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Seeing in Depth*

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The ship is the heterotopia par excellence.
—Foucault (1986, p. 27)

In so far as scientific knowledge does not float free in some abstract, context-free domain but is instead situated, a key question arises: How can one describe the way in which the concrete place where scientific work is done has consequences for the knowledge produced there (Ophir & Shapin, 1991; Shapin, 1988)? The description of such a space raises a host of questions. Thus, Lynch (1991) noted that "the place of laboratory work is not a locale within a unitary physical space, since it is constituted by the actions that *dwell* grammatically within it" (p. 53). From such a perspective, relevant spaces are reflexively constituted through the organization of the actions that simultaneously make use

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of the structure(s) provided by particular places while articulating and shaping them as meaningful entities appropriate to the activity in progress. In this chapter I describe the interdigitation into a common course of action of a diverse patchwork of different kinds of spaces and representational technologies by differently positioned actors working together to take samples on an oceanographic research vessel.[1]

A research ship constitutes a bounded, tool-saturated environment for the doing of a range of different kinds of science. A most salient characteristic of oceanographic ships as work sites is their heterogeneity. Because of the cost of chartering a ship, scientists from quite different disciplines, each pursuing his or her own research project, are forced not only to cooperate in a common endeavor but literally to set up their laboratories next to each other. This creates unique possibilities for communication across disciplines. Unlike the publication and discussion of findings that occur at a conference or through journals, scientists on a research ship are directly exposed not only to the ideas but also to the tools and work practices of their colleagues as they bump elbows while trying to pursue their separate projects in the limited space available. Moreover, to get their science done, they must work closely not only with other scientists but also with sailors. This collection of participants from diverse disciplines and occupations, with separate tool kits making possible different kinds of research endeavors, is strongly segregated from ordinary social life on land as it sails alone through the sea.

The primary object of study for scientists on the ship is the sea, and they spend a great deal of effort and money to position themselves precisely at specific points within it. However, many of the spaces that are most important to them are found not outside the ship but within its laboratories. Representations provided by various kinds of printed and electronic documents are the objects of intense scrutiny.[2] Rather than constituting collections of information in the abstract, such inscriptions are themselves spatial arenas for the organization and production of meaningful action. An analytical framework is thus needed that can en-

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[1]Very relevant analysis of how oceanography has developed as a discipline within the political and economic structure of world capitalism, and the United States in particular can be found in Mukerji (1989). In this chapter, with its focus on in situ work practices within the laboratories of such a ship, I provide a perspective that complements Mukerji's.

[2]How representations are used in the organization of scientific practice has been the topic of much insightful analysis (e.g., Knorr-Cetina & Amann, 1990; Lynch, 1988; Latour & Woolgar, 1979, 1988). For a comparison of the practices used by archaeologists to make maps with those used by lawyers to shape and contest perception of graphic images at a trial, see Goodwin (1994).

compass at least (a) the spatial organization of the laboratory, (b) the visible orientation frameworks created by the positioning of the human bodies that inhabit the laboratory, (c) the frameworks for perception and action situated within the documents being attended to, and (d) the spaces and phenomena that those inscriptions represent—for example, features in the sea. Foucault used the term *heterotopia* to mark "a relatively segregated place in which several spatial settings coexist, each being both concrete and symbolically loaded" (Ophir & Shapin, 1991, p. 13).[3] Ophir and Shapin proposed that in the modern West, the sites where science is done are fundamentally heterotopic spaces. Central to such spaces is a segregated world inhabited by a restricted range of social actors, which contains within it a second space where the phenomena that animate the discourse of a particular scientific discipline are made visible. A major function of such places is to force "the invisible to manifest itself, to leave traces, to betray a hidden presence. Yet the invisible appears only to the eyes of those authorized to observe it. The heterotopic site is at one and the same time a mechanism of social exclusion and a means of epistemically constituting conditions of visibility" (Ophir & Shapin, 1991, pp. 13–14).

Among the heterotopic places described by Foucault (1986) are theaters and the cinema, "a very odd rectangular room, at the end of which, on a two-dimensional screen, one sees the projection of a three-dimensional space" (p. 25). A laboratory on the ship contains a conjunction of spaces that is both analogous and, in relevant ways, quite different. In the following, two scientific technicians, Phyllis and George, stare intently at a pair of two-dimensional inscriptions provided by two different tools, a computer and a Precision Depth Recorder (PDR), which contain representations of the sea they are probing (see Fig. 4.1).

Like the screen in a cinema, these inscriptions are the focus of intense, engrossing scrutiny. Indeed they are the place in this laboratory where phenomena in the world the scientists are trying to study, the sea under their ship, are made visible. Moreover, like an unfolding movie, these inscription surfaces are not static but instead show a spectacle of relevant, meaningful events that are constantly changing in significant ways. However, unlike the story in a cinema, the drama that these screens contain is available to few, if any, members of the larger society on shore. Indeed, even within the tiny group visible here, the ability to see what these images have to offer is unevenly distributed; the man on

[3]See also Foucault (1986).

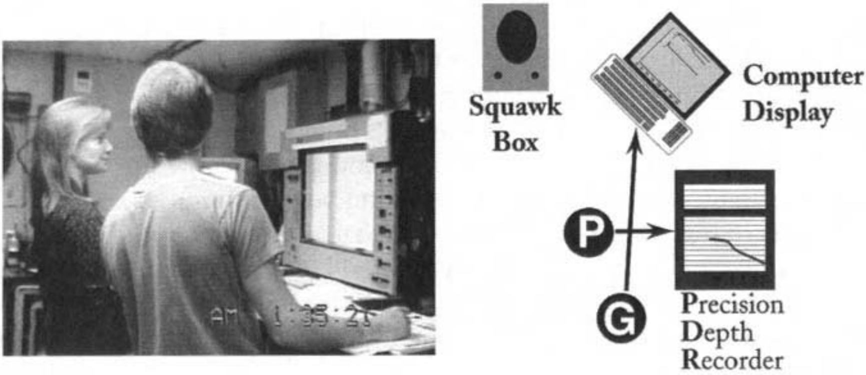

FIG. 4.1. Two scientists positioned in ship's laboratory, heterotopic space.

the right does not know how to competently read the complicated squiggles on the PDR that is the focus of his coworker's attention. In that two different screens are being intently scrutinized, the space is more like a multiplex than a single cinema, but a strange one in which the audience is positioned to watch, simultaneously, two different shows. However, unlike the discontinuous stories told in separate films, these two separate screens each provide very different representations of exactly the same place. Moreover, their carefully chosen audience does not sit passively until the images on the screen come to an end but instead uses them to perform consequential actions while the events they display are still unfolding. The screens provide not just a window into the sea but the resources required to move other inscription devices within it including some of the machines that are producing these very representations. The audience for these images is simultaneously the crew that produces them, a crew that reaches through the images to move things in the world they represent.

The flow of images is sporadically accompanied by a relevant soundtrack. However, rather than capturing the noises that are occurring at the place being looked at, it takes the form of talk over a squawk box from a third member of their team who is working in a different place. Most of his talk consists of reports about where he thinks they are at the moment: for example, "11 meters." The two scientists are thus attending not only to visual representations of the place they are investigating but also to spoken ones. Unlike the self-contained world of the cinema, the multiple spaces they must attend to to do their work encompass a patchwork of mutually relevant but discontinuous places, including not only the sea they are sampling and the laboratory where they are working with its disparate spatial representations but also other places on the ship to which they have highly structured but very limited access.

Positioning in space(s) is central to the work that is occurring here. Understanding that work requires both ethnographic analysis and detailed examination of the specific activity in progress.[4]

SAMPLING GRID

These two people are part of a large team of scientists on the AmasSeds project investigating what happens when the Amazon River meets the Atlantic Ocean. The Amazon is far and away the largest river in the world (one of the islands in its mouth is the size of Switzerland). As it hits the Atlantic ocean, a range of very complex processes occur. The scientific project is especially interested in tracking the way in which the river and the sediments it carries mix with the waters of the ocean and deposit sediments on the sea floor. Figure 4.2A is an example of one of the products they are trying to produce. It is a graph that uses salinity differences to trace where the fresh river water goes as it moves into the sea.

How is such a product made? First, a sampling grid is imposed on the area of interest (Fig. 4.2B). The decision as to precisely where samples are to be taken is the outcome of an intense political process both among the scientists whose different research agendas require different kinds of data (e.g., some are particularly interested in sediments near the shore, whereas others want to study phenomena that are best observed further out to sea) and between the scientists and the Brazilian government, which was unwilling to allow an American ship loaded with equipment for collecting vast amounts of data to probe too closely in its territorial waters (an observer from the Brazilian navy was present on the ship at all times). The grid was thus shaped not only by the competing theoretical interests of different disciplines but also by Brazil's reaction to America's history of imperialism in South America. Finally, the characteristics of the tools being used also constrained where samples could be taken. The draught of the ship, how deeply it sank into the water, limited quite forcefully its ability to sail into shallow water with-

[4]Close attention to the situated details through which courses of practical action are accomplished in endogenous settings is central to ethnomethodologically informed studies of practice in science and the workplace (e.g., Button, 1992; Garfinkel, 1986; Garfinkel, Lynch, & Livingston, 1981; Heath & Luff, 1996, 2000; Heath & Nichols, 1977; Lynch, 1985, 1993; Sharrock & Anderson, 1994; Sharrock & Button, 1994; Suchman, 1987, 1992).

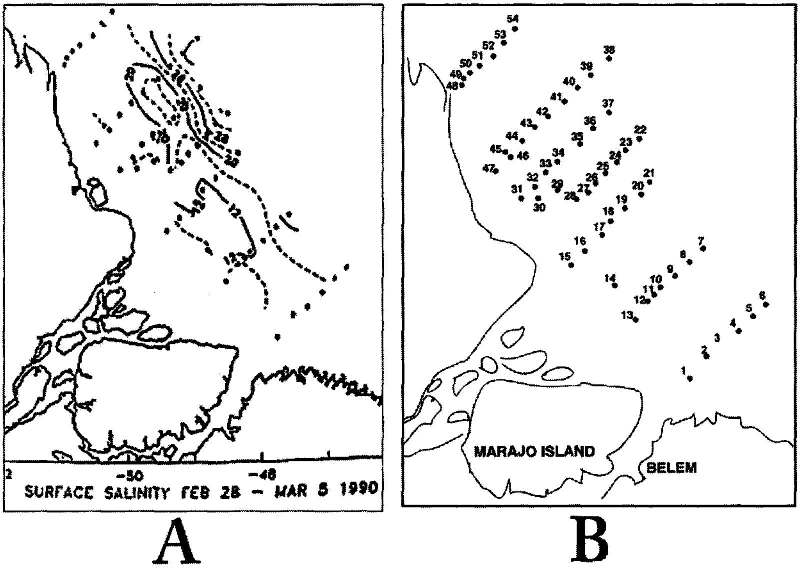

FIG. 4.2. Surface salinity graph (A) and sampling grid (B).

out running aground, and this was complicated by the fact that the charts being used were known not to be accurate. Many of the scientists had a very strong interest in gathering data much closer to shore but were unable to do so because of the sampling grid that emerged from the sum of these political negotiations and technical constraints.[5] The social and political processes required for an American research ship to do field research in the territory of another country also had the effect of constituting the project as one of international collaboration in which Brazilian as well as American scientists were very active participants.

For the actual collection of data, an oceanographic research ship is hired at considerable expense. The ship chosen for the Amazon study was 170 ft (51.8 meters) long, had a gross tonnage of 281 tons (255 metric tons), and a draught of 10.5 ft (3.2 meters). It was staffed by six officers and six crew members, all of whom were men. It sailed from Florida (where some teams of scientists loaded their equipment) to the port of Belém on the Amazon River near its mouth. From there it made a series of cruises into the area defined by the sampling grid, most of which lasted approximately 10 days to 2 weeks. Typically, scientific teams

[5]On-shore samples were taken in other phases of the project by other teams of scientists.

would change during the 1- to 2-day layover between cruises in Belém, although some teams might sail on successive legs of the study. One of the goals of the project was to sample the same place at different points during the year (when seasonal changes in the river would lead to sharp differences in the amount of water being discharged, the corresponding sediment load, and other relevant phenomena). Thus, over the course of the project, the same scientific teams would make multiple cruises.

At sea, the ship sails to each point or station on the grid. Once there, it stops, and samples are taken. Intense activity occurs "on station," as people from different scientific teams move about the ship to collect data. Frequently, teams converge at specific places (such as the quarter-deck where instruments are lowered into the sea), and there, members of one team will sometimes help others move their equipment and fill sample bottles. As soon as samples have been collected, a process that typically took less than 2 hr, the ship sets sail for the next station, usually reaching it within another 2 hr. While in transit, each team retreats back into its own laboratory where they process the samples that have been collected at previous stations and prepare for the next station.

In that the sampling grid is written on a piece of paper, a map, one might be tempted to analyze it primarily as an inscription, an immutable mobile (Latour & Woolgar, 1979) that allows scientists sitting in their offices in North America to plan where they can best test their theories in the seas off another continent. Although entirely valid, such an analysis ignores the way in which the sampling grid structures the lifeworld of those on the ship. The major factor governing the distribution of their activities is the distinction between being on station and "in transit." Inhabitants of the ship do different things and frequently work in different places at each of these times. Like the seasons in an agricultural community, the sampling grid establishes the basic rhythms that structure the life of scientists working on the ship.

Because ship time is so expensive, there is a strong emphasis on collecting as much data as possible. The ship moves quickly from station to station, pausing to allow those on board time to rest is a luxury that simply cannot be afforded. If, as frequently happens, a work crew does not have enough personnel to organize two shifts, it is not at all unusual for scientists and technicians to work for 36 hr or 48 hr without stopping to sleep and to continue day after day at a pace in which they might average only four hours of sleep a day. Night and day lose their meaning as frameworks for the organization of work. Instead of taking time to go to their bunks, technicians sometimes drop to the floor next to their laboratory benches to try and catch a quick nap before the ship reaches its next station. Rather than existing only in a conceptual space defined by the scientific theories it is probing or as geographical coordinates on a map, the sampling grid as an inhabited space structures the work, movement, and lived experience of those caught within it as inexorably as do the clock hands on the assembly line that Charlie Chaplin (1936) tried to follow with his own hands in *Modern Times*.

Because of its position in their world, scientists on the ship can find events in the sampling pattern that would be completely invisible to the reader seeing it in a journal report. For example, the points on the grid are arrayed in sets of lines extending out to sea, with closely spaced stations within each line but much larger gaps between each line. The ship will take much longer to traverse these gaps (e.g., to go from Station 6 at the end of the first line in the south to Station 7 at the beginning of the next), and those on the ship see in these places times when rest might be possible.

In contrast, the ship's crew worked a regular schedule consisting of four hours on duty followed by eight hours off. In a variety of ways, their lives were segregated (although not entirely) from those of the scientists. Most of them worked most of the time in different areas of the ship (e.g., the wheelhouse, engine room, and kitchen), and they had their own sleeping quarters. Everyone ate at the same times in the ship's single dining room, but scientists and crew were assigned to separate tables. Many of the tasks performed on station, such as lowering instruments into the sea, required close collaboration between crew and scientists, but as I show in more detail later in this chapter, actors from these separate occupations were usually stationed at different places (e.g., a crewman on the bridge would handle the ship's winches for scientists working on deck or in a laboratory). In brief, the very small space provided by the ship contained two distinct communities, each drawn from different social backgrounds and possessing separate sets of skills. Despite their very close proximity in space and activity and the fact that sailors and scientists would sometimes visit with each other in off hours, these communities lived and worked within quite different temporal and spatial lifeworlds.

Wittgenstein (1958) argued that the meaning of a representation is not its bearer (for instance, the territory marked by the sampling grid superimposed on a standard map) but is rather the grammatical processes used to articulate the representation within a relevant language game. The sample grid is embedded successively within a variety of different, although related, activities. Months before the ship leaves port, the grid is built through an intense political process involving scientists with different agendas and whole nations. At sea, positioning the ship at the points specified by the map is an intricate, artful, ongoing situated accomplishment. Global satellite positioning systems are used to place the ship as close as possible to a point defined simultaneously as (a) a patch of actual ocean water that can both float the ship and provide a water column to study; (b) a position defined within a global system of latitude and longitude; and (c) a station in the sampling plan—that is, a point constituted through its embeddedness within a larger structural system, a network of other places that will give this one contrastive meaning within the research plan. As noted previously, the tasks of carrying out the structure specified by the sampling grid build a lived temporal and spatial lifeworld for those charged with accomplishing its regularities.[6] Moreover, the two communities on the ship have different relations to the symbolically loaded spaces constituted by these different, although interrelated, systems of meaning. The ship's crew is responsible for placing the ship at the latitude and longitude defined for each station (aforementioned b), something that requires competent deployment of a range of skilled practices and tools. However, they have no professional interest in the larger research processes within which work at the station (aforementioned c) is embedded. The crew's interest in the station ends when the ship is properly positioned. For the scientists, the work done at a particular station is just a beginning, a small part of a larger, still unfolding process, one that will involve considerable work not only at other points at sea but also back at their laboratories on the mainland, at conferences, in the pages of journals, and so on.

After the voyage, as the grid is moved to other activity systems, it becomes a different kind of object: a way of coordinating measurements made at different times in a single space, a field for visibly showing patterns, a boundary object that can be used to compare the findings of different scientific disciplines (Star & Griesemer, 1989), and the like. Both the larger goals of the research project (for instance, measuring properties of the interface between river and ocean including their change over time) and invariant, portable features of the grid itself provide

[6]For analysis of the situated work required to produce such regularities as a schedule, map, or record of changes that occurred in a sample medium on successive days, see Lynch (1985, 1988), and Suchman (1992).

deep continuity between these separate activities. However, at each stage in this process, different grammars instantiated within locally relevant activity systems, each with its own constellation of tools and practices, are deployed properly to use the grid and to "see" quite different things within the phenomenal field it provides.

CONVERGENT DIVERSITY

At each station, separate teams of scientists, each pursuing their own research agenda, set out to work (see Fig. 4.3). In that different kinds of scientists share the ship on each cruise, what will be done at each station will vary considerably from cruise to cruise. At a typical station from the cruise I investigate here, two teams of physical oceanographers drop separate instrument packages into the sea. One team of geochemists collects water samples at different depths and at some stations uses a box core to obtain a column of mud from the sea floor. The water and mud are used as sources of data by biologists as well as

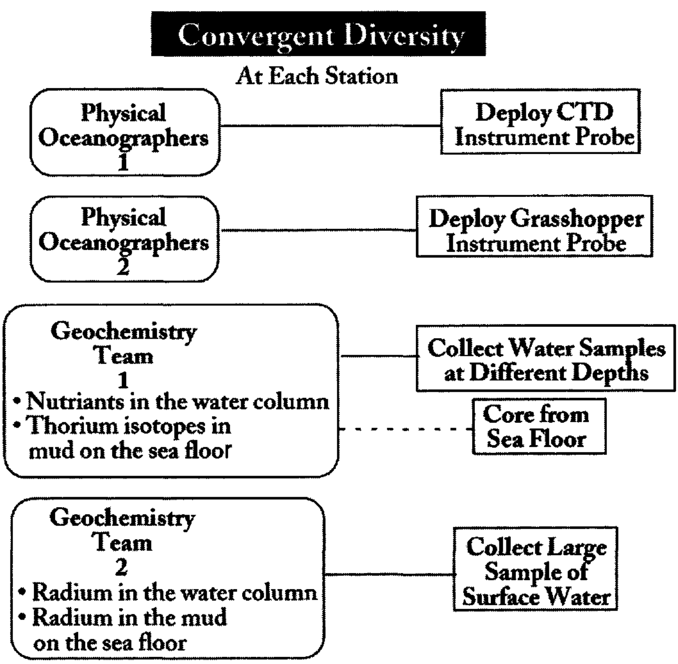

FIG. 4.3. Activities of different research teams aboard ship illustrate case of convergent diversity.

geochemists. A second team of geochemists collects a very large sample of surface water to track the source and distribution of different components of the water.

Although all of these scientists want to look at what happens at this particular place, the things they are interested in are in fact quite diverse. Phenomena of interest to one field might be quite irrelevant to another. In a very real sense, although all of these groups are in precisely the same place and probing exactly the same patch of sea, each will in fact see something quite different there. However, as I will show in more detail, the interests and findings of the separate groups of scientists are not incommensurate with each other. Although one reason that they share the ship is to distribute the considerable expense of running it, another is that the findings of these separate disciplines complement each other. Having geochemists, physical oceanographers, and biologists take samples at precisely the same spot provides a perspective on the processes they are investigating that would be impossible for a single discipline. Despite their disciplinary boundaries, they attend conferences together where they exchange and compare findings. The sea they are all investigating thus constitutes a clear example of a boundary object that facilitates collaboration across disciplines while being constituted differently within each.[7]

In addition to shaping the objects around which collaboration is structured, such phenomena also have consequences for the organization of activity in particular kinds of places. Thus, the activity that occurs on deck at each station as different groups take samples provides an example of *convergent diversity*. By this, I mean a place where separate individuals, groups, or teams converge; however, when they converge, they do not all work with each other in the pursuit of a single plan of action but instead follow rather separate agendas, which may interlock at points with the agendas of others. Points of convergent diversity are thus characterized by interrelated heterogeneity. Although most research in the social sciences (recent investigations of science being an exception) has concerned itself with single activities shaped by coordinated action around a common focus,[8] points of convergent diversity appear to be both com-

[7]The sea floor itself provided a particularly clear example of a boundary object. Different research projects defined where it occurred in different ways (e.g., how much sediment had to be present before a sample stopped being muddy water and started to be the mud of the sea floor), and talks were initiated across disciplines to try to create a common definition.

[8]Note, for example, Goffman's (1964) classic definition of an *encounter* as "a single, albeit moving, focus of visual and cognitive attention" (p. 135).

mon and important. Indeed, they provide a prototypical example of the kind of multiactivity settings that were investigated by the "Workplace Project" (Brun-Cottan et al., 1991; Suchman, 1992).

TOOLS

Convergent diversity is instantiated concretely in some of the tools used on the ship. The heterogeneous organization of such tools has strong consequences for the way in which phenomena of interest to the scientists are perceived, manipulated, sampled, and studied and for the organization of interaction within work practices.

One of the most important tools used by physical oceanographers is the "CTD." This is an instrument probe that is lowered into the sea on a cable where it makes a range of measurements about the physical properties of the water it passes through, including its conductivity, temperature (or more precisely resistance across a set of platinum sensors that is translated into a temperature measurement), and pressure (translated through appropriate equations to an extremely accurate measurement of depth). Measurements made by these instruments are sent back to the ship on an electrical cable where they serve as input to a computer. The computer both translates sensor readings into measurements of temperature, depth, and so on and uses those figures to graph changes in the water column as the CTD moves through it. The CTD is thus a complicated tool, one that brings together both precise and expensive instruments that are sent to the bottom of the sea and a relevant body of theory that is reified as a set of equations and algorithms in a computer on the ship. The most important component of the CTD is not the probe itself but the equations used to translate the measurements obtained from it into accurate, meaningful data. The development of this tool has a complex history that weaves through a number of different disciplines. It began not as a tool for physical oceanographers but as a chemical instrument. The crucial equations governing (for instance) the translation of conductivity to salinity were formulated by physical chemists. This instrument was then appropriated by physical oceanographers for their work—for example, as a way of getting information about temperature and salinity that could be used to measure the density of water and thus to investigate issues such as how buoyant some parts of the ocean are relative to others. Perhaps because of the central importance of the information it makes visible (e.g., accurate measurements of the precise depth at which significant features of the water column change), the CTD is a tool that has a history of being appropriated by one discipline after another. Indeed, several different research teams had CTDs of their own on the cruise I investigate here. One, owned by a team of physical oceanographers, was particularly important. Lowering it to the sea floor was a central component of the work done at every single station.

For their work, one team of geochemists needed samples of actual water collected at different depths. To obtain these samples, they used a "Niskin bottle"—essentially, a long tube with stoppers at each end that are closed when a signal is sent from the ship, thus trapping the water in them at that particular depth. How do the geochemists get their Niskin bottles to the depths where they want to take samples? The physical oceanographers already have a platform descending to the bottom, the CTD. The geochemists attach their instruments to that platform producing a heterogeneous tool in which the CTD of the physical oceanographers is surrounded by a ring of the geochemists' Niskin bottles (see Fig. 4.4). What results is a complex tool that ties together two different scientific disciplines and two different communities of practice that have a common interest in studying the sea. Like the sea itself, the "CTD rosette" is a boundary object (see Fig. 4.4).

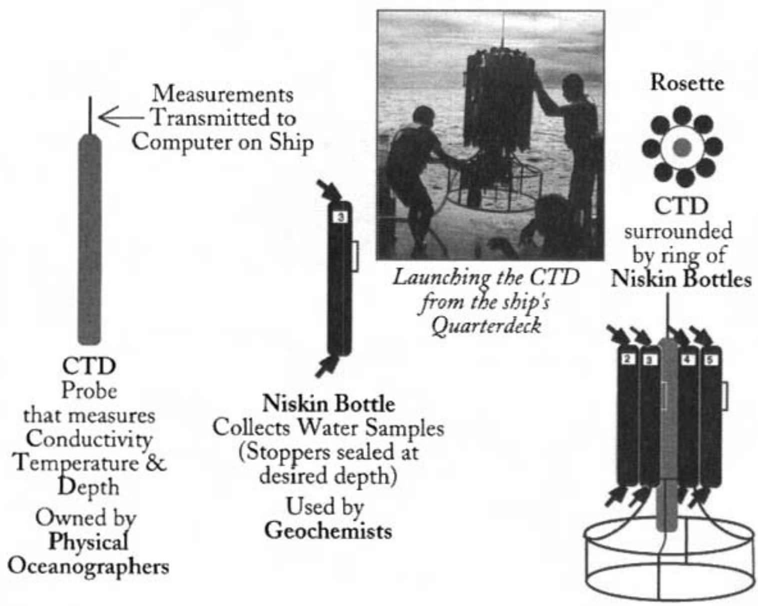

FIG. 4.4. Convergent diversity instantiated in a heterogeneous tool (CTE rosette), a boundary object.

CTD as a Tool for Perception

What the scientists want to study is the distribution of different kinds of phenomena in the water column. As river water pushes out on the surface, sea water moves back beneath it, producing a water column of considerable complexity. The sea under the ship is thus not homogeneous but instead consists of a patchwork of different kinds of water and sediments (greatly oversimplified in Fig. 4.5). The scientists are particularly interested in properties and distribution of these bodies of water and in the location of "fronts," places where two different kinds of water meet.[9]

How can these underwater features be seen so that they can be sampled and studied? The CTD sends measurements it is making back to the ship as it moves through the water. The computer graphs made from these data provide a continuously changing picture of relevant features in the water column. For example, as the CTD passes through a front, salinity and temperature change. Computer software that displays such changes graphically provides a way of "seeing" these fronts and other features that are of interest to the scientists. The CTD thus provides the

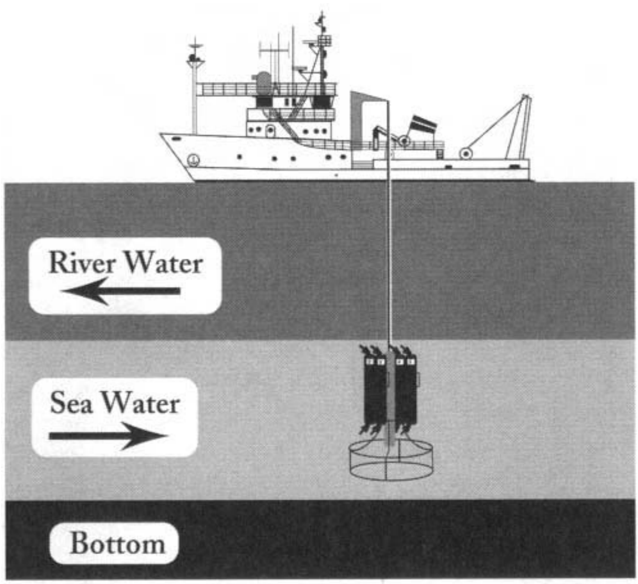

FIG. 4.5. Simplified illustration of the water column being sampled.

[9]See Friedman (1989) for a historical study of the development of the conception of polar front in meteorology.

scientists on the ship with perceptual access to the world they are sampling while simultaneously shaping what they are able to see there (e.g., just those properties of the environment that their sensors capture and software can make visible as organized patterns). This is true not only in the narrow sense of "new hardware" that makes it possible to see things such as salinity differences as graphs on computer screens, but more crucially in the "theoretical" sense that both the objects made visible (such as fronts and gradients), and the current interest of the scientists in such objects are provided by the historical development of a particular theoretical field.

The history of the tools being used is not, however, confined to a single discipline. Equations developed by physical chemists to describe the relation between conductivity and salinity provide another discipline, physical oceanography, with tools for probing phenomena of interest to it. Appropriation across disciplines is central to this process. Where does this occur, and how might it be organized? Aspects of this process I now investigate in more detail.

I noted previously that on research ships, scientists from different disciplines are required to do laboratory work in close proximity to each other. The two people gazing intently at separate screens we examined earlier are scientists working in the ship's CTD laboratory. Phyllis (P) is a physical oceanographer, and George (G) is a geochemist (see Fig. 4.6). How does the fact that the CTD with its ring of Niskin bottles brings together the tools of their two separate disciplines organize their work? An initial possibility might be that they operate side-by-side in parallel but independently of each other. This turns out not to be the case. The geochemist is staring intently at the CTD display (see Fig. 4.7). Although this CTD is owned by and gathering data for another discipline, physical oceanography, George can use the picture of the water column it makes available to determine where to take his own samples. The juxtaposition of tools thus produces a creative synergy, as a tool embedded within the work practices of one discipline provides new resources and opportunities to view phenomena for another.

MULTIPLE PERCEPTUAL FRAMEWORKS

The physical oceanographer (Phyllis) is intently scrutinizing not the CTD display but instead a PDR. For simplicity, I treat this as a form of sonar, which records echoes of phenomena in the water (including the bottom) on a moving paper chart, and I refer to it as a "sonar chart" in

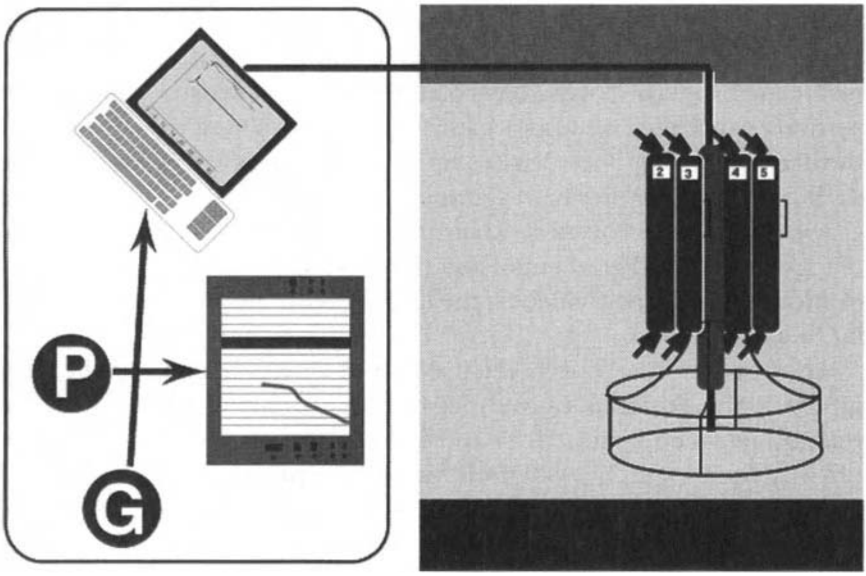

FIG. 4.6. A hybrid tool produces separate screens observed by two scientists.

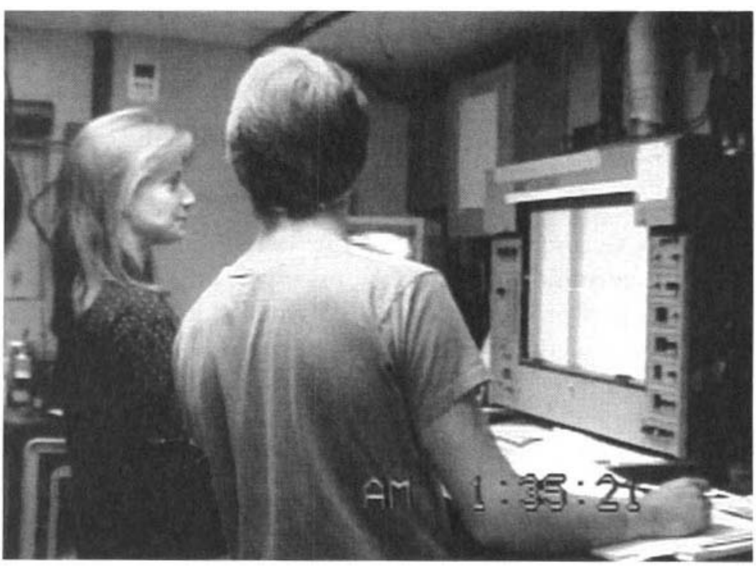

FIG. 4.7. Tool juxtaposition produces creative synergy between scientists from different disciplines.

this chapter (see Fig. 4.8). The CTD is one of the most important tools of Phyllis' profession, an instrument that sits at the cutting edge of current technology in physical oceanography. The pressure gauge it carries provides a far more accurate measure of depth than the complicated, confusing image provided by the sonar chart. Why then isn't she staring at the CTD display as intently as the geochemist?

To answer this question, it is necessary to look more closely at the work involved in taking samples with this CTD. The device, with the equipment attached to it, costs approximately $25,000. If she slams it into the bottom, there is a real chance that she will cut the cable and lose the instrument (anticipating such a possibility, the ship carried a second CTD as backup). However, both she and the geochemist want to get as close to the bottom as possible, for it is there that some of the phenomena of most interest to them are to be found. She must thus walk a very fine line between two conflicting constraints: (a) getting as close to the bottom as possible (b) without actually hitting it. To do this, she begins a CTD cast by lowering the instrument almost to the bottom but with an adequate safety margin to prevent actually hitting it. During the descent, data are collected and displayed, and it is these graphs that the geochemist uses to help him decide where to take samples as the instru-

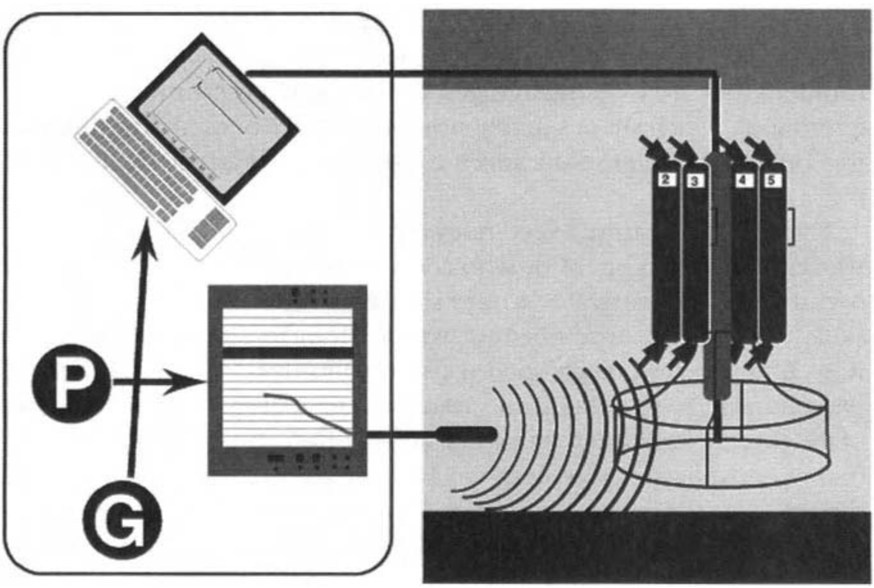

FIG. 4.8. Physical oceanographer prefers geochemist's "sonar" to judge position of CTD relative to bottom.

ment platform ascends. Once the CTD reaches its safe point near the bottom, the physical oceanographer reanalyzes the situation in the light of the new information provided by the descent and decides exactly how much deeper she can safely go.

The most accurate measure of depth available to her is provided by the pressure gauge on the CTD. However, what is crucial for her current work is not accuracy in the abstract but instead a measurement of depth that is relevant to the tasks she is currently engaged in—that is, the position of the CTD relative to the bottom. The tool that best makes visible this relation is not the pressure gauge (which reports only the position of the CTD while being oblivious to the bottom) but the sonar (PDR) that juxtaposes the CTD to the bottom while giving a less accurate measure of the absolute depth of the CTD.

Depth is thus dealt with by these scientists not as an abstract, context-free measurement[10] but instead as something to be defined indexically—that is to say, with reference to something else. What that something else is is defined by the specific activity that the act of measuring is helping to accomplish. Thus, for the geochemist, the relevant position of the CTD is constituted by its relation to features of the water column that he wants to sample. For the physical oceanographer in her capacity as "driver" of the CTD (but not necessarily in her capacity as research scientist), relevant depth is defined in terms of the relation between the CTD and the bottom. Each activity requires a different view of the environment they are working in together. Therefore, each attends to a different tool, which shapes perception of that environment in a different way but one relevant to the specific tasks that the party doing the looking is engaged in.

There is yet a third, very relevant participant in the CTD cast—Warren, the winch operator who actually lowers the CTD through the ocean. The winch operator is not a scientist but a sailor. His task and the skills he brings to it are embedded within a long tradition of seamanship (e.g., lifting heavy objects such as fishing nets into a boat). Indeed, the perceptual requirements for his task are instantiated in the architecture of the ship. In addition to the window in front of the wheelhouse, a second window has been built in the back so that the winch operator can see the objects he is manipulating. By using the tools available to him, he is thus building on the work of his predecessors in this job who have

[10]For analysis of measurement as an indexical, situated process, see Lynch (1991), Sacks (1989), and Sacks (1992).

developed solutions to the systematic problems posed by such tasks and embodied these solutions in concrete tools (Leont'ev, 1981). What is found here is quite literally a historically constituted *architecture for perception*, a history that is instantiated not in the texts that report earlier political events but rather in the tools built by anonymous ancestors that shape in quite detailed ways the life and activity of their successors.

The window overlooking the quarterdeck where the CTD will be lifted back on to the ship has close task-relevant parallels to the sonar display that the physical oceanographer uses. Just as she was most concerned about not having the CTD hit the bottom, Warren risks losing it if he slams it into the top of his crane by reeling in too much cable. Just as the sonar display enabled Phyllis to see the relation between the CTD and the bottom, the wheelhouse window provides Warren with a view of the crane that will lift the CTD out of the water, the quarterdeck where it will be placed, and the sea it will emerge from.

It is absolutely crucial that the winch operator know when the instrument package is approaching the surface. However, he is in a different location from the two scientists and cannot see the images visible on their screens. The only way that he can measure the position of the CTD is by the amount of cable he has played out. It is known by everyone that currents can pull the CTD so that the length of cable deployed can give a very inaccurate reading of absolute depth. Despite this, cable length is the depth measurement provided by the tools that the winch operator is working with, and, if he zeros it correctly when he launches the CTD, it will accurately tell him when the probe is returning to the ship. Its measurements work for the particular tasks he is charged with accomplishing.

Central to the activity of deploying the CTD is the task of positioning it in appropriate places. However, within this activity there are in fact a number of different, task-relevant views of where the CTD is (see Fig. 4.9). The activity of deploying the CTD thus involves the articulation in real time of multiple views of how the tool being worked with is positioned within its relevant environment. Although three parties are collaborating in the activity of moving the same tool through its environment, each has different perceptual access to that environment, that access being shaped by the tools that each is using and these tools being selected in terms of the specific tasks that each is facing. What is involved in this activity is not simply a division of labor but a division of perception.

It is frequently argued in anthropology that the analyst must work to get the participant's perspective. However, there is no single partici-

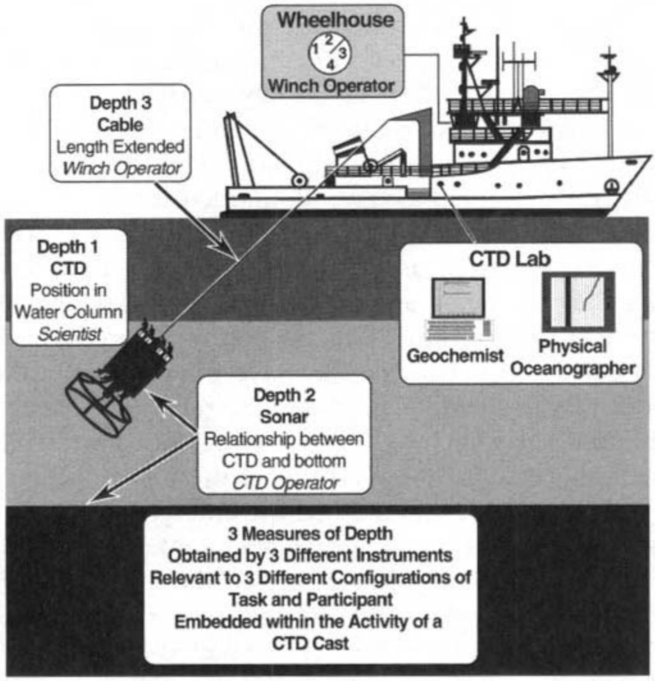

FIG. 4.9. Division of perception as a form of social organization.

pant's perspective but instead multiple perspectives (Haraway, 1988). Moreover, these alternative views on what is to be seen are not random, idiosyncratic, or haphazard but instead are systematic products of the organization of the endogenous activities in progress.

What is at issue here are processes of perception. The organization of this perception is not, however, located in the psychology of the individual brain and its associated cognitive processes but is instead lodged within and constituted through situated endogenous social practices. Such perception is a form of social organization in its own right.

A clear demonstration of the situated nature of the perceptual processes being examined here is found in the way in which they require for their accomplishment the tools that build the setting that makes the activity possible in the first place—for example, the sonar charts, computer graphs, and the like that constitute a CTD laboratory. These tools shape perception through the way in which they construct representations. The structure of representations in scientific practice has been the topic of insightful analysis.[11] In this chapter, I complement this work by looking at how representations are articulated by differentiated participants to accomplish something within temporally unfolding sequences of action. Perception and action are inextricably linked. Moreover, the activity of these scientists and sailors is structured not only by their tools but also by the perceptual frameworks provided by their disciplines and the routine work practices that have developed for the accomplishment of this task. Consistent with Hutchins' (1990) analysis of distributed cognition, the "knowledge' " required to perform a CTD cast is not lodged within any single individual but is instead distributed throughout a system that includes not only human actors of very different types but nonhuman actors as well (Latour, 1987). Perception is something that is instantiated in situated social practices rather than in the individual brain.

ARTICULATING THE DOCUMENT SURFACE

In that the separate perceptual frameworks of each participant must be integrated into a common task (for instance, putting the CTD in a particular position), the task of translating the view from one perspective into the frame of reference of another is posed. Investigation of how this is done provides the opportunity to look in more detail at how two- dimensional inscriptions, such as documents and images on computer screens, are (a) organized as conjunctions of diverse spaces with heterogeneous properties and (b) articulated as frameworks for the production of meaning and action.

The CTD display on the computer in the ship's laboratory provides a graph of the water column that the geochemist can use to guide his sampling (see Fig. 4.10). However, to use this graph to collect samples, the geochemist must be able to tell the winch operator where to go. To do this, he has to translate the information on the graph into a statement that can be expressed in meters, the only measurement system available to the winch operator who must reel in a specific amount of cable. The CTD display provides the resources for doing this—a scale at the bottom of the screen (as well as a range of other scales that I ignore in this discussion). Like many documents, the display is a complex heterogeneous surface bringing together on a single flat plane structurally different types of information (e.g., a representation of the environment that

[11] See Footnote 2.

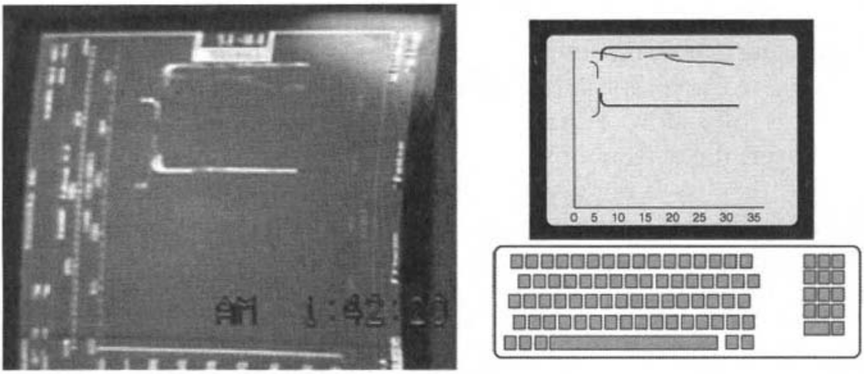

FIG. 4.10. CTD graphic display brings together structurally different representations.

the scientists are sampling and tools that can be used to work with that representation). However, the ruler at the bottom of the screen is distant from the graph of the structures being sampled. The geochemist is thus faced with the task of bringing together two points of information that are distributed spatially on the document surface he is working with. He does this by using another tool. The pencil he has been using to make entries in the log book is now placed on top of the screen so that information provided by the scale can be juxtaposed to the graph (see Fig. 4.11). The task of reading the screen in a work-relevant way thus leads to a situated improvisation, as implements designed for other purposes are tailored to local projects. Within this process, the object in George's hand becomes two different tools when embedded within alternative activities—in this case, a writing instrument when log entries are to be made and a straight edge when distant points have to be juxtaposed on the computer screen.[12] For its part, the screen is not simply a flat inscription, a place where information is to be apprehended through vision alone, but the base of a three-dimensional work area, something that can be touched and manipulated to shape the material it provides into the phenomenal objects required for the tasks of the moment.[13] Reciprocally, the marks on the screen as instantiations of the fea-

[12]The possibilities for such mutation are not unlimited; crucial to the use of the pencil as a way of measuring events on the screen in the present case is its size, straightness, and the fact that it is readily at hand.

[13]The transformation of events visible in the pixels of a screen into new discursive objects is by no means a neutral process. See Goodwin (1994) for analysis of how the Los Angeles policemen who beat Rodney King worked with the video image of his body writhing under their blows to "demonstrate" that he was in fact the aggressor, struggling to rise and attack them.

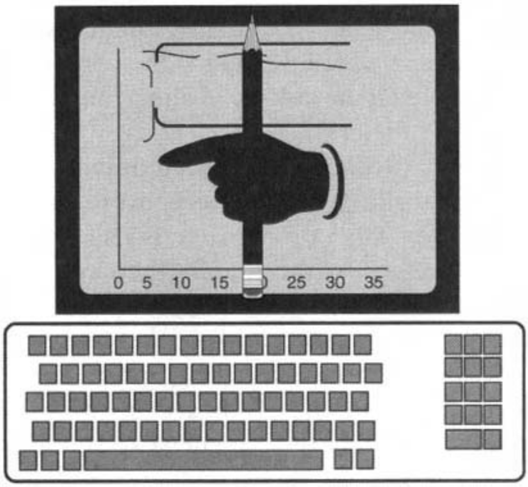

FIG. 4.11. A pencil is a tool for juxtaposing scale and graph.

tures being investigated by the scientists provide a framework of intelligibility that constitutes what George's hand is doing as meaningful action rather than aimless movement. Like the mirror in Cocteau's *Orphee* (Paulve, Film du Palais-Royal, & Cocteau, 1950) the graph on the screen is not merely something to be looked at but instead an open gateway to a world where the human body can move and act within new frameworks of meaning.[14]

Like a playing field that builds a landscape within which certain moves, such as a "goal," become both possible and visible, the graph on the computer screen creates an arena for the perception and constitution of relevant action. Consider, for example, the access that the scientists in the laboratory have to the actions of their coworker in the wheelhouse. As the sampling run unfolds, the scientists will tell the winch operator to move to a place, specified as a depth, where they want to take samples. In that the CTD will provide a more precise and up-to-date picture of the sample place as it gets close to it, instructions for further movement may be given to the winch operator before samples are actually taken. Relevant instructions and acknowledgments are given over the ship's squawk box: the physical oceanographer tells the winch operator to move to a particular

[14]For analysis of a physicist transporting himself from one kind of space to another as his hand moves over the surface of a graph, see Ochs, Jacoby, and Gonzales (1994).

depth (e.g., "Warren, bring the CTD up to 11 meters please"). When the winch operator arrives at what he thinks is the correct spot, he tells the scientists he has completed the task given him by announcing the new location of the CTD ("11 meters").

The work-relevant activities of the winch operator are available not only in the reports he makes over the intercom but also through the way in which he moves the CTD, a process that is visible to the scientists in the laboratory as changes in the graphs they are looking at. These graphs provide mediated access to not only the sea they are studying but also their coworker. As representations of the lived activity of another human being, the squiggles traced on the graph are quite different from the talk heard over the squawk box. Almost everything that one thinks of as constituting the embodied performance of a human actor has been stripped away: the visible body itself, language, the features of a human voice that allow participants in interaction to recognize a specific individual, his affect, the stance he is taking toward the activity in progress, and the like. However, although the graph offers an extraordinarily attenuated vision of the winch operator as an embodied coparticipant, it provides the scientists with their best record of precisely those features of his action that are most relevant to the task at hand—in this case, where he has placed the CTD. To determine what to say next to the winch operator, the scientists will in fact pay more attention to his actions as visible on their graphs than they will to what he says. Goffman defined the primordial site of human interaction, the *social situation*, as "an environment of mutual monitoring possibilities, anywhere within which an individual will find himself accessible to the naked senses of all others who are 'present,' and similarly find them accessible to him" (Goffman, 1964, p. 135). Here, rather than Goffman's simple but clear case of immediate embodied presence to the naked senses of others, what one finds is a complex texture of mediated access as the scientists attend to multiple representations of the winch operator's action (both his talk and the traces of his activity on their graphs) available through media with quite disparate properties. Although the graphs lose most of what Goffman defined as crucial for the organization of interaction, they in fact provide the most pertinent arena for the perception of the winch operator's action, situating what he is doing as moves on the very playing field that is structuring the activity in progress—that is, as movements occurring within a particular landscape: the features of the water column that the scientists are trying to sample, which are instantiated in the graphs.

Crucial to the status of the marks on the graph as interactive events that help structure the future course of the activity in progress is their unfolding temporal organization within a project that has not yet come to completion. By monitoring through their changing graphs both the actions of the winch operator and the features that his probe has revealed, the scientists decide what to do next.[15]

This temporal horizon is lost (or at least radically transformed)[16] when the CTD cast is completed, and these same marks become records of a past event rather than resources for the shaping of future action. The graphs visible on the scientists' displays during the CTD cast are thus not flat, timeless, two-dimensional inscriptions but instead constitute inhabited spaces that provide an architecture for the perception, monitoring, and production of relevant action as the night's work unfolds in lived time.

Similar arguments can be made about the language that occurs here. Consider, for example, the winch operator reporting that he has reached a requested depth by saying "11 meters." Like the graph, these words provide a representation of an event in the sea under the ship that is relevant to the activity in progress: a statement about the current depth of the CTD. Many approaches to the philosophy of language would treat a statement such as this as a proposition about some possible state of affairs in the world it describes. A central game played with propositions, one that links language to the world, is evaluating their

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[15]It is by no means unusual for temporal processes of human interaction to occur entirely within the space constituted by an electronic document. At one of the airlines studied by the Xerox PARC Workplace Project (e.g., Brun-Cottan et al., 1991), flap settings for planes taking off all around the country were computed at a single control room in Texas. These settings can only be computed after all of the passengers, fuel, and baggage have been loaded on the plane. Between the moment that a plane left the gate and the time it reached the end of the runway, workers in the local Ops Room in California would be monitoring an electronic document on their computers to check on whether Texas had put the appropriate number in a particular place on the computer form. Although their entire interaction is filtered through the keyhole of these numbers in one cell of a document on a computer screen, the workers in Texas and those in California work together under very tight time constraints to get planes safely off the ground. In even more attenuated fashion than the situation of the ship (where sequences of talk are also exchanged), the space constituted through an electronic document provides an arena for the production and monitoring of meaningful action within temporal sequences of interaction.

[16]As data inscriptions back on the mainland, the graphs will of course have a new projective horizon in terms of the analysis they help develop. However, the prospective horizon that is structuring action here—the problem of where to go to take the next sample—will no longer be available. The loss of the possibility of agency within a temporally unfolding situation that occurs when the graphs become records is a central component of the process through which the embodied work being investigated here is erased within subsequent reports that will use the products of this night's work as data.

truthfulness. Within such a framework, the winch operator's statement is accurate and truthful if the CTD is actually 11 meters under the sea and false if it is not.

Is this in fact the way that the scientists listening to the report evaluate it? Note that they are in an especially strong place for making such a evaluation. Not only do they have an interest as scientists in measuring this depth, but the pressure gauge on the CTD, when interpreted by the equations in the computer producing the display that the scientists are looking at, gives the most accurate reading of depth possible with the tools currently available to science. Despite this, those in the laboratory do not reply to the winch operator by calling him a liar because their instruments show the probe to be actually 10.25 meters deep or gloat over the superior knowledge provided by the expensive tools of modern science when compared with the crude instruments of the working sailor. Instead of using the framework provided by a correspondence theory of truth to interpret "11 meters," they hear that utterance as an appropriate sequential move within a relevant language game[17]—that is, as a report that the last instruction given the winch operator ("Bring the CTD up to 11 meters") has been accomplished so that the sample run can now move to its next stage. Indeed, differences in the perspectival frameworks provided by the tool kits being used by alternatively positioned actors are one of the things that make such a move necessary. In that everyone knows that the measurements of the winch operator are at best approximations of absolute depth (e.g., currents can pull the probe horizontally), the scientists cannot simply look at their graphs to see when the CTD reaches the requested depth but must instead get a report from the perspective of the winch operator, situated within the phenomenal world provided by his tools, to know that he is finished. The winch operator's report is properly heard not by looking in the abstract to the world it describes but instead by embedding it within a relevant language game. Investigating the endogenous organization of situated activities makes it possible to develop a framework for the study of representations that does not create an arbitrary division between language or "mental" phenomena and material objects such as maps, graphs, and other inscriptions but instead analyzes the

[17]Analysis of how utterances are organized as actions within the unfolding sequential structure of talk-in-interaction lies at the heart of the approach to the analysis of conversation initiated by Sacks in collaboration with Schegloff and Jefferson (e.g., Jefferson, 1973, 1987; Sacks, 1963, 1974, 1992; Sacks, Schegloff, & Jefferson, 1974; Schegloff, Jefferson, & Sacks, 1977; Schegloff & Sacks, 1973). For examples of how such a framework can elucidate the organization of talk and action in work settings, see Drew and Heritage (1992).

meaningfulness of any representation by describing the grammar for articulating it—that is, how to use it to make an appropriate move within a relevant activity system.

SEEING IN COMMON

To place the pencil on the screen, George walks right in front of Phyllis (see Fig. 4.12). In that his movements occur within a setting for human interaction, they can be seen and interpreted as meaningful action by others. Phyllis comments on what he is noticing (see Fig. 4.13). Note that Phyllis does not inquire about what George is looking at. Instead, by treating what he is noticing as already visible to her, she demonstrates her ability not only competently to read a relevant display but independently to determine what in it he would find interesting.

What does it take to be able independently to notice a "nice feature"? Standing there, I did not see anything like a nice feature. The ability to see such an event is embedded within an endogenous community of practitioners, the work of which provides a guide for seeing—interpretative structures that locate particular phenomena as relevant and interesting—and the tools and intellectual frameworks that make such phenomena visible in the first place (Goodwin, 1994). Such seeing constitutes an instantiation of culture as practice. Note also that in seeing this event, Phyllis is integrating analysis of two very different kinds of spaces: (a) the events instantiated on the surface of the document being examined and (b) movement through the laboratory itself by an actor performing an activity that becomes recognizable by attending to both his actions and the tool he is working with.

Phyllis embeds what is being seen here within a temporal horizon as well. With her "again" in "That nice feature again," she links the phenomena now visible on the screen to events seen earlier in other spaces that the ship has sampled.

Why is it relevant for one coworker to be able to see what another is doing? One very basic answer to this question is provided by the task(s) of producing collaborative action. Phyllis and George will be working together to take samples as the CTD is lifted to the surface. Three and half min later, after taking a set of samples at 22 meters, Phyllis asks George where the next sample will be taken (see Fig. 4.14). In his reply in line 5, George does not provide a precise number but a visibly approximate one: "About eleven meters." Moreover, his answer is noticeably delayed by two long pauses (lines 2 and 4) and an "Uh:m"

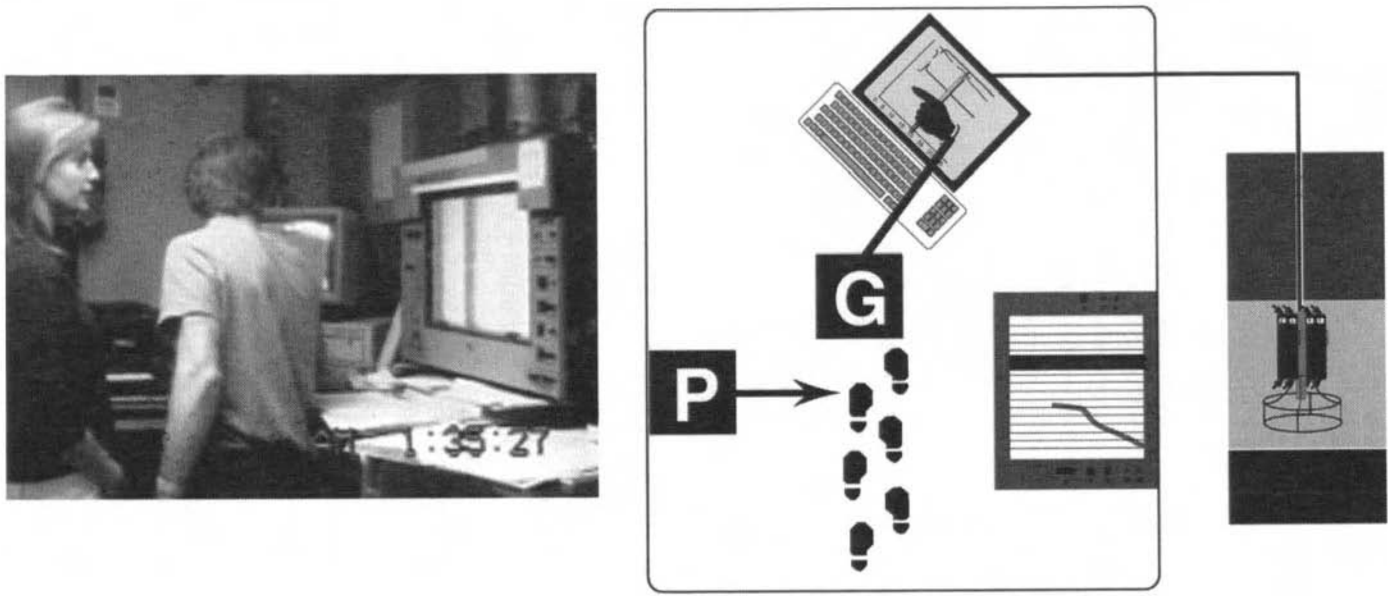

FIG. 4.12. George's move in front of Phyllis is interpreted in context.

Phyllis: I looked at that.
It was ni:ce.
(0.2)
Yeah.
(1.6)
That ni:ce feature ag[ain.
George: [Yeah.

FIG. 4.13. Phyllis requires no verbal explanation to interpret George's noticing.

accompanied by a hand gesture displaying uncertainty. For an addressee accustomed to the unambiguous instructions that typically occur in such sequences, such displays can raise the question of why this particular number has such a penumbra around it. At the beginning of the pause in line 6, Phyllis turns and starts moving toward the intercom she uses to give depth instructions to the winch operator. However, instead of completing this action (e.g., by telling the winch operator to go to 11 meters, as in line 11) she turns back to George with the query in line 7: "Wanna try en hit that?" This utterance ends with an indexical *that* accompanied by a hand gesture pointing to the computer display. What she appears to be referencing is the "nice feature" that she had earlier commented on, and that George's activity of measuring on the screen

1 Phyllis: Where next.
2 (0.8)
3 George: Uh:m.
4 (1.0) 
5 About eleven meters.
6 (1.1)
7 Phyllis: Wanna try en hit that? 

8 George: Yeah.
9 (2.2)
10 Phyllis: Warren.
11 Bring the CTD up to eleven meters please.

FIG. 4.14. Producing collaborative action involves talk within locally relevant spaces.

had made so salient. Her question thus offers an hypothesis that would account for the approximate character of the number she has just been given—namely, that George is interested not in a particular depth per se but in the feature they've observed. Indeed, when they get to 11 meters, they do not take a sample there but instead begin an elaborate chase as they work to position the CTD precisely at the feature so that they can sample it. The talk that occurs here is thus tied retrospectively to prior action (for instance, to the earlier noticing and measuring of the feature), whereas prospectively it sets the agenda for what Phyllis and George will do together in the future. Making sense out of that talk, such that Phyllis knows what George is trying to do when deciding where to take samples (e.g., to "hit the feature"), requires not only competence in the larger work practices that constitute their domains of professional responsibility but also close attention to both the meaningful articulation of a range of different kinds of locally relevant spaces and the details of how talk is produced within sequences of human interaction.

Access to such phenomena is restricted to those in the CTD laboratory, the only people positioned to see both each other and the representations that are guiding the sampling. Thus, although the winch operator is an important coparticipant in the activity, he knows at this point only that the CTD is to move to a particular depth, not that a feature is being hunted—and indeed, the study of features is not part of his work. Once again, alternatively positioned actors have quite different access to what it is that they are doing together.

HYBRID SPACES: SPACE AS LOCALLY ORGANIZED, HISTORICALLY SITUATED PRACTICE

Central to the work that these scientists are doing is their placement within and organization of spaces of many different kinds. Lynch (1991) drew attention to the problem of locating where the action is occurring in scientific work in terms of the distributed *activity field* implicated by a specific course of action. However, most analysis of the human use of space has focused on the organization of more bounded, self-contained, and internally consistent types of space—for example, spatial frameworks that provide organization for human interaction,[18]

[18]See, for example, Kendon (1990) for analysis of how the organization of human bodies in space provides frameworks for the organization of their interaction with each other and Duranti (1992) for analysis of how the movement of bodies through spaces constituted socially with specific cultures provides interpretive frameworks for the organization of meaningful action.

the way in which different languages encode spatial relationships (Hanks, 1990; Levinson, 1992), the organization of graphic displays by scientists (Lynch & Woolgar, 1988), and so on. When the organization of endogenous *activities* is taken as the relevant unit of analysis (as it is here), this conceptually neat and clean division of phenomena into isolated, self-contained systems becomes inadequate. The activities of the scientists in the CTD laboratory repetitively and systematically cut across the ways in which space has been partitioned by social scientists for systematic study. The spaces they inhabit and articulate to get their work done are "hybrid spaces." Thus, the spatial organization of events on the computer screen is consequential for and intimately tied to the interactive organization of human bodies in the space of the CTD laboratory. The participation frameworks being sustained by these bodies include orientation not only to other human beings but also to tools and documents of various types. In attending to these documents, the scientists are organizing their actions with reference to spaces that extend far beyond the laboratory itself. In brief, to do their night's work, the scientists on the ship must juxtapose a heterogeneous collection of very different kinds of spaces. To study this process, one must look not just at each of these separate orders of space (which do require systematic analysis as coherent phenomena in their own right) but also at the activity that the scientists are engaged in as an unfolding course of practical action within which particular kinds of space emerge as relevant at particular moments and are then articulated with reference to each other. For example, manipulating the surface of the computer screen to position a probe at a particular place in the sea below the ship requires noticeable movement through interactive space that makes visible to others present an orientation to particular theoretical events instantiated on the screen and so on. Although those working in the laboratory attend seamlessly to various orders of space as interconnected components of coherent courses of action, it is useful to distinguish at least provisionally and perhaps inaccurately some of the structure and complexity of the different kinds of space they so easily move through. In the 10-sec sequence I have been examining, the spaces being attended to by these scientists include at least the following (see Fig. 4.15).

1. The environment they are studying: the sea outside the ship.
2. A representation of that environment displayed by tools that make visible structures of interest to the scientists.

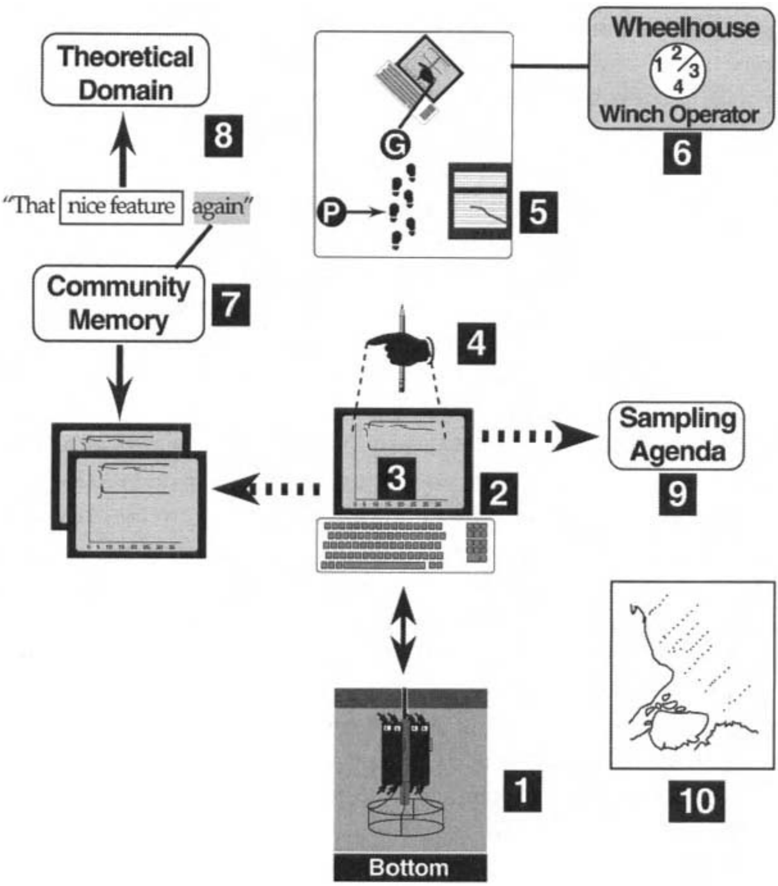

FIG. 4.15. A conceptualization of multiple spaces being attended to by scientists.

3. The spatial organization of the screen displaying that representation.

4. Transformation of this two-dimensional screen into a three-dimensional locus for visible activity as the document surface is articulated in a work-relevant way.

5. The work setting itself, the CTD laboratory, which includes both tools distributed in space and orientation frameworks being sustained by its inhabitants. Thus, to get to the screen where he wants to take measurements, the geochemist must traverse the orientation space constituted through the physical oceanographer's gaze toward the sonar screen she is working with.

6. This setting is linked to other work settings also implicated in the organization of the activity such as the wheelhouse where the winch operator is positioned. A *culture* sustained by this community of practitioners provides for the appropriate seeing of both the representations provided by their tools and the work that the participants are doing—for example, the transformation of squiggles on a screen into an independently seeable "nice feature."

7. This community is also able to link what is currently being seen to other spaces seen in the past.

8. A conceptual, theory-defined world (built in part through graphs and other spatial artifacts), which the present instance helps further to constitute.

9. The collaborative seeing that occurs here has a prospective orientation as well, as it sets the agenda for future work sampling the feature identified here.

10. The ship on which the scientists are working has been positioned at a place defined by the sampling grid being used to organize data collection on this cruise. This point is constituted through a conjunction of space constituted by a particular theoretical agenda (shaped by a variety of political processes), a global framework of latitude and longitude, and an actual physical spot in the ocean. Locating this spot requires another intricate conjuncture of space and activity (navigation satellites, maps, the work of other crew members, and the like), whereas the spot as a sample point links the products of this night's work to a larger scientific project.

To take their samples, these scientists must navigate through an array of different kinds of space, articulating one with reference to another and improvizing within them to perform an ordinary night's work, another station. The mundane nature of this work rests on an infrastructure of historically sedimented practice that is mobilized as a situated, temporally unfolding process to accomplish the work at hand.

Such processes are quite relevant to the question of how human cognition is to be analyzed. The analysis of spatial organization has recently become a major focus of research within cognitive science. However, within such research, the organization of space is conceptualized as a mental entity, divorced from practical action in endogenous settings. By way of contrast, the analysis developed here focuses on human cognition as a historically constituted, socially distributed process encompassing tools as well as multiple human beings situated in structurally different positions.[19] Restricting the analysis of cognition to processes located within the brain (including the sedimentation there of processes that have a larger social life, e.g., de Saussure's, 1966, *langue*) gives a very inadequate view of human cognition. As has long been recognized by Vygotsky (1962) and his followers, crucial to the development of human cognition is the ability of our species to secrete cognitive artifacts (including but not restricted to language) into the external world where they can shape not only our own actions but also those of our colleagues and successors. Such an expanded view of cognition seems especially important for the analysis of space in that human beings perceive space from within socially organized settings and conceptualize, articulate, and traverse space through a rich collection of tools that have been appropriated from the cognitive activities of our predecessors (maps, graphs, ships, etc.). Central to the organization of space are local activities and processes of human interaction within which different orders of space are tied together into the structures necessary for the accomplishment of relevant action. It is only within endogenous activities in actual settings, with their constellations of relevant tasks and tools, that the full richness and complexity of human spatial cognition becomes visible.

ACKNOWLEDGMENTS

I am deeply indebted to Willard S. Moore for inviting an anthropologist to observe oceanographers doing their work at sea and for obtaining grant money that would allow me to sail as one of his technicians. Without his help and support, the research reported in this chapter would never have come about. I am also very deeply indebted to the scientists and crew on the ship for allowing me not only to observe but also to videotape the work that they were doing. Very special thanks to Heather Astwood, Ruth Gorski, Steve Harden, Holly Kelly, Dick Limeburner, and Robin Pope.

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[19]This work is thus quite consistent with the approach to cognition that has emerged within studies that have investigated the sociology of scientific knowledge (e.g., Collins, 1985; Latour, 1987; Pickering, 1992; Pinch, 1988, and many others). It is also consistent with work on situated action in the workplace (Brun-Cottan et al., 1991; Suchman, 1987), and on activity theory (see Cole, 1985; Engeström, 1987; Leont'ev, 1981; Vygotsky, 1962). Recent developments in cognitive and linguistic anthropology that focus on cognition as a distributed process (see Hutchins, 1993) and that make use of the spatial organization of endogenous settings (Duranti, 1992) are also consistent and relevant.

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