We have to enlarge the area of Earth devoted to the natural world enough to save the variety of life within it.

THE HALF-EARTH PROJECT

The formula widely agreed upon by conservation scientists is to keep

half the land and half the sea of the planet as wild and protected from human intervention or activity as possible. This conservation goal did not come out of the blue. Its conception, called the Half-Earth Project, is an initiative led by a group of biodiversity and conservation experts (I serve as one of the project's lead scientists.) It builds on the theory of island bio-geography, which I developed with the mathematician Robert MacArthur in the 1960s.
Island bio-geography takes into account the size of an island and its distance from the nearest island or mainland ecosystem to predict the number of species living there; the more isolated an ecosystem, the fewer species it supports. After much experimentation and a growing understanding of how this theory works, it is being applied to the planning of conservation areas.

So how do we know which places require protection under the definition of Half-Earth? In general, three overlapping criteria have been suggested by scientists. They are, first, areas judged best in number and rareness of species by experienced field biologists; second, "hot spots," localities known to support a large number of species of a specific favored group such as birds and trees; and third, broad-brush areas delineated by geography and vegetation, called eco-regions.
All three approaches are valuable, but applying them in too much haste can lead to fatal error. They need an important underlying component to work-a more thorough record of all of Earth's existing species. Making decisions about land protection without this fundamental knowledge would lead to irreversible mistakes.

THE LITTLE KNOWN PLANET

The most striking fact about the living environment may be how little we know about it. Even the number of living species can be only roughly calculated. A widely accepted estimate by scientists puts the number at about 10 million. In contrast, those formally described, classified and given two-part Latinized names (Homo sapiens for humans, for example) number slightly more than two million. With only about 20 percent of its species known and 80 percent undiscovered, it is fair to call Earth a little-known planet.

Paleontologists estimate that before the global spread of humankind the average rate of species extinction was one species per million in each one- to 10-million-year interval. Human activity has driven up the average global rate of extinction to 100 to 1,000 times that baseline rate. What ensues is a tragedy upon a tragedy: Most species still alive will disappear without ever having been recorded. To minimize this catastrophe, we must focus on which areas on land and in the sea collectively harbor the most species.

Building on new technologies, and on the insight and expertise of organizations and individuals who have dedicated their lives the environment, the Half-Earth Project is mapping the fine distribution of species across the globe to identify the places where we can protect the highest number of species. By determining which blocks of land and sea we can string together for maximum effect, we have the opportunity to support the most biodiverse places in the world as well as the people who call these paradises home. With the biodiversity of our planet mapped carefully and soon, the bulk of Earth's species, including humans, can be saved.

By necessity, global conservation areas will be chosen for what species they contain, but in a way

that will be supported, and not just tolerated, by the people living within and around them. Property rights should not be abrogated. The cultures and economies of indigenous peoples, who are de facto the original conservationists, should be protected and supported. Community-based conservation areas and management systems such as the National Natural Landmarks Program, administered by the National Park Service, could serve as a model.

To effectively manage protected habitats, we must also learn more about all the species of our planet and their interactions within ecosystems. By accelerating the effort to discover, describe and conduct natural history studies for every one of the eight million species estimated to exist but still unknown to science, we can continue to add to and refine the Half-Earth Project map, providing effective guidance for conservation to achieve our goal.

The best-explored groups of organisms are the vertebrates (mammals, birds, reptiles, amphibians, fishes), along with plants, especially trees and shrubs. Being conspicuous, they are what we familiarly call "wildlife." A great majority of other species, however, are by far also the most abundant. I like to call them "the little things that run the world." They teem everywhere, in great number and variety in and on all plants, throughout the soil at our feet and in the air around us. They are the protists, fungi, insects, crustaceans, spiders, pauropods, centipedes, mites, nematodes and legions of others whose scientific names are seldom heard by the bulk of humanity. In the sea and along its shores swarm organisms of the other living world-marine diatoms, crustaceans, ascidians, sea hares, priapulids, coral, loriciferans and on through the still mostly unfilled encyclopedia of life.

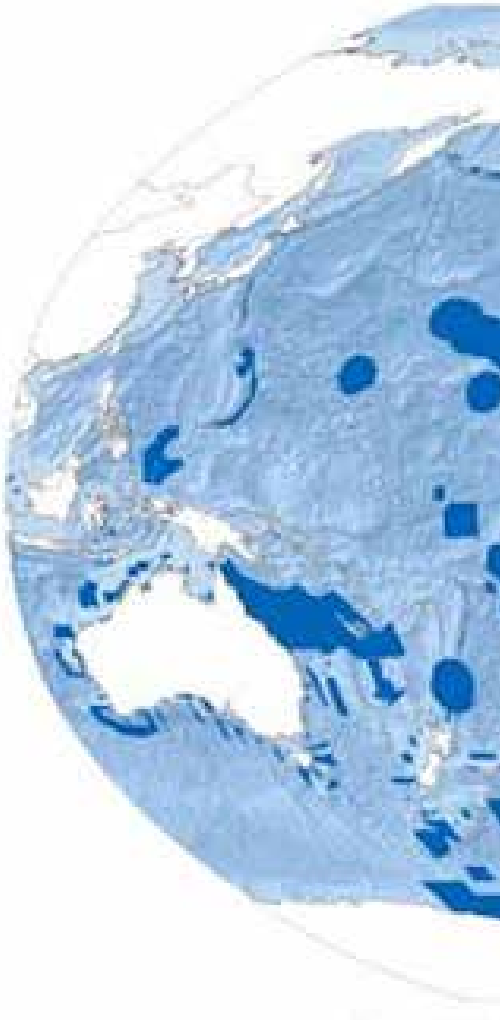
Do not call these organisms "bugs" or "critters." They too are wildlife. Let us learn their correct names and care about their safety. Their existence makes possible our own. We are wholly dependent on them.

With new information technology and rapid genome mapping now available to us, the discovery of Earth's species can now be sped up exponentially. We can use satellite imagery, species distribution analysis and other novel tools to create a new understanding of what we must do to care for our planet. But there is another crucial aspect to this effort: It must be supported by more "boots on the ground," a renaissance of species discovery and taxonomy led by field biologists.

Within one to three decades, candidate conservation areas can be selected with confidence by construction of biodiversity inventories that list all of the species within a given area. The expansion of this scientific activity will enable global conservation while adding immense amounts of knowledge in biology not achievable by any other means.

By understanding our planet, we have the opportunity to save it.

As we focus on climate change, we must also act decisively to protect the living world while we still have time. It would be humanity's ultimate achievement.



Source
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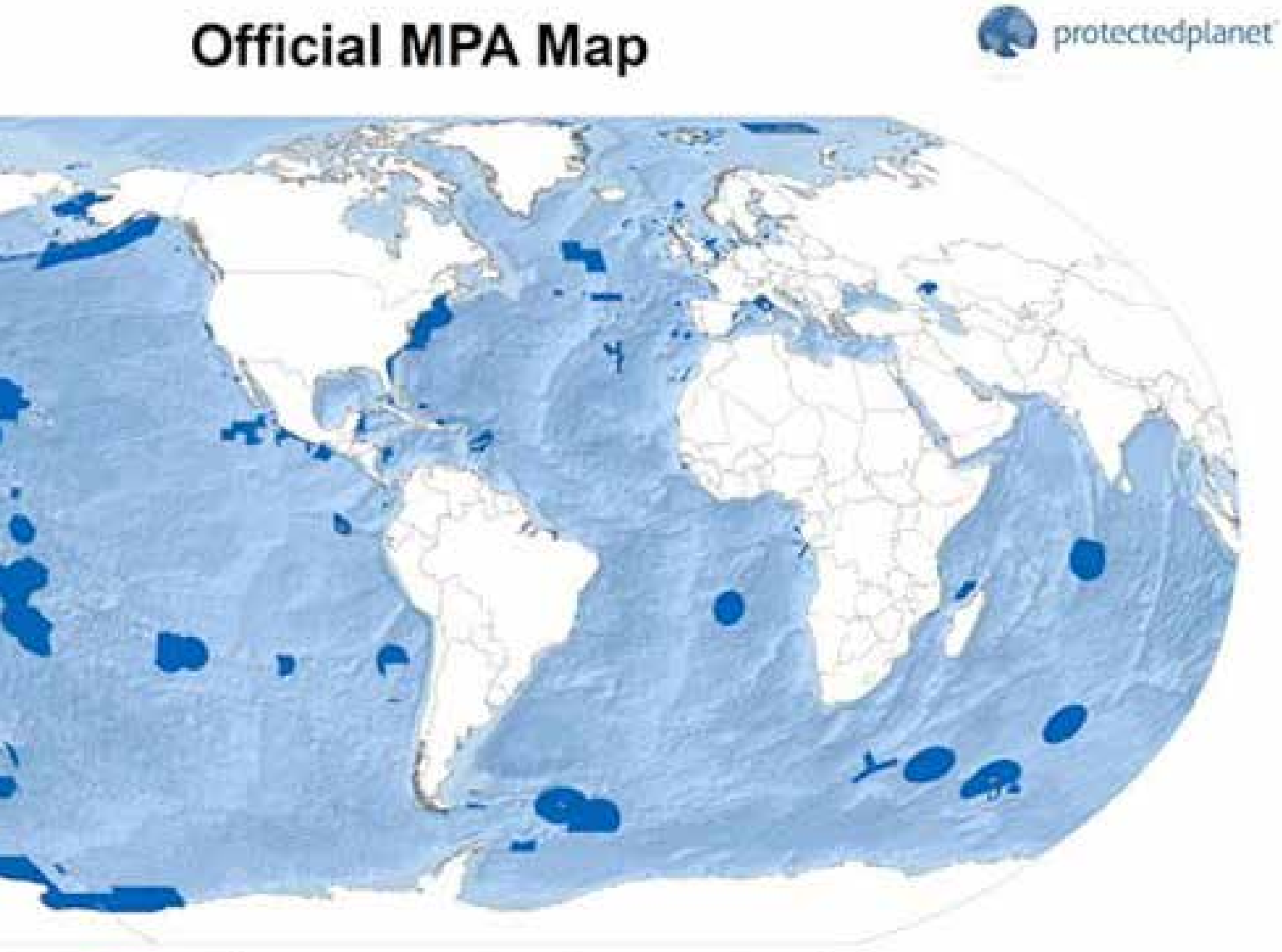
About the Author
Edward O. Wilson is a university research professor emeritus and an honorary curator of entomology at Harvard, and a scientist on the Half-Earth Project. He is the author of many books, including Half-Earth: Our Planet's Fight for Life.

To learn more about the Half-Earth Project, visit half-earthproject.org.

Marine Protected Areas map courtesy of Protected Planet.
tUNEP-WCMC and IUCN (2018)



Above: World Oceans Day 2018
Joe Piasecki, News, Playa Del Rey
World Oceans Day, Dockweiler Beach
Playa del Rey, California
Below: Ilocos Norte,
Movement Against Plastic Pollution

World Oceans Day

WORLD OCEANS DAY provides a unique opportunity to recognize the ocean and humanity's dependence on a healthy ocean for our survival. It also provides a chance for people to do something to keep the ocean healthy and safe. The Ocean Project "adopted" World Oceans Day in 2002. At that time, there were no World Oceans Day events in the US and very few worldwide. The Ocean Project envisioned this event growing as a global platform to capture people's imaginations with engaging experiences that inspire them to take action. Since then they helped secure official recognition in late 2008 by the United Nations General Assembly of June 8th as World Oceans Day and developed it into an event that aquariums, zoos, youth groups, schools, green business, agencies, conservation organizations, divers, surfers, sailors, bloggers, and many more participate.

Director: Bill Mott

Media Contact: bmott@theoceanproject.org

WORLDOCEANSDAY.ORG has many plastic pollution resources including guides, videos, infographics and reports to inform and enable organizations and individuals in their efforts to advance actions that prevent plastic pollution and encourage solutions.

ABOUT THE WORLD OCEAN OBSERVATORY

The World Ocean Observatory (W2O) offers a new model for ocean communications, aggregating comprehensive ocean information, consolidating educational resources, promoting other organizations' programs and successes, amplifying the ocean message, and multiplying ocean engagement with an audience above and beyond that of any individual endeavor. We are a collective voice for many ocean voices, a central place of exchange of content and accomplishment, and the promoter of best practices, innovation, and effective connection to the global ocean community.

CONTACT

DIRECTOR@THEW2O.NET

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