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Figuring Out the Human Dimensions of Fisheries: Illuminating Models

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Abstract.—Both natural scientists and economists commonly use quantitative data to create models of the systems that interest them and then use these models to inform fisheries management. Other social scientists rely on lengthier, descriptive texts based primarily on qualitative data to assess the human dimensions. To their dismay, fisheries social scientists find that much of their rich narrative with keen insights ends up filling pages that are neither read nor meaningfully integrated into decision-making in fisheries management. Nevertheless, what all scientists, practitioners, and managers want and need is information that will lead to a better understanding of the ecosystem (comprised of interdependent ecological and human systems) and therefore to fisheries management that benefits the whole system. Based on the belief that only a combination of high-quality quantitative and qualitative data will provide both the numbers and the context needed for success in ecosystem-based management, we discuss efforts to present social and cultural information in forms that are more familiar to those who rely on models for a representation of reality in the fisheries context. We point out how the designers of these models (or how we) think the models might be applied to fisheries management, noting how each model attempts to incorporate qualitative data to depict context essential for grounding the more commonly used biological and economic models. We also assess the benefits and limitations of these models, including the constraints on their development and use.

Natural scientists are accustomed to using models replete with quantitative data to help analyze or depict the status of natural resources. Economists, too, are accustomed to using quantitative data for models to estimate the costs and benefits of human–environment interactions. Both attempt to use their models to achieve a compelling illustration of what they believe the data reveal, yet both recognize that models do not necessarily reflect reality. Instead, models are abstractions that tend to capture a moment in time, suggest probable scenarios, and provide best guesses as to how the system works and will be affected by change.

Other social scientists, however, tend to rely on lengthier, descriptive text based largely on qualitative data to assess the impacts of management on fishing communities and other stakeholders. Unfortunately, those of us who are fisheries social scientists find that much of our hard-won expertise ends up filling pages that are rarely read or, if read, are used as background but not meaningfully integrated into decision-making in fisheries management.

The debate over the value of quantitative versus qualitative data is not a new one. In fact, it has been referred to as the "paradigm wars" by Guba and Lincoln (1994). Fisheries social scientists have long argued that qualitative data can provide explanations for outcomes inexplicable by reference to strictly quantitative measures (Berkes et al. 1989). However, social scientists now also recognize the pragmatic necessity of converting the information they gather into a form that is quickly comprehensible and applicable in the fisheries management context.

What *all* scientists, practitioners, and managers want and need is information that will lead to a better understanding of the ecosystem and therefore to fisheries management that benefits the whole system. Unfortunately, available data are limited and imperfect, yet in order to successfully move towards ecosystem-

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based management, only a combination of high-quality quantitative *and* qualitative data will provide both the numbers and the context needed for success. Furthermore, Heemskerk et al. (2003) suggest that interdisciplinary development of conceptual models may be a useful communication tool for social and natural scientists, ultimately leading to more effective ecosystem management. Heemskerk et al. (2003) argue that "model building consists of determining system parts, choosing the relationships of interest between these parts, specifying the mechanisms by which the parts interact, identifying missing information, and exploring the behavior of the model." The drawing of visual (conceptual) models in an interdisciplinary context forces contributors to articulate why certain elements are considered necessary, what assumptions are being made, and how key concepts are defined in their own discipline.

In this article, we discuss several efforts to convert the information that noneconomist social scientists gather into a form more familiar to those who rely on models for a quick picture of the world as it relates to fisheries management. We point out how the designers of these models (or how we) think the models might be applied to fisheries management. In particular, we explore how the models attempt to incorporate qualitative data to depict context essential for grounding the more commonly used biological and economic models. We also assess the benefits and limitations of these models, including the constraints on their development and use.

First, however, we consider why it is important to understand the social or human dimensions of fisheries. We could simply point out that "it is the law" and leave it at that. However, it is too easy to follow the letter of the law and ignore the spirit if the rationale for the law is not understood. In the context of managing data-poor fisheries, one might legitimately weigh the demands of gathering data on the human dimensions against gathering biological data, for example. Nevertheless, as Miller and Van Maanen (1979) once tellingly entitled an article written about fishing in Gloucester, Massachusetts, "Boats don't fish, people do." As the title implies, without information about the people and communities involved—the human dimensions—it is virtually impossible to manage fisheries. Fulton and Adelman (2003) and others before them have underscored this, noting that "fisheries management is 10% biological resource management, and 90% people management."

Many of the models being developed by noneconomist social scientists recognize the critical point that fisheries management is most effective and successful when participants in the fishery believe that they indeed have a stake in the outcome and will benefit from appropriate management. Sometimes, however, the benefits of interest to participants are not those commonly attributed to fishermen. Noneconomist social scientists, for example, have found that some fishermen are more interested in maintaining a "way of life" than in making great sums of money. Maintaining community, working on the water, and passing on their skills to their children are all values or goals expressed by individual fishermen (Hall-Arber et al. 2001). Such values and goals, however, are most easily revealed through participatory research.

The active participation of stakeholders allows both the collection of data that might otherwise be missed and the groundtruthing of models developed by using all available data sources. In turn, active participation in the form of cooperative research tends to increase confidence among all participants in the results of the research (Kaplan and McCay 2004; Hartley and Robertson 2006). Besides, as some have said, "Natural resources are human constructs; it is through the *perception* of value and utility that features of the natural environment come to be defined as resources" (italics added; Forest Ecosystem Management Team 1993).

It is also worth noting that the effort to consider humans in fisheries management is not unique to the United States. Referring to stocks managed under the European Union's Common Fishery Policy: "Organized groups with interests at stake increasingly require a management system that addresses technological, social, and economic questions, as well as biological issues" (Schwach et al. 2007). The same report notes that "Fisheries management is a political system with technical components operating within political constraints" (Schwach et al. 2007:802). In other words, managers keep looking for scientific advice that allows them to justify their decisions, while still allowing them to retain the ability to make politically acceptable decisions. "People in all major stakeholder groups call for a more interactive system of producing a common knowledge base to address uncertainty" (Schwach et al. 2007:801).

The importance of the human dimensions has also been recognized in the management of other natural resources. In forestry, for example, a fundamental failure identified by researchers was a "lack of shared vision about the future" (Forest Ecosystem Management Team 1993). The authors (Forest Ecosystem Management Team 1993:VII–114) argued that decision-making processes must fairly consider all values of concern to society; actively build trust; recognize the differences between the roles of scientists, policymakers, and advocates; facilitate participatory processes; and seek an open and fair process leading to solutions based on collaboration (inclusion, leadership, and vision).

It is clear that many observers share the view that stakeholders have much to contribute to natural resource management. Most pertinent, however, for thinking about managing in the face of data-poor fisheries are comments by a well-respected authority on the use of traditional or local knowledge in management. Johannes (1998:243) pointed out that "management carried out in the absence of the data required for the parameterization and verification of models that predict effects of various management actions with useful statistical confidence limits" (i.e., data-less management) has been done in tropical fishing cultures since before European contact. Importantly, he adds that data-less management does not mean management without information. The information may be based on "knowledge gained from research on other, similar systems" or it may be the "knowledge possessed by fishers concerning their local marine environments and fisheries." This knowledge is not limited to the marine ecological system, use patterns, and revenues generated but also encompasses the dynamics of resource use, local institutions that govern use, and the values, perceptions, and beliefs of resource users and communities in the fisheries context.

In this article, we review efforts by social scientists to adopt models as a way of presenting data succinctly while retaining the value of a qualitative approach. Although there are limitations inherent in each, they do enable viewers to grasp a sense of the complexity in natural resources management and therefore to consider trade-offs that might lead to management that better achieves the mix of ecological and social goals and compromise more acceptable to all. Before outlining the models, however, we reflect on the current vehicle for informing management about the social aspects of regulatory change.

Social Impact Assessments

In the United States, social impact assessments (SIAs) are the primary mechanism for formally incorporating information about the human dimensions into fisheries management. The SIAs are designed to identify potential consequences of proposed regulations. Appropriate SIAs should help regulators to either choose options that reduce negative impacts or develop appropriate mitigation measures. An SIA is also a required element of all federal fishery management plans (FMPs), a requirement strengthened in 1996 when the Magnuson–Stevens Act was amended by the Sustainable Fisheries Act.

Social impacts considered by an SIA may include changes in peoples' ways of life, their culture, their community, their political systems, their environment, their health and well-being, their personal and property rights, and their fears and aspirations (IAIA 2003). Indeed, a wide range of social and economic indicators has been identified as important in the development of FMP SIAs (the National Marine Fisheries Service [NMFS] draft manual; the National Oceanic and Atmospheric Administration Fisheries [NOAA Fisheries] has prepared a draft guide to the development of SIAs for FMPs, but the guide has not completed the approval process. Earlier guidance was prepared by the Interorganizational Committee on Guidelines and Principles for Social Impact Assessment, "Guidelines and Principles for Social Impact Assessment" May 1994). In practice, a lack of data for many of the indicators has limited their use. Nevertheless, NMFS social scientists have been working diligently to create community profiles that record basic demographic information about fishing communities (e.g., populations, households, housing, income, education, etc.) to facilitate SIAs. Because the data that are most accessible are those available from the U.S. Census—essentially objective counting of people and specific attributes—as well as some economic data based on fisheries landings and prices, there is little incorporated in SIAs that helps address concepts such as quality of life or sustainability. (Sustainability has multiple meanings that variously address the ecological and human dimensions [Gale and Cordray 1994]. In fisheries, sustainability pertains to livelihoods and communities as well as fishery resources and supporting ecological systems.)

In California, the passage of the Marine Life Management Act (MLMA) in 1998 and the Marine Life Protection Act in 1999 reformed state fishery management policy, emphasizing ecosystem-based concepts and adaptive management for "long-term sustainability of the marine system, not just selected parts of it" (Pomeroy and Hunter 2007). While the implementation efforts have led to more effective integration of biophysical information about the stocks, physical oceanography, habitat, and other aspects of the marine ecosystem, a lack of social science information hinders adoption of ecosystem-based management. As Pomeroy and Hunter (2007:2) explain, "a lack of systematic information on the human dimensions of marine resource use limits policymakers' ability to evaluate trade-offs, anticipate reactions, and prevent unintended consequences for the marine and human environments." The "essential fishery information" that the MLMA identifies for the state's FMPs includes employment, expenditures, resource demand, revenue, and user/industry demographics, information comparable to that usually included in the SIAs for the federally regulated species but insufficient to fulfill the MLMA's objectives. Pomeroy and Hunter (2007:10) report that their interviewees—state and West Coast federal fishery management personnel—identified the following important socioeconomic information needs: social and economic relationships; individual behavior, including adaptive strategies; and community structure and dynamics.

As noted, SIAs are written in anticipation of regulatory change. The predictions made about potential impacts to the sustained participation of fishing communities and other aspects are used (albeit irregularly) to select regulations that, to the extent possible, minimize social impacts while achieving conservation goals. Rarely, though, do state managers, the regional fishery management councils, or NMFS social scientists analyze the actual impacts of the regulations that are ultimately implemented.

Methodology

Picking Up the Pace for Policy

As social scientists, we have long been proud of our discipline's devotion to qualitative research, believing that this methodology lends itself to a holistic understanding of social and cultural life derived from thorough analysis of data obtained through such techniques as "participant observation." Unfortunately, policy makers seem to always need access to "relevant, timely, accurate and useable information"—yesterday (Campbell 2001:381). In the 1970s, when development aid was rapidly expanding, rapid rural appraisal (RRA) was devised as a way to determine the essential issues worthy of further specialized study (Campbell 2001:381). Use of secondary sources, semistructured interviews, and observation were the techniques employed in the context of international aid but have been applied occasionally in the context of fisheries management (Dyer and McGoodwin 1994).

Recognition that shortcomings in RRA could lead to biases resulted in a move towards participatory rural appraisal (PRA). This was an effort to increase local participation in development, in part so that the aid projects would better suit the needs of the local people. Though modeled on the RRA (whose techniques were overtly adopted), insufficient attention was paid to the details that made the techniques reliable. For example, social science fieldwork has long relied on the use of semistructured interviews with full attention to context and careful listening. Appropriate choices of whom to interview and crosschecking of data are considered essential. Similarly, when focus groups are used, the choices of who should participate (including the choice and training of the facilitator), who should record the group interview, and who should analyze the recorded data are extremely important.

The operative word for both RRA and PRA, however, is the term, "rapid." Often a week or less is devoted to each site visit. Most of the work is undertaken as a team, and the outcomes pursued are often team-building and consensus-building. What is sometimes not taken into account is how different portions of the population will be affected by the proposed development aid or, for our purposes, proposed regulations. In keeping with the tenets of social science (and SIAs), impediments to achieving or retaining a positive quality of life, both at the individual and community (or societal) level, should be considered for and by the different sectors.

It should also be noted that a small number of focus groups may not be representative of the whole population, and therefore findings may or may not be appropriately generalized (Campbell 2001:383). Nevertheless, Ward et al. (1991) found that to the extent that a focus group was appropriate to the problem being investigated and was properly utilized, it functioned effectively in combination with surveys or individual interviews or as a stand-alone technique (Campbell 2001:385). It is important to keep in mind, however, that neither RRA nor PRA was intended as a substitute for in-depth qualitative and quantitative research. In any case, a transparent account of the research process is critical.

While we strongly support collaborative or participatory research in order to identify issues of concern to the stakeholders, it is not uncommon to meet resistance. All too often, potential participants avoid committing to participation on the grounds that "the data will be used against me." This reluctance dovetails with a long tradition in the fishing industry of considering information about fertile fishing grounds and other topics central to fishing success as proprietary. Before the advent of the electronic wheelhouse, a young fisherman's prized possession was often a coffee-stained, salt-encrusted logbook passed on from his father or grandfather with records of favored fishing areas, catches, weather, "hangs," and other information vital to success.

In the following paragraphs, we provide brief overviews of recent innovative approaches to gathering data useful for SIAs. Each of these efforts is an attempt to present the qualitative human dimensions data in a form that managers, scientists, and even economists can more easily comprehend. Many of these are based on the drawing of figures, a heuristic device recommended by Polya (1945) for problem-solving or conceptual models.

Mapping

Maps are excellent for focusing discussions. With the popularity and ubiquity of the Global Positioning System, Google Earth, and other responses to the proliferation of applications of geographic information systems, participatory mapping has become increasingly feasible and desirable. The familiarity of fishing charts to participants in fisheries and maps to other stakeholders also enables a conversation that all can understand. The visual depiction can also be very effective in drawing attention to certain aspects of the human dimensions that might otherwise be ignored. Mapping is gaining popularity worldwide for marine spatial planning as an attempt to cope with (i.e., plan and manage) increasing competition for the use of marine and coastal space (for instance, see St. Martin and Hall-Arber 2008).

Two examples of mapping applications to fisheries management are described here. In both cases, the maps showed (among other things) the primary fishing grounds associated with different place-based communities. This depiction allowed a visualization of just which communities would be most affected by closures, for example, and where communities on the water comprise fishermen from various communities on shore. The maps depicting Atlantic herring *Clupea harengus* show not only where the Atlantic herring fishermen and the other sectors of the industry are based but also draws the connections with the American lobster *Homarus americanus* industry. (In New England, and particularly in Maine, Atlantic herring is the bait of choice for the lobster industry, so regulations that control [e.g., limit] the catch of Atlantic herring or change the timing of landings can affect both the cost and availability of bait.)

Atlas Project

In the Atlas Project, St. Martin and Hall-Arber (2007) worked with community researchers to identify fishing communities at sea: "We were interested in creating maps and narratives that would locate fishermen as embedded within a variety of community processes and would link their community and fishing practices to common fishing grounds and specific fisheries habitats" (St. Martin and Hall-Arber 2007). The first step in the process was the production of charts of fishing locations based on aggregated data from federal vessel trip reports (VTRs). Community researchers then presented a series of three charts of increasing specificity (depicted according to gear type, vessel size, and usual fishing locale) to selected fishing representatives and asked each to consider whether the charts accurately depicted the patterns of their group or community, to discuss relationships among those who worked in the same area, and to tell what they knew about the ecology of the areas. The Atlas Project interviewed about 60 fishermen from the Gulf of Maine, and generated approximately 180 edited charts (see Figure 1A–C for examples of these maps). "Aggregated, formally presented, and vetted by fishermen themselves, data representing community territories are becoming weighty icons of the 'human dimensions' of fisheries (cf. Jensen and Richardson 2003)" (St. Martin and Hall-Arber 2007). Mapping the social landscape of the marine environment is essential not only for fisheries but also for the many sectors wishing to incorporate human dimensions to improve marine spatial planning and management (St. Martin and Hall-Arber 2008).

Atlantic Herring Fishery Map

In this project, Pinto da Silva and Fulcher (2005), both of NOAA Fisheries, designed a map that illustrates links between Atlantic herring stocks and coastal communities in New England (Figure 2). The map shows the geographic distribution of the stocks, primary landing ports, gear types, processing plants, bait dealers, and lobster permit holders. The authors anticipated that the maps would help viewers visualize how regulations might affect use patterns and consequently lead to socioeconomic impacts. Furthermore, the map may be a useful tool as a "visual baseline" to see changes in the fishery over time (Pinto da Silva and Fulcher 2005). The data used to generate the maps include VTR data for Atlantic herring vessels and state permit data for the lobster permits. Eventually, the authors plan to link text from the "Affected Human Environment" portion of the SIA to appropriate icons featured on the map. Ideally, the data linked to the maps will be drawn from site visits, interviews, literature reviews, census data, and web links.

Assessment

The first step in the creation of both the Atlas Project and the Atlantic herring maps relied on access to NMFS VTR data. The following step, the visual characterization of the fleet and other stakeholders, was fairly straightforward and presumably could be done even in the context of data-poor fisheries as long as some information about resource use is available about the fishery from federal or state agencies. Attempts to move beyond basic information, however, to include primary and other secondary sources and to test whether the depictions are accurate were (in the case of the Atlas Project) and will be (in the case of the Atlantic herring mapping) more time consuming.

Though VTR data are essential for preliminary

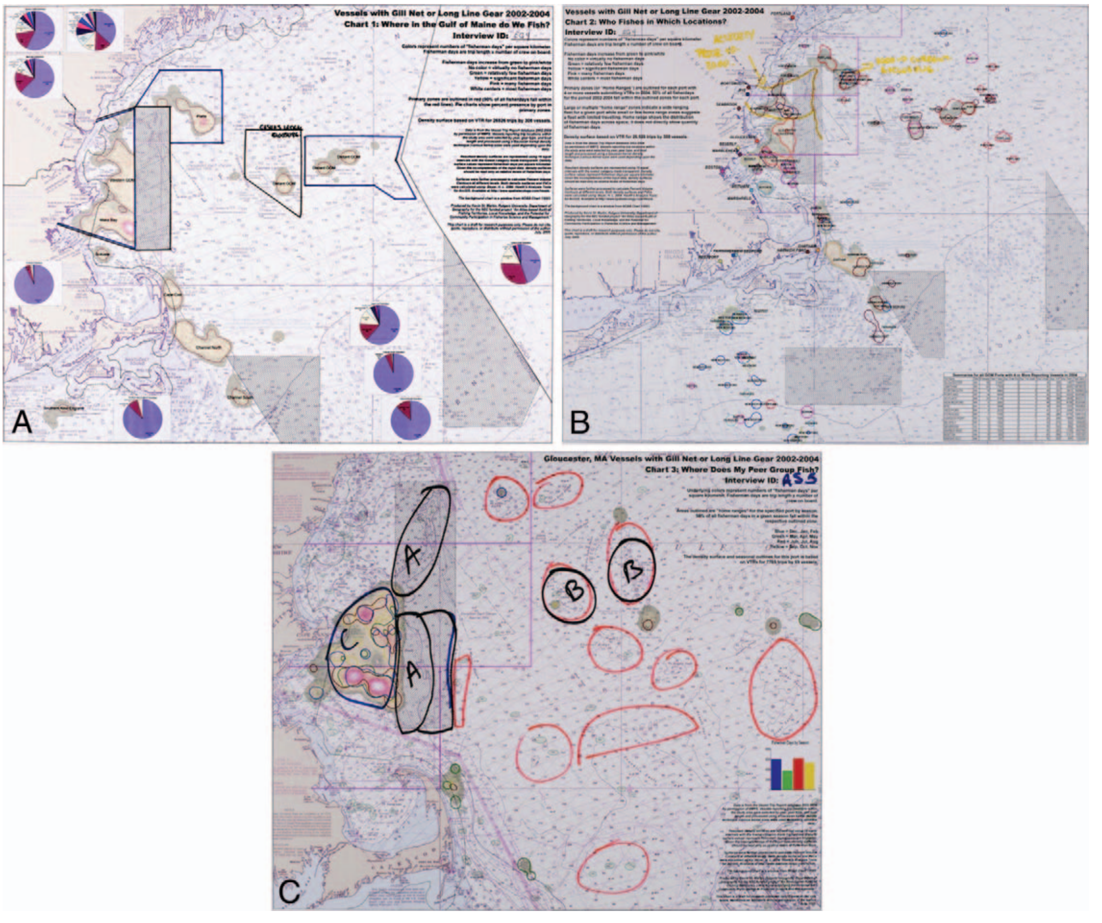

FIGURE 1.—Atlas Project sample maps entitled **(A)** "Where in the Gulf of Maine do we fish?"; **(B)** "Who fishes in which locations?"; and **(C)** "Where does my peer group fish?" (St. Martin and Hall-Arber 2007).

mapping of federal fisheries, constraints exist. If there are fewer than four vessels out of a single port, the data cannot be aggregated sufficiently to disguise participants, so NMFS will not permit release of the data. Furthermore, the researchers had anticipated that there would be major changes in the depiction of fishing areas because the fishermen are required to only record the geographic coordinates of where they start fishing. Their day's mobility is thus not recorded in the VTR. To everyone's surprise, the aggregation of thousands of bits of VTR data resulted in charts of fishing areas that were fairly accurate at the broad scale. There were more corrections, however, on the finer-scale charts. In state fisheries that collect their data based on "trip tickets," as in California, indications are that the data may not accurately reflect actual landings or catch locations, partly because these often are filled out by the dealers rather than the fishermen and may not fully or accurately reflect the information.

Projects that rely on interviews to "vet" the maps add a time constraint to data gathering, although this may make the outcomes more reliable. As noted above, a greater problem may be the reluctance of members of the fishing industry to participate. In the Northeast, the first of the mapping projects described above was initially stymied by the lack of interest in participation. A paradigm shift occurred, however, when one of the local fishing organizations, the Cape Cod Commercial Hook Association, successfully convinced the New England Fishery Management Council to allocate its "sector," a portion of the total allowable catch of Atlantic cod *Gadus morhua*, based on the group's catch history. About the same time, the potential for area management came up for debate. Suddenly, fishermen became aware that it might be in their best interest to create a record of what they considered their traditional grounds in order to maintain access (and forestall closures or allocation to competitors).

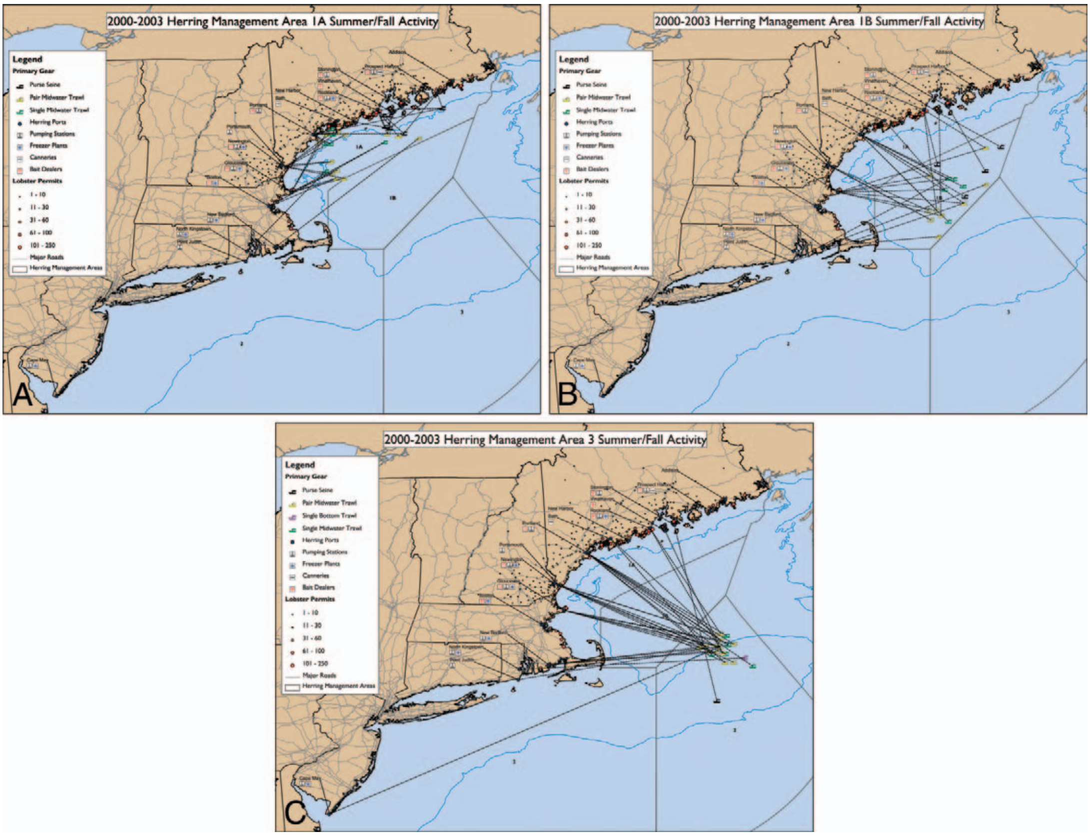

FIGURE 2.—Atlantic herring fishery maps linking fishing groups to ports and infrastructure in **(A)** management area 1A, **(B)** management area 1B, and **(C)** management area 3 (Pinto da Silva and Fulcher 2005).

Several articles presented at the Managing Data-Poor Fisheries Workshop in California suggested that local area management could be an important way to manage when there is insufficient data for traditional management. Mapping as described above would be invaluable for such an effort. When combined with interviews to collect local ecological knowledge (LEK), the results could be used to examine how closely scientific data from assessment cruises or other research and LEK resemble one another. Great differences might suggest a need for additional data.

Networks

The small-world phenomenon popularized in American culture through the idea of "six degrees of separation" and expanded through social networking Internet sites, such as Facebook and MySpace, has been transformed from the dry descriptions of social networks in academic literature to very practical applications. With the exception of work by Maiolo and Johnson (1989), investigation of social networks in fisheries has been slow to capture researchers' interest. Nevertheless, recent work has begun to show that tracking people's connections, communication methods, sources of trusted information, and sharing of other goods and services can reveal the normally hidden structure of formal and informal networks in fishing communities (e.g., Hartley et al. 2008). This can be valuable to fisheries decision makers not only for accessing information but also for learning how information is shared and interpreted so that outreach efforts can be made more effective. For fishing communities, social network analysis can help build human, social, and organizational capital, leading to greater resilience and sustainability.

Intriguingly, network science has begun to leap disciplinary boundaries with, for example, ideas from physics being applied to social phenomena and ideas from social science informing biology. Communication networks, social networks, and biological networks are actively being studied not only in the social sciences but also in physics, biology, artificial intelligence, and mathematics (Hoche et al. 2006). Such diverse systems as "the cell" and "the Internet" are commonly described as complex networks and it is "increasingly recognized that the topology and evolution of real networks are governed by robust organizing principles" (Albert and Barabási 2002). "Both graph theory" and recently developed techniques for studying complex networks . . . "allow us to answer questions in common to these networks like aspects of adaptability, error and attack tolerance, complexity, community structures, and propagation patterns" (Hoche et al. 2006).

In ecology, the best-known network is probably the food web, used to quantify the interactions between species, but data collection demands for food web analyses is a challenge. Likewise, the statistical analyses requisite for network science may be daunting for social scientists; however, the development of specialized software has facilitated this work.

Community Panels Project

The World Bank takes a "four capital approach to sustainable development": (1) natural capital is considered the "stock of natural assets such as land, water, wood, minerals, flora and fauna," which is the "environmental dimension"; (2) produced or man-made capital includes "machinery, factories, buildings, and infrastructure such as roads" and is regarded as the economic dimension; (3) human capital is people's capacities based on "skills, education, health"; and (4) social capital includes "*social networks, associations and institutions* tied by common norms and trustful relationships that facilitate cooperation" (emphasis added; World Bank 1997). Together, human capital and social capital constitute the social dimension.

A collaborative research project under the Massachusetts Fishermen's Partnership organized six community panels in the Northeast region of the United States (Hall-Arber 2007). Each panel consisted of 10–12 individuals representing a cross section of harvesters, processors, shoreside business owners, and other members of the fishing communities. The panels identified issues of concern to their ports; with the help of coordinators and the principal investigators, they gathered data through interviews and focus group meetings and then drafted and reviewed reports. The community panels began to develop their own "social capital" by creating networks among the participants that were based on a consensus of values, norms, and trust. The panels also provided an avenue for building people's capacities, especially by sharing information, i.e., education (Hall-Arber et al. 2006). This in turn facilitated discussions that addressed topics regarded as critical to the subjective concerns of panel members but also were relevant to realistic and effective management of fisheries. (For example, Gloucester panel members were worried that shoreside business owners would sell their property to real estate developers with plans for luxurious waterside condominiums, changing Gloucester from a "fishing community" to a bedroom community for Boston. Such a change would diminish the availability of working waterfront for the fishing industry as well as raise the specter of increased class distinctions.)

The project found that collaboration between scientists (both natural and social) and fishing industry participants is critical to understanding the ecological, economic, and social aspects that lead to effective management. The accuracy of natural science research and monitoring results (e.g., assessments) is consistently questioned by fishing industry participants. While collaborative projects do not always end with consensus among the collaborators, those who participate in these projects have opportunities to share information and educate each other.

The community panels project found that concerns about retaining the infrastructure necessary for a viable fishing fleet, given fishery management regulations, were common to all six fishing ports, although the details differed. The infrastructure as defined by the panels included not only the produced or man-made capital (piers, facilities, etc.) but also the social and human capital that provides the expertise needed for the industry. While some of the data gathered by the panels was applicable to SIAs for FMPs, most of the panels were concerned with cumulative impacts not only of federal fisheries regulations but also zoning issues and other local changes. Consequently, the panels often focused on issues pertinent to local government and planning.

Assessment

Originally envisioned as a way for communities to decide which attributes of their community should be accounted for in SIAs, the panels were more interested in both a broader approach (concerned with multiple fisheries as opposed to SIAs' single-species concerns) and a more local approach. The panels (and their coordinators) that were most successful in generating useful data and discussion devoted quite a bit of time to the project. The selection of a representative sample of the community and maintaining participation over time are additional serious constraints. An advisory group identified individuals with multiple roles in their communities to provide the panels with a good cross-section of the human capital represented in their communities. Not surprisingly, many of these individuals were too busy to commit to regular meetings. The

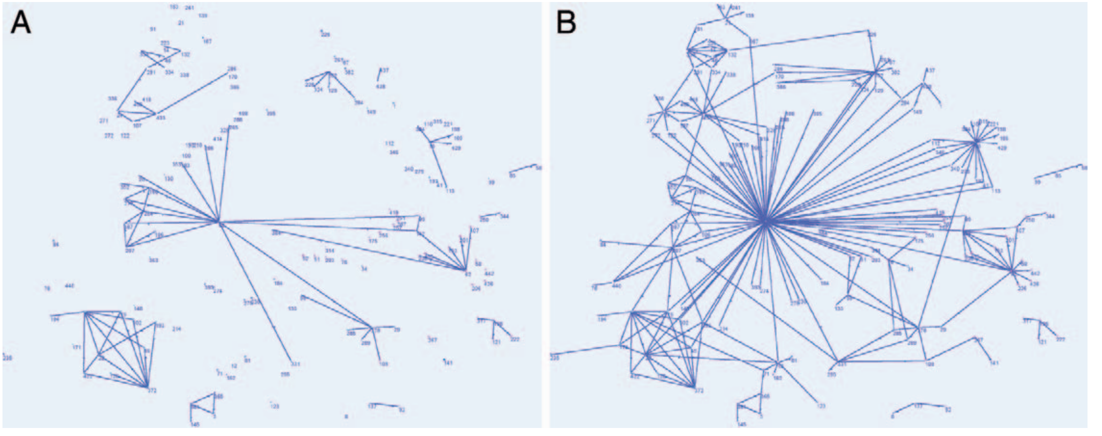

FIGURE 3.—Herring Fisheries Management, Amendment 1, spring 2007 communication network maps: **(A)** daily communication frequency (eight groups; group A: $N = 28$, density = 5%, weighted average path length = 2.23; group B: $N = 10$, density = 14%, weighted average path length = 1.34) and **(B)** weekly communication frequency (one group: $N = 146$, density = 1%, weighted average path length = 2.51; Hartley 2008).

coordinators also had to be very flexible and persistent when arranging meetings. Nevertheless, the panels that evolved may be considered a network cluster, albeit artificially constructed at the outset.

The panels were useful in identifying priorities for data collection. Such information or priority setting could be very valuable for SIA, particularly when, for example, communities are as vulnerable as the stocks being managed. The panels could also be useful in setting management goals and objectives. This is particularly important in the data-poor context since panels or other forms of input from stakeholders are more likely to ensure that whatever limited resources are allocated will be used towards achievement of mutually agreeable goals. In their presentations at the 2008 Managing Data-Poor Fisheries workshop, Catherine Dichmont and Jeremy Prince independently reiterated the value of the "pooled knowledge of scientists, industry and managers" to successful management.

Atlantic Herring Networks

Troy Hartley (Virginia Sea Grant, personal communication) has been approaching the need for integrated fisheries management by looking at communication networks and using the New England Atlantic herring fishery as a case study. Communication network mapping is a conceptual tool to help look for patterns in qualitative data about how participants relate to one another. Hartley suggests that managers of networks "mobilize resources that belong to many organizations; orchestrate a web of relationships: multi-organizational, cross sector, and multi-governmental" while remaining "accountable to public objectives and mission." By conducting a mail survey of those identified as involved in the Atlantic herring fishery, Hartley collected sufficient data to explore the links between the actors, analyzing the strength of the links (e.g., frequency and duration of contacts), the patterns of the linkages (e.g., density and path length), and the role of certain actors who are, for example, "bridgers, liaisons, or equivalents." The visual depictions of the daily, weekly, and monthly contacts are also color coded to help identify various groups (Figure 3).

One of the results of network analysis is a clear illustration of the importance of key individuals. This information is valuable in the context of fisheries management for learning which individuals are most likely to serve as conduits of information between and/or among managers, scientists, and fishery participants. If such key individuals are left out of the process; are uninformed of changes in regulations, science-based knowledge, or local knowledge; or have personal goals that conflict with either management goals or the community's goals, the information transmitted may be distorted. Without the ability to track communication networks, it is very difficult to intercept and correct such messages.

Assessment

In order to conduct network analysis, numerical data are necessary. Surveys are commonly used but not always satisfactory. Furthermore, a serious problem that beset this research is the protocol on the use of human subjects; this protocol is required of social scientists when conducting federally funded research that demands anonymity. Consequently, it is difficult for other researchers to replicate the findings, to consult with either the key individuals or those poorly linked in order to build on this work to develop SIAs, or to provide information to key individuals for dissemination and feedback.

While states do not all have the same provision requiring anonymity, social science research is based on the development of trust between researcher and subjects (or participants). It is essential for the researcher to obtain informed consent for the release of information that might be considered private or proprietary. In most cases, however, aggregation of data will sufficiently cloak details so participants are protected. When fishery participants are sufficiently engaged in the research to understand why specific questions are asked, most are willing to provide responses and ask others to do so as well. Furthermore, with the increasing move towards electronic monitoring of fishing, some captains shrug off privacy concerns with comments like, “Why not [show favorite fishing grounds]? They know everything anyway!”

Cultural Models

Cultural models are perceptual frameworks—that is, they are the lens of beliefs, values, and experience through which people filter the information they receive about the world. Innovative social science research indicates that effective fisheries management may best be achieved if all stakeholders recognize the differences in their cultural models (or mind maps; Paolisso 2002; Glaser 2006). Ross and Medin (2005) argue that “culture may produce different ‘habits of the mind’ that have consequences for people’s conceptualization of nature,” so that even if there are certain levels of agreement due to shared experience, there may be underlying differences due to the way culture shapes the “interpretation of experience and attention to various aspects of nature.”

In fisheries, the work on cultural models has primarily focused on the differences among those of fishermen, scientists, and managers; such differences have led to distrust, conflicts over stock assessments, lawsuits, and great economic uncertainty. Paolisso (2002), investigating the “lack of fit between traditional and scientific knowledge,” found that differences in the cultural models of Chesapeake Bay watermen and scientists studying the blue crab *Callinectes sapidus* explained the conflict between the two groups. Though a brief summary about the differences in the two cultural models and their effect on management is difficult, one basic tenet of the watermen’s cultural model is that “human agency cannot influence the provisioning of crabs, but only the degree to which the crabs provided are used productively and sustainably.” In contrast, the scientists and managers maintain that managing fishing will protect the spawning stock, even if its decreasing size is due to environmental factors. “According to watermen,” however, “science cannot understand nature because there is just too much variability, which is part of God’s plan.” Similarly, Bender (2001) found that the cultural model of “God as provider” held by many Tongan fishermen had the corollary that regulations for the protection of fish are therefore unnecessary.

Researchers who focus on cultural models anticipate that once the differences are made explicit, improved understanding among the various groups will lead to more collaborative models of management. At the very least, an understanding of the cultural models can remove some of the stereotypes of the different groups (e.g., greedy fishermen, scientists trying to put the fishermen out of business) that hinder collaborative processes.

Research on cultural models suggests that analyzing interviews and “explanations offered as part of natural discourse on the topic or domain at hand” (often in the form of slogans, clichés, or wise words), leads to an identification of underlying cultural models (Paolisso 2002; following Holland and Quinn 1987; D’Andrade 1995; Shore 1996; Blount and Kitner 2007). Cultural models integrate values and beliefs and, in the case of the blue crab watermen, these include views on religion, spirituality, nature, morality, work, independence, responsibility, and experience-based ecological and economic knowledge. In contrast, scientists have shared cultural models that focus on biological fact and reflect a strong belief in the predictability of resource trends (given adequate data) as well as a lack of belief in traditional ecological knowledge. Illumination of the differences in the two cultural models has led to a focus on the issues, values, or beliefs that the two models share, offering a basis for negotiation of more satisfactory outcomes.

Assessment

Time is a factor in the gathering of sufficient data to draw inferences about cultural models. Furthermore, cultural models are abstract, revealed indirectly through the analysis of talk. The methodology runs the gamut from formalistic discourse analysis or pile sorts of word choices to pattern analysis of folktales or oral histories. This may be the most demanding of specialized social science training, but it also may reveal points of view that are disguised by the “talking past one another” that can occur when words but not meanings are shared. The depiction of different cultural models associated with scientists and resource users parallels the differences among scientists (social and natural) noted by Heemskerk et al. (2003) in their discussion of collaborative model building in interdisciplinary contexts.

Modeling Social Indicators

Researchers tend to agree that for planning to be successful (in a development context or fisheries management context), there must be a much more concerted effort to pay attention to social indicators that go beyond demographic data and other objective characteristics (McGregor et al. 2003; Noll 2004). While economics is an important component, social factors pertaining to such issues as sustainability, equity, and social cohesion are presented as equally significant. A more holistic approach to all aspects of fisheries management (e.g., ecosystem-based), business, and life style is currently being pursued.

For example, researchers working on the European System of Social Indicators to measure the welfare of their citizens and guide social policy point out that material wealth and rates of economic growth were not adequate measures since the "notions of what constitutes a good life or a good society" are extremely varied (Liebniz Institute for the Social Sciences; www.gesis.org). They have moved towards incorporation of more qualitative measures, although they also note the difficulties associated with operationalizing the measurement of concepts such as "livability, social cohesion, social exclusion, social capital, human development, sustainability, and social quality" (Berger-Schmitt and Noll 2000).

They are attempting to develop an ideal approach that incorporates both objective and subjective measures. Moreover, moving beyond the conceptualization of quality of life as focusing just on "individual" characteristics, they are looking at societal qualities, such as "equality, equity, freedom, security, or solidarity." These raise distributional and relational issues that are likely to be ignored in a focus only on individuals. What is clear from their work is that sustainable development (and sustainable fishery management) has economic, social, and environmental (or ecological) dimensions that interact and are interdependent. Moreover, as in the discussion of developing cultural models, researchers working on indicators in marine policy and legislation note the importance of good communication among both agencies and disciplines (Bayer et al. 2008) as well as the "interfacing" of scientific, social, economic, and legal policy goals.

Well-Being Model

Pollnac et al. (2006) introduced a model for fisheries SIA intended as a first step in developing quantitative social assessments comparable to economists' and biologists' assessments and thus more easily used by regional fishery management council members. The idea was to develop a "dependent measure or output analogous to economists' use of jobs, income, or total economic output in their models." The dependent variable selected is "well-being."

The report on the model points out that SIA data should be "amenable to comparison across space and time and should be cross-referenced with biophysical and economic data" (Pollnac et al. 2006). To do this, however, requires the variables to be "identified, defined, and operationalized in a consistent way, and sufficient data must be gathered to make the comparisons statistically and scientifically defensible." Significantly, the authors emphasize that economic welfare is not synonymous with well-being. As many social scientists have shown, fishing and involvement with marine resources is "much more than solely an economic activity" (Apostle et al. 1985; Pollnac and Poggie 1988; Gatewood and McCay 1990). The model shows the interaction of social variables and their effect on community well-being and individual well-being, noting feedbacks and interrelationships (e.g., cause–effect, resonance, and cumulative impacts). The authors refer to this as a heuristic model that can be used to develop a quantitative model (Figure 4).

Modeling Risk and Vulnerability

Building on their work focusing on assessing vulnerabilities in fishing communities (Tuler et al. 2008), Tuler and colleagues are refining a vulnerability and consequence scenario-building computer tool, TIPVAC, designed to be used in participatory processes (Seth Tuler, Social and Environmental Research Institute, Inc., personal communication). This approach is based on "a conceptual characterization of hazards [that] encourages people to examine threats, their consequences, and management interventions as a causal sequence resulting from a stream of choices and activities." The tool "is a java program written to compose a graphical display of a causal chain based on a database of nodes and links." The database entries were produced from information collected in semi-structured interviews and the content analysis of written documents. Because it is impossible to show all impacts of regulatory change on a community in a single diagram, the researchers supplemented their diagrams with written descriptions.

Importantly, the visual depiction of hazards and their consequences makes clear that management can interrupt the flow, leading to reductions in the "exposure" or mitigating the consequences. The

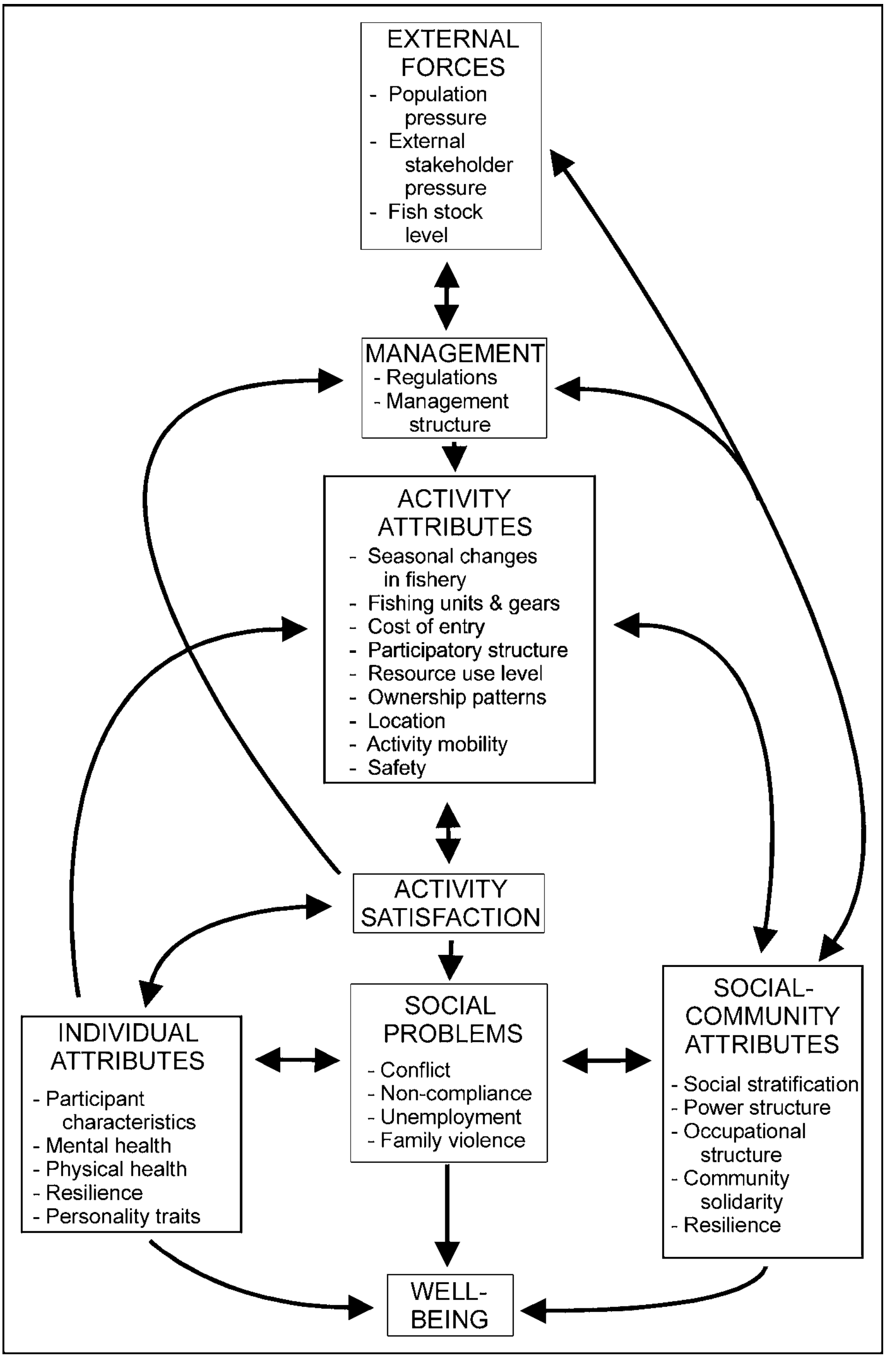

FIGURE 4.—Simplified fishery social impact assessment model and selected indicators (Pollnac et al. 2006).

research group has added the concept of vulnerability to draw attention to the point that both the exposure to hazards and the susceptibility of some people, groups, and communities to loss are "differentially distributed," as are their abilities to cope with the loss (i.e., adaptive capacity). Applying this model to the commercial groundfisheries in New England, the group illustrates, for example, how the impacts of regulatory

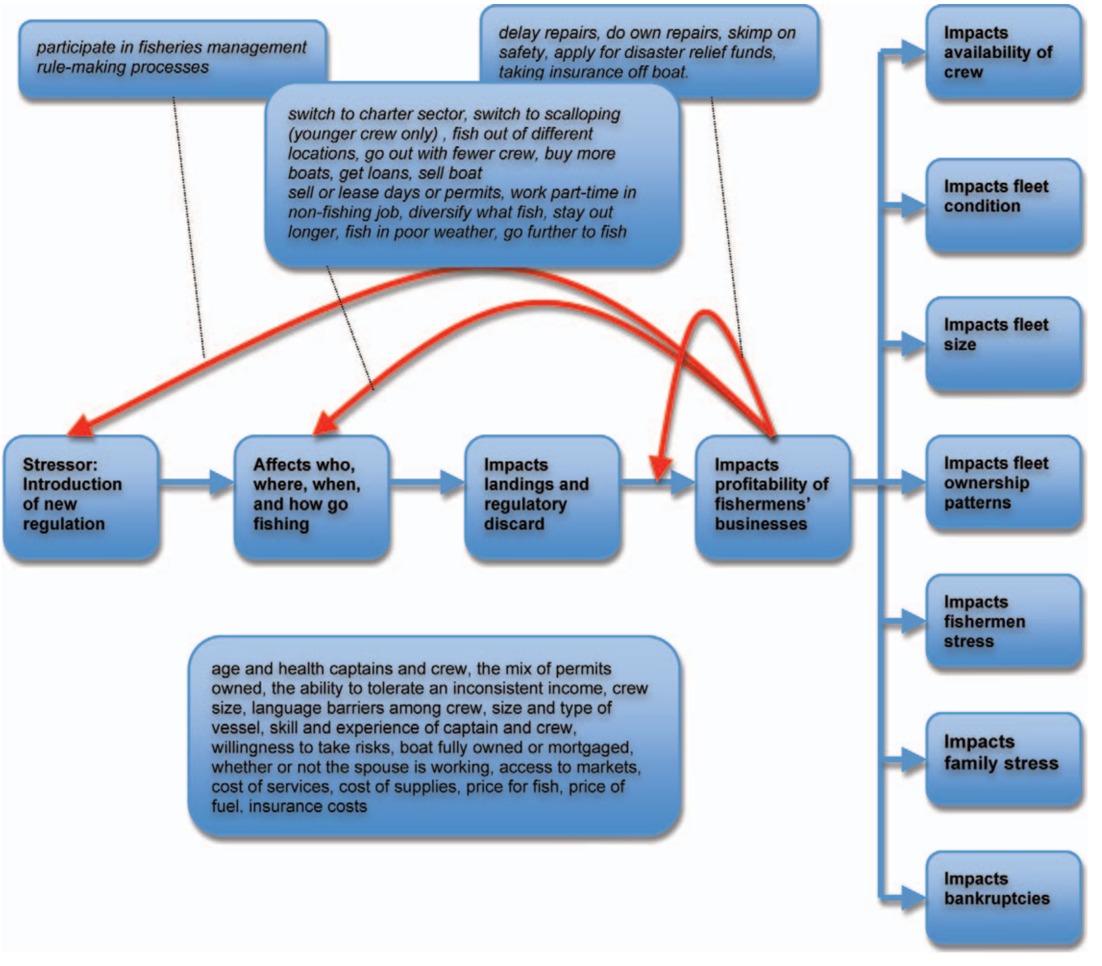

FIGURE 5.—Example of diagram produced in TIPVAC to depict commercial fisheries' sensitivities (lower boxes) and adaptive responses (upper boxes) to regulatory change (Tuler et al. 2008).

change on shoreside services are mediated by various "sensitivities and adaptive responses" (Figure 5).

Assessment

The modeling of indicators has not yet been fully operationalized, although Pollnac (Richard Pollnac, Department of Marine Affairs, University of Rhode Island) and his students are currently testing portions of the model with the cooperation of various Rhode Island fishermen (Pollnac and Westwood 2009). Also, Tuler et al. (2009) have made available several case study reports on using their approach in New England fishing communities.

Tuler et al.'s (2009) New Bedford case study report is rich in the level of detail pertaining to each theme, sensitivities and adaptive responses or absence of adaptive responses. The latter point may prove particularly useful to individuals and communities in drawing attention to the potential for adaptive responses to alleviate certain direct or indirect consequences of regulatory change. It may take some time, however, for managers and others to learn enough about the model to be able to comprehend it without having to read lengthy text explaining what is being illustrated.

The depictions in both of the described models are particularly useful reminders of the complicated feedback mechanisms inherent in the organization of a whole industry. They also succinctly show diverse effects, themes, sensitivities, and adaptations in graphic form (e.g., boxes) and so will be useful for drawing attention to potential barriers to well-being, the particular vulnerabilities of certain subgroups, or both. How these models can be used to actually weigh the variables in social reality to derive conclusions about risk and vulnerability is not yet clear. Furthermore, the success of these models relies on the availability of high-quality, qualitative data.

Conclusions

The models outlined offer various approaches to depicting data that may help all involved to more quickly comprehend the complexity of human systems. Furthermore, models that incorporate LEK and local perspectives on priorities, goals, and objectives could help managers establish the goals and objectives of their management plans as well as determine risk points. It should be noted, however, that while the models provide a means for neatly depicting qualitative data, they do not eliminate the need for collecting that data by using responsible, academically justifiable methodologies.

As we move to ecosystem-based management that explicitly includes humans in the system and recognizes the linked and interdependent nature of social and ecological systems, models may be a necessary, if not sufficient, step towards the evaluation of the myriad variables comprising the human dimensions of fisheries. Regardless of how the data are presented, we argue that the role of noneconomist social scientists is critical to the development of effective and equitable fisheries management.

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