SIMULATION AND ITS DISCONTENTS

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INTIMATE SENSING

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We make much of the sea as an immersive medium. From Freud's "oceanic feeling"—a human nostalgia for a lost communion with a watery mother nature—to Jacques Cousteau's contemplative scuba diving and reverence for the underwater realm, European and American culture overflows with images of the sea as a zone in which boundaries between self and world dissolve.[1] And, indeed, some kind of full, unmediated presence in the deep sea has become a signal aspiration of oceanography. Marine scientists have moved from dredging the deep with buckets to mapping the seafloor with sonar to, today, employing remotely operated robots and human-occupied submersibles to deliver full-color portraits of the world below. These technologies do more than deliver information. As anthropologist Charles Goodwin has pointed out, marine scientists encounter the sea through thickets of technologies that come

packaged with sets of social relations—relations often built right into the structure of research ships themselves.[2] At the center of my story here are relationships between marine scientists, ship's crew, and a deep-diving, remotely operated robot—known as an "ROV," for "remotely operated vehicle"—a device that offers telepresent optical access to the undersea world as well as the capacity to remotely move and manipulate objects in this realm. Although ROVs are not the sort of vehicles into which humans can physically crawl, many of the marine scientists who use them feel a direct body-to-body connection with these objects. These scientists see themselves as involved not so much in remote sensing as in *intimate sensing*.[3]

SEEING IN DEPTH

Over its century and a half of existence, deep-sea science has examined the ocean ever more closely, with the technical goal of *seeing into* the submarine realm. Oceanographers, as historian Sabine Höhler has suggested, have long deployed their tools with the ambition of approximating the visual, of creating images that evoke dimension and volume. "Depth," she writes, "became a matter of scientific definitions, of the right tools to see beyond the visible surface, of huge amounts of sounded data, and of their graphic representations. The opaque ocean was transformed into a scientifically sound oceanic *volume*."[4]

The ROV that is the focus of my narrative promises transparent visual access to the underwater zone by offering high resolution, full-color images of the seafloor and its life. It transmits images from the deep for real-time interaction with scientists and crew

on ships. Unlike more everyday equipment oceanographers send down to get readings of temperature, salinity, and depth—equipment that delivers graphed readouts to ship computer screens—the ROV offers a more literal sensation of what Goodwin calls "seeing in depth."

Technologies of deep-sea telepresence alter a sense of self for both marine scientists and ship's crew. As visualization technologies "make possible new ways of seeing and doing," they also shape the identities—professional and personal—of those people who employ them.[5] Historian and ocean engineer David Mindell asks a question that sums up one concern of oceanographers using remote technologies: "Are you a real oceanographer if you don't descend to the seafloor? Are you a real explorer if you never set foot in a new world?"[6]

In what follows, I report on two oceanographic expeditions in California's Monterey Bay. Each day-long expedition was on the *Point Lobos*, a ship operated by the Monterey Bay Aquarium Research Institute (MBARI), the research sibling of the more famous Monterey Bay Aquarium, situated on California's central coast. My larger project examines the intersection of marine microbiology and genomics, in sites from Hawaii to Massachusetts. Here, I narrow my focus to what it is like to do science at sea in a computational culture, when research vessels are increasingly outfitted with robots, computers, and Internet connections. At least for the handful of marine biologists with whom I worked, ROVs are embraced as tools that make them feel as though they are "real explorers." ROVs provide a sense of close encounter but not necessarily that of a lone adventurer. Scientific experience of the deep sea via the ROV is mediated not only by its technological appendages—robotic

arms and remote camera-eyes—but also by the skilled, collaborative labor of the crew who work on the ship and with the ROV more regularly than the scientists who cycle through.

For its part, the ROV exists within a constellation of controls and extensions—computer monitors and television screens, kilometer-long tethers into the sea—that can make it a very different beast to the range of actors involved in its deployment. Scientists and technicians at sea as well as computer programmers, video librarians, and Internet users on shore all develop distinct relationships with the ROV, relationships that constitute important aspects of their scientific and technical selves. The sensation of intimate sensing has a different feel for different players (and, indeed, may not adequately describe everyone's experience). The mediations are multiple and so are the selves.

THE SHIP AND THE ROBOT

I am groggy and it is early morning, 7 a.m. I am finding my feet on the drizzly deck of the *Point Lobos*, a small oceanographic vessel. Today I am joining the *Point Lobos* cruise as an anthropologist, doing a participant-observational study about marine biological fieldwork. The ship is gliding out of Moss Landing, a tiny town just north of Monterey.

This cruise will be a one-day expedition employing an ROV to examine deep-sea ecologies known as cold seeps, muddy seafloor environments that host methane-metabolizing microbes. These microbes keep toxic greenhouse gases out of our atmosphere. Seeps are ecosystems only recently discovered by marine science, thanks in large part to such technologies of access as research

submersibles and robots. The chief scientist on board, marine biologist Rob Haldane, in his early thirties, briefed me a few days before our cruise.[7] We spoke over a precruise calamari lunch at Phil's Fish Market in Moss Landing. The task of the science party and crew, explained Haldane, will be to dredge up mud from methane-rich zones for further study; along the way, we will find tubeworms and clams that thrive in intimate symbioses with bacteria that live off of compounds poisonous to most creatures.

Every step of the way, our journey will be mediated—by water, camera, and computer. Some sensing equipment on the ship works without direct human guidance, but on our trip humans constitute a key part of the research ecosystem. There are practical reasons for this: guiding the robot demands human interpretations of what is important to investigate. There are also reasons to include humans that are linked to the culture of marine science: when scientists stay "in the loop," they preserve a sense that they are explorers. There are broader cultural reasons, too: because the deep is imagined as a mysterious place, a realm full of scientific surprise, scientists want to be there; indeed, without human apprehension, the sea would not manifest at all as a site of otherworldly difference. Oceanographic discovery is about *human* encounters with the sea. The cruise is not just about raw information; it is about *meaning*.

As we curve away from shore, the seven crewmembers of the *Point Lobos* hustle across well-worn paths, securing swinging doors and tying necessary knots down the length of our 110-foot ship. Today the *Point Lobos* carries a small party of researchers, including me. Haldane, who is coordinating the cruise, works as a postdoctoral fellow under MBARI microbial biologist Ralph Leiden, in his mid-forties, who has done pioneering work in environmental

marine genomics, the sequencing of DNA from seawater. Haldane sets everyone at ease with his generous humor and quiet ability to cajole chaotic collections of ocean-going machinery into coordinated action. A graduate student from nearby University of California–Santa Cruz, Adam Trilling, in his late twenties, has signed on to participate in the sampling and will eventually be keen to figure out how to extract genetic material from the mud we collect. Nadine Rodin, also in her late twenties, is an assistant to an MBARI marine geologist. She has joined up to learn about the ship's global positioning navigation system.

I glance at a printout of our program for the day:

Cruise Plan, Friday, March 7, 2003
Ship: R/V Point Lobos
Chief Scientist: Rob Haldane

Subtract 7 hours during PDT to convert to local time, 8 hours during PST
Scheduled Start Time: Friday 7 March 2003 1500 UTC
Scheduled End Time: Saturday 8 March 2003 0030 UTC

Purpose: To collect seep sediments for dissolved gas analysis, nucleic acid extraction, and other analyses.

We are just getting out to sea when the drugs begin to take hold. Rodin tells me she has taken Meclizine. Trilling has downed six Dramamine and four Vivarin. Haldane says that he, too, is well prepared—though he jokes that he has steered clear of Scopolonia, which tends to make people hallucinate at sea, not ideal for doing careful marine science. I have taken nothing against seasickness. Having determined that everyone else is dosed up, I nervously consult my stomach.

We are summoned by Dave Wolin, a deckhand in his forties, who asks the four of us to sign waiver forms. He gives us a briefing on life jackets and lifeboats. Life, it would seem, is about floating. And floating at sea, Wolin tells us, is often about throwing up. He shows us the "place to yak," an area on the port side of the boat, a location, he kindly informs us, not monitored by the ship's cameras.

As Trilling and I sway about on deck, Rodin comes up from below and announces, "I just saw you on TV." *Point Lobos* is studded with cameras for two reasons. One is for safety, in case there is an accident. The other is to transmit images from the ship over to the Monterey Bay Aquarium, a major tourist destination. The gorgeous fish tanks at the aquarium invite patrons to "come closer and see." The ship's cameras allow patrons to come closer to us. What we see on the ship will become a distributed experience.

The most important cameras on the *Point Lobos* are not attached directly to the ship itself. They are built into the massive, two-and-a-half-ton robot sitting on deck. This is *Ventana*, the ship's ROV, which can be dispatched into deep water off the ship's port side. The half-a-million-dollar *Ventana* uses space-age technology to withstand extreme atmospheric pressure and temperature.

Ventana is Spanish for "window," and, true to its name, it offers a framed glimpse into the ocean. It receives commands through a stream of fiber-optic cables running from the ship—what researchers call an "umbilical cord." This tether allows the robot to travel down to 1,500 meters, a zone characterized by crushing pressures and permanent darkness. This the *Ventana* can illuminate with full-spectrum and incandescent lamps. The images *Ventana* captures from the depths are transmitted up to the ship's control room. There, they can be monitored in real time and, if desired, sent via

microwave to shore and uploaded to the Internet. On the Internet a curious public can leap into the virtual deep.[8] The robot is outfitted, too, with manipulator arms and a suction sampler to collect tangible items like starfish and clams.

The *Ventana* is itself a condensed history of deep-sea exploration. During the earliest oceanographic voyages, in the late nineteenth century, ships like Britain's HMS *Challenger* drew their knowledge of the sea from dredging—bringing up objects from the sea bottom using bags or buckets attached to piano wire. *Ventana*'s grasping metal manipulators will later today deliver coarse, cold mud up from the seafloor, sediment not very different from that caressed by Victorian naturalists. Sonar, or *so*und *na*vigation *r*anging, an invention of the early twentieth century created to detect submarines, is used to help steer the robot. *Ventana*'s prominent zoom lens, attached to a Sony HDC-750A high definition camera, plugs us into the history of innovation in underwater photography, which has now definitively entered the digital age.

The use of computer technology to sound the sea is a central goal of MBARI, founded by computer entrepreneur David Packard, a cofounder of Hewlett-Packard. MBARI has become a key player in the development of deep-sea robotics as well as the development of telepresence techniques for ocean ecosystems research. In recent years, MBARI researchers have also been drawn to genomics, sequencing DNA from sea creatures such as those we hope to gather today.

Ventana has been outfitted by instrumentation technician R. L. Hopper with a bank of plastic cylinders that will be pushed into the seafloor to collect cross-sections of methane-infused ooze. Looking for signs of life at the bottom of the ocean is a relatively recent

possibility. In the early nineteenth century, naturalists thought the deep to be devoid of life, in part because of a prevailing belief that seawater was *compressible,* that

> seawater grew more and more solid until a point was reached beyond which a sinking object would sink no farther. Thus, somewhere in the middle regions of the great abyss, there existed "floors" on which objects gathered according to their weight. Cannon, anchor, and barrels of nails would sink lower than wooden ships, which in turn would lie beneath drowned sailors.[9]

The ocean into which *Ventana* descends is much transformed from the ocean of the Victorians. We now know it to be a medium with living things all the way down.

As I look at *Ventana*'s plastic cylinders, called *push cores,* Trilling talks to me about marine mud. He points out that methane oxidation by methane metabolizing microbes is environmentally important because almost 75 percent of methane emanating from seeps and other methane systems may be consumed by these bugs. If it were not, he laughs, we humans would be drowning in smelly methane. We head inside to the mess, where we study a wall map of the Monterey Canyon, on which serpentine lines representing the underwater canyon's branches snake out from a shore-based origination point at Moss Landing. This sonar atlas delivers a from-the-sky blueprint of a topography invisible to the eye. It is a perfect symbol of the transparency promised by *Ventana,* a digitally fashioned dreamscape in which imaging media erase their work of mediation.

We arrive at our dive site, twelve nautical miles out of Moss Landing, 36.78°N, 122.08°W. We are not that far from land. The Monterey Canyon, deeper than the Grand Canyon, escorts deep

water close to shore. We settle into a one-hour wait until the robot reaches the methane-saturated ecologies that interest Haldane. The color of the water on the ship's TV feed from *Ventana* begins to change, from a light blue to a thick azure, and finally to black.

ENCOUNTERING AN EXTREME MARINE WORLD

Ventana has arrived at the seafloor and now floats just off the bottom, one thousand meters below the ship. Scientists on board congregate in the ROV control room, a snug, wedge-shaped chamber squeezed into the front of the ship, on the lowest deck. In the dim light, we can almost discern the inside-out outline of the bow. The *Point Lobos* used to be an oil-field supply vessel named the *Lolita Chouest,* and this room housed sailors' sleeping quarters. Where once people sunk into a seesaw sleep, scientists now remotely ride the *Ventana.*

Ventana's cameras point in many directions. We are most interested in the forward view, presented on several screens, at many sizes in the ROV control room. The most prominent video screen is adjacent to a VCR, just next to a monitor hosting an annotation system called VICKI, for "Video Information Capture with Knowledge Inferencing." Next to the VICKI is a monitor displaying "frame-grabs" from ongoing ROV video feed; frames are captured when a researcher clicks the appropriate icon in the annotation system. On this trip, at least at the beginning, that researcher will be me.

Haldane has stationed me in a chair in front of VICKI, where I will change videotapes every hour and click pictures as instructed. He hands me a timer. As I look around the room, each screen sways to its own rhythm. Haldane seats himself to my left, in front of a keyboard from which he can control *Ventana*'s cameras and lights.

The ROV pilots, Jerry Malmet and R. M. Engel, sit in the leftmost two chairs, which are outfitted with joysticks for steering, or, as they prefer to say, *flying* the ROV. The pilots also control two robot arms, with which *Ventana* can be made to nudge things, grasp instruments, and pick up stuff. Rodin is sitting in back, studying the navigation console. We are all wearing headsets, allowing us to speak with one another over the dull, slowly modulating hum of the boat. Haldane addresses me through my headset: "Stefan, go ahead and snap as many frame grabs as you want of the push cores going in, coming out, whatever looks good." A CD player has been left on and quietly percolates a gentle reggae. The room is a multimedia event and a sensory scramble, a layering of ocular, auditory, and corporeal disorientations. We project our presences into *Ventana,* whose cameras are now to be our steady eyes.

Haldane instructs me to take frame grabs of tubeworms that we have found near a methane seep. Living inside these tubeworms are microbes that metabolize sulfide. We are far from the sunny, salutary ocean. One biologist at MBARI suggested to me that rather than demonstrating that the ocean is a zone of ecological harmony, sites like seeps should lead us to see the ocean as a giant refuse heap; life exists here not because the medium is so friendly to life, but because life is so adaptable, and can make its way in the most noxious of environments. I am not sure if this is fair to tubeworms, though it is true that they have been persistently associated with the creepy, unearthly, even extraterrestrial—a chain of associations more emotional than logical. But the alien connection is a prevalent one, even for some scientists. Haldane tells me that enthusiastic artists have plopped tubeworms into fancifully painted seascapes of alien planets, a graft he says makes no sense. If metazoans evolved

on other worlds it is unlikely they would so closely resemble earth creatures.

Science fiction turns out to be one of Haldane's inspirations for becoming a deep-sea biologist. Over our lunch in Moss Landing, he told me that as a child he was riveted by *Star Trek*, by the notion of traveling and doing science in three dimensions (Haldane's mother, not insignificantly, was a ground engineer for some of the *Apollo* missions to the moon). As an adolescent, he studied the migration of large animals and particularly liked the movie *Star Trek IV*, in which the crew of the *Enterprise* returns to twentieth-century Earth to save the whales (specimens of which they find at a fictional "Cetacean Institute" portrayed in the film by the Monterey Bay Aquarium!). The similarity between the view-screen on the starship *Enterprise* and the screens through which we look at the video feed from *Ventana* makes the comparison with *Star Trek* seem natural. Some of Haldane's older colleagues grumble that MBARI has not invested in human-occupied submersibles, but Haldane so identifies with the ROV—it feels to him an extension of self—that he disagrees. For Haldane and for his counterpart on the next cruise I would join, ROVs provide a satisfying sense of being there, of immersion. Goodwin observes of abstract, computerized graphs of deep-sea data fed to ships something that might actually apply more fittingly to images on ROV video screens: "Like the screen in a cinema, these inscriptions are the focus of intense, engrossing scrutiny. Indeed, they are the place in this lab where phenomena in the world the scientists are trying to study, the sea under their ship, are made visible."[10]

The scientists I study *want* to be immersed in the sea. In some sense, they want to lose themselves in the place they study. Many grew up on the beach and know how to scuba dive. They love the

ocean. The story of MBARI science and ROV *Ventana* would be very different if the scientists working with these tools found the ocean to be terrifying and monstrous, a view that predominated among most people before the rise of nineteenth-century Romantic visions of the oceanic sublime. In the twentieth century, this sublime fused with ecological imaginaries of the beautiful, fragile sea. People came to see the union of self and sea as one of the most privileged ways to appreciate nature.[11] The techno-immersion offered by the ROV builds on this sensibility.

In the instance of oceanographic research Goodwin observed, scientists and crew occupied different locations on the ship, controlling different aspects of the same device from separate indoor and outdoor locations. They existed as if in different worlds. Goodwin suggested that that research ship embodied "a historically constituted *architecture for perception*." Oceangoing scientists and crew enacted "not simply a division of labor, but a division of perception."[12] This is true with ROV operation, too, though to a less extreme extent.[13] Although there are mechanical aspects of managing the *Ventana* that scientists would be ill prepared to undertake, operations in the ROV control room put the scientists and crew in close relations of interdependence.[14] It is understood that scientists direct the action, but the boundaries are often blurred. An exchange between Haldane and ROV pilot Malmet illustrates. Note the shifting use of pronouns:

Haldane: Tubeworms! We landed right on them. Can I zoom in a little bit? Look at all of those! Let's do a flyby. Is it easy to get some of those tubeworms?

Malmet: We can't guarantee that we'll be back to the tubeworms, so let's do it now.

Haldane: Stop here. Come wide. Zoom in. There's one right next to your wrist there.

Both ROV pilot and scientist use "we" to refer to the joint enterprise of maneuvering the robot. Haldane slides into "I" to flag his particular concern and "you" to direct the ROV pilot's embodied expertise. When he says "your wrist" however, he is referring not to the pilot's fleshy arm but rather to a joint near *Ventana*'s claw. The substitution is telling. I am told that the ROV control system makes use of software similar to that of the Sony PlayStation. The ROV uses joystick controls familiar to those who have played video games on this platform. Video games are opaque, the innards of their programs hidden from users—a fact that, paradoxically, people experience as "transparency."[15] A similar dynamic is at work with the ROV. Its opacity/transparency makes it possible to identify one's hand with the claw, as in a "first-person" video game. Like any prosthetic technology, the system affords scientists with "perceptual access to the world they are sampling, while simultaneously shaping what they are able to see there."[16]

In her analysis of jellyfish tanks at the Monterey Bay Aquarium—exhibits crafted to transfigure viewers by bringing them into intimate relation with seductively displayed cnidarians—historian Eva Shawn Hayward says that, "Water is the proposed factor in the refiguring, but the viewer is endlessly confronted by the various instruments that produce the experience. Immersion, then, here, conveys the experience of being totally inside the technologies and ecologies of this MarineWorld."[17] Similarly on the *Point Lobos*, the sensation is not of detachment from nature, but of a pleasurable, technological immersion *in* it—an experience felt as at once

immediate and hypermediated (that is to say, mediated in lots of ways, all at once).

By now, a whole bush of tubeworms has been pulled free of its moorings—a process I have been documenting with frame grabs. (Later, I will visit the Institute's video lab, where such images are annotated. Since 1988, MBARI has made some 12,000 tapes of dives, in assorted formats. At the institute onshore, three women work in the video lab, a windowless, temperature-controlled room. They review footage and mark when and where creatures show up on the tapes. One of the video librarians calls bemused attention to the gendered division of land-and-sea labor that has women like her running between kids and work, while an all-male crew of ROV pilots stays out all day operating heavy machinery.)

We deploy another push core. It presses into the mud and captures a clam. "This guy comes back with us!" says Haldane. We spy sessile relatives of jellyfish. I glance at my monitor and see that it features a digital count of Greenwich Mean Time, tweaked to display melting numerals. The numerals morph, Dalíesque, into their successors. Surrealist invention is allowed to flower in the corners of our computer screens, but realism is sternly enforced for the screens delivering images from *Ventana*. Haldane continues in movie-director mode, panning and tilting the ROV amidst the ship's pitch, rock, and roll.

I realize that my stomach, too, is rolling. I get up to find some air. I race to the yak zone. Other people in the science party have gotten sick, too, in spite of the drugs. Trilling remarks that it is hard to do science under these conditions; you're either sleepy or you're sick. And you do not want to throw up all over the control room.

I remark that this is not the meditative sea so celebrated in poetry, but more like the perfect storm in your stomach.

When I reenter the control room, Trilling, without comment, has done my job of changing the videotapes and taken my place at the screen. I meditate on the floor at the back of the room. Intimate sensing turns out to depend not just on the opacity/transparency of technology, but also on seasickness pills! After a while, operations are finished and the ROV begins its slow ascent to the surface. People leave the room to get fresh air.

DIVERGENT PERSPECTIVES ON THE INNER HISTORY OF THE ROV

On a second *Point Lobos* cruise, on which we focus on the study of symbiotic bacteria that reside inside marine invertebrates, the social dynamics in the control room are much the same as they were on the cruise with Haldane. On this cruise, the director is Tamara Robena, in her mid-thirties, a MBARI specialist in the clams and tubeworms that live at methane seeps.[18] At ease and experienced, Robena gazes into the cathode ray tube transmitting the ROV's point of view. She asks ROV pilot Thad Cormant, mid-forties, to turn this way and that, to poke at the mud. Clam beds come into view. Robena tells the pilots where to place ROV's claws and how to position its push cores. A push core is drawn from the ROV's quiver of twelve and the question arises of whether more than one sample should be packed into the same tube:

Cormant: How about multiple pushes with the same core? Probably fine if you don't want context. We're not with geologists today! Hmm. This push isn't working.

Robena [in pirate voice]: That thar be rock. Hey! That looks like a bacterial mat!

Cormant pulls back. Robena moves the camera using a mouse pad. We find more clams.

Robena: There's a clamshell already. Clam-o-rama!
Cormant: Scoop them up? I'll just drop them in the drawer. [*Ventana* has a bin for storing things picked up on a dive.]
Robena: Slurp those guys!

The ROV pilot projects himself into the body of *Ventana,* transposing his movements into the robot below. He is gingerly trying to keep the robot from making too much commotion but is not being entirely successful.

Cormant: Might be some collateral damage, but it's okay. Hey, what's that?
Robena: Well, I have no idea. That could be a sponge, but maybe bacteria. Can we get it? [He imitates a radio transmission from a bad science fiction film.] We think it's a blob. Nope, it's sliding out. No blob for us.

Robena and the ROV pilots speak as though they are connected—almost as if they share a body, with Robena the eyes and the pilots, in the instance here, acting as the hands. As if to reinforce this overlapping division of perception and labor, Robena refers to herself as "I" when she is talking about ideas and "we" when she and the pilots relate through the ROV.

I ask Cormant how he maneuvers *Ventana*. He demonstrates its robot arms. The left one has several joints, named with words suggesting an amalgam of the mechanical (swing), the bodily (shoulder, elbow, wrist, grip), and the nautical (pitch and yaw). The right arm, which is newer, boasts hydraulics capable of lifting 500 pounds. The user can freeze the arm's position in computer memory and then,

after moving it physically, reactivate the stored position, which now no longer corresponds to where the arm is in real space. This is useful if you get your own fleshy arm into a contorted position. Cormant lets me play with *Ventana*'s arm as the robot rises to the surface. It is an experience of disconnection, if not disembodiment; there is no force feedback (he tells me) from the joystick. This reinforces the sense of weightless, outer-space-like travel that inspires comparisons between the ROV and space ships.[19] This is telecommunication without teletacticality, intimacy without immediacy, a gap that makes explicit the work required to realize *telepresence*, presence from afar.

The seemingly seamless experience of intimate sensing—individual and communal—is not only enabled by the different yet interdependent perspectives of scientists and crew working together. It must be actively maintained, supported. Simply put, there is a fair amount of work necessary to keep the ROV running. Cormant tells me that sometimes he is up until midnight fixing things before a dive day. He often serves as a mechanic to the ROV; it is like a car that he has to look after and fix. He sees into it in a way that the scientists do not, and it is important for him to have a sense of mastery over the device. He gives me an example of a modification that the ROV pilots made to *Ventana*. Normally, the *Lobos* finds out where *Ventana* is through "pinging" a sonar signal off of it. The information is later fed to shore, where computer programmers receiving data points use a mathematical formula to come up with a best-fit line for the path of the ROV for a particular dive. The pilots, however, have not found the sonar as fine-tuned as they would like. So, they have outfitted the ROV with a Doppler Velocity Log, measuring movement relative to seafloor (rather than in "absolute" space). This

has been accurate about how *fast* the ROV is going, but not always about *where* it is. When the data from this modified ROV system has been fed to shore, software engineers have found themselves confused about the absolute coordinates of the robot, since they were not initially privy to the modifications—done in the name of shoring up ROV pilots' experience of control. But Cormant mentions that sometimes the software people confuse the people at sea, too, for example when they upgrade the ship's software without notice. Sometimes the onshore technicians even make modifications in programs during a sail: cursors move around on ship screens as though the boat is haunted. Between those at sea and those on land there is a difference in perspective and of who is authorized to exercise power where and when. The disjunctures that result can unravel people's sensations of intimate sensing.

Shoreside software engineer Jay Bluestone, in his mid-forties, is one of the people who had to grapple with the mysterious Doppler modifications. His job has been to put together a relational database from the many kinds of data collected by *Ventana*. My interview with him centered on how he thought about the sea. For Bluestone the ocean on the screen was conceptual, not immediate. Dealing with traces of the ROV's path, and with data it delivered, he was not able to project his consciousness into the robot. When he considered the ocean through the medium of his database, he said, "I don't think of it as a wet thing. It's a construct that places constraints on what we do. It's not the same ocean that we go to when we step outside and go to the beach." For him the ocean is alien: "*The ocean is not of us.*"

As Cormant and I watch the screen in the *Point Lobos* control room, a docent at the Aquarium interrupts our conversation. She

appears as a tiny image on one of the video screens. She says in a tinny TV voice:

> Nothing is larger or more important than the ocean. We get food, minerals, and pharmaceuticals from it. And with the ROVs, we can enter this alien world. None of this would be possible without MBARI's research vessels. The scientists are on the boat right now! They can beam images to us live. If I go live to the boat, we see . . . not much.

She speaks to us for the benefit of Museum visitors: "*Point Lobos*, are you there?" she asks. Cormant says yes. "What did you do today?" Cormant explains about the clams and the tubeworms and the cold seeps. The docent then proceeds, on the fly, with the help of a vast video menu, to explain to her audience what all these are. "Over and out," she says.

We all end up on the bridge of the *Lobos*. There is talk of decommissioning the ship, transforming it into a craft that can maintain elements of MBARI's next technological undertaking: a distributed ocean observatory, a network of remote sensing buoys that can provide continual Web access to data from the sea. I later hear a talk at MBARI about how such networks would allow scientists to sit in their living rooms gathering oceanographic data. No need for seasickness pills or yak sites. The *Point Lobos* might do maintenance in such a system (and *Ventana* might shift from a glamorous tool for exploration to an everyday repair device, rearranging technologies and selves yet again). A crewmember jokes that without scientists onboard, they could do some proper salmon fishing. Extending associations between the oceans and outer space, projected marine observatories have acronyms like MARS (Monterey Accelerated Research System), NEPTUNE (NorthEast Pacific Time-series Undersea Networked Experiments), and VENUS (Victoria

Experimental Network Under the Sea). In the future, scientists might explore the ocean by surfing the Web. One scientist who looked forward to marine observatories told me that when they came online, she would be able "to bring the ocean into [her] living room." This will be a new order of intimate sensing.

THE MULTIMEDIA OCEAN

Marine biologists at MBARI encounter the sea as a media experience, one in which they seek to be experientially and technologically immersed. The ocean encountered by researchers using *Ventana* is the object of a rapt optical attention aimed at comprehension through vision. Given the mission of MBARI, it is not surprising that the deep appears as a place to be technologically explored, a darkness to be illuminated. This underwater domain oscillates between the unfamiliar and the ready-to-be-apprehended, if not domesticated. We might find, as the MBARI software designer told me, that, "the ocean is not of us," that the ocean represents, as the Aquarium docent put it, an "alien world." Or, we might hear—as I did when I was certified as a scuba diver just south of Moss Landing—that, "The ocean really is us. We are its eyes." My dive instructor meant to enlist his listeners into an ethos of ecological monitoring, into an intimate enfolding in which we could alternately appreciate oceanic difference and commune or identify with it.

Much of such rhetorical oscillation, such fashionings of intimate sensing as at once elusive and achievable, has to do with apprehending the ocean as a medium characterized by its shifting transparency and opacity. Wavelengths of light taper off into blackness the deeper one travels. Descriptions of the deep as dark and *therefore* mysterious,

full of secrets, unknown, draw on a reservoir of association linking sight and light with knowledge; indeed, the word *theory* derives from the ancient Greek *theorein,* which means both "to see" and "to know." Visualizing the ocean has become the governing goal of oceanography, the grail of techniques of remote sensing.[20] With ROVs, such visions are imagined as at once immediate and objective.

In recent years, the objectivity associated with vision has hybridized with computer imaging and the oceans are now coming to be viewed through online interfaces, or through the robot cameras of entities like *Ventana.* Oceanographic knowledge is nowadays uploaded into computer images and text. Understanding today's scientific sea means engaging with this new media ecosystem. Marshall McLuhan once suggested that "the medium is the message"—that is, that media extend and modulate our sensorium, that "the effects of technology do not occur at the level of opinions or concepts, but alter sense ratios or patterns of perception."[21] With this lesson in mind, we can say that the medium of water, now fused with technological media, offers a new kind of immersion, an intimate sensing of a multimedia ocean.

In *The Second Self,* Sherry Turkle argued that in the early days of the personal computer, people came to see the machine as a kind of mirror for their own minds—a second self. In these days of distributed, polyglot computing and visualization of the sort crystallized by *Ventana,* people see constellations of computers not so much as second selves but as an array of selves that move along a number line from the zero point of self-identification to the multiple identities of distributed, prosthetic subjectivity. Not just life on the screen (to borrow the title of another Turkle book), then, but lives on, through, with, and between the screens.[22]

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15. Conflicts have been known to occur between scientists and engineers on oceanographic expeditions. H. Russell Bernard and Peter D. Killworth, "Scientists and Crew: A Case Study in Communications at Sea," *Maritime Studies and Management* 2 (1974): 112–25.

16. Squyres, *Roving Mars*, 246.

17. Ibid., 251.

18. Ibid., 377.

19. Ibid., 377.

Stefan Helmreich, Intimate Sensing

1. Sigmund Freud, "Civilization and Its Discontents," in *The Standard Edition of the Complete Psychological Works of Sigmund Freud*, trans. and ed. by James Strachey, et al. (London: The Hogarth Press and the Institute of Psychoanalysis, 1953–1974), vol. XXI; Jacques Cousteau with Frédéric Dumas, *The Silent World* (New York: Harper and Brothers, 1953).

2. Charles Goodwin, "Seeing in Depth," *Social Studies of Science* 25, no. 2 (1995): 237–274. Drawing on 1990s fieldwork conducted on an American research vessel off the Brazilian coast, Goodwin describes how scientists from diverse disciplines collaborate with one another and with a ship's crew to fashion portraits of the sea beneath. His narrative has at its center a commonplace piece of oceanographic equipment called a CTD, a package of sensors that generates readings of ocean conductivity, temperature, and depth (hence "CTD") and that also takes samples of seawater as it is lowered by pulley from the side of a research ship into the water column. In onboard control rooms, scientists monitor scrolling computer screens of data sent from the CTD as the device travels through different depths, a descent they guide in coordination with the ship's crew, who work on deck, operating a winch. The whole system affords scientists "perceptual access to the world they are sampling, while simultaneously shaping what they are able to see there," 250.

3. Hillel Schwartz suggested this term to me.

4. Sabine Höhler, "Floating Pieces, Deep Sea, Full Measure: Spatial Relations in Oceanography as a 'Field Science.'" Paper presented at the meetings of the Society for the Social Study of Science, Cambridge, Mass., November 2001.

5. Sherry Turkle, Joseph Dumit, David Mindell, Hugh Gusterson, Susan Silbey, Yanni A. Loukissas, and Natasha Myers, "Information Technologies and Professional Identity: A Comparative Study of the Effects of Virtuality," in *A Report to the National Science Foundation on Grant No. 0220347* (Cambridge, Mass.: Massachusetts Institute of Technology, 2005), 2.

6. David Mindell, "Between Human and Machine," *Technology Review* (February 2005), available at <www.technologyreview.com/computing/14171/> (accessed October 22, 2008). I thank David Mindell for commenting on an earlier draft of this essay.

7. The membership of MBARI science teams and ship crew is public. The convention of this volume is to provide pseudonyms.

8. See <www.mbari.org/cruises/lobos/map_image.html> (accessed October 22, 2008).

9. James Hamilton-Paterson, *The Great Deep: The Sea and Its Thresholds* (New York: Random House, 1992), 168.

10. Goodwin, "Seeing in Depth," 239.

11. Alain Corbin, *The Lure of the Sea: The Discovery of the Seaside in the Western World 1750–1840.* Translated from the French by Jocelyn Phelps. (Berkeley: University of California Press, 1994; French edition, 1988).

12. Goodwin, "Seeing in Depth," 256. Classical sociologies of relations between scientists and crew at sea meditate upon the different kinds of expertise these parties have, on how class hierarchies are often reinforced through divisions between "mental" and "manual" labor. See H. Russell Bernard and Peter D. Killworth, "On the Social Structure of an Ocean-Going

Research Vessel and Other Important Things," *Social Science Research* 2, no. 2 (1973): 145–184.

13. Together, scientists and pilots enact what Edwin Hutchins, in his ethnography of navigation on board a Navy ship, called "cognition in the wild," converting and communicating information through a "cascade of representations" channeled through analog and digital machines and different people's embodied expertise, different sorts of selves, which are here brought into intimate, close-quarters relation. See Edwin Hutchins, *Cognition in the Wild* (Cambridge, Mass.: MIT Press, 1995).

14. This essay only scratches the surface of a more technical history of ROVs (or, in another direction, what Sherry Turkle has called an "inner history," focusing on subjectivity) that could be written. For an instructive primary source, detailing the control system of the Woods Hole Oceanographic Institution's JASON ROV, see David A. Mindell, Dana R. Yoerger, Lee E. Freitag, Louis L. Whitcomb, and Robert L. Eastwood, "JASONTALK: A Standard Remotely Operated Vehicle (ROV) Vehicle Control System," *Proceedings of the IEEE/MTS Oceans Conference, Victoria, B.C., Canada., 1993* (Piscataway, N.J.: IEEE), 253–258. See also Sherry Turkle, ed., *The Inner History of Devices* (Cambridge, Mass.: MIT Press, 2008).

15. Sherry Turkle, *The Second Self: Computers and the Human Spirit* (Cambridge, Mass.: MIT Press. 2005 [1984]), 7–12.

16. Goodwin, "Seeing in Depth," 250.

17. Eva Shawn Hayward, "Jellyfish Optics: Immersion in Marine Techno-Ecology." Paper prepared for the meetings of the Society for Science and Literature, Durham, NC, October 14–17, 2004.

18. The charter:

Cruise Plan, Wednesday, March 26, 2003
Ship: R/V Point Lobos
Chief Scientist: Tamara Robena

Subtract 7 hours during PDT to convert to local time, 8 hours during PST

Scheduled Start Time: Wednesday 26 March 2003 1500 UTC
Scheduled End Time: Thursday 27 March 2003 0030 UTC

Purpose: To visit the 1500 m cold seeps. To collect clams (a new species currently being described) and sediment cores.

Required Equipment: Animal drawer push cores (8 total) clam scoop or gravity sampler Niskin bottles (2)

19. Matters would be different with other ROVs, which do feature force feedback.

20. Media theorists Jay David Bolter and Richard Grusin offer that: "Our culture wants both to multiply its media and to erase all traces of mediation; ideally, it wants to erase its media in the very act of multiplying them." Jay David Bolter and Richard Grusin, *Remediation: Understanding New Media* (Cambridge, Mass.: MIT Press, 1999), 5. As Turkle and her colleagues suggest, "Rather than 'dematerializing' humans or their objects, computer technologies 'remediate' the practices and 'stuff' of science, engineering, and design." Turkle et. al., "Information Technologies and Professional Identity," 39.

21. Marshall McLuhan, *Understanding Media: The Extensions of Man* (New York: McGraw-Hill, 1964), 7, 18.

22. See Turkle, *The Second Self,* and *Life on the Screen: Identity in the Age of the Internet* (New York: Simon and Schuster, 1995).

BUILDINGS AND BIOLOGY

Yanni A. Loukissas, Keepers of the Geometry

1. I have studied architects and their collaborators in numerous professional and academic environments; this essay focuses on the stories of two organizations, addressed here through the pseudonyms Paul Morris Associates and Ralph Jerome Architects. All interviews reported in this essay were conducted between 2002 and 2005. I wish to express my deep gratitude to my informants. I would also like to thank Sherry Turkle for reviewing