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SAVING CORAL: A STORY OF RISK AND RESILIENCE

SNS SPECIAL LETTER

SAVING CORAL: A STORY OF RISK AND RESILIENCE

By Stuart Sandin, Clinton Edwards, and Eliah Aronoff Spencer

Introduction | Berit Anderson

Every four years, the National Intelligence Council publishes the *Global Trends Report*, which does its level best to identify key trends and uncertainties that will shape the global strategic environment over the next 20 years.

The most recent, published in March 2021, outlines main themes for the decades ahead. Key among them is what they call *adaptation*, which, they write, "will be both an imperative and a key source of advantage for all actors in this world" in dealing with the climate emergency, demographic shifts, and shifting international political tides.

A superior word, in my opinion, is *resilience*. Resilience, as a term, captures not only the idea that adaptation is needed to adjust to our rapidly changing world, but also the emotion behind that act. Adapting will be difficult and gritty, yes, but our collective ability to do so will reap immense ecological, emotional, and cultural benefits.

There are few people I know who embody the idea of resilience more than the team of authors behind this week's Special Letter.

Evan Anderson and I began working with Eliah Aronoff Spencer last fall on behalf of Future in Review to support a set of interdisciplinary initiatives out of UC San Diego focused on fostering resilience through the intersection of technology, scientific research, creativity, and community.

This letter outlines just one of those initiatives: a groundbreaking approach to global coral stewardship out of Scripps Institution of Oceanography that blends cutting-edge academic research, advanced machine learning, and digital twins with citizen science, narrative change, and creative storytelling to uplift and support community-based ecological management.

You'll have the chance to meet the authors – and to play with digital twins of coral from their 100 Island Challenge at this year's FiRe conference.

In the meantime, we couldn't be prouder to count them as members of Strategic News Service. I trust you'll feel the same after reading this week's *Global Report*.

Our planet's coral reefs are in peril, suffering myriad insults that have raised fears that ours will be the last human generation to see these ecosystems alive. The implications of this possibility are profound. Coral-reef ecosystems provide essential food for hundreds of millions of people worldwide. The unparalleled biological diversity of coral reefs produces drugs that extend the lives of billions more. When coral reefs are lost, tropical shorelines become unprotected from the waves linked with even modest storms. And for many low-lying island nations, the growth of coral reefs is fundamental to keeping the land itself above sea level. The gravity of the potential loss of coral reefs globally is terrifying and has permeated our perspective on ocean futures.

But the story of the planet's coral reefs has not yet been closed.

Decimation and Resilience

A review of the status and trends of our planet's ecosystems tells a striking and consistent story – on land and in the sea, the natural world has diminished in the past century in ways that humans have never experienced before. Hundreds of vertebrate species, and likely thousands of invertebrate and plant species, have been driven extinct, populations of countless more have been decimated, and the structure of many ecosystems has been altered dramatically. We find ourselves struggling within a geological epoch that is dominated by the activities of humans – what some term the *Anthropocene*.

The environmental and ecological changes seen across the globe, however, reflect only one element of the process of human spread. Even as we have witnessed some species falling off the cliff of extinction, active resource management has helped to restore the populations of others. Concurrent with the growth of human-inhabited regions of the globe, the past century has seen a rapid rise in protected areas, both terrestrial and marine. The prominent decline in the functioning of natural ecosystems has been met with committed efforts to use ingenuity to find ways to reverse that decline.

That said, of all the planet's ecosystems, coral reefs globally are superlative in suffering catastrophic and potentially irreparable losses. The compounding impacts of over-harvesting, nearshore pollution, and climate change already have resulted in ecological damage. Regions have seen such extensive degradation of coral-reef ecosystems that despair often leaks through into media reports. Indeed, so striking was the impact of the marine heat wave that hit the central and northern Great Barrier Reef in 2015–16 that Rowan Jacobsen published an obituary for this national treasure of Australia: "Great Barrier Reef (25 Million BC–...)."

Although a powerful warning, an obituary for coral reefs is certainly premature, as we are finding evidence of resilience across the globe. Our research team at Scripps Institution of Oceanography, along with colleagues across the tropics, is discovering "special," resilient reefs with corals that are growing – often fast – despite the list of modern threats. There are reefs thriving in the warm outflow waters of power plants. There are surprisingly intact reefs growing offshore of smoldering trash islands. There are reefs that suffered catastrophic loss following marine heat waves, only to show signs of regrowth within a handful of years.

The challenge today is to learn from this mounting evidence of resilience and adaptation and leverage tools of human ingenuity to build the ecosystems that we want for tomorrow.

Human Expansion, Inevitable Habitat Loss, and New Opportunity

A mere 100 years ago, the human population had just topped 2 billion; today, it surpasses 8 billion. Predictably, each of those 8 billion humans has needs, and this growing population has put an enormous demand on the planet's ecosystems.

Consider the changes in a single metric: the biomass of life on the planet. Thousands of years ago, before the growth and spread of humans, there were about 120 million tons of mammals on land (e.g., elephants, buffalo, and deer), complemented by another 120 million tons of mammals in the sea (e.g., whales, dolphins, and seals). Through human harvest and habitat conversion, these numbers have shifted to about 20 million tons of mammals on land and 40 million tons in the sea, a reduction to one-sixth and one-third of historical amounts, respectively. However, the biomass has not been lost. Mammals within the livestock industry are estimated to exceed historical total biomass of the planet, now topping out at about 630 million tons worldwide – with humans tipping the scales at a full 390 million tons. There are significant ecological costs associated with feeding this redistributed and massive biomass of livestock and humans.

The cumulative impacts of human activities – including harvesting of wild species, repurposing of habitats for housing and agriculture, conversion and diversion of waterways, and release of waste into the environment – should thus not be surprising. But yet another transition is upon us: human population

growth is slowing. Demographers now are predicting that we will reach human peak population before the end of the century.

The epoch of rapid human growth holds promise to soon give way to an epoch of efficiency and global recalibration. The time is upon us to seize this opportunity to solve problems of common interest and put into action the tools of community-led natural-resource improvement. This can be done, if we act without delay, through collective sharing of knowledge and sincere collaboration.

Applicable Lessons from Large Ocean States

Through the environmental concerns of the past decades, stewards of our coastal tropical islands have been offering leadership in natural-resource management. Community-based management of natural resources has remained common within small-island populations. For example, community leaders (with roles elected or inherited per tradition) have found many means to reinforce resource stewardship, especially for marine resources. In some cases, seascapes are partitioned into regions for regular use and regions of limited use, the latter creating *de facto* protected areas that provide refuge for stocks of exploited species. In others, resource use varies in synchrony with the breeding cycles of targeted species or in response to observed depletions of particular species.

Small-island communities are not only managing via local efforts. Leadership in some of these communities have led initiatives to create some of the largest and most ambitious marine management programs on the planet. Wide expanses of the Republic of Palau, the Federated States of Micronesia, and the Hawaiian archipelago have been designated by island leadership as regulated, well-managed marine protected areas. While international agencies refer to some of these geographies with the political designation of “small island states,” the leadership advancing these ambitious management programs have suggested the alternative designation of “large ocean states,” as the actions of these peoples reinforce the cultural importance of marine natural-resource stewardship.

The leadership in marine stewardship from the peoples of large ocean states appears linked to the intimate integration of marine resources into the everyday lives of many of their citizens. Dr. Eleanor Sterling, a global thought leader in applied resource conservation, has written extensively on the need for the joint perspectives of biology and culture to be integrated to fully realize human potential in effective resource management. As she and her co-authors stated in a 2017 article in *Nature Ecology & Evolution*:

Biocultural approaches explicitly start with and build on local cultural perspectives – encompassing values, knowledges, and needs – and recognize feedbacks between ecosystems and human well-being.

There is potential for the global community to learn from the biocultural approaches of coral reef management that are guiding many of our colleagues from across tropical islands.

The "Catch" to a More Sustainable Tomorrow

While there are many lessons to be shared from examples of coral-reef management in island communities, a critical challenge needs to be recognized: tomorrow's natural systems are destined to be different from today's. An existential threat faces our natural resources in the form of the changing climate. The total heat content of the ocean, and of the planet itself, is increasing, and the global climate is shifting in both predictable and many as-yet–unpredictable ways.

One of the most prominent consequences of climate change is the increase in marine heat waves hitting tropical shorelines. When anomalously hot water bathes coral-reef communities, the consequences can be immense. The elegant symbioses that define the growth of reef-building corals cannot withstand sustained events of increased water temperature. The symbiotic algae and the coral animal within which they live are cooperatively adapted to the local water temperatures. With even a few weeks of a marine heat wave keeping water temperatures a couple of degrees higher than the local thermal maximum, the entire coral complex can break down – termed *coral bleaching* – which can lead to widespread coral loss.

Without significant efforts (and tangible successes) in mitigating climate change, coral reefs as we know them will be lost. Projections show that under "business as usual" models, frequent marine heat waves and associated global coral-bleaching events will become a regularity rather than an anomaly. Under such scenarios, there are effectively no ways to preserve the viability of coral reefs for the coming generation.

However, there is an alternative. Proactive efforts can be (and in many cases are being) made to prevent the business-as-usual climate future from becoming a reality. We can complement efforts to manage climate with coordinated efforts of local reef stewardship, building from successes realized by island communities.

Further, there is exciting new evidence that the coral animal has impressive capabilities to adapt to changing temperature conditions, preventing "new" coral colonies from bleaching or dying in conditions that might have destroyed colonies in recent past generations. This capacity for adaptation has limits, of course; it will not be enough to keep corals growing if ocean temperatures keep increasing without limits.

A History of Decline and Reemergence

If current reports of the worldwide demise of coral reefs under little-managed climate change are our starting point, where do we go from here? The geological record offers one suggestion of what the future may hold.

The last time all the world's coral reefs were nearly lost was about 10,000 years ago. With Earth tilting into a bit more of an exposed position, and a bit more heat from the sun penetrating the atmosphere, the planet warmed. The ice that had covered the continents started to recede, and the ocean got thicker. The corals, and the reefs they had formed over the past generations, were flooded as the ocean rose almost 100 meters over the period of a millennium or so. Coral-reef ecosystems were lost to the depths of the ocean – beyond the depth where sufficient light existed to support the incredible productivity that defines these ecosystems.

Despite the flooding and dramatic changes in regional ocean temperatures, the ecosystem was able to make adaptations, creating the coral reefs that exist today. Corals grew on newly submerged coastlines and in the recently warmed water. In exploring the geological record, we find that coral reefs were able to again flourish following the end of the climatological shift.

Today's reefs hold in their very shape and structure this history of decline and subsequent reemergence. We may thus set as a nominal expectation that following our current climatological change, coral reefs will hold the capacity to return to their glory within a few thousand years.

With, as one context, the geological record during a wholly profound shift in the ocean's volume and heat content (i.e., that linked with the passing of the last Ice Age), we now can face the management of the world's coral reefs with a firm grasp of our worst-case scenario. Many lines of evidence suggest that with human ingenuity and community engagement, we can do much better than to let coral reefs have a few-thousand–year hiatus from our existence.

We have many levers of resource management that can prevent the long-term demise of these natural treasures. We can:

- Commit to accelerated modernization of our energy systems with climate goals in mind
- Support expansions of community-level management of local coastal communities, bolstering long-standing forms of resource stewardship
- Explore exciting new areas of biology, learning how coral species can and do adapt to shifting environmental conditions

- Leverage our global insights to design and implement strategies to maximize the success of our coastal ecosystems, passing tools of learning, planning, and implementing management and mitigation strategies throughout the world's tropics

With all of these levers at our disposal, the die is not cast on losing coral reefs for the millennia ahead.

Building Resilience in the Face of Change

When the modern environmental movement began, its goals were focused on slowing change and preventing the loss of historical ecosystem structures. "*Save the* [fill in the blank]" was a common refrain, summarizing shared goals to slow or prevent change and restore populations or ecosystems to some baseline state. Today, however, it has become clear that neither consistency nor permanence is possible; we must adapt to evolving conditions in the next era much as humanity has adapted to shifting conditions since the dawn of time. The distinction now is that, while having more people, we also have better tools, and more data available to inform our processes of adaptation.

The process of building adaptive strategies begins with finding a shared vision of what our future can look like. Marty Cooper, the engineer credited as being the "father of the cell phone," found inspiration for his inventions through science fiction. Having seen Dick Tracy communicate through his wristwatch and Captain Kirk chirp orders through his shirt-mounted communicator, Cooper imagined, then built, a new narrative with his team: that wireless telephones were wholly possible. Similarly, but in response to international threats, President John F. Kennedy launched a national vision for the United States to swiftly and safely complete a manned lunar mission. Without a new mythology and marketplace assuring us that rapid innovation was possible, the incredible achievements of space travel would never have been realized.

It is now time for the global community to visualize a new challenge – a "coral shot" based on a new way of doing business and engaging our 8 billion citizens. In contrast to fearing inevitable millennia without coral reefs, we have the opportunity right now to leverage the breadth and strength of the human spirit, novel economic mechanisms, and the technologies we have built. Much as island communities employ biocultural approaches for managing natural resources, we have the capability to unite, as citizens of our shared planet, our ingenuity to develop strategies for global coral stewardship as the vanguard for a planetary resilience plan.

This is an opportunity to find solutions through the engagement of human capital in transparent and virtuous marketplaces, to build on successful stewardship efforts, and to adapt and connect technology in platforms that unlock positive human capacity. These efforts will create new mechanisms to tap into the worldwide care and fascination for coral reefs while lowering the barriers to participation.

Local and indigenous stewards are the archetype of this approach – tasked today, and historically, not only with shouldering the day-to-day management of coral reefs, but also with inspiring current and future communities to learn from and join in their leadership. These local leaders are not alone in their earnest interests to preserve the viability of their ecosystems; a global constituency is interested and available to share the load. International fundraising campaigns are a start, but broader crowd-raising efforts provide complementary support. Purposeful implantation of technology can accelerate monitoring of management efficacy, providing much-needed insights for adaptive management of conservation and restoration efforts.

Imagine a world in which a concerned citizen in Copenhagen can contribute invaluable person-power to the tracking of coral fates in Sri Lanka. The challenges lie in creating a functional ecosystem – a marketplace – that facilitates communication, generation and use of big data, promotes invention, and engages human capital through work as well as through serious play. Tackling this challenge will require new ways to collaborate, cohesive systems of science-based targets, economic incentives, and validated methodologies for monitoring reporting and verification. These are challenges that can and will be solved as we embrace a shared vision of hope and resilience.

Tomorrow's coral reefs will not look the same as yesterday's, as tomorrow's human society will never again look the same. But "different" need not mean "dead." We now have the ability to design our interactions with Earth's ecosystems as a positive-sum game. The future of coral reefs, and that of our greater planetary reef, will be defined by our collective actions and investment of time and tools that allow all of us to contribute. As today's coral reefs tell the history of the greater global ecosystem, saving coral – and the methods we use – may be a critical narrative that we contribute to our planet's future. Let's build a new operating system for change with a rational marketplace for Earth's resilience, starting with our coral reefs.

Resilient is a collective of people who want to make it easier for concerned citizens to change the world together. Its quest to save coral is led by the Scripps Institution of Oceanography; you can learn more about these efforts at http://resilient.ucsd.edu/coral and https://sandinlab.ucsd.edu.

Special thanks to those who helped shape this letter and our thinking: Kevin Whilden & Leah Hays, Kristian Poe, Christopher Gibbons, Alex Hubenko, Reed Berkowitz, Berit Anderson, Arlene Harris, and Marty Cooper.

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Eliah Aronoff Spencer, MD, PhD, is an infectious-disease and global–public-health physician and scientist at UC San Diego. He is the director of the Center for Health Design and leads Resilient, a collective for global change converging people power and citizen science through design thinking, human technology teamwork, and serious games.

Your comments are always welcome.

Sincerely,

Berit Anderson

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WHERE'S MARK?

• On September 19–21, Mark will be keynoting the Info-Tech LIVE 2023 Conference at the Cosmopolitan Hotel in Las Vegas, along with Geoffrey Hinton, Ray Kurzweil, and a few other tech friends. • And on November 6–9, he will be hoping to see many of our members in person, at the FiRe 2023 conference, now in its 20th year, at the Terranea Resort.

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