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XXI Century Science

XXI Century Science: Oceanography

Marine Monitoring,
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The XXI Century Science series is designed to represent a cross-section of research in contemporary natural and social sciences that are devoted in their practice and theory to the examination of qualitatively new scientific questions and objects. Each title in the series engages with new formations of scientific knowledge—in oceanography, in microbiomics, and in climate engineering, to take the topics of the first three books we have edited—adopting a mix of natural scientific, social scientific, and humanistic perspectives and methodologies. With contributions from scholars in the sciences and humanities, this series seeks to record the emergence of new scientific landscapes. It privileges interdisciplinary and multi-disciplinary viewpoints, speculative thinking and theories-in-the-making. In offering such a view, the series aims to illustrate some of the synergies and differences that are shaping natural and social sciences at the beginning of the twenty-first century.

Dominant understandings of science often posit that new knowledge comes directly from empirical methods that deliver increasingly “objective” pictures of the world. Historians of science Lorraine Daston and Peter Galison diagnose such a view as promising a fantasy of “seeing without inference, interpretation, or intelligence,” writing that, on this view, “to be objective is to aspire to knowledge that bears no trace of the knower—knowledge unmarked by prejudice, or skill, fantasy or judgement, wishing or striving... [Objectivity] filters out the noise that undermines certainty.”¹ We are interested in bringing that noise (i.e. complexity) back in, firmly situating new knowledge within the social and historical contexts of

the early twenty-first century. We hope, in the process, to argue for a remodeled objectivity, joining with science studies of Donna Haraway, who writes that “only partial perspective promises objective vision.” Haraway tells us that, “Feminist objectivity is about limited location and situated knowledge, not about transcendence and splitting of subject and object. It allows us to become answerable for what we learn how to see.”² Learning how to see XXI Century Science means responsibly confronting the challenges specific to this age: anthropogenic climate crisis, desertification, the loss of biodiversity, global poverty (what Edgar Morin calls “polycrisis”—a nested set of globally overlapping socioeconomic, ecological and cultural-institutional crises).³

In the twentieth century, academic sciences in the West fixed into a number of scientific and humanistic disciplines and these divisions remain more or less intact to this day. The divide between contemporary natural and social sciences may be useful as an organizing principle for university departments, but it bears little to no relation to the actual conduct of scientific inquiry, which often connects issues and phenomena across subject domains. The XXI Century Science series with its curated collections of articles to make those cross-cutting connections clear, in hopes of generating new channels of interdisciplinary communication that may reconstruct practices in educational and professional contexts.

We wish to help readers think across theory and practice. To do so, we offer, on the same analytical plane, both primary scientific sources and critical humanistic work about science. It is our view that we must think simultaneously

1. Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007), 17.
2. Donna Haraway, “Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective,” *Feminist Studies* 14, no. 3 (1988): 583.
3. Edgar Morin, *Homeland Earth* (Cresskill: Hampton Press, 1999).

about the empirical, the philosophical, and the political as we engage with science—and in so doing also refuse any reflex relativism. It is important for us to present scientific research as it is. We do so in order to open up scientific findings, to make them available to new translations of the sort suggested by the work of philosopher Michel Serres (particularly his 1980 book *The Parasite*), seeing scientific works as patterns of communication that contain both signal and noise, that always need to be translated and therefore cannot escape being transformed as they travel into public culture. We are interested, too, in the ways scientific knowledge can be productively reconfigured and fed into other fields.

We wish to proliferate new ways of thinking, transferring methods and concepts across the natural sciences, social sciences, and humanities. We want the readers to reframe their usual mindset and areas of interest by bringing forth new language and analytical concepts that bear on questions of knowledge.

The books in the XXI Century Science series look at the emergence of new scientific objects (e.g., the microbiome), the recombination of old knowledges into new paradigms, directions, and fields (in, e.g., oceanography) and the creation of sciences to face immediate sociotechnical problems (e.g., with climate engineering). We aim to show families of possibilities for sciences now and in the coming future.

On Oceanography
Armen Avanesian, Werner Boschmann, and Karen Sarkisov
 in dialogue with *Stefan Helmreich*

Stefan, in your research as an anthropologist you focus on the ocean—particularly in your book, *Alien Ocean: Anthropological Voyages in Microbial Seas* (2009), one reason we approached you as a dialogue partner. That oceanic focus seems, at first, counterintuitive, since the ocean is a realm so often considered to be “beyond the human.” How do you approach the ocean anthropologically?

Stefan Helmreich: I’ve been interested in the classical anthropological question of the relation of nature to culture for a long time, and as an anthropologist of science, in how ideas about nature are shaped by authoritative cultural practices of representing that realm. And you’re correct, the ocean is often understood as a kind of hyper-natural place, an essentially nonhuman or even inhuman zone. But human enterprise is thickly stirred into both the notion and the substance of the ocean. And oceanography, as the science of the sea, is very much informed by human politics, economics, aesthetics, and more. I am interested in what that looks like in the contemporary moment. My book *Alien Ocean* took a close look at biological oceanography, which has seen the arrival of a whole set of new tools in recent decades—primarily to do with genomics and bioinformatics, which have really changed the way oceanographers think about the life of the sea. Many have come to apprehend the oceans as largely microbial. That has huge implications for understanding the ocean itself as a kind of living thing—not only as a *container* of living things, but also as a living entity and force itself. The ocean has for microbial oceanographers become a place of genomic assemblages and microbial ecologies, all of which are, in my view—and often theirs, too—hyperlinked to human politics, economics, histories.

One might be tempted to draw a chronological-historical line tracking developments in human-ocean relations—starting from practices of navigation, to oceangoing mercantile and colonialist enterprises, to today’s treatment of oceans as bodies of water that may be at once

surveilled, exploited, and/or conserved. Maybe we could think about that trajectory through the figure of the *horizon*.

SH: I follow the gaze of the people I’m studying as an anthropologist and try to figure out what horizons *they* see. Oceanography has been aimed at knowing oceans as watery surfaces, watery volumes, processes, kinds of time-and-motion forms that are shaped by the regularity of physics and suffused by biology and chemistry. That means that oceanographic accounts and experiences of depths, surfaces, and horizons all intersect and are in constant transformation. Think about the boundary between the air and the sea. There are scientists these days studying the spray and splash of waves and using those dynamics to track how greenhouse gas operates in the atmosphere. The boundaries between air and sea—the substances we imagine to make the horizon in some sense—are coming to be understood by scientists as ever more fluid at ever more fractal scales.

What’s the bigger “horizon” story? What might be most relevant for many oceanographers these days is the fact that the oceans are under stress, and largely from anthropogenic forces and more specifically from the forces of industrialization and of extractivist capitalism. Think also about nuclear contamination, environmental deregulation, overfishing... Several new horizons are then in view for current oceanographic research. One is the dynamics of sea level rise—certainly a horizon-shifting dynamic if ever there was one! That process is bound up with hurricanes, with storm surges, with ocean circulation, eddies, tides. Another area of study would be ocean acidification, which is a consequence of global warming that follows from the uptake of carbon dioxide into the atmosphere. There are ocean organisms that incorporate calcium into their bodies, such as crustaceans or corals. When, because of ocean acidification, they are no longer able to do that effectively, that can have a cascade effect on food chains and ecological webs, changing the variety of creatures that even exist in the ocean. There is also ocean plastification, the result of lots of plastics circulating into marine

environments. Public culture presents us with lots of photographs of plastic debris capturing or snarling in the digestive or respiratory apparatus of turtles or birds. But it's also the case that plastics molecularize, which makes the problem often less visible; toxic and deleterious chemicals travel into the sea, things like endocrine and hormone disruptors, for example. That connects with the ongoing presence of toxins and nuclear materials in the sea, both at depth and in circulation. Deep-sea mining is another practice that will have effects on the ocean — maybe not on the horizon, to use your word, but at depth. Although as soon as I say that I think of the oil spill disaster of the strangely, but tellingly named, *Deepwater Horizon* platform.

Let's discuss oceanography as an inter- and multidisciplinary science par excellence. In a previous conversation we had with you, you mentioned that oceanography has many histories. Tell us more about that.

SH: Oceanography has lots of subfields and these include physical oceanography, biological oceanography, studies of air-sea interaction, chemical oceanography, marine biology, marine mammal research, fisheries research. All those researches fall under the heading of oceanography because they're connected with, well, seawater. Sciences that look at freshwater or at rivers have only ancillary been connected to how oceanography has configured itself — though there have always been people working at that meeting point of fresh and salt. And there has long been a robust conversation between oceanography and limnology, the study of lakes.

Oceanography in the twentieth century became, generally speaking, dominated by physical oceanography, because of the rise and prestige of physics in that period, which was linked to the Cold War. Physical oceanography fixed on formal processes of propagation — from surface ocean waves to the propagation of sound underwater, which was bound up with submarine and anti-submarine warfare. The dominant place of physical oceanography shifted a bit as eco-

logical concerns came to be significant in popular and public arenas, starting in the 1970s. These days, physical and biological oceanography are coming newly together — particularly as things like ocean pollution of various kinds have made it necessary for oceanographers to really think carefully about how ecosystems and biogeochemical networks are simultaneously biological, chemical, and physical.

That connects to an idea developed by Kimberley Peters and Philip Steinberg; they urge a kind of "Wet Ontology" for thinking about the ocean.¹ They argue that the ocean must be understood not only as a bounded body — or bounded bodies — of water, but also as a force that diffuses and connects. Through rain, ice, and much, much more. Think also of the interiors of animal and plant cells as themselves containing a kind of "hypersea" (to use geobiologists Dianna McMenamain and Mark McMenamain's term).

If we keep in mind that "ocean" refers etymologically to *Ōkeanós*, the ancient Greek Titan who personified a vast global flow — Homer suggested that *Ōkeanós* embodied the very origin of the world, an encircling river — this might be seen as a prefiguration of this recent scientific attempts to consider the ocean as a kind of hyper-connected "hypersea." How could such a view be compared with the Gaia-hypothesis, which is gaining traction in public as well as scientific discourse?

SH: I think that the Gaia story and the microbial story have come together in recent decades. James Lovelock, who introduced the Gaia hypothesis is himself an atmospheric chemist and was very much thinking about planetary systems when he began formulating this frame. It is interesting that his model system originally was Mars. He later, as is well known, then turned back to Earth and tried to figure out whether one could detect from earthly atmospheric processes the presence of carbon-metabolizing life. Meanwhile,

1. Philip Steinberg and Kimberley Peters, "Wet Ontologies, Fluid Spaces: Giving Depth to Volume through Oceanic

Thinking," *Environment and Planning D: Society and Space* 33, no. 2 (2015).

the evolutionist Lynn Margulis was working at the microbial level, thinking about the ways that symbiosis between different organisms generated the continuous possibility of the ecologies within which they existed. So, there is a connection that can be made between the metabolism of the entire planet and the symbiopoietic metabolism of organisms. Views of the ocean as a living thing are certainly connected to the rise of the Gaia hypothesis and to the kind of microbial evidence that emerged in the last forty years to give that model some kind of multi-scale empirical basis.

Microbial sciences as well as the Gaia-hypothesis bring the ocean realm under a new spotlight. What other paradigm shifts do you consider crucial for new scientific images of the ocean?

SH: I might comment first that the notion of the paradigm shift has been fully embraced as a term of art within the sciences themselves—so it's no surprise that scientists often find themselves using that frame to name and sometimes promote transformations in their fields, although I do think it is true that there are substantial reframings of methods, theories, and questions unfolding in oceanography today. And many of them are pressed, as they always are, by forces in the wider social milieu.

Let me go back in time a bit and point to the work of historian of oceanography Naomi Oreskes, whose research and writing on Cold War oceanography has done significant work to demonstrate how the questions of mid-century oceanography were very much created and maintained, in the US, by military—that is to say, Navy—interests.² Those interests really turned the ocean into a paradigm space for physics rather than a space for biology. Nowadays? New paradigms? There's the microbial, symbiopoietic story and its entanglement with biogeochemical Gaia approaches that

2. Naomi Oreskes, *Science and Technology in the Global Cold War* (Cambridge, MA: MIT Press, 2015).

we talked about a moment ago. There's still, of course, the systems theory that was pioneered in the mid-twentieth century, which has had continuing import for considering the ocean today as a system of inter-locking processes—from the chemical processes bound up with a nitrogen cycle or the phosphorous cycle or the carbon cycle up to the ways that ocean currents and sea coastal upwellings provide nourishment for sea life.

New ways of connecting diverse systems are in part indebted to the rise of new kinds of infrastructures for measurement and data gathering, as Jessica Lehman has shown in her contribution to this volume, which examines new kinds of ocean observatories, systems of remote sensing. For her, such observatories also produce a “data double” of the ocean. That data double also then has a life in computer models of the ocean—of its circulation, its seasonality, and more.

And increasingly, anthropogenic processes have a life in such models of the ocean—chemical oceanographers are trying these days to understand how it is that synthetic chemical material gets into the atmosphere through the ocean and vice versa. So, you might say that the kinds of systems in play are now much more various than earlier, so that things like fossil fuel consumption are being brought into the same formal frameworks that describe systems of currents, circulation and upwelling.

That leads us to another shift, which is that the ocean is becoming increasingly understood as a place suffused by industrial human enterprise. The historian Naomi Oreskes, in the abstract that originally traveled with the *Isis* article you've reproduced in this volume, called her colleagues in the history of science to think about the history of ocean in a new way: “Global climate change and ocean acidification point to the now-pervasive impact of humans on the ocean environment. And conversely, the crucial importance of the oceans and the development of human affairs.” I think that's exactly right.

A colleague of mine, Jeremie Brugidou, came up with a provocative term for the new human-saturated ocean in motion today: the *Anitropocean*. Like the Anthropocene, the term will want all kinds

of querying and specification. Which people? When? With and through which political economic forms?

Speaking of Anthroocean, leads us to the point Jessica Lehman emphasizes in her article about the Global Ocean Observing System (GOOS) and how it creates this flow of data that doubles as a kind of informational ocean, an *Infocean*, one might suggest. Nature, technology, and politics are co-constituted in this infrastructure. How has that happened?

SH: The way that politics and technology come into the representation of the ocean is in some ways not too difficult to describe because questions of patronage and funding for research are hugely important for the ocean sciences. Many of the technologies instrumental for knowing oceanic expanse and volume are extremely expensive. And it's often the case that nation state or international bureaucratic patronage determines what those instruments are going to be. Imperial European projects and Cold War projects — including the International Geophysical Year (IGY) 1957/58 — asked questions using those instruments, questions driven by geopolitics. What are the tides? What are the currents? How does radioactivity travel through the sea? Oceanography has very much been a state-sponsored field and has long been tied to the fortunes of nations. The early oceanographic organizations are British, French, German, Russian, and American. Later Japanese, Indian, Chinese... Part of bringing the unknown volume of the sea into legibility has been about projects that have been of interest to those kinds of nation states and of course, the kinds of economic or geostrategic enterprises with which they're bound up.

Go back to the height of the British Empire and consider that the Royal Navy was instrumental in funding research into the tides. Or, thinking about the nineteenth-century United States, consider Matthew Fontaine Maury, who was the superintendent of the US Naval Observatory from 1842 to 1861 as well as a Navy officer, astronomer, historian, and who came to be very interested in mapping

ocean currents and wind patterns to aid ship navigation. What was the ship navigation about? Well, it was about commerce and reducing the time for ships to travel — an early form of what economic geographer David Harvey would call *time-space compression*, consequent upon emergent capitalism.

As we are thinking about challenges for oceanography on a global and planetary scale, it is also important to think about how local scales are transforming. Something like sea-level rise is a global process — caused, e.g., by the melting of the ice caps — but it is also a local phenomenon that gets experienced very differently in different places. Think about the Maldives islands in the South Pacific, which are increasingly being inundated because of rising sea levels.

SH: Yes, for the inhabitants of these regions that is indeed a fundamental shift in their horizon, to invoke the word you used earlier. There is, as you say, a very big global story that oceanographers like to tell through models. But, yes, there are also these more “local” stories which are also still global — like plastics landing in certain places, or radioactivity enduring in contaminated regions of the Pacific Ocean that were poisoned by earlier moments of nuclear testing. The work of Marshallese poet Kathy Jetñil-Kijiner speaks directly to these matters.

Your question makes me think, too, of the work of a marine ecologist in Canada called Max Liboiron, who is leading a marine ecology lab to study plastic pollution in the waters around Newfoundland. She is working to study plastic pollution in a way that attends to the priorities of indigenous peoples around that area of what is now called Canada. The work is vital, a crucial genre of ocean science that understands the marine world as social, natural, and political at every scale.³

3. Max Liboiron et al., “Low incidence of plastic ingestion among three fish species significant for human consumption on

the island of Newfoundland, Canada,” *Marine Pollution Bulletin*, no. 141, (2019): 244–48.

And that certainly is true for such practices as deep-sea mining, which is driven by big companies and big nation states. We are observing something like the rise, too, of NGOs that are actively taking part with local inhabitants to unite and organize. There are often very interesting post-colonial responses to multinational corporations, activities undertaken to protect coastlines from a global capitalist, or even neo-imperialistic invasion.

SH: There is an interesting history to the regulatory frame known as the Exclusive Economic Zone — around which so many contests around sea territoriality are organized, around which resistance to corporate incursion are organized, like that happening in Papua New Guinea in recent years, resisting the Nautilus deep-sea mining project. The EEZ, a two-hundred-mile boundary around maritime nation states, is meant secure national rights to the economic proceeds of whatever happens in that space. Some of the earliest nations to claim that kind of territory were Chile and Argentina. They made that move as a kind of resistance to other countries coming into their nearby waters and trawling their fish. But once they made that move, and it became part of the United Nations Convention on the Law of the Sea, the United States — which has never signed the convention, by the way — started to claim ocean space, too. President Ronald Reagan treated the EEZ as a tool to make a giant territorial grab for the imperial powers of the United States. So, although EEZs may have had some origins in postcolonial resistance, they now have a much more multiple life, both tools of domination and of resistance.

How much is what you are describing a transformation from what Carl Schmitt called the “Nomos of the Earth” to a kind of “Nomos of the Sea”? Are we witnessing a move from everything being seen politically and territorially from the land towards a logic that is now much more about the sea, about the hegemony and primacy of the ocean?

Does it make sense to come up with a notion for a Nomos of the Sea as a way to think of twenty-first-century politics?

SH: There are a couple of risks in rushing to celebrate the ocean as some kind of deterritorialized twenty-first-century space — especially since it is *not at all that*. Oceans continue to be carved up in all kinds of legal and regulatory ways. And artificial islands like the one being constructed by China in the South China Sea certainly show us that land imaginaries are not dead! Meanwhile, attempts to exercise control over volumes — by going vertical rather than horizontal, across — still hold on to old bounded notions of sovereignty, too. Franck Billé calls it *volumetric sovereignty*.

Throwing away notions of bounded territory does not quite generate an alternative political imaginary either. The oceans become — as they were even for Hugo Grotius, who wrote *Mare Liberum* in 1609, basically to claim the rights of the Dutch to sail wherever they wanted — a libertarian space of “pure” freedom. Our contemporary moment sees all sorts of “sea-steading” projects in the proposing, some of them by Silicon Valley tech bros, who want to make nation states into things that can float around and attach themselves to different places. That reactivates a very colonial imaginary — but not it’s not ships as floating token for nations, but floating ship-nations as tokens for themselves, and usually for just one person, a venture capitalist.

As you mentioned, some scholars have moved toward thinking of the ocean as human, all too human — perhaps like Brigidou, who coins the term to which you alerted us, the “Anthropocean” — a word that suggests connections with the proposed new geological era, the Anthropocene. At the same time, people like Steinberg plead for an oceanography that is not so distinct from the various nonhuman vitalities of the ocean. Would that be, perhaps, an inhuman or post-human oceanography? How would you locate your research in this space?

SH: I guess the first question I would ask would be what *vantage* could be taken on things oceanic that would be something other than human? Of course, there is some ocean “without us” — though the question of how “we” “humans” represent it and, more parochially, of how some of us do oceanography still requires grappling with questions of representation. So, I’m going to offer a pretty old-school move here and recall that the word oceanography is *ocean-writing*. You could ask then some kind of *nonhuman* or *on-beyond* or *over-to-the-side-of-human* question like: What is writing the ocean? Are microbes a kind of writer? Are they writing in the way that they’re making the ocean realm around them in terms of chemical gradients? Is that a kind of writing? And if so, is that maybe a kind of oceanography? That’s a kind of oceanography that is not about the inscription techniques of humans. Or another example, drawing on the work of Nigel Thrift and John Durham Peters: What about whale and cetacean communication, which is largely sonic and underwater? A kind of cetacean or whale oceanography would think about the soundings that whales engage in as a kind of writing. Or coral reef writing, you know, is *that* what coral reefs are doing as they build their bony infrastructure? Those are ideas about an *other-than-human* oceanography. Those would offer a different form of knowing and intelligence, a different kind of modeling of things oceanic.

We do like this picture: the whales as the nomads of the ocean, a fluid culture and coral reefs creating its own infrastructure. Which leads us back to a very human question, which is about maritime law. Facing all the challenges we have spoken about, perhaps one of the most glaring differences between land and the sea, can be seen in questions concerning maritime law. What challenges is maritime law in our time facing and what will it face in the future? How are national and supra-national institutions dividing the vast realm of the seabed, for example? Is there a natural frontier of law?

A dialogue with Stefan Helmreich

SH: Legal and literary scholars Irus Braverman and Elizabeth Johnson have just published a book called *Blue Legalities*. And it’s precisely about law at sea. There is an ongoing discussion about de- and reterritorialization around sea level rise. What happens if a nation state is submerged underwater? Where does its Exclusive Economic Zone go? Who owns it?

Another place law is operative is in shipping routes — which are changing as the polar ice caps melt. What kinds of laws pertain to which places boats can go and ports is also something to keep an eye on. There’s also the legal regime of the seabed and the legal regime of the high seas, which are different from each other. The seabed, ever since 1967, is meant to be the common heritage of humankind. But if you’re in waters outside of national sovereignty, above that area, that’s considered the property of whomever works there first. There are also matters of local or customary law — think of how these have worked in such places as the archipelago of Indonesia, with islands and waters inhabited by people who have very diverse senses of who owns what, senses that may or may not align at all with international law. The question of how law pertains to oceanic territories is going to be increasingly multiple.

We are thinking about the Foucauldian concept of “heterotopia,” for which the paradigmatic example is the ship. The ship is a floating piece of space, a “place without a place that exists by itself that is self-enclosed and at the same time is given over to the infinity of the sea.”⁴ It is no wonder that the heterotopia is instantiated and probably best embodied by this image of a ship. That brings us back to the question of how oceans shape and complicate and disassemble and reassemble our understanding of territories, localities, and space in general.

SH: Foucault’s notion of the “heterotopic ship” views the ship, on one hand, as something like a fragment of the nation it hails from —

4. Michel Foucault, “Of Other Spaces,” *Diacritics* 16, no. 1 (Spring 1986): 22–27.

On Oceanography

maybe even in a more perfect and regimented form. Think of the idea of the Royal Navy ship, where everything is organized and there are classes and everything stays in its assigned place, like a fantastical Britain. But then consider, on the other hand, that a ship—like a pirate ship—could be anarchic, chaotic, heretical, everything falling apart. Ocean space is kind of like that—it's both. But I think it would be interesting to accompany that question about space with one about *time*. What does the ocean do to notions of *time*? There exist some caricatures out there of the ocean as a space without time or as a space without history. Do those make any sense? The poet Derek Walcott, of course, famously said “the sea is history.” And I'm thinking here, too, of the Barbadian poet Kamau Brathwaite who offers the idea of *tidalec-#cs*—a kind of inversion of dialectics that refuses the idea of the thesis-antithesis-synthesis and the idea that the ocean exists in linear time. The ocean, he suggests, might exist in a looping and circular time where the past and the future constantly break in and out of one another. Attempts to territorialize the ocean can now be understood as attempts also to territorialize time.

What are the further trajectories of oceanography today?

SH: One thing that is interesting about oceanography these days is the way people are trying to generalize stories about oceans—even to think about other planets. I was at a conference in Santa Barbara recently, and there was an oceanographer there who's working on oceans on Titan, which is one of the moons of Saturn. He was thinking about what oceans would look like on other planets. There used to be big debates about whether you could do *geology* on Mars. If *geo* means *Earth*, then shouldn't the study of Martian rocks be something else? Or is “geology” universal? Same question can be posed to “oceanography.” What makes a body of water on another planet an “ocean”?

One of the other volumes we are editing is about climate engineering. The ocean plays a huge role in some projects envisioned to reengineer the planet. What do you think about those attempts?

SH: Climate engineering occurs to us if one thinks of the environment as an abstract system. I don't hear many oceanographers these days—the 1960s were different, with utopian plans to feed the world through global aquaculture, schemes for underwater hotels—celebrate the idea of engineering the oceans. I might be talking to a very particular crew of people, though. Certainly many oceanographers are interested in doing science that might help regulate human interaction with the ocean—though that regulation is often in the key of policy thinking.

The microbiome—the topic of another book in this series—seems to be widely researched in oceanography today. How have microbiome researches entered oceanography, if they have?

SH: It's interesting that the microbiome has become so exciting to people in medicine and also in ecology—so much so that ocean is understood to have a kind of macro-microbial biome or geo-biome. There's a strange reductionism, though, in understanding the microbiome to be the appropriate level of analysis. The microbiome is only one component of a system. An analogy: you can't think about cardiac therapy or brain surgery through the microbiome alone. So the question is: A what scale and in what context does it make sense to think in terms of a microbiome? In that sense, the microbiome is like the ocean, an *object* to think and live with when considering and inhabiting the interconnectedness of different scales and disciplines.