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Report of the
Workshop on Boundary Organizations in Environmental Policy and Science

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The Global Environmental Assessment project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

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Publication abstracts of the GEA Project can be found on the GEA Web Page at http://environment.harvard.edu/gea. Further information on the Global Environmental Assessment project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, 79 JFK Street, Cambridge, MA 02138, telephone (617) 496-9469, telefax (617) 495-8963, Email nancy_dickson@harvard.edu.

FOREWORD

This paper was written as part of the Global Environmental Assessment Project, a collaborative, interdisciplinary effort to explore how assessment activities can better link scientific understanding with effective action on issues arising in the context of global environmental change. The Project seeks to understand the special problems, challenges and opportunities that arise in efforts to develop common scientific assessments that are relevant and credible across multiple national circumstances and political cultures. It takes a long-term perspective focused on the interactions of science, assessment and management over periods of a decade or more, rather than concentrating on specific studies or negotiating sessions. Global environmental change is viewed broadly to include not only climate and other atmospheric issues, but also transboundary movements of organisms and chemical toxins. (To learn more about the GEA Project visit the web page at http://environment.harvard.edu/gea/.)

The Project seeks to achieve progress towards three goals: deepening the critical understanding of the relationships among research, assessment and management in the global environmental arena; enhancing the communication among scholars and practitioners of global environmental assessments; and illuminating the contemporary choices facing the designers of global environmental assessments. It pursues these goals through a three-pronged strategy of competitively awarded fellowships that bring advanced doctoral and post-doctoral students to Harvard; an interdisciplinary training and research program involving faculty and fellows; and annual meetings bringing together scholars and practitioners of assessment.

The core of the Project is its Research Fellows. Fellows spend the year working with one another and project faculty as a Research Group exploring histories, processes and effects of global environmental assessment. These papers look across a range of particular assessments to examine variation and changes in what has been assessed, explore assessment as a part of a broader pattern of communication, and focus on the dynamics of assessment. The contributions these papers provide has been fundamental to the development of the GEA venture. I look forward to seeing revised versions published in appropriate journals.

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ABSTRACT

Boundary organizations are institutions that straddle the shifting divide between politics and science. They draw their incentives from and produce outputs for principals in both domains and thus, it is hypothesized, facilitate the transfer of useful knowledge between science and policy. This paper brings ideas from the social studies of science pertaining to boundary organizations to bear on the study of institutions in environmental policy and science. It summarizes a set of five case studies on candidate boundary organizations in both the domestic U.S. and international context: 1) the Health Effects Institute, jointly funded by the Environmental Protection Agency and the automobile industry to support and review research relevant to air pollution regulation; 2) agricultural extension, which mediates between the needs and interests of local farmers on one hand, and the work of researchers on the other; 3) the Sea Grant program, which provides extension services for mediating between coastal interests and researchers; 4) the International Research Institute for Climate Prediction, which is attempting to create from large climate models information more usable by populations vulnerable to climate change; and 5) the Subsidiary Body for Scientific and Technological Advice, which is a forum for negotiating scientific aspects of the work of the Intergovernmental Panel on Climate Change. The cases, with additional commentary, conclude that the concept of boundary organizations is a useful one for understanding the relationship between environmental policy and science.

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INTRODUCTION

Bill Clark, Harvard University

Research on boundary organizations at the Harvard Global Environmental Assessment (GEA) project involves collaboration—bringing scientific and technical information to bear on an international level. GEA studies of United Nations "ozone diplomacy" suggest that scientific information is presumed to be tainted by the political interests of the particular country producing it. They have found sets of evolving institutions, processes, and organizations living at this interface of "presumptively politicized science" that need to be given political legitimacy across different international realms. On a vertical scale, the ability of principals negotiating environmental agreements at the international level depends on a set of legitimations carried out so that the scientific information would not be viewed by their own citizens as a political sellout.

In examining the processes at work in the UN ozone assessment, GEA researchers increasingly found themselves drawn into the social science field, looking at broad studies in science and technology studies and in political science and examining the kinds of institutions and processes that had managed to mediate the presumptive politicization of technical knowledge—what those on the scientific side of the boundary had set up to enable them to vouch for the credibility of the scientific information.

The GEA research, in conjunction with David Guston's work at Rutgers, has revealed the extent of the literature and lines of thought going on in the social studies of science and political science communities that might illuminate these problems of bringing science to bear in politically charged situations. At the same time, the researchers hope to reciprocally enrich this field with their own findings.

INTRODUCING BOUNDARY ORGANIZATIONS

Dave Guston, Rutgers University

The idea for this workshop emerged from the 1998 GEA meeting, which identified as critical the challenge of crossing the functional and cultural boundaries between domains of jurisdiction and scales of organization. Boundary organizations may be one solution to this challenge. This workshop hopes to provide compelling accounts of the organizational apparatus behind successful relations between environmental policy and science.

Boundary organizations are institutions that straddle the shifting divide between politics and science. They draw their incentives from and produce outputs for principals in both domains, and they internalize the provisional and ambiguous character of the distinctions between these domains. It is hypothesized that the presence of boundary organizations facilitates the transfer of usable knowledge between science and policy. The workshop is not directed at a formal testing of this hypothesis, but rather at something of a plausibility probe to discover whether there are organizations in environmental policy and science that fit the criteria given for boundary organizations, to gather data and experience in the operation of such organizations, and to set the stage for further hypothesis development and testing.

Boundaries in Science

The concept of boundary organizations derives significantly from scholarship in the social studies of science, which over the last three decades has argued convincingly that what demarcates science from non-science is not some set of essential characteristics or methods, but rather an array of contingent

circumstances and strategic behavior known as "boundary work." Although initially formulated to explain how scientists maintain the boundaries of their community against threats to its cognitive authority from within (e.g., fraud and pseudo-science), boundary work has found such useful, policy-relevant applications as studying the strategic demarcation between political and scientific tasks in science policy, e.g., Jasanoff's work on the advisory relationship between scientists and regulatory agencies. This work finds that the blurring of boundaries between science and politics, rather than the intentional separation often advocated and practiced, can lead to more productive policy making.

One can easily imagine, however, how this boundary work might lead to confusion or even dangerous instabilities between science and non-science, perhaps involving the politicization of science or the scientification of politics. Scholars have discussed some possible stabilizing factors, including (but not limited to) the identification of *boundary objects*, *standardized packages* and, now, *boundary organizations*.

Boundary objects sit between two different social worlds (like science and non-science) and can be used by individuals within each for specific purposes without losing their own identity. For example, a patent on research results can be used by a scientist to establish priority, or for commercial gain. It can simultaneously be used by a politician to measure the productivity of research. In some cases, entire organizations can serve as boundary objects, as did many of the public interest organizations created by scientists in mid-century to facilitate political goals while protecting scientific ones. *Standardized packages* are more robust than boundary objects, changing practices on both sides of boundary. For example, model agreements for cooperative research between government scientists and private firms can encourage both parties to engage in more frequent and productive cooperation.

However, to the extent that boundary objects and standardized packages provide stability, they do so through the consent of actors on both sides of the boundary, for example, to the extent that researchers voluntarily engage in patenting or politicians accept patents as a measure of productivity. Moreover, even if blurred boundaries can be more productive for policy making, there is little sense of how much blurring is productive and how much might be destructive.

The Logic of Boundary Organizations

Boundary organizations attempt to solve these problems by meeting three criteria. First, they provide the opportunity—and sometimes the incentives—for the creation and use of boundary objects and standardized packages. Second, they involve the participation of actors from both sides of the boundary, as well as professionals who often serve a mediating role. Third, they exist at the frontier of these relatively different social worlds of politics and science, but they have distinct lines of accountability to each.

In this third criterion, boundary organizations borrow from principal-agent theory, which holds that organizational relations may be understood as delegations of authority from principals to agents. These delegations may be modeled by contracts. Regular problems of adverse selection (also known as hidden information) and moral hazard (also known as hidden behavior) plague the delegatory relationship and elicit regular solutions of incentives and monitoring.

The success of boundary organizations is determined by principals on either side of the boundary, both of whom rely on the boundary organization to provide them with necessary resources. A successful boundary organization will thus succeed in pleasing two sets of principals and remain stable to external forces astride the internal instability at the actual boundary. The success of the organization in performing these tasks can then be taken as the stability of the boundary, while in practice the boundary

continues to be negotiated with the greatest nuance within the confines of the organization. This dual agency makes the boundary organization a site of what Jasanoff has labeled "co-production," the simultaneous production of knowledge and social order. Boundary organizations are involved in co-production in two ways: they facilitate collaboration between scientists and nonscientists; and they create the combined scientific and social order through the generation of boundary objects and standardized packages.

Boundary organizations differ from the "boundary-spanning" organizations previously defined in the sociology of organizations. The concept of "boundary-spanning" helps explain how organizations insulate themselves from external political authority. Organizations engage in such activities to draw resources, exploit opportunities, or respond to threats from their environment. The boundary organization draws its stability not from isolating itself from external authority, but precisely by being accountable and responsive to opposing, external authorities. The boundaries most important to the spanning literature are those determining the organization's membership. The boundaries most important here are the conceptual ones between politics and science that the organization internalizes in order to be flexibly undifferentiable from either politics or science. Boundary organizations may use cooptation—the incorporation of representatives of external groups into their decision-making structure, as a spanning strategy—but they attempt to balance it between scientific and political principals.

Illustrative Organizations

The logic of the boundary organization's stability is akin to the logic, for example, used to describe the situation of the former congressional Office of Technology Assessment (OTA). Prior to its elimination by the new Republican Congress in 1995—primarily as a sacrifice to the agenda of fiscal discipline—OTA had established itself as a respected and politically neutral institution for the analysis of policy problems with high technical content. Wondering why OTA did not suffer the same fate of politicization over time as other organizations for policy analysis, scholarship points to the dual accountability of OTA to both Democrats and Republicans on OTA's governing board, as well as in OTA's congressional audience. The decentralized demands on OTA elicited a strategy of neutrality that channeled its pursuit of policy analysis. The need to respond to two partisan principals prescribed a balanced and, with respect to the role of politics and science in the performance of analysis, stable approach to OTA's mission. As a politically neutral organization, OTA did not teeter atop a narrow divide between Democrats and Republicans, but it internalized partisan differences, negotiated them for each study, and produced a boundary object or standardized package that either party (or any of several congressional committees) could use for its own purposes.

This workshop examines five candidate boundary organizations, some of which cross boundaries of scale as well as jurisdiction. At the national level, Terry Keating explores the role of the Health Effects Institute in the production of research relevant to air pollution policy. Examining the crossing of scales from national to regional and local, David Cash and Suzanne Moser address Agricultural Extension and Sea Grant, respectively. Focusing on the crossing of national and international scales, I examine the International Research Institute for Climate Prediction, and Clark Miller examines the Subsidiary Body for Scientific and Technological Advice to the UN Framework Convention on Climate Change. Through these studies, the workshop hopes to further clarify the analytical category of the boundary organization. It also hopes to probe the hypothesis that such organizations facilitate the transfer of relevant and usable knowledge and generate other hypotheses based on new observations and analysis.

Conclusion

Like Bruno Latour's Janusian visage of science, the boundary organization speaks differently to different audiences. Latour's science is able to project authority by appealing to either face in a strategic fashion—for example by claiming that science is a messy, creative process and also by claiming that it is a neat, rational process. Similarly, the boundary organization is able to project authority by showing its responsive face to either audience. To a political principal, it may say, "I will do your bidding by assuring that researchers are contributing to the political goals you have for sponsoring research." To the scientific principal, it may say, "I will do your bidding by demonstrating to the politicians that you are contributing to their goals, and I will help facilitate some research goals besides." The boundary organization thus gives both policy makers and scientists an opportunity to construct the boundary between their enterprises in a way favorable to their own perspectives. This solution is almost Madisonian in its use of a balancing of interests to reduce the threat that either side will find the boundary organization inimical, because it will actually pursue the interests of both parties.

The late political scientist and science policy scholar Don K. Price argued against the old idea of unitary sovereignty, and in favor of a new kind of federalism in the sponsorship of academic research by the federal government. Likewise, boundary organizations suggest that the old idea that politics and science should be neatly cleaved should be abandoned in favor of the newer attempt to mix the interests of both. It should not be worrisome that the implementation of boundary organizations may at times be characterized by a political intrusion into the workings of science, largely because there is a reciprocal intrusion of science into politics. These are undoubtedly slippery slopes. But the boundary organization does not slide down either slope because it is tethered to both, suspended by the co-production of mutual interests.

HEALTH EFFECTS INSTITUTE

Terry Keating, U.S. Environmental Protection Agency

The late 1970s was a time of antagonism between EPA and the auto industry, particularly over the setting of emissions standards and ambient air quality standards. Many questions existed about the science behind the regulations; for example, there was a great deal of controversy about the science behind the first carbon monoxide studies. In the midst of this antagonistic environment, Congress stepped in with the 1977 Clean Air Act Amendments, including a provision requiring the EPA Administrator to ban any new vehicle or part thereof found to constitute a threat to public health. Along with that provision was an obligation on the part of the auto industry to prove that its products do not cause a threat to public health. This obligation put a significantly high burden on the auto industry, while doing little to allay EPA's fears regarding its ability to trust research from the auto industry.

Perceiving this situation and believing there was a better way to accomplish these goals, two people became the major catalyst for the creation of the Health Effects Institute (HEI): Chuck Powers, who was then Vice President and Chief Environmental Officer of Cummins Engines represented the private sector, and his counterpart in the public sector Michael Walsh, then EPA Deputy Assistant Administrator in charge of the Office of Mobile Sources. They worked as advocates to "sell" their vision to a very high level of leadership, including the heads of major auto companies. Their vision was to create an independent institution to provide public and private decisionmakers with the best possible scientific information about the health effects of motor vehicle-related air pollution. HEI originally fulfilled this mission through two major activities. The first—funding original research on a variety of topics related

to motor vehicle air pollution—was accomplished early on by joining the debate about carbon monoxide and, most recently, the current and contentious discussions about fine particles.

HEI's second major activity is reviewing existing literature to ascertain the state of the current science in the field. During its twenty-year history, HEI has published a number of special reviews, including those on gasoline vapors and plans for studying the effects of electromagnetic fields. Recently HEI has looked at cancer studies, which play a very important role in some of the discussions about diesel emissions and carcinogenesis.

Structure

HEI's structure has several important characteristics that are crucial to understanding how the organization operates. The institute was created as a true public-private partnership with balanced funding from both EPA and the auto industry. Each side provided equal funding—about $3 million each. This $6 million budget has stayed relatively consistent throughout HEI's history, due largely to the lack of a provision in the original agreement to increase it.

HEI also features an independent board of directors. The original advocates for HEI immediately put together a distinguished set of individuals that gave HEI instant credibility: the board was chaired by Archibald Cox, former Watergate special prosecutor, and included the presidents of Stanford University and Bell Labs in its membership. The Board of Directors continues to serve as HEI's "guardian of credibility."

HEI's expertise comes from three types of expert advisory panels:

1) the *research committee*: experts who decide what research HEI should engage in, selecting investigators and overseeing work;

2) the *review committee*: individuals who oversee the external peer review of any research done under HEI's funding, performing their own review and critiquing the quality of science and regulatory implications of the work, which is then published along with the final report from the investigators;

3) *special expert panels* set up to oversee special projects, such as scientific literature reviews.

These advisory panels work together in what is known as the "HEI model" composed of:

1) *Actors:* Within HEI, actors include the board of directors, the various committees, and HEI staff. External to the organization, actors in the model are the sponsors (EPA and the auto industry), investigators who are engaged to do work and outside reviewers who provide peer review of HEI-sponsored research. The sponsors approve the board's appointments, but once they do so the board acts as an independent body, appointing research and review committees and managing staff. Staff and review committees then make recommendations about investigators and reviewers, which may be approved by the board.

2) *Process:* The cycle of HEI activity begins with a request from the research committee and staff to the sponsors for their research needs. The research committee and staff then develop a set of research projects and circulate a request for applications to investigators. Submitted proposals are reviewed both externally and by the research committee and HEI staff, who make recommendations to the board of directors. The board then approves the selection of investigators and the research committee and staff enter into negotiations with them. HEI's

process is unique in that the institution enters into an actual contract with investigators, through which HEI is able to shape the scope of work, define the products of the research, bring different investigative groups together in a collaboration, and generally to have increased control over what investigators do. HEI's process is also unique in that the research committee and staff continue to work with investigators throughout the research process, performing regular, highly managed quality assurance audits.

At the completion of the research project, a draft report is prepared for the review committee, which reviews the work for quality and regulatory implications and commissions external reviews. This critique, as well as the comments of external reviewers, is included with the investigators' final report.

National Academy Review

In 1993, the National Academy of Science (NAS) completed a review of HEI, finding that the organization was producing high quality research that was nonetheless lacking in relevance and timeliness. NAS recommended that HEI:

- diversify its research agenda;
- improve its relationship with sponsors;
- broaden its leadership and staff to improve understanding of HEI's constituency;
- develop a strategic plan;
- broaden sponsorship by looking outside the auto industry; and
- relax the idea of the need to have "balanced" funding.

Since the 1993 NAS review, in partial response to the Academy's recommendations, HEI has:

- expanded its board of directors, bringing in representatives from various institutions who could connect the organization to other communities outside the HEI research community;
- expanded its mission, beginning to look beyond sources of motor vehicle-related air pollution to other sources;
- broadened its activities to include re-analyses of empirical data;
- improved its relationships with the larger environmental science community by encouraging staff to contact other researchers; and
- expanded its sponsorship, expanded its idea of what their constituency is and expanded their annual meeting.

AGRICULTURAL EXTENSION

David Cash, Harvard University

The challenges for agricultural decisionmaking involve linking science and decisionmaking across different levels of organization (including general types of decisionmaking, such as that practiced by farmers on a day-to-day basis). The national Agricultural Extension program provides a laboratory for this research question: what characteristics of cross-scale information and decision support systems are associated with effective management?

The characteristics of boundary organizations help answer this question. Boundary organizations are entities that: negotiate the boundary between science and decisionmaking; lie between two distinct social

worlds with definite responsibility and accountability to both; have principals, agents and specialized mediators; and provide a "space" to legitimize the use of boundary objects (e.g., models).

In addition, boundary organizations may also:

- negotiate the boundaries across scales;
- provide multi-directional information brokerage;
- involve long-term trust building and network construction; and
- facilitate the capitalization on comparative advantages between worlds.

The paper hypothesizes that information and decision systems that have the characteristics of boundary organizations result in more effective management. The case study on the depletion of a High Plains aquifer supports the hypothesis. The case involved many overlapping political and geographical boundaries and many levels of interaction among government agencies at the federal, state and local levels. Acting as a boundary organization, Agricultural Extension offices mediate information from a land-grant institution to farmers, sometimes through management districts.

The case involves both a descriptive and causal analysis, based on: interviews of more than 80 federal, state, county and other scientists, managers, extension agents, and farmers; a survey of 220 county agricultural extension agents; data from the United States Geological Survey (USGS), the Department of Agriculture (USDA), and local and county sources on hydrology and irrigation; and miscellaneous documentary material. The study drew on data from nine counties in Nebraska, Kansas, and Texas, which have other overlapping associations with the boundaries of water districts, extension areas, and other political jurisdictions.

Land Grant and Agricultural Extension

With the passage of the Morrill Act of 1862, the U.S. Congress laid the foundation for a nationwide system of agricultural research and education. The act granted federal public lands to each state be sold. Proceeds from these sales could then be used to create colleges of agriculture and mechanical arts in each state – the land-grant colleges.

Following implementation of the Morrill Act, it became apparent that there was an absence of organized scientific research that could form the backbone of curriculum at the newly established land-grant colleges. Congress then passed legislation in 1887 which established and funded state agricultural experiment stations "to conduct original and other researches, investigations, and experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States… having due regard to the varying conditions and needs of the respective States."

The third pillar upon which agricultural information production and diffusion rests is extension, embodied in the Smith-Lever Act of 1914, which created the Cooperative Extension Service, a collaborative effort between the USDA and the land-grant colleges. The primary functions of the service were to disseminate information and make educational opportunities available to people not enrolled in the colleges.

Since 1914, the research-education-extension system has evolved through numerous federal amendments to these statutes, new federal legislation, and through initiatives at the state and sub-state levels to tailor the system to local circumstances. The most recent reorganization of the USDA has consolidated under the tri-partite system into the Cooperative State Research, Education, and Extension Service (CSREES). The system has become a partnership among federal, state, and local agencies and educational institutions

with shared responsibilities and funding. Given the objectives of research and dissemination of CSREES, and its presence throughout the U.S., it provides an excellent case in which to explore the underlying conceptual foundation of boundary organizations and their functions.

High Plains Aquifer

The primary focus of this paper is on only one of the many issues that CSREES addresses: water management for irrigated agriculture. Irrigated agriculture is particularly well-suited to the High Plains region in the central United States. It is a semi-arid region with extremely variable precipitation, yet abundant and fertile soil with moderately long growing season. Underlying parts of eight states is the High Plains (or Ogallala) Aquifer. In the High Plains region, the total number of cultivated acres irrigated by groundwater has increased almost seven-fold from 1949 to 1990. With relatively low natural recharge rates, declining water levels were noticed as early as the 1940s and 1950s. By the 1970s, farmers and officials at all levels of government were expressing a need to more closely examine the issue of aquifer depletion.

One of the central issues that focused state and local attention during this time was the common pool resource attribute of the aquifer. While pumping water in Nebraska will have no impact on water levels in Texas, at local levels (farms, counties, and immediately across jurisdictional lines), exploitation of the resource at one point decreases water availability at other points. In addition, current research, management and legal concerns are focusing on the relationship between ground and surface water, particularly how depletion of the aquifer affects adjacent surface water levels and vice versa. By the mid-1980's, both the USGS, states and multi-county water management districts within the region had undertaken individual and collaborative ongoing monitoring, analysis, and modeling efforts to assist in the management of the resource, often involving the CSREEES.

Given the national, state, and local concerns and the common pool characteristics of the resource, it has been increasingly identified as a multi-level problem, requiring attention at many scales of organization.

Results

While there is some variance in samples analyzed, in general, the agricultural research, education, and extension system in the High Plains region can be characterized by the attributes of boundary organizations.

- *Negotiating between science and decision-making.* Through legislative intent and mission statements of state land-grant colleges and state CSREES partners, it is clear that an intended role of the system is to serve as negotiator between scientific researchers and users (decision-makers) of scientific and technical information. For the most part, this intention has been realized. County educators, for example, mediate between farmers and scientists at area research stations, and researchers at the land-grant college in a variety of ways. They act as facilitators of dialogue between farmers and scientists to encourage research agendas that reflect the interests and needs of farmers. They act as translators of scientific information produced at land-grant colleges, putting general findings into site-specific practical language and guidance. And they manage demonstration projects and field applications that integrate farmers into researchers' field experiments.

- *Accountability to both sides of the boundary.* Sitting between the farmer, specialist, and land-grant scientist, the county educator is bound by institutionalized mechanisms that clarify responsibilities and accountability to principals on both side of the boundary. The job of the county educator is essentially overseen by an elected committee from the county which helps the educator set program

priorities, design agendas to be communicated to scientists, and establish contacts with the farmer community. The educator is held accountable to the committee through the ability of the committee to make hiring and firing recommendations to the county educator's employer – the land-grant college. Thus, the educator is also held accountable to the land-grant college, and its scientists.

- *Use of boundary objects.* The county extension office is a site at which boundary objects can serve as meeting grounds between actors on either side of the science/decision-maker boundary. Boundary objects play a critical role here, allowing "members of different communities to work together around them, and yet maintain their disparate identities." In the High Plains, county educators (and area extension specialists) facilitate the production and use of a variety of different kinds of models (e.g., cropping models, hydrogeologic models, and economic models.) The models themselves act as boundary objects, dependent on both the participation of farmers to get inputs that reflect reality and outputs that are useful, and scientists who incorporate basic research and understanding of the systems under study, and technical capacity to guide the endeavor. Neither community could produce a model that was relevant and perceived as being scientifically sound without the other's participation. The county educator, in this case, acts as the facilitator across the boundary between these two groups.

Empirical evidence points to at least three additional hypothesized functions of boundary organizations:

- *Negotiating the boundary between levels.* The extension system has been integral in the negotiation of the level at which scientific research about the aquifer is produced. County educators, area specialists, and scientists at the land-grant colleges have articulated the view of the need for integrated (across levels) information production to address the problem of aquifer depletion. They have worked with colleagues in neighboring states and with federal agencies such as USGS in defining the depletion as a regional problem with implications from the local to federal level, and in defining who has what responsibilities for which scientific agendas, at what level.

- *Mediating information flow across levels.* Perhaps one of the primary functions of CSREES has been to facilitate communication among the local, state, and federal levels. This was seen in the discussion of county educators' role in linking farmers to state land-grant scientists in setting research agendas and producing relevant research. It is also seen, however, in the objective of the extension system to link specialists at area experiment stations, research teams at state land-grant colleges, and federal research facilities. If CSREES' objectives are being met, for example, one would expect to see communication between county educators and researchers at multiple levels. While county educators do not talk to *all* players at multiple layers, they do communicate frequently with local farmers, scientists representing area research stations, and scientists at the state land-grant colleges. Not surprisingly, the majority of communication happens within the extension system or with its clients (farmers). Network analysis grounded in interview data complements these survey results. Both the county extension office and area research/extension offices act as loci, connecting individual farmers, ultimately to researchers at land-grant colleges and USDA research facilities. More important, however, is that county and area personnel actively help construct networks that bridge local-federal entities, and this has been evidenced in many places throughout the region in water management. As water management districts have come into being and evolved in the last several decades, the extension system has proven to be vital, as a pre-existing network with established trusted relationships, in helping link the managers and constituencies of local districts to higher level research entities. In so doing, county and area extension offices have provided another critical function as a boundary organization between different levels of organization.

- *Helping capitalize on scale-dependent comparative advantages*. Capturing how the large-scale phenomenon (depletion of an aquifer which underlies eight states) influences the local-scale (e.g.,

individual farmers overpumping and/or noticing dry wells, interstate conflicts over water rights, etc.), and *vice verse*, has traditionally been difficult. One way to address this challenge is to harness scale-dependent comparative advantages. For example, the computing and modeling resources of a federal agency like USGS complements the site-specific knowledge and monitoring ability of a local water management district, neither of which could individually undertake a regionally complete and locally relevant assessment effort of the status of the High Plains aquifer. In many places throughout the High Plains, county extension offices have been instrumental in coordinating and harnessing of scale-dependent comparative advantages. The result of these efforts is the production of scientifically credible models of the aquifer that are relevant to decision-makers on the ground. This use of models can be seen as supporting the notion of boundary object described above. In this case multiple actors with different perspectives and interests can agree on fundamental aspects of the model, and use the model as a meeting ground over which to share information. The model, however, might still be interpreted differently and serve differing functions depending on whose lens is being used.

The case shows that the boundary organization is a concept that can illuminate the relationship of science and policy in the context of multi-scale environmental problems, and can be an institutionalized part of an information/decision support system.

SEA GRANT

Susanne Moser, Union of Concerned Scientists

The Sea Grant concept closely parallels the land grant college concept, but Sea Grant was developed about 100 years after the land grant college program was instituted. Sea Grant began its work in earnest in 1968; originally administered under the National Science Foundation, it became part of NOAA in the 1970s.

The National Sea Grant Office has existed only since 1990 within NOAA; before that, the administration was more diffuse. The focus of research remains at the state level, though funding and some direction come from above. The state program manager of Sea Grant consequently has a significant role in setting the main research agenda. There are currently 29 state Sea Grant programs, each one made up of one or a consortium of local (often state) universities.

Clientele varies according to perspective. In some ways, the universities themselves can be seen as clients of Sea Grant in that they receive funding from the Sea Grant program. In terms of the products or "boundary outputs," however, clientele may include coastal zone managers, planners, teachers, state and local decisionmakers and industry representatives.

Sea Grant has a very broad mandate: to develop the skilled labor, including scientists, engineers and technicians, and the facilities and equipment necessary for exploitation of marine resources. This charge evolved amidst the emerging concern in the late 1960s about development pressure on the coastal zone, and the concurrent recognition that marine resources were something that people hardly knew anything about. Sea Grant seeks to fulfill its mandate through a 3-tiered approach: 1) original research (much of it applied); 2) training, extension work, and technology transfer; and 3) education and outreach. The relative importance of each of these efforts depends largely on the particular issue being considered. The research agenda may be influenced by factors including the maturity of the issue and the individual biases of the state program director.

Self-Image: "Science Serving the 21st Century"

Sea Grant's logo symbolizes its strong reliance on science and the practical and beneficial application of that science. It also emphasizes the organizations forward-thinking mission and inclusive definition of its clientele.

Sea Grant describes itself in several ways:

- *A partnership and bridge between academia and other scientists*: Sea Grant makes a distinction between what happens in the "ivory tower" of academia and what goes on in industry, government and among private citizens. The choice of the words "bridge" and "partnership" underscore the idea of a contract between these disparate elements.

- *A bond that unites NOAA, 29 Sea Grant programs, all the universities and millions of clients*: Sea Grant is more than a forum, providing not just the opportunity but the incentives for these entities to come together in a relatively formal way.

- *An interactive network of research institutions*: Sea Grant is not just a passive provider of information, but it responds as well, conducting research and directing the research agenda.

- *An agent*: Sea Grant is not only a repository for scientific discovery, but also a facilitator of technology transfer, economic growth, and public education. The organization has a very specific policy goal, and often describes itself as a mediator between a variety different interests in order to achieve that goal.

Additionally, Sea Grant addresses:

- *Scale*: Sea Grant exists at the nexus of local, state, national and sometimes international interests. At this nexus, local needs receive national attention and, conversely, national commitment is fulfilled at the local level.

- *Impartiality or neutrality*: Sea Grant considers itself an impartial source of scientific information for public policy and decisionmakers, transferring knowledge to businesses, industries, government, and the public.

- *Policy goals*: their charge is to wisely use coastal and marine resources to promote economic growth and to do human resource development. This raises the question: to what extent can a boundary organization have its own policy goals, rather than being an impartial player between people who try to figure out their policy goals and pursue them?

- *Accountability*: Sea Grant has a responsibility to be credible to the scientific community and to clients, and to be cost-effective in addressing long-term strategic national goals to the government.

- *Boundary objects*: Sea Grant packages and delivers products including research, outreach, and educational information. Examples include:

    - Research funding: Sea Grant both administers research funding and conducts new research itself. Funded research often focuses on local, immediate needs and is very applied.

- Workshops: South Carolina and North Carolina conducted training on sea level rise, focusing on people's concerns and how they thought it could be addressed through the existing regulatory apparatus. Although this effort may not have led to actual regulatory change, it took the form of a "consciousness-raising" exercise for participants.

- Training: Sea Grant in Maine is currently training local residents to perform beach profiles to measure shoreline change. This training has two major benefits: it increases the number of people gathering needed data and increases public confidence in the process through participation.

- Education: Several years ago the Hawaii Sea Grant conducted a number of workshops on climate change and sea level rise for teachers and planners in the Pacific region. Sea Grant became an important information source on these issues for teachers.

- Outreach: New York Sea Grant was asked by the media to do a series on sea level rise and its specific effects on local areas. The resulting animated website provided future projections of sea level rise on the New York area and proved popular with the public.

Barriers to Climate Change Research

Sea Grant staff were asked about the reasons they do not do more on sea level rise and global climate change education. Their responses included:

- *Research directives and funding from above*: Hawaii was compelled to stop educating teachers about global climate change when the national Sea Grant office changed the education agenda. An important implication of this phenomenon is that local relationships at the state level may be compromised by the national control of resources.

- *Lack of a local information need*: Sea Grant's mandate is to respond to local needs; thus, if there is no local interest in climate change and global seal level rise information, but the national office prioritizes it, progress may be impeded.

- *State program leadership and preferences*: Local research may be frustrated if it does not coincide with the interests of the state Sea Grant program director.

- *Limited resources/limited number of regional and local foci*: Because Sea Grant is dependent on appropriations, Congress determines how much money and staff it has to work with. Because climate change research is a global issue rather than an immediate local need, it often tends to be the first area cut from the research agenda.

- *Historical legacies*: Historical "turf wars" between agencies and institutions with particular expertise may surface when the research agenda changes.

- *Pure v. applied science*: Science is not a homogenous entity in opposition to policy. The scientific community is sensitive to the degree to which science is perceived as "pure," and this may affect the ability and willingness of scientists to collaborate.

- *Bridging capabilities*: Within Sea Grant, a variety of talents and capabilities exist. This provides a challenge to Sea Grant to bring appropriate abilities to bear on the achievement of the organization's goals.

Questions

Does Sea Grant function as a boundary organization in this context of climate change and sea level rise?

- Not automatically: Sea Grant was not *designed* as a boundary organization, although finds itself playing that role.

- Sea Grant is constrained by a number of issues, one of which is its accountability to Congress, to the national Sea Grant program office, etc. Accountability may be a limit to how well it can function as a boundary organization.

How can Sea Grant establish itself more prominently as a boundary organization?

- It must receive more continual assured funding from the national level.

- It must create local sea level rise information, not wait until the need arises from somewhere else.

- It must build on its reputation of neutrality, impartiality, and credibility.

INTERNATIONAL RESEARCH INSTITUTE FOR CLIMATE PREDICTION

Dave Guston, Rutgers University

In 1986, two climate modelers predicted an El Niño event for 1987, which in fact materialized. The forecast permitted some meliorative action, for example, in Peru, where agricultural production had seriously declined with lower rainfall caused by the unpredicted 82/83 event, but where there was a modest growth in production with a similarly low, but predicted, level of rainfall in 1987. A major conclusion the researchers drew from this novel experience of prediction was that for predictions to be most useful, they must be regular. The question of institutionalizing a seasonal-to-interannual predictive capacity thus rose to the agenda.

After a number of recommendations from international and domestic US bodies, the US National Oceanic and Atmospheric Administration (NOAA) launched a pilot project to test the concept of an institution dedicated not just to forecasting, but also to training and enhancing the application of forecasts. This pilot IRI had centers at the Scripps Institute for Oceanography at the University of California, San Diego, and at the Lamont-Doherty Earth Observatory at Columbia University. NOAA later issued an RFP for a major grant for an institute, and awarded the grant to Scripps and Columbia over two other major competitors. The nascent IRI was active in the forecasting and response to the 1997 El Niño, and it has been engaged in training and applications activities as well, although the Applications Research Division has really only been organized for the past several months. IRI is currently in the process of consolidating its bi-coastal enterprise into a new building on the Lamont campus in Palisades, New York.

The mission of IRI is still being negotiated, yet alone the finer level of procedures that seem so important to boundary organizations. The most concise statement of IRI's mission is to "make and apply climate forecasts," but the relative emphasis on "make" and "apply"—and what each of those terms means—has changed over time. From discussion with some IRI staff and review of some of the documents of IRI's history, it seems as if the concept of application has become more clearly and centrally articulated over time. But there is still tension. In the words of briefing notes for an October 1999 Applications Planning Meeting, "Should the core of IRI be its production [sic] capability, upon which applications are then based, or should it be the application of prediction information, which may require a prediction capability?" Another way to conceive of the question is how should IRI array its efforts along what it calls its "end-to-end" mission from technically skillful prediction to socially beneficial applications. This is a dilemma one would expect to find in planning at a boundary organization, suspended between science and politics.

IRI as a Boundary Organization

J. Michael Hall, the director of NOAA's Office of Global Programs and the governmental patron of IRI, describes IRI as an organization at "two boundaries." One of those boundaries is in the midst of the "end-to-end" mission, between research and applications. The other is the boundary between the developed and the developing world.

In other words, IRI participates in both the new and the old denotations of technology transfer. The new is the movement of research-based knowledge into socially useful products; and the old is the movement of research-based knowledge and its products from a locale of development to a culturally different locale for use, respectively.

As an organization involved in the new version of tech transfer, IRI has two sets of principals:

- the relevant portions of the scientific community, who will judge the technical virtuosity of IRI forecasts and decide, among other things, whether future IRI proposals will be funded or whether IRI will find willing research partners in forecasting circles; and
- user communities who will determine whether IRI has produced forecasts that are relevant and reliable for application to a variety of public and private decision making.

As an organization involved in the old version of tech transfer, IRI's strategic position is complicated somewhat. For example, it needs to negotiate the international but unevenly distributed nature of the relevant scientific communities. The current structure risks being identified as a US-dominated institution because it has, till now, foregone development of originally conceived Applications Centers as peripheral nodes in a network around a Core Facility in favor of early development of that Core Facility. User communities may have highly specific and diverse local needs: political, social, and economic systems will differ among the international user community, as will the areas of important application—for example, agriculture, fisheries, water management—and the specific resources—the types of crops, fish, or management techniques—within those areas.

Conceiving of Products

This incredible diversity of client groups makes the conception of products—the boundary objects or standardized packages—particularly critical. The concept of standardized packages is more appropriate in this case, because it is through them that behavior in the two distinct social worlds is modified, and IRI's goal of making predictions useful appears to demands at least some change among both the producers and consumers of forecasts.

A few quick examples of how this change is beginning to happen:

- *Scale of resolution*. One is the relatively obvious desire on the part of consumers to have forecasts with a fine enough spatial and temporal resolution to be useful. As one IRI staff member told me, “Every farmer will ask, 'what will happen in my backyard?'“ Now, as that same staff member told me, “You don't need an institution to tell you about better spatial resolution.” True, but you may need an institution to consistently articulate that criterion to the modelers and hold them accountable to its production, and you may need the institution to elicit the specifications of that criterion from users. In constructing models with finer resolution, IRI can demonstrate success to both its principals—the scientific community, who can observe greater technical virtuosity, and the users, who can observe greater applicability. Moreover, creating an institution to do that may get you additional benefits from transactions between modelers and users, including innovations in modeling for relevance, joint demands for better data inputs to modeling, and more sophisticated users.

- *Terciles*. A second example is a standardized method for communicating the probabilistic forecast. IRI estimates the chances that precipitation or temperature in a forecasted time period will fall into “tercile classes”—that is, the wettest or hottest third of years, the normal third of years, or the driest or coolest third. IRI produces such outlooks for precipitation and temperature every quarter-year but, as it notes, “This Outlook is relevant only to seasonal time scales and relatively large areas; local variations should be expected.” This information, presented as simply as it is, still requires a consumer with the capacity to use probabilistic information in decision making. Indeed, in my conversations with IRI staff, it seemed—and I say this very tentatively—that local capacity to accept outputs from a model—which often meant having a local model to plug IRI's forecasts into—was critical to the relationship. The literature on IRI's brief institutional history describes how “[p]otential pilot applications are advancing where predictive skill is high, information needs are clear, and a supporting local infrastructure exists.”

- *Models*. More specifically, one fascinating application of the precipitation forecasts is the decision by local hydropower managers in Brazil (where a huge fraction of the nation's energy is supplied from hydroelectric sources) about how high to keep the water behind the dam. If the water is kept too high, and it rains more than expected, the reservoir floods—destroying local property and wasting the valuable resource of retained water. If the water is kept too low, and it does not rain enough, the managers may need to buy water on the expensive spot market to supply their customers. There is thus a potentially costly optimization problem that, if they can be coupled with the local reservoir models, IRI predictions can assist. This technical coupling between the local reservoir model and the IRI climate model needs negotiating—for reasons of both technical fit and confidence-building. But the existence of the reservoir model and the technical capacity it represents suggests a local opportunity without which IRI's technical virtuosity would be wasted.

- *Training and Capacity-building*. Recognition of this fact is no doubt part of why local training and capacity-building is an important part of IRI's agenda, even and especially from the period of the pilot program. This capacity-building does not, of course, build local reservoir models for hydropower managers, but it does help create a cadre of locals who may share—subsequent to training—information about forecasts, skills in creating and manipulating climate models, and perspectives on the role of transferred knowledge in local decision making with IRI (as well as with other trainees distributed elsewhere in the expanding network).

Challenges of End-to-End

- *Mechanisms of Collaboration*. In the production of these more refined, standardized probabilistic forecasts and local training and capacity-building, the operations of IRI parallel the operations of the new, that is, domestic, technology transfer organizations that I have studied previously. In the case of domestic tech transfer, however, the scientists, professionals, and decision makers involved had the benefit of pursuing economic impact as a principal goal. They also had the ready-made mechanisms of patents and licenses to both facilitate collaboration and create incentives around the joint pursuit of the productivity of research. IRI lacks the benefit of these ready-made mechanisms and must innovate on a project-by-project basis.

  In the domestic case, offices of technology transfer had to innovate around the new contractual form called a cooperative research and development agreement (CRADA). At the Office of Technology Transfer (OTT) at the National Institutes of Health, tech transfer specialists initially created a working group to negotiate each CRADA on a project-by-project basis. But over time, OTT created a model CRADA upon which different projects could be based. IRI might contemplate how to standardize additional kinds of relationships in this way. Of course, the knowledge about what goes into the creation of a flexible template will come only with experience that IRI is still living.

- *Internal Reward System*. A second point I'll make about the similarity between domestic tech transfer and IRI is the difficulty that tech transfer professionals had in integrating into the extant reward system in their organizations. Even repeated follow-up by Congress did not ensure either that the professionals managing tech transfer had appropriate job ladders, or that scientists engaged in tech transfer were recognized for that contribution at promotion time. Similarly, at IRI, it is not clear whether the academic employment structure that exists at Lamont is appropriate to the end-to-end mission, and perhaps some of the Extension people here have or could speak with IRI about how the academic system handles Extension agents.

- *Cultural Change*. In the domestic case, OTT toes a narrow line of creating some cultural change without alienation. In its case, it needs to change the perceptions and habits of researchers who were not familiar or comfortable with intellectual property and economic incentives. For IRI, the task of creating a certain amount of cultural change is somewhat more loaded. IRI needs to encourage change not just among researchers, who now have the requirements of applications to think about, but also among local researchers and users who import IRI products.

  People at IRI I spoke with were sensitive to the challenge of avoiding "social engineering," "not making these critical social judgments that people don't want outsiders making," and about being self-conscious on issues of equity, inclusion, and unintended consequences. Indeed, one of the roles of the social scientists at IRI is to function in a reflexive mode and scrutinize the attempt to change researchers and users, while at the same time planning for and facilitating that change. Nevertheless, the training and capacity-building is still "teaching people to think" in a certain way. Focusing on forecasting and other seemingly neutral technical aspects is a way of spinning the intervention as an opportunity, not an imposition. Access to technical training is a specific incentive for the direct participants, and applications are a society-wide promise in exchange for collaboration. All these elements exist in the domestic case as well.

> The organizational theorists Paul DiMaggio and Walter Powell describe three types of organization change that drive organizations in the same field to become more similar to, or isomorphic with, one another. First is coercive isomorphism, which results from political influence and cultural expectations. Second is mimetic isomorphism, which results when uncertainty encourages imitation of supposedly successful organizations. Third is normative isomorphism, which results from the professionalization of members of organizations.
>
> What boundary organizations seek is minimizing organizational isomorphism, or perhaps minimizing the appearance of organizational isomorphism. Boundary organizations do what they do between other organizations so that those other organizations can go about their business more or less as they had been doing. But change among the producers and consumers is, to some extent, necessary. IRI seems to want to limit its influence over this change to normative isomorphism, as OTT did as well, and I think for good reason.

In conclusion, let me say that I have really only scratched the surface of IRI as a boundary organization, just as IRI has only scratched the surface of applying climate forecasts for social betterment.

SUBSIDIARY BODY FOR SCIENTIFIC AND TECHNOLOGICAL ADVICE

Clark Miller, Iowa State University

The institutions linking science and policy in modern societies form an extraordinarily rich and diverse landscape of competing, overlapping, and interacting social networks and processes. Those peculiar to the emerging international regulatory regime addressing climate change are no exception. Many people are familiar, for example, with the Intergovernmental Panel on Climate Change (IPCC). Fused within the IPCC's institutional structure reside a complex array of scientific and political elements. Beyond the IPCC, science and politics intertwine in numerous other institutional settings throughout the climate regime, including the Conference of Parties of the UN Framework Convention on Climate Change, national and intergovernmental research programs, government laboratories, and international organizations such as the World Meteorological Organization.

Within this complex and dynamic institutional landscape, an underexamined organization that I believe sheds important light on theories of science-policy interaction is the Subsidiary Body for Scientific and Technological Advice (SBSTA). SBSTA occupies a unique position within the climate regime. Created in 1992 by the UN Framework Convention on Climate Change, SBSTA has emerged, as I note elsewhere, as "the principal forum in which regime participants have articulated and negotiated among competing models of institutional design for providing expert advice about climate change." In this paper, I argue that SBSTA constitutes an ideal case study for investigating and theorizing science policy, particularly in the dynamic and fluid contexts of emerging regimes of global environmental governance. The model I propose to explain SBSTA's activities is one of *hybrid management*. The model of hybrid management offers, I argue, an approach that helps bring the theory of *boundary organizations* into line with the empirical phenomena observed in global environmental science and policy than does that of boundary organizations.

Hybrids and Hybrid Forms of Life

Debates about science and its proper role in public policymaking are essentially phenomena of the mid- to late-20th century. After World War II, scientists received significant visibility for their role in creating the

atomic bomb, radar, and other technologies. Consequently, science, as a distinct domain of activity, began to occupy a prominent place in American political discourse and institutions. This trend accelerated in the 1970s with the constitution an array of scientific advisory committees as formal components of the regulatory processes created by environment, health, and safety legislation. Indeed, science has taken on greater importance in American politics than just a reservoir of skills, knowledge, and communities of people. Science has acquired a privileged ideological and institutional status in the formation of public policy that goes beyond mere know-how, incorporating normative connotations of objectivity, honesty, neutrality, and truth-telling. Science has become "incorporated into liberal-democratic ideological strategies for presenting, justifying, and criticizing the exercise of political power."

The growing power of science has made procedural and discursive strategies for differentiating science from non-science (facts from values, rational from irrational, etc.) into key sites in broader cultural debates over the proper norms and practices of liberal democracy (Jasanoff 1990). Even as liberal democratic policymaking has sought to construct clean divisions separating science and politics, however, students of science policy have for almost as long recognized the inevitable problems inherent in such an endeavor (see, e.g., early work by Don Price, Thomas Kuhn, and Alvin Weinberg along with later work by Bruno Latour, Sheila Jasanoff, and Thomas Gieryn). This work has emphasized the *hybrid* character of contemporary life. The French philosopher Bruno Latour has perhaps gone furthest in explicitly theorizing modernity as the "proliferation of hybrids," by which he means the mixing up of facts and values, knowledge and identity, nature and culture, science and politics in our conceptual frameworks, material technologies, and social networks and institutions.

Viewing modern societies as filled with hybrids provides a new set of questions for students of science policy. First, what do hybrid forms of life look like? Research in science studies has focused over the past thirty years on in-depth analyses of scientific communities, laboratories, and disciplines. Likewise, political science as a discipline has developed intricate models of legislative, executive, and judicial institutions as well as other forms of political life. Only a relative handful of studies has sought to provide detailed descriptions of the norms, practices, discourses, and ideas characteristic of hybrid forms of life. Second, can models of hybrid activities be generalized beyond individual cases? Third, what kinds of normative standards can and should be used to evaluate and assess the construction and operation of hybrid forms of life, particularly in the cross-cultural context of global policymaking? In the following section, I address specifically the first and second of these questions, drawing out of the literature on science and technology studies and the specific activities of SBSTA a model of *hybrid management* in global politics.

Hybrid Management in SBSTA

The legal mandate for the Subsidiary Body for Scientific and Technological Advice (SBSTA) is established in Article 9 of the 1992 UN Framework Convention on Climate Change (UNFCCC). Article 9 asserts two basic principles concerning SBSTA. First, its basic mission is to "provide the Conference of the Parties [of the UNFCCC] and, as appropriate, its other subsidiary bodies with timely information and advice on scientific and technological matters relating to the Convention." Second, its members "shall comprise government representatives competent in the relevant field of expertise." Subsequent to its formal commencement in 1995, however, SBSTA has taken a somewhat different path than these two principles might at first suggest.

For the most part, SBSTA delegates have not sought to provide expert advice. Rather, they have viewed the organization more along the lines of a legislative subcommittee with authority over issues relating to science and technology. They have solicited and received expert advice from other groups and institutions on a variety of topics. They have rendered collective judgments regarding the informative value of this

advice to the regime and formally passed these judgments along to the Conference of the Parties. And they have, on a small number of occasions, legally constituted new expert advisory arrangements to supplement or replace other sources of expert knowledge.

In carrying out these activities, SBSTA has been the site of widespread debate and disagreement over the organization and role of expert advisory arrangements in the formulation of global climate policy. At times, these controversies have reflected competing interpretations of scientific evidence and theories. At other times, they have reflected deep-seated conflicts among competing models of global governance. Frequently, these scientific and political conflicts have been indistinguishable as SBSTA participants have grappled with the hybrid character of the issues at stake in their deliberations. From an analysis of the content of these debates, however, it is possible to begin to derive an analytical framework to describe the efforts of SBSTA participants to manage the hybrids within its domain of authority.

A key hybrid management function performed by SBSTA is that of hybridization. Using science in policy formulation and implementation often involves creating hybrid, policy-relevant standards and measures that incorporate both facts and values. For example, standardizing methods for counting greenhouse gas emissions for the purposes of implementing the climate regime involves establishing what it is necessary to measure and also how best to measure it. Each of these choices embeds both normative and technical judgments, and the successful integration of these judgments so that they meet the epistemological and normative criteria of multiple expert, policy, and public audiences frequently involves a great deal of work. SBSTA has facilitated communication among experts and political officials, engaged in formal and informal efforts to clarify both technical requirements and value choices, and helped negotiate compromise settlements among regime participants. Since its creation in 1995, SBSTA has operated as the forum in which the bulk of this negotiation and activity has taken place.

A second key hybrid management function performed by SBSTA is that of deconstruction. Scientific facts, evidence, and theories frequently undergo deconstruction in public controversies over science and technology (Nelkin 1992). The deconstruction of science that takes place in the American media, legislative and administrative hearings, and courts is often rightly viewed as a major hurdle to the effective use of science to shape policies. Deconstruction can and does play a useful role in the policy process, however, when it acts to reveal previously tacit assumptions and values laden in scientific knowledge claims. By rendering such assumptions and values visible to participants in policy debates, critical examinations of scientific claims helps increase the transparency of the policy process and may help prevent subsequent controversies and enhance policy effectiveness.

The ability of participants in the climate regime to deconstruct scientific knowledge claims rests to a great degree, obviously, on their ability to mobilize competing interpretations of scientific evidence and theories. The structure of decisionmaking within SBSTA significantly strengthens the ability of participants to deconstruct science within the climate regime, most notably through its consensus voting rules. Although few if any issues ever come to a formal vote, the tacit ability of any country to halt progress on a given issue helps to guarantee that even small voices of skepticism have an opportunity to express their views.

Another hybrid management function performed by SBSTA concerns boundary demarcation and maintenance. Policy-relevant knowledge is a hybrid entity whose construction involves work by a wide array of expert and political institutions. One of the significant questions raised in the process of constructing policy-relevant knowledge is which institutions will carry out what work. This involves the demarcation of the relevant domains of authority of expert and political institutions. Put differently, the boundaries of what constitutes scientific work, what constitutes political work, and what kinds of work must be dealt with by hybrid decisionmaking bodies. In terms specific to the climate regime, the precise boundaries of authority over the various kinds of decisions rendered in constructing emissions inventories

must be delineated (by formal rule-making, informal judgment, collective discourse, or tacit convention) among expert communities, the IPCC, SBSTA, national governments, and the Conference of the Parties. This process is inevitably dynamic in that boundaries are constantly being delineated, criticized, defended, and adjusted over time as participants respond to events.

The process of boundary demarcation and maintenance frequently involves discursive efforts to differentiate science from politics. Nevertheless, the actual process of distributing decisionmaking and knowledge-making authority among institutions like expert communities, the IPCC, SBSTA, national governments, and the Conference of Parties involves differentiating among distinct, hybrid forms of life—each combining its own set of norms, practices, ideas, and discourses. When analyzing science policy, this observation is critical for several reasons. One reason is that the practice of treating these institutions as forms of life can help avoid the trap of imagining that activities taking place in those domains labeled as "scientific" are somehow free of normative concerns while activities taking place in domains labeled as "political" are somehow not involved in the production of knowledge. A second, equally important reason is that the norms, practices, ideas, and discourses of distinct forms of life may differ considerably from one another, even if they fall largely under the umbrella of science (or politics).

Perhaps the most important reason to adopt a hybrid perspective regarding these institutions, however, is that although these domains constitute distinct forms of life, there must still be a considerable degree of cross-domain coordination. Precisely because the work of each involves normative considerations as well as ideas that may be of interest to the others, the activities of each are not independent. Delegates to the Conference of Parties frequently express concerns over the rules and procedures by which organizations such as the IPCC operate. Likewise, scientists frequently express concerns about how scientific knowledge is interpreted and used by institutions like the Conference of Parties. SBSTA has played a critical role in helping to coordinate across the various domains of decisionmaking and knowledge-making authority within the climate regime to resolve such issues. This has taken a variety of forms, including the development of rules for new expert advisory arrangements created under its authority, the negotiation of joint programs of work with the IPCC, and the provision of a forum to which the IPCC can offer its advice for formal, collective evaluation and certification by the regime in addition to its interpretation and use by individual governments.

The issue of boundaries and distinct domains of decisionmaking and knowledge-making authority also involves a process that Latour has labeled purification, although it is important to recognize that this process only nominally involves either purifying facts of values or vice-versa. Within the framework developed in this paper, purification refers to the process of assigning hybrids and hybrid choices to distinct domains of authority. One activity that SBSTA has engaged in, on occasion, has been to explicitly designate certain choices or activities as scientific or political and so to turn them over to particular institutions for resolution.

The final hybrid management function I want to discuss today is the warranting of credibility. One of the principle challenges of knowledge-making, particularly in global contexts, is the multiplicity of audiences to which knowledge must ultimately seem credible—and the multiplicity of expectations and procedures for assessing truthfulness that may therefore be in play. SBSTA participants have sought to find ways to enhance the credibility of emissions inventories across multiple audiences. One approach has been to leave specific methodological choices up to individual countries, which presumably know best the requirements for establishing credible statistical information within their own domestic political cultures. Another approach has been to establish an informal working group in which government delegates can negotiate behind closed doors amongst each other, and with representatives of expert groups, about a wide variety of issues concerning measurement standards. A third approach has been to establish the formal authority of SBSTA to make rules regarding measurement standards through consensus voting. In this manner, the normative weight of collective agreement helps buttress the credibility of value-laden

choices. Still another has been to regularly seek the advice of IPCC expert working groups regarding the construction of default measurement standards, against which countries are asked to explicitly compare their own methods to enhance the transparency of their choices.

Conclusion

In this paper, I have presented a model of *hybrid management* to describe the activities of institutions involved in science policy. This model is superior to competing models, such as that of *boundary organizations*, for several reasons. First, the basic narrative underlying the model of boundary organizations suggests that two relatively homogeneous, autonomous domains, science and politics, exist unproblematically and are reasonably well-characterized. Instead, we have observed in the case of the climate regime that institutions differ dramatically from one another in their forms of life, even when they are conventionally located within the same domain. Understanding the dynamics of science policy thus demands attention to the specific norms and practices of scientific and political institutions involved in any given context as well as those of hybrid institutions that occupy spaces in the institutional landscapes of societies which are neither explicitly scientific or political.

Moreover, theories of boundary organizations tend to emphasize the weakness and vulnerability of these institutions by pointing to their dependence on securing credibility and authority vis-à-vis science and politics. By serving as a lever for managing hybrids, however, institutions like SBSTA can actually wield a great deal of power and authority over both the domains of science and politics, shaping how knowledge is produced and decisions are made. Perhaps most importantly, however, a theory of hybrid management focuses empirical attention on the functions performed by boundary organizations and how they are divided up among different institutions. In efforts to evaluate and improve knowledge-making and decisionmaking in global environmental policy on either technical or normative criteria, an accurate assessment of the functions performed by various institutions constitutes an essential baseline from which to work.

COMMENTARY

Charles Powers, Rutgers University and EOHSI

A driving factor in these boundary organizations is that, in politically controversial issues, they are the places within which people try to keep facts relevant. HEI was described this way initially: as a place that people would go about the process, with the best minds in the country, defining what needed to be known. That this institution lives on now nearly 19 years later, still going about that same fundamental work, is a statement about the importance of that tradition. The other organizations that we have covered at this workshop suggest that, in fact, they too are working with the same fundamental concepts:

- *Characteristics of the Person or Thing Trusted*: "Trust" assumes both confidence and truthfulness in those you trust. Boundary organizations have this nature, requiring them to be empathetic to a diverse set of constituents. The boundary organizations we have talked about assume that users are seeking the truth, and that the organizations understand the needs of and the impacts on those who are going to trust them.

- *Empathy*: Those with whom they must empathize are diverse. It is different to be empathetic to a group of farmers who desperately need your system and to a regulatory agency trying to establish the risk associated with new devices. The whole organization must remain empathetic to whoever the constituents are.

- *Autonomy and trust*: the fundamental issue for us as a democracy is trying to figure out how an individual can give informed consent. Even if one makes an autonomous free choice, one must have accurate information. Therefore, one needs to know someone competent to tell the truth about those issues on which one will make an informed choice. That means that no matter what one says about autonomy, one *must* trust that this relationship is there in the institutions.

I am fundamentally not of the school that maintains the social construction of facts. In my view, social construction is not good enough for the farmer, or for the worker who is going to be fired by the fishing company that is anticipating seasonal climate variation. Nevertheless, the truth can mean many things:

- the "whole truth and nothing but the truth," and that is what many of these institutions think they are doing (but are not); or
- the "truth insofar as I believe that my hearer can understand it"; or
- "I tell the truth, but I don't believe that my hearer can understand it"; or
- "I tell the truth, but expect the hearer to misinterpret what I said and believe it is the opposite of what I know to be true"; or
- "I say something ambiguous and expect that the hearer will not select the meaning I know to be true"; or
- "I say something that is not true in negotiation, and I am confident that the hearer will know that it is not true"; or
- "I lie, but think it is of no consequence."

A primary job of boundary organizations is to be empathetic and to tell the truth to their constituents. As in the case of HEI, we are right to worry about "to what?" and "to whom?" they are boundary organizations. We must fully understand that it is not just the automotive industry and the EPA, it is also environmental groups, and communities, and the UAW, that need to be involved. HEI took a long time to learn how that was.

Other examples of boundary organizations that build trust and tell the truth to their constituents are:

- Clean Sites Inc.;
- Institute for Evaluating Health Risks;
- Industriplex Custodial Trust;
- Institute for Responsible Management (brownfields);
- Consortium for Risk Evaluation and Stakeholder Participation (CRESP)
- NY Harbor Coalition (New York Academy of Sciences)

Each of these institutions is a boundary organization to the extent that its first priority is <u>not</u> "survival," which is fundamentally different from any other kind of organization. To be a boundary organization, competent truth-seeking must be a higher principle than its own survival.

TOWARD A RESEARCH AGENDA ON BOUNDARY "STUFF"

Bill Clark, Harvard University

We have talked about it so much, we might sometimes forget to ask: What is the problem we are trying to solve? Why are we spending this time worrying about boundary organizations? I imagine myself trying

to recruit other people by telling that what is it we are talking about, and what is it we are not talking about. Whatever the problem is, it is not just the problem of communicating technical information to publics and users. It is not the body of material in risk communication. That material is not irrelevant, but neither is it the centerpiece.

It also is not the whole set of principal-agent problems—that organizations do not do what they set out to do. This problem is a real for boundary organizations and processes, but it does not do us a lot of good to take all the principal agent-like problems in all the organizations that happen to touch on the intersection of technical knowledge and practice and throw that into this hopper as well. So I would get rid of all that stuff—and only import back the parts that are special to what kinds of defections are you likely to see in boundary organizations of that sort.

Our problem is rather the creation and use of scientific knowledge in *political* contexts. There is a very different set of things going on if a scientist is creating information in secret to give to his or her boss. I would be careful to say that the "publicness" of this matters a great deal!

In this conference, did we see one class of problems about the use of technical knowledge and political contexts, or at least three classes? We heard about:

1. *Shared knowledge*: Here is an action problem. *I* might be happy to get technical knowledge into the arena to be what we solve the problem on, as long as it is my technical knowledge. The problem is, *you* are going to want to do the same thing. Can we do something to build up some set of knowledge that, for whatever reasons, in whatever ways, we will agree to share and both defer to?

2. *Useful extension*: If the user gets the wrong information, the user loses a great deal of money; in some countries and situations, if the user gets the wrong information, the user may even starve to death. This situation is not a good one, but it is not the same thing as, "I think you're putting this information into the pot because you want one solution, and you're putting it into the pot because you want another, and I'm fighting for it." Rather, "I'm hoping that you're providing information that is relevant to me, I'm probably a little suspicious that you may not be empathetic with me, and you might even wish me ill." But it is not that you and I are different farmers and we are simply worried about whose information gets on the table. Rather, the question is, "do I trust you, or are you some new guy that just parachuted in today?" I think it would be useful for us to be clear from both the producer and the user sides how they are posing similar or different problems.

3. *Deciding what science society is going to support*: Science has an interest in saying that society should support whatever scientists want to do, while society often has an interest in supporting what will reasonably be expected to answer questions.

Barriers

The barriers to productive boundary work in these organizations turn out to be similar from the user side, but we do not have much information from the side of the producers. There are three sorts of problems, as the user decides whether or not to use the information provided:

1. Is this science really in the users' interests, or do the producers not care, or are they trying to get the user to do something or conform to existing power structures?

2. Is this science serving one user's interests over another's?

3. Is this science trying to dictate users' decision? One empirical fact we all agreed on: good boundary organizations do not do policy or reach conclusions about what the user should do with the scientific data. The autonomy of the boundary organization as an agent should not look like an attempt to absolve responsibility and say, "the techies made me do it."

Efforts to Address these Barriers

The distinction between boundary work (a process) and boundary organization (a structure) is important because it is important to remember the process and not focus solely on the structure. Every person here has emphasized the process components of how that organization did its work as being central to its successes and failures. I think the notion of focusing on organization as a term makes it difficult for people like me to keep remembering that this is not an argument about structure argument—it is an argument about structure and process. In some cases, as in Agricultural Extension, it may be almost entirely an argument about process.

What are the distinguishing characteristics of the boundary organizations and processes that work vs. the ones that do not?

1. The ones that work tell the truth, build trust, and do it empathetically. Imagine the HEI problem without HEI, or the Agricultural Extension problem without Agricultural Extension.

2. The ones that work do not make policy recommendations, but the user must be able to make use of the information they provide. They must be in a position where they can make autonomous decisions. But the ones that work do collaborate with, foster, train and build capacity in users that can integrate their information into their decisions.

3. The ones that work change the research agenda—but do they change the decisions of users, or the knowledge produced by the knowledge producers?

4. What of credibility, relevance, legitimacy? These terms need to be better defined. It is very important to obtain more analytic clarity. What makes the process one that people "feel good about" and are willing to keep working with?

5. The ones that work have accountability mechanisms to both the science community and the user community, as well as review mechanisms to stand outside of the structure and look at whether one of the principals has "stolen the agenda." Building such authoritative review mechanisms for handling the principal-agent and defection problems is one of the difficult design issues.

The "Bottom Line"

I am skeptical, but very enthusiastic to expand beyond the couple of international cases we originally looked at to other cases and literature. There is a great deal of work yet to be done.

APPENDIX A: ABOUT THE PARTICIPANTS

David Cash is a doctoral candidate in public policy at the John F. Kennedy School of Government at Harvard University, and a research fellow on the Global Environmental Assessment Project at the Belfer Center for Science and International Affairs. His research investigates the role of science in the development and implementation of environmental policy, focusing on 1) how scientific assessment of global environmental risks are linked to local decisionmaking and local environmental risk management - with specific interest in how information and decision making systems can best support the management of cross-scale environmental risks; and 2) how participation is structured in environmental assessment processes and what influence participation has on the outcome of assessments. Cash has also worked extensively with the U.S. Global Change Research Program/Office of Science and Technology Policy's U.S. National Assessment of Climate Change.

William C. Clark is the Harvey Brooks Professor of International Science, Public Policy and Human Development at Harvard University's John F. Kennedy School of Government. He is Vice Chairman of the University Committee on Environment and served as Director of the School's Center for Science and International Affairs (1993-4). Clark, trained as an ecologist, is focusing his current research on the sources of long term social learning to cope with the policy issues arising through the interactions of environment, development and security concerns in international affairs. In particular, he has studies underway on the development of better assessment frameworks for use in the management of global environmental change and on the problems of monitoring and evaluating progress towards sustainable development. Clark's previous research has included policy analysis for resource and environmental management, work on understanding societal risk-taking behavior, evaluation of human development strategies being pursued in the Third World, and basic research and modeling studies on the stability and resilience of ecological systems. He is co-author of *Redesigning Rural Development: A Strategic Perspective* (Hopkins, 1982) and *Adaptive Environmental Assessment and Management* (Wiley, 1978), editor of the *Carbon Dioxide Review* (Oxford, 1982), and coeditor of *The Earth Transformed by Human Action* (Cambridge, 1990), *Sustainable Development of the Biosphere* (Cambridge, 1986), and *Learning to Manage Global Environmental Risks* (MIT, forthcoming 1999). Clark was awarded the MacArthur Prize in 1983.

David H. Guston (Workshop Coordinator) is Assistant Professor of Public Policy in the Bloustein School of Planning and Public Policy at Rutgers University. He is also a member of the Environmental and Occupational Health Sciences Institute and of the faculty of the Global Environmental Assessments project of Harvard's Kennedy School of Government. He is the author of *Between Politics and Science: Assuring the Integrity and Productivity of Research* (Cambridge University Press, 2000), co-author of *Informed Legislatures: Coping with Science in a Democracy* (with M. Jones and L.M. Branscomb, University Press of America, 1996), and co-editor of *The Fragile Contract: University Science and the Federal Government* (with K. Keniston, MIT Press, 1994). Professor Guston is currently working on an NSF-sponsored project on the construction of socio-technical syntheses that has led him to explore such institutions as the National Toxicology Program and such policies as New Jersey's Freshwater Wetlands Protection Act. He received his B.A. from Yale and his Ph.D. in political science from MIT, and prior to coming to Rutgers he worked at the (now-defunct) Office of Technology Assessment and at the National Academy of Sciences.

Terry Keating is currently an AAAS Environmental Science and Engineering Fellow in the Office of Policy Analysis & Review within the Office of Air & Radiation at the U.S. Environmental Protection Agency. He received his Ph.D. in Environmental Sciences and Engineering from the University of North Carolina at Chapel Hill with a minor in Public Policy Analysis. His dissertation research, under the direction of Dr. Deborah Amaral, involved using decision analysis techniques to characterize and

compare the analytical perspectives of stakeholders involved in the assessment of alternative motor vehicle fuels to control tropospheric ozone in Los Angeles. Prior to moving to Washington DC, Keating was a post-doctoral fellow with the Global Environmental Assessment Project based at Harvard University, where his research focused on the role of predictive modeling and impact analyses in the development of tropospheric ozone and acid rain policies in North America and Europe.

Clark A. Miller is Assistant Professor in the Department of Political Science at Iowa State University and a research scientist at the International Institute for Theoretical and Applied Physics, a joint initiative of Iowa State and UNESCO to promote collaborations between scientists in the U.S. and developing countries. His research examines the links between scientific knowledge, democratic governance, and sustainable development on global scales. He is in the process of completing work on two edited volumes from MIT Press: *Changing the Atmosphere: Expert Knowledge and Global Environmental Governance* and *Building Sustainable Societies: Planetary Management and National Political Cultures* (both with Paul Edwards, University of Michigan). The first explores how the emergence of climate change as a major site of contestation over the future of global governing arrangements has shaped and been shaped by the evolution of climate science. The second examines how purportedly global risks are taken up into and help transform the cognitive and institutional landscapes of national political cultures. He has received two NSF grants to support research on global environmental science and politics.

Susanne Moser studied Physical Geography and the Earth Sciences at the University of Trier, Germany before coming to Clark University in Worcester, MA where she continued her work in human geography, focusing on hazards and global change studies. She received her Ph.D. in Geography from Clark in 1997. Her dissertation examined both the level of understanding and integration of human dimensions in scientific assessments and the incorporation of uncertainties into state-level policy responses in Maine, North Carolina and South Carolina. The dissertation is currently under review for publication at Earthscan Press. From 1997-1999, she was a post-doctoral fellow in the Global Environmental Assessment Project at Harvard's Kennedy School of Government. Her work, developed in tandem with David Cash, focuses on coastal zone management in Maine and Hawai'i and is summarized in the GEA Working Paper entitled "Talk Globally, Walk Locally: The Cross-Scale Influence of Global Change Information on Coastal Zone Management in Maine and Hawai'i." She has also worked on the "Evaluation of Erosion Hazard" project of the Heinz Center in Washington, DC. As of September 1999, Moser works as Staff Scientist in the Global Resources Program of the Union of Concerned Scientists in Cambridge, MA, where she coordinates the UCS's research and advocacy work on global climate change.

Charles W. Powers, Professor in the Department of Environmental and Community Medicine at UMDNJ-RWJMS and a member of the Environmental Policy Division of EOHSI. He conceived and serves as the Executive Director of the Consortium for Risk Evaluation with Stakeholder Participation (CRESP). Dr. Powers is also President of the Institute for Responsible Management, which has led efforts to facilitate restoration of the nation's brownfields. An ethicist by training, he is recognized for diverse contributions to the evolution of environmental policy and to understanding and creating the institutional contexts in which that policy is implemented, including the creation of the Health Effects Institute.

OTHER PARTICIPANTS IN THE PROGRAM:

Clinton J. Andrews, Assistant Professor of Urban Planning in the Bloustein School of Planning and Public Policy at Rutgers University.

Roni Avissar, Chairman of the Department of Environmental Sciences and Director of the Center for Environmental Prediction at Rutgers University.

Kenny Broad, Research Scientist in the Applications Research Division of the International Research Institute for Climate Prediction, Lamont-Doherty Earth Observatory, at Columbia University.

Jim Goeke, Research Hydrogeologist with the UNL-IANR Conservation and Survey Division stationed at the University of Nebraska Research and Extension Center at North Platte.

Bernard D. Goldstein, M.D., Director of the Environmental and Occupational Health Sciences Institute, a joint program of Rutgers University and UMDNJ-RWJMS.

Bonnie J. McCay, Professor of Anthropology and Ecology, Department of Human Ecology, Rutgers University.

Jack Rabin, Assistant Director of the New Jersey Agricultural Experiment Station at Rutgers University.

Jay Tanski, Coastal Processes Specialist with New York Sea Grant at Cornell University.

Virginia M. Walsh, Assistant Professor of Political Science at Rutgers University and Executive Director of the International Project Office of the Institutional Dimensions of Global Environmental Change Project (IDGEC) at Dartmouth College.

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APPENDIX B: ABOUT THE SPONSORS

Environmental and Occupational Health Sciences Institute (EOHSI) at Rutgers University and UMDNJ-RWJMS

Established in 1986, EOHSI is a jointly-sponsored program of Rutgers University and the University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School. The Institute sponsors research, education, and service programs in a setting that fosters interaction among experts in environmental health, toxicology, occupational health, exposure assessment, public policy and health education. It houses a select group of scientists, physicians, educators, and policy researchers. EOHSI strives to: improve the understanding of the impact of environmental chemicals on human health; find ways to quantify and prevent exposure to hazardous substances; develop methods to identify and treat people adversely affected by environmental agents; devise approaches for educating the public about the relative risks from chemical exposure; evaluate public opinion and recommend policies to regulate environmental health hazards; and serve as a credible source for objective scientific data on environmental health issues.

Global Environmental Assessment Project at Harvard University

The GEA Project is a collaborative, interdisciplinary effort to improve the linkage between science and policy in society's efforts to deal with problems of global environmental change. The project is based at Harvard under the auspices of the University Committee on the Environment, drawing on faculty and students from the natural sciences, social sciences, and professional schools. The project also has substantial participation from scholars and practitioners of global environmental assessment around the world. The Project's goal is to explore how assessment activities can better link scientific understanding with the progressive design, implementation, and evaluation of effective policy responses to global environmental change.

Edward J. Bloustein School of Planning and Public Policy

Distinctive as both a strong policy center with a first-rate planning group, the Bloustein School is one of the few schools with the capacity to address local, state, regional, national, and international policy and planning issues with genuine expertise and credibility. The school's fivefold mission is to: 1) prepare students for public- and private-sector careers, teaching and research, service at all levels of government, and in nonprofit organizations; 2) serve as a national and international locus of planning and policy scholarship, providing the supportive environment for research and innovation; 3) provide service and support to all levels of government; 4) serve as a public policy forum, addressing major concerns of the present and future policy options; and 5) serve as an intellectual center within the university for applied social science research and its public policy implications.

Common Waters

Centered at Cook College, Common Waters is a multi-disciplinary working group of Rutgers faculty and others interested in issues of water, wetlands and marine fisheries science and policy.