INTEGRATING FISHERMEN AND THEIR KNOWLEDGE IN THE SCIENCE POLICY PROCESS: CASE STUDIES OF COOPERATIVE RESEARCH IN THE NORTHEASTERN U.S.

by

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ABSTRACT OF THE DISSERTATION

INTEGRATING FISHERMEN AND THEIR KNOWLEDGE IN THE SCIENCE POLICY PROCESS: CASE STUDIES OF COOPERATIVE RESEARCH IN THE NORTHEASTERN U.S.

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This dissertation explores the boundaries between science and non-science, including different forms of expertise, when citizens with experience-based knowledge (EBK) are included in the science policy process through cooperative research. This study focused on industry-science cooperative research between fishermen and scientists in the Northeastern U.S.

Ethnographic research primarily consisted of semi-structured and informal interviews and direct observation of the science-policy process, as well as a review of relevant fisheries science and management documents. Five different types of cooperative research with fishermen were examined in eight case studies: real-time data collection in the *Illex* squid fishery (chapter 4), the Northeast Regional Cod Tagging Program (chapter 5), gear selectivity/bycatch reduction research in the *Loligo* squid and whiting fisheries (chapter 6), industry-based surveys in New England and the Mid-Atlantic (chapter 7), and an industry-science advisory panel to improve the federal resource survey (chapter 8). Stakeholder perceptions regarding cooperative research were examined using the social science method discourse analysis (chapter 9).

This dissertation concludes that fishermen and their experience-based knowledge are being incorporated at important stages into scientific research through cooperative research. Cooperative research functions as an effective boundary institution. It allows for translation, communication, and mediation across the boundaries of diverse knowledge cultures. Cooperative research makes fishermen's knowledge more relevant or usable in the large-scale fisheries science policy process either by making it fit the requirements of the scientific method or by aggregating it to a scale more compatible with science-based management.

This research found that capacity building (such as learning or the sharing of expertise between fishermen and scientists) and boundary-spanners (those individuals who are able to span the boundary between science and non-science) facilitate the effectiveness of cooperative research. In addition, the peer review process is a critical site of boundary management. However, peer review of cooperative research is not dominated entirely by scientists, but instead includes an "extended peer review" process that includes participation by fishermen and other stakeholders.

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Dedication

To my father,

Ray Leroy Johnson.

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CHAPTER 1: INTRODUCTION, LITERATURE REVIEWS, AND RESEARCH QUESTIONS

Introduction

As a response to the global fisheries crisis, fisheries managers are looking for new strategies to rebuild degraded marine ecosystems and the fish populations they support. Recognizing environmental uncertainty and ecosystem complexity, many scholars advocate more adaptive or ecosystem-based approaches to fisheries management (e.g., Sissenwine and Murawski 2004; Pikitch et al. 2004; Castilla and Defeo 2005) which require new, reliable sources of information at different scales than traditional data collection. Fishermen's local knowledge is considered to be one such information source. Although many scholars have demonstrated the value of fishermen's knowledge and advocated its use, fishermen's knowledge has generally played a limited role in science and management (Pálsson 2000; Neis et al. 1999). In addition, a parallel discourse calls for improving the effectiveness of fisheries management by including stakeholders in decision-making. A significant body of literature has illustrated how user participation in fisheries management decision-making in "co-management" can produce legitimacy and more effective regulations (Wilson, Nielsen, and Degnbol 2003; Jentoft, McCay, and Wilson 1998; McCay and Jentoft 1996). Today an expansion of this discussion focuses on the role of users in fisheries science through cooperative (or collaborative) research (e.g., Kaplan and McCay 2004; McCay 2005; Reid and Hartley 2006), the focus of this dissertation. Cooperative research can most simply be defined as fishermen and scientists engaged together in scientific research, with the nature or scope, level, and quality of engagement being critically important (McCay et al. 2006; Johnson and van Densen 2007).

Cooperative research must be understood in light of a long-standing tension between calls for both greater scientific oversight and increased public participation in public policy-making, which reflects a long-standing debate regarding the role of expertise. Even in the earliest history of the United States, the “republican instinct” advocated by Adams and Madison argued that governance should be left to the best and the brightest, while the “populist instinct” associated with Jefferson had more faith in the public to govern itself (Willard 1996). This debate is often depicted as being between those advocates of “representative democracy” who feel that non-expert citizens lack the knowledge and abilities to make complex decisions (the deficit model), and those who emphasize the virtues of active citizen involvement (e.g., legitimacy and local knowledge) and support a “participatory democracy" (Fischer 2000). Civic, citizen, civil, and participatory science are among the terms used to describe the growing “participatory paradigm” in science policy that views citizens as having a meaningful role to play in the production and use of knowledge (e.g., Irwin 1995; Fischer 2000). This is in part a response to the perceived scientization of politics, as well as the transition to post-normal science, where uncertainty is accepted as the norm, warranting greater political debate (Backstrand 2003).

Today, observers of the fisheries management process are aware of the tension between public participation and expertise, as is reflected in calls for “increasing the role of science in fisheries management” at the same time that greater transparency and stakeholder involvement are also increasingly encouraged. One example of this is through incorporating fishermen and their knowledge in management through cooperative research, which is now widely promoted and funded nationally (NRC 2004a).

Cooperative research may be thought of as a process that, in theory, integrates fishermen's knowledge with scientists' research-based knowledge to produce a new source of knowledge for decision-making. It can make fishermen's local knowledge more relevant or usable in the large-scale fisheries science policy process either by making it fit the requirements of scientific method or by aggregating it to a scale more compatible for science-based management. Cooperative research also functions as one of the mechanisms that enable public participation in decision-making. As with any more participatory form of policy-making, the collaborative process through which this knowledge is generated is expected to produce more legitimate and effective management institutions by generating broader acceptance of both fisheries science and the management decisions based on that science. Cooperative research, therefore, is both a mode of scientific knowledge production and a form of public participation. It can be thought of as "democratized science" (Guston 2004) and an extension of "joint fact-finding" (Andrews 2002) principles from the dispute resolution field, where diverse stakeholders seek out experts or information that are accepted as credible and relevant (Hartley and Robertson 2006b). Yet, there remains a tension between scientific expertise and fishermen's expertise, and about which should dominate in policy-making. In increasing the role of science in fisheries management (such as through legislation such as the Sustainable Fisheries Act and the precautionary approach) and funding industry involvement in scientific research, the U.S. Congress appears to be searching for a balance between scientific authority and public participation.

This research examines case studies in cooperative research and the significance of this “new” form of knowledge production, specifically whether and how it creates opportunities to integrate fishermen’s experience-based knowledge with scientists’ research-based knowledge for use in fisheries management. Does it indeed function to enable public participation and the integration of citizen knowledge into the science policy process? Does it facilitate dispute resolution and joint fact-finding?

This research focuses on the Northeastern U.S., where fishermen have opportunities to participate in fisheries science in ways that they feel never existed before. As one New England fisherman proclaimed: “Fishermen and Scientists working together - imagine that! Twenty years ago, it would not only be unthought of, but it would be considered criminal” (Wells 2002). The financial, institutional, and personal investment in cooperative research has been significant. Over thirty million dollars has been allocated to the Northeast region to fund cooperative research from 1999 to 2006, funding more than 250 projects.[1] Hundreds of fishermen have participated, with some fishermen participating in four to five different projects each year. Many fishermen now make their annual business plans based on how much financial support they will receive from collaborative research, and many count on this source of income. There has been significant investment by scientists and their staff in this research as well. For example, the regional fishery science center hired a cooperative research coordinator and other staff dedicated to cooperative research. Academic and non-profit organizations have also hired staff to support cooperative research programs. Both the New England and Mid-

Atlantic Fishery Management Councils have created cooperative research committees and implemented processes to handle cooperative research. In the Mid-Atlantic the National Fisheries Institute's fisheries auction functions to translate quota into research dollars (Stevens 2005). Similarly, the Commercial Fisheries Research Foundation was formed to organize and fund cooperative research in Rhode Island (Stevens 2006). The resurgence of cooperative research appears to be more significant than anything seen in the past and will likely be a permanent component of the science policy process in the Northeast (funding pending). Yet, surprisingly, cooperative research has received little attention by scholars. For example, the National Research Council (2004a) reported that "few studies of cooperative research have appeared in the published literature and what have appeared have been the results of cooperative research projects, not an evaluation of cooperative research" (8).

A few of these studies of cooperative research in the U.S. are notable.[2] Most relevant to the region of interest in this research, scholars at the University of New Hampshire, led by Drs. Troy Hartley and Rob Robertson, have started to explore some of the social and economic impacts of cooperative research in the Northeastern U.S., focusing on one funding mechanism: the Northeast Consortium (NEC). Hartley and Robertson (2006) referred to the Northeast Consortium as "a multistakeholder-driven process, open to all fishermen, encouraging and facilitating partnerships, promoting the transfer of findings to managers and other end-users, and monitoring progress to ensure that it would remain fair, inclusive, and credible" (Hartley and Robertson 2006a). Like other cooperative research programs, the NEC seeks to "provide economic assistance to fishermen, giving fishermen a voice in science, and address the underlying uncertainties in the science by promoting the integration of fishermen's knowledge with the scientific framework" (6). Although the authors do not define cooperative research explicitly, they do describe it as "partnerships" between the fishing industry and scientists (7). Hartley and Robertson suggest that the resurgence of cooperative research and the expansion of programs in the Northeast occurred because of a convergence of the problematic status of the region's fish stocks, socioeconomic hardship, and adversarial climate, rather than as a solution to specific policy and management problems.

Most studies looking at public participation in science policy focus on ordinary citizens' involvement, but fishermen possess specialized knowledge that "ordinary citizens" lack, based on their particular experiences. Collins and Evans (2000) define this "experience-based knowledge" as special technical expertise that is not recognized by certification. The value of fishermen's experience-based knowledge and its potential contributions to fisheries science and management is well documented (e.g., Neis and Felt 2001a; Johannes 1984; Pálsson 1995). In addition, U.S. fishermen are more than ordinary citizens in that they are also critical participants in the regional fishery management councils. The U.S. fisheries management system resembles a form of "co-management," where managers and users share in decision-making responsibilities (Jentoft and McCay 1995; Jentoft 1989; Pinkerton 1989).[3] Jentoft et al. (1998, 423) define co-management as a "collaborative and participatory process of regulatory decision-making among representatives of user groups, government agencies and research institutions." In theory, a participatory and relatively decentralized system, such as can be argued to exist for federal fisheries in the U.S., should facilitate the use of localized knowledge (Hayek 1945), in this case the knowledge held by fishermen.

However, U.S. law requires that management of resources be based on “the best scientific information available” (i.e., scientific knowledge) (NRC 2004b), which does not include fishermen’s experience-based knowledge. Moreover, it is extremely difficult, if not impossible, to incorporate the knowledge of fishermen, which is usually on a relatively small scale, into the large-scale, quantitative fisheries science and management paradigm (St. Martin 2001). For those and other reasons, institutional constraints limit the kind of data scientists can utilize when providing advice to managers (Wilson 2003a; Wilson and Degnbol 2002). Moreover, here and elsewhere in the world, non-scientific knowledge is treated as “anecdotal” and rarely acknowledged as legitimate to include in public decision-making (Pálsson 1998), even though such knowledge is often used (for a fisheries example see Wilson and Degnbol (2002)). Non-scientists are viewed as being “locked up in a particular natural or cultural world, driven by genetic makeup, ecological context, superstitious beliefs, or local concerns” (Pálsson 1998, 51). Thus, although there is significant interest in incorporating fishermen’s knowledge in management, such integration remains a challenge. In theory, cooperative research is a way to integrate fishermen’s knowledge into the science policy process, or, in terms of this project, allow fishermen and their knowledge to span the boundaries between science and non-science. In order for this to happen, knowledge produced from cooperative research must meet legal standards, including “the same level of peer review as traditional efforts” of knowledge production (Hogarth 2005, 42). This potential integration is explored in this research.

Relevant Literature Reviews and Research Questions

Science Studies

This research may be considered part of the interdisciplinary field of study known as “science studies” or “science and technology studies,” especially that part of science studies that emphasizes the social production of knowledge.

Traditionally, science is viewed as providing a rational basis for decision-making, and scientists are given privileged roles in this process. In this view, expertise is exclusive, where only scientists can be experts. Scientific knowledge is accepted based on the process through which it is created. Most individuals are familiar with the “scientific method” used by rational, objective scientists to produce new knowledge; i.e. the positivist philosophy of science. The central aim of science is to make observations, ask questions (i.e., set up testable hypotheses), conduct experiments to test the hypotheses, evaluate the results/data collected, and then reformulate the hypothesis and/or ask new questions. Most scientists accept Popper’s theory of falsification (Popper 1961): the testing of hypotheses with the understanding that hypotheses can never be proven, but only disproved. This view of science trusts that a truth exists to be understood, but again accepts that we may never “prove” what the “truth” is. Because nothing can ever be proven, scientists, in theory, should be driven to conduct new experiments so that an incorrect theory may be refuted and this process will allow scientists the possibility of hitting the correct theory (but without proof). Therefore, science is a process: the search of evidence to falsify theories. The falsification principle is the traditional demarcation method of science used to distinguish between science and non-science.[4] In this view, only those who follow the scientific process are experts, while others are non-experts.

It wasn't until the early 1970s that social scientists first began to fully appreciate science as a subject worthy of research, opening up the debate of how to demarcate science. However, as Collins and Evans (2002) discuss, this "first wave" of science studies explained and reinforced the success of science, without really questioning its basis.[5] Perhaps the most well known of this phase of science studies is the work of Robert Merton, who presented science as being guided by the "norms" of universalism, communism, disinterestedness, and organized skepticism (Merton, cited in Gieryn 1995). These together represent the "ethos" of science, which can be thought of as another way to demarcate science from non-science (Gieryn 1995). Universalism requires scientists to evaluate knowledge claims using objective and impersonal criteria. Communism refers to the sharing of scientific work among scientists, which is necessary for scientific progress. Disinterestedness refers to the idea that scientists should have no interest (e.g., financial or emotional) in the outcome of their work. Organized skepticism refers to the idea that scientists should wait until all of the facts are in before making a judgment regarding a theory. Merton identified these "norms" through a survey of scientists; therefore they reflect what scientists claim are the accepted guidelines for science and are merely rhetorical. Science scholars have assured us that these norms do not serve as an appropriate demarcation principle for distinguishing between science and non-science (Mulkay 1980). Yet, while such norms may not in fact exist or be exclusive to science, they do tend to be revered by scientists. Scientists use these norms as a resource to demarcate science from non-science, a form of boundary-making intended to legitimize their authority (Gieryn 1995). Thus, it is important to pay attention to the use of these norms by scientists, especially as they use them to differentiate themselves from others. In this research, therefore, I was interested in how, if at all, science is distinguished from other modes of knowledge production (i.e., fishermen's knowledge and cooperative research).

This dissertation follows in this "second wave" of science studies (Collins and Evans 2002), which opened the debate over the meaning of expertise. It emphasized the "social construction" of science, re-conceptualized science as a social activity, and suggested it did not represent anything socially exceptional (i.e., different than other social processes or institutions). This phase of science studies functionally began with Kuhn (1962) who, attacking positivist views of science, distinguished between when scientists accept the dominant paradigm (normal science) and when consensus is lacking and a paradigm is challenged and may ultimately be replaced (revolutionary science). Kuhn argued that the "new" paradigm is not adopted solely on empirical grounds, but that theory drives the selection process. Kuhn also emphasizes that science is not cumulative in the sense that a new theory is necessarily an improvement on the one it replaces. Many social scientists refer to science as "socially constructed." Many social constructivists go further than Kuhn by adopting a relativist epistemology that views scientific knowledge primarily as socially constructed rather than an objective description of reality and rejecting the role of empirical observations in the formation of scientific knowledge. Others, such as Hacking (1999) and Cole (1992), argue that empirical evidence is important in the development of scientific knowledge while still accepting that science is not always practiced in the rational rules-governed way described in the positivist philosophy of science. This view is also articulated in the concept of "co-production" (Jasanoff 2004), which is a conscious effort to avoid giving primacy to either the social or natural in science studies (i.e., social or natural determinism) (see also Latour 1993). In this view, science both "embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions" (Jasanoff 2004, 3). Adopting this perspective, I assume that while social processes shape the process and outcome of cooperative research, including its acceptance or rejection, so do empirical evidence and the tools used to analyze that evidence.

Public Understanding of Science

Research Question 1: How do stakeholders perceive the meaning of cooperative research? Does involving stakeholders in cooperative research improve stakeholder perceptions of science (i.e., generate buy-in to science policy)?

One of the most oft cited motives of cooperative research is to improve the public perception of science, resulting in scientific advice being taken more seriously by fishermen and fishery managers. In this study I explore the fate of collaborative research and investigate whether cooperative research is creating a better understanding of science and, thus, creating "buy-in" to fisheries science and management. Unfortunately, it is too early yet to know for sure whether cooperative research will create buy-in to fisheries science and management in the long-term, because of the pace of change in fisheries management, but I offer a preliminary examination into the perception of science conducted cooperatively with the fishing industry and identify several factors that are likely to hinder or enhance the buy-in of cooperative research to science and management.

A substantial body of literature related to science studies has examined the public perception or understanding of science (e.g., White and Hall 2006; Hull, Robertson, and Kendra 2001; Brossard, Lewenstein, and Bonney 2005). Generally, there are two dominant and countering discourses on the public perception of science. The first is the "traditional" discourse that views science as objective, rigorous, logical, productive, and unbiased (Ozawa 1996). This view tends to believe public policy issues related to scientific or technological issues should be left in the hands of the experts. This view is also sometimes referred to as the "deficit model" –suggesting that the public lacks the capabilities to participate in decision-making or is unable to understand the meaning of science (Irwin and Wynne 1996). The other view is more critical of science. Science is considered imperfect, and public rejection of science is not considered irrational. Reasons for public skepticism include exposure of "bad science" to the public, disagreement among experts and the deconstruction of experts in the policy-process, and academic critiques of science (White and Hall 2006). In this view, members of the public are viewed as rightful participants in policy-making.[6]

Improving the public understanding of science is important to scientists, especially those whose subject interacts with policy-making. This is especially true in fisheries. In fisheries, science tends to be poorly received by the public, particularly the fishing public, and often dismissed.[7] The fisheries crisis in New England has been blamed in part on the poor perception of the science, specifically the lack of consensus regarding the status of fishery resources and the need to reduce fishing mortality (Smith 1995). As Dobbs (2000, 5) noted, "the rift between fishermen and NMFS scientists over how to look at the ocean and think about fish fostered a level of discord, doubt, and mistrust that made it almost impossible to convince fishermen and regulators to curb overfishing." Fishery managers, responding to pressures from the fishing industry, tended to ignore scientific advice recommending that fishing effort (or fishing mortality) be reduced (Smith 1995; Hennessey and Healey 2000). The consequence has been the "groundfish crisis" where the traditional groundfish stocks (e.g., cod, haddock, yellowtail flounder) were depleted to exceptionally low levels, as members of the fishing industry and managers resisted taking corrective action (Boreman et al. 1997; Hennessey and Healey 2000).

Such distrust is exacerbated by public disagreements about data analysis and interpretation (Browman and Stergiou 2004). Mace (2001, 285) claims many papers exaggerate the severity and hopelessness of the fisheries crisis, saying that "the current perception of the status of marine species and ecosystems is overly alarmist; at best unhelpful and at worst destructive." For example, recently scientists' claims of large-scale biomass reductions in marine communities on the order of eighty to ninety percent (Myers and Worm 2003) have been publicly disputed by scientists (e.g., Hamilton et al. 2005). A more recent example is a report released in November 2006 that projects that ninety percent of fish stocks will be gone by 2048, a finding that NOAA and other scientists found to be too pessimistic (NPR 2006).[8]

Given the variability of marine ecosystem and fish populations, scientific assessments are bound to be controversial, as shown above, and uncertain (Hilborn and Walters 1992; Ludwig, Hilborn, and Walters 1993; Wilson et al. 1994). Yet, public expectations of fishery scientists are high. For example, Browman and Stergiou (2004, 270) ask insightfully, "Why does society have higher expectations of fishery scientists {than of meteorologists] with respect to their ability to accurately predict the number of fish that will be in the sea several years into the future?" Further, they ask "why is it so difficult for fishery scientists to convince society, authorities, and stakeholders to take a precautionary approach?" Because of the inherent uncertainty of stock assessments and the expectations for predictions, fisheries scientists become the focus of socio-political criticism, which Browmand and Stergiou (2004, 269) say is "surely one of the reasons that advice on catch quotas is not often strictly heeded."

Communicating science to the public is viewed as critical to improving the science policy process. Lewenstein and Brossard (2005) describe four conceptual models of public communication of science. In addition to the deficit model, where the problem is viewed as needing to educate an uninformed public, they describe the contextual, lay expertise, and public engagement models. Whereas the deficit model views individuals as responding like empty containers, the contextual model views individuals as processing information through cultural and experiential filters. Like the deficit model, this view has been criticized for conceptualizing the problem as involving the response of information in a way that is viewed as inappropriate to scientists. The third model, the lay expertise model, argues for the need to acknowledge knowledge and expertise of non-scientists. This model has been criticized for being "anti-science" and privileging lay expertise over scientific expertise. The final model is the public engagement model, where public participation in science policy is considered necessary, such as in consensus conferences, citizen juries, science shops, etc. This model can be criticized for focusing on the process of science and not the substantive content, rather than communicating information to the public, and for having an anti-science bias. Lewenstein and Brossard also note that where the first two models are concerned with communicating information to the public, the other two are about engaging citizens in science.

Cooperative research may be another model, one that advocates the public participation model, while avoiding the privileging of either scientific or lay expertise.

Mandated Science and Boundary-making

Research Question 2: What does cooperative research do to the boundaries between non-scientific and scientific knowledge in the context of the fisheries science policy process? What evidence is there of boundary making, spanning, and management as a result of cooperative research?

Especially relevant to this study on the knowledge used in the formation of fisheries management policy, scholars have focused on the interaction between science and the regulatory process. Salter (1988) argues that science used and evaluated for the purpose of making public policy is an atypical science and calls this "mandated science."[9] Mandated science is an idealized science; it is assumed to be value free and credible, and is depicted as an inherently public enterprise with open debate, peer reviews, and academic publication (Salter 1988). Yet, Salter, looking at standard setting for harmful chemicals, argues that mandated science conforms to none of these ideals. Similarly, McCarty (cited in Jasanoff 1987) identifies three classes of issues related to what he calls "science policy" – (1) questions cast in scientific terms, but unanswerable by science for practical or moral reasons; (2) questions that cannot be answered because of insufficient data but theoretically could be; and (3) questions characterized by expert disagreements about the interpretation or inferences drawn from them.

Certainly fisheries management based on scientific assessments of the status of marine fishery resources involves "mandated science" and the challenges of "science policy." Fisheries science is often done for the purpose of creating fisheries management policies.[10] Quantifying how many fish are in the ocean (i.e., stock assessment) is inherently difficult (if not impossible) to do given the highly variable, stochastic, and complex nature of the marine environment and fish population dynamics. Even if theoretically possible, this task is hindered by insufficient data (NRC 1998a). Also, in fisheries one sees different scientists, often from different institutions, arguing over the validity of stock assessments, and fishermen (a different kind of expert) more often than not disagree with scientific findings related to the status of fishery resources.

Sheila Jasanoff, looking at the U.S. regulatory process, examines how the use of science in the policy process puts unusual strains on science (Jasanoff 1990, 1995). When scientists are called upon to participate in policy-making, the authority of science is jeopardized. Knowledge claims by scientists are deconstructed when areas of weakness or uncertainty are exposed by competing claims. Regulators then must reconstruct science to present the public with a convincing scientific rationale for actions taken regarding scientific or technological issues. The process of deconstruction tends to exaggerate the extent to which science deviates from the Mertonian norms (Jasanoff 1987). It suggests that scientists frequently disagree in their interpretation of the data, that experts can be found to support virtually any reading of the evidence, and that the choice among different interpretations is colored by political interest (Jasanoff 1987, 198). For example, in natural resource management the deconstruction of science is precipitated by adversarial institutions, such as the courts (White and Hall 2006).

One outcome of the use of science in policy-making is that it forces scientists to transgress their area of expertise (Nowotny 2003). When asked to contribute as "experts" scientists most often do not answer questions that they had asked themselves, as they do in their research, but try to answer questions that others ask of them. These "experts" are often called upon to respond to a crisis in decision-making; such as when insufficient knowledge/information is available. Scientists also feel pressure to act as if they know the answers, and so are unable to say "we don't know." Notwotny (2003) identifies two ways expertise is "transgressive" - (1) when it addresses issues that cannot be reduced to purely the scientific or technical information and (2) addresses audiences that are not composed of fellow-experts (pressures with transparency, public access). This transgressivness of expertise increases its vulnerability to contestation, often in the form of litigation.

In order to maintain their cognitive authority and identity within the policy process, scientists often impose their own boundaries between what counts as science (i.e., distinguish between science and policy or non-science). For example, the "mandated" or "science policy" nature of fisheries management forces scientists and managers to impose boundaries between "scientific" knowledge and "non-scientific knowledge" (including fishermen's experience-based knowledge) and between "science" and "policy." This "boundary-work" often takes the form of discursive assignment of select qualities to scientists, scientific methods, and scientific claims (Gieryn 1999; Jasanoff 1987). In this view, the line or boundary between science and non-science is socially constructed and flexible, a result of boundary disputes. Non-scientists are also engaged in such boundary disputes. In policy-making, boundary-making functions as a resource. Parties involved in policy-making tend to agree that scientists should do science and policy-makers should make policy, but each party seeks to draw the line between science and policy to enlarge their own control over social decisions. In this view, studies of science need to examine the "territory" and write chronicles of the boundary disputes (Lynch 2004).

In studying the "territory," Gieryn (1999) suggests looking for three instances where boundary work may become important: expulsion, expansion, and protection of autonomy. Expulsion refers to a contest between rivals over what is to be considered "scientific" and what is not. For example, some may consider cooperative research "real" science and others may not because of the involvement of fishermen. Expansion refers to contests over jurisdictional authority over ontological domains. Different scientists, and fishermen, may try to expand their jurisdictional authority based on their involvement in cooperative research. Boundary-making arises when the professional autonomy of scientists is weakened by the exploitation of science as a resource by those outside. For example, federal fisheries scientists may seek to maintain their privileged role as providers of knowledge for fisheries management by reducing the legitimacy of cooperative research or by seeking to increase their role as gatekeepers of what is good science.

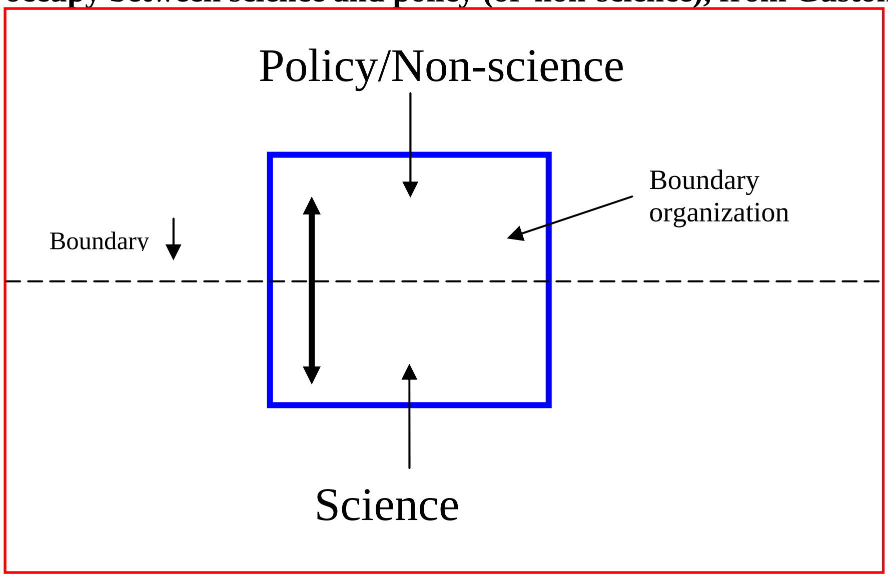
In addition to boundary-making, boundary management is critical in policy-making. Boundary management is necessary in order to avoid either the politicization of science or the scientification of politics (Guston 1996). Boundary management is done through "boundary organizations" which are institutions that negotiate the boundary between science and policy and are responsible to both sides of the boundary (Cash 2006; Guston 1996, 2000). The boundary organization is depicted in Figure 1-1. Boundary organizations make use of boundary objects and standardized packages. Boundary objects serve as a meeting ground between actors on both sides of the boundary (or the two social worlds of science and non-science), and they can be used by individuals within each for specific purposes without losing their own identity (Star and Griesemer 1989). Looking at the case of agriculture extension, Cash (2006) gives the example of models as boundary objects, as they depend on participation by both farmers and scientists for relevancy and credibility. Standardized packages are more robust than boundary objects, as they change practices on both sides of the boundary (Fujimura 1992).

Cash et al. (2003), looking at a variety of "knowledge systems" found that those that effectively harness science and technology for sustainable development do so by managing boundaries between "knowledge and action" (or experts and decision-makers or science and policy-making), while simultaneously enhancing credibility, legitimacy, and salience of the information they produce. Effective boundary management requires communication, translation, and mediation across the boundary. First, boundary organizations need to allow for communication across the boundary, such as by creating opportunities for exchange and learning. Second, it is important that there be mutual understanding, which is often hindered by language barriers and differential experience. Finally, there needs to be an established means for mediation of conflicts that will arise even with communication and translation that will maintain legitimacy of the process, such as through increased transparency, openness, and established criteria for decision-making. The authors further caution against making boundaries too porous or too rigid.

Cash et al. (2004) and others are concerned primarily with the boundary between science and policy (or knowledge and action), yet in this research this boundary must be expanded to include fishermen's knowledge since fishermen are both experts and managers in the U.S. management system. This research examines cooperative research as a boundary organization (or institution) that can function to effectively link knowledge to action in fisheries management, specifically fishermen's knowledge in the science policy (but also link science to policy). I examine whether cooperative research provides boundary management by (1) encouraging communication between experts, decision-makers, and harvesters, (2) increasing understanding (or expertise) between groups by translating information between stakeholders, and (3) increasing legitimacy by increasing transparency and order.

Another important boundary management practice important in this research is the peer review process that ensures that the boundary between science and non-science is not made too porous. Chubin and Hackett (1990, 2) define peer review as "an organized method for evaluating scientific work which is used by scientists to certify the correctness of procedures, establish the plausibility of results, and allocate scarce resources." Jasanoff (1990, 62) describes peer review as a "social compact created and sustained by the self-centered communal needs of science." Peer review "drives a wedge between nonscientists and the process of claims-making" because "scientists jealously guard their power to accept or reject the findings of their peers" (Chubin and Hackett 1990, 4). In fisheries, the peer review process is used in the context of the legal mandate to ensure the "best scientific information available" is used in fisheries management. Thus, to be useful, cooperative research must also be subject to "the same level of peer review as traditional efforts" of knowledge production (Hogarth 2005, 42). The peer review process may function on some occasions to limit the use of cooperative research in fisheries management, a boundary-making activity.

Figure 1-1: Depiction of the space that boundary organizations (solid blue line) occupy between science and policy (or-non-science), from Guston (2000, 149).



Expertise in Policy-making

Research question 3: What kind of expertise is involved in these cooperative research efforts– and what, if any, expertise is shared across the boundary between scientists and non-scientists?

In studying the boundaries between science and non-science and how they are managed, I look closely at what kinds of expertise are involved in these collaborations. I question whether involvement in cooperative research can increase fishermen's expertise in science and the subject of study from "no expertise" to "interactional expertise" to sometimes "contributory expertise" – and if so, what this does to the boundary between science and non-science. When expertise is gained, I refer to this as capacity building, which enables communication and a shared understanding across the various knowledge cultures.

When studying science, it is critical that one retains an appreciation of expertise. Within science studies, Collins and Evans (2002) note that "deconstruction" studies leave unanswered the question of what it means to be an expert. This "relativist" view makes it difficult for productive dialogue regarding the role of science, expertise, local knowledge, and the public in policy-making. Evans (2005) argues that there is a need to rescue expertise from the anti-essentialist consensus that there is no demarcation between science and non-science. He cautions:

> "Despite the tendency among science studies scholars to urge, and even celebrate, the "dethroning" and "democratization" of science, the consequences of this should at least cause us to pause and ask if, despite what we know, there is a need to retain a delimited but still privileged role for science in society" (page 13).

Accordingly, there needs to be recognition that some claims to expertise are better than others. For example, elites and others with political power can take advantage of the "democratization of expertise" by promoting knowledge that supports their interests in decision-making regardless of its "scientific" legitimacy. Looking at climate policy in the U.S., Lahsen (2005) illustrates the picking and choosing from among available scientific evidence on the climate issue in ways that suit specific belief structures. Lahsen (2005, 161) argues for the need to "discriminate between better and worse sources of scientific claims" and be aware of information produced by less rigorous methods and studies funded and designed to benefit, financial and political elites over the general good.

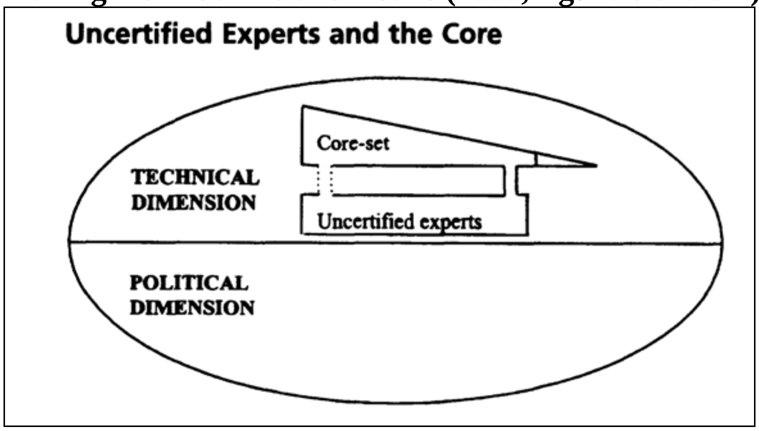
Similarly, we would expect that some cooperative research to be "better than others" and we should not expect that it would all be incorporated into science and management. When it is not, it does not mean that cooperative research is treated as inferior to traditional research. In some cases, the results are inconclusive, such as when not enough samples are taken or the research is not conducted across relevant spatial and temporal ranges. In some cases expectations are not achieved and so there is nothing relevant for the policy process (e.g., a gear configuration tested fails to achieve bycatch standards). Similarly, as I discuss later, it is also critical to not assume that all fishermen's knowledge is the same, or always better than scientific knowledge, and is always relevant to science and management. At the same time, it is also important to pay attention to the motivations of those advocating the use of or funding for certain research. As in Lahsen's climate policy research, there is an incentive for individuals to pick and choose information depending on whether the outcome suits their beliefs or interests. It is important to be critical of all stakeholders in this regard. For example, scientists may reject certain results because it conflicts with information collected historically. Or fishermen may reject certain results that they feel are politically motivated and might result in unwanted management (e.g., results of studies assessing the impact of dredging on habitat).

Collins and Evans (2000) argue for the "reconstruction of knowledge" and more "studies of experience and expertise" (SEE), which they refer to as the "third wave" of science studies. This is needed to address what they call the problem of extension: how far to extend participation in decision-making and whether there are any limits to "non-expert" participation. First, they abandon the oxymoron "lay expertise" and instead use the term "experience-based expertise" to refer to members of the public who have special technical expertise that is not recognized by certification. Collins and Evans further identify three levels of expertise: (1) No Expertise, (2) Interactional Expertise, and (3) Contributory Expertise. No expertise means that they do not have any knowledge or experience related to the subject. Interactional expertise refers to individuals with enough knowledge or experience to interact with participants and understand the science related to the subject, but not enough to contribute to the science. Those with contributory expertise are the experts that have the knowledge and experience to contribute to the science.

Although an analytical simplification, I find this characterization of expertise provided by Collins and Evans (2000) useful. As I discuss later, fishermen are one example of individuals possessing "experience-based" expertise. Depending on the subject, different fishermen are likely to have different levels of expertise. For example, a lobsterman may have *no expertise* related to bottom trawl fishing gear. Some fishermen only have interactional expertise about a fishery that they do not participate in based on knowledge communicated to them by other fishermen and because of their experience in a similar fishery. Most fishermen likely have contributory expertise related to the fishery and local area that they are most familiar with. This categorization is also relevant to scientists. A stock assessment scientist focusing on cod may have no expertise related to gear technology, but interactional expertise related to haddock stock assessment. Interactional and contributory expertise would be applicable for both science and management. Some fishermen and scientists hold contributory or interactional expertise that allows them to participate in some science projects and management debates, and not in others.

Depending on the level of expertise they possess and the kinds of scientific issues being considered, different members of the public are likely to contribute differently to policy-making. Similarly, all scientists are unlikely to always have something to contribute simply because they are certified experts, but their contribution will vary by the circumstances of the problem being addressed (i.e., they will contribute based on their specialties). The contribution of the public and experts to decision-making is depicted in Figure 1-2. Certified (from the core-set of scientists) and non-certified experts with contributory expertise are expected to contribute to the technical dimension of the problem, whereas the public (including the scientists who are not members of the core set) still has rights (or opportunity) to participate in the political side of decision-making.

Figure 1-2: Depiction of the contribution of "experts" and the public to decision-making from Collins and Evans (2000; figure 6 therein).



The Nature of Knowledge and Expertise in Marine Fisheries

Research Question 4: Does cooperative research enable the use of fishermen's experience-based knowledge (FEBK) in the science policy process? Does cooperative research enable the integration of local FEBK into the large-scale, research-based knowledge (RBK)-based paradigm of fisheries management? What is the nature of the interaction between FEBK and RBK in cooperative research?

I now discuss the expertise most relevant in fisheries management – that held by fishermen and scientists. As noted, in the case of fisheries science and management, fishermen can be considered non-certified, experience-based experts, borrowing Collins and Evans terminology. Scientists can be considered to have certified, research-based knowledge. As I discuss, merging these two forms of expertise is desirable, but has proven inherently difficult, especially since expertise is more complex than the typical “two cultures” view.

Fishermen’s Experience-based Knowledge

> “Artisanal fishermen offer a shortcut for obtaining important basic natural history data for these species. They know much about local marine resources which biologists do not. This is not surprising since they were plying their trade and passing on accumulated knowledge long before we marine biologists entered the picture.” (Johannes 1984, 32.)

Local Knowledge and Its Variants

Traditional ecological knowledge (TEK), indigenous knowledge, local knowledge, and local ecological knowledge (LEK) are variants of knowledge that is traditionally differentiated from science-based knowledge. TEK is defined as “a cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission” (Berkes, Colding, and Folke 2000). TEK and indigenous knowledge mainly refers to the knowledge found in indigenous societies with hundreds or thousands of years of association with their local environment (Inglis 1993). Mailhot (1993) defines it as the “data and ideas” acquired by individuals based on their “use and occupation” of an environment over generations. In addition to being site specific, TEK is also both dynamic and cumulative. The utility of this type of knowledge is well documented (e.g. Drew 2005; Inglis 1993).

Modern fishermen’s knowledge (i.e. non-indigenous) must be differentiated from TEK and indigenous knowledge, because contemporary fishermen are typically more transient and more influenced by external factors such as technology and social/economic systems compared to indigenous societies (Neis and Felt 2001;13). Accordingly, some researchers studying fishermen's knowledge often use the term "local ecological knowledge" (LEK), emphasizing that it is both local and derived from experience in a unique social and physical environment (Neis and Felt 2001b). It is considered local because it is generated through interactions with specific social, technological, and natural environments (Kloppenberg 1991). Murray et al. (2006) describe fishermen's knowledge as fundamentally dynamic that changes along with the socioecological network in which it is embedded. They further describe a continuum from small-scale, locally situated, long-term, harvest-oriented LEK to globalized harvesting knowledge (GHK), "a combination of experiential, intra-fleet and formal extra-fleet knowledge about a broader range of ecologies and practices." Oles (2004) uses the term "fishermen's ecological knowledge" (FEK) to refer specifically to knowledge derived from fishing and is analogous to fishermen's LEK.[11]

In this research, I use the term "fishermen's experience-based knowledge" (FEBK). This term, I believe best conveys the idea that the expertise held by fishermen includes the knowledge and skills related to marine ecosystems and fisheries, produced from repeated interactions between fishermen and their social-ecological environment (i.e., from experience). In addition, fishermen's knowledge also has a social component, such as knowledge of local norms and institutions, which is often missing from descriptions of fishermen's knowledge. A critical aspect of fishermen's experience-based knowledge missing from traditional definitions like TEK and LEK, but included in the definition offered here, is the technological-ecological knowledge related to handling and innovation of fishing gear technology. This knowledge can be considered ecological in that fishermen know how to use certain fishing technology in certain environments, including what will be caught and how it may interact with the environment and habitat. In addition, like TEK and LEK, FEBK is dynamic and cumulative. FEBK is heterogeneous among members due to differential experience. Consequently, as discussed above and following Collins and Evans (2000), I accept that not all expertise or FEBK is the same or equal; i.e. some FEBK is “better” than others in certain situations or contexts. FEBK is expertise that is not “certified” but based on experience and is valid for use in public policy.

Drew (2005) identifies three advantages of using TEK in marine conservation: location-specific knowledge, knowledge of environmental linkages, and local capacity building and power sharing. According to him, TEK falls into three categories that match and therefore can augment conservation biology: folk taxonomy and systematics, population level knowledge, and ecological relationships. FEBK, in particular, has been documented extensively by scholars. Robert Johannes (1984) argues that more attention should be paid to fishermen’s knowledge, showing how reef fishermen’s knowledge of spawning times and locations and fish migration enhanced biologists knowledge and contributed to management. Indeed, fishermen possess knowledge about stock structure , migration patterns, spatial and temporal locations of fish populations, fish identification, fish behavior, bottom characteristics (including habitat) and current and historic spawning grounds, juvenile habitat locations, and spatial patterns in fish morphology (e.g., Maurstad and Sundet 1998; Neis and Felt 2001a; Ames 1997; Johannes 1984). Fishermen’s knowledge has also been shown to include valuable information about schooling behavior (Parrish 1999) and habitat and gear selectivity (Glass 2000; Hall-

Arber and Pederson 1999). Fishermen also understand the social and economic systems in which they are imbedded, and so their knowledge has a social-economic component. For example, fishermen's knowledge includes understanding of effort changes in response to regulatory change (e.g., Neis and Felt 2001). Clayton (2000) argues that fishermen can contribute their perceptions on the state of the stock and factors influencing fishing effort levels to stock assessments.

FEK Research

A number of studies include the documentation and aggregation of fishermen's knowledge for use in science and management. Holm (2003) refers to these studies as "FEK research" and explains how the intention is to clean up or translate fishermen's knowledge into a form that is usable by scientists and managers. The idea is to take local knowledge and make it generalizable or simply prove it has validity.

Several examples of such studies are illustrated in Neis and Felt (2001 in their edited volume: "Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management." This volume presents case studies of fishermen contributing their knowledge to scientific research by sharing their knowledge with scientists. In general, fishermen in these case studies often contributed knowledge about locations and uses of fishery resources and were not necessarily always involved in the implementation or design of the study. Researchers in these case studies generally celebrated fishermen's knowledge, illustrating how it was vital to the success of the project and advocating its future use. A few examples from the collection are noteworthy: Gisli Pálsson describes the challenges of integrating fishermen's knowledge with scientific knowledge and provides the example of the Icelandic "Trawling Rally" – where fishermen tow the same path as part of a systematic fishery-independent survey. In this case, fishermen are involved in scientific research primarily by providing research platforms, and many remain skeptical regarding the design and results. Wroblewski illustrated how fishermen's knowledge of different cod stocks (based on color variation and behavior) was confirmed through scientific research. Scientific methods were used to "prove" hypotheses based on fishermen's knowledge. In this case, fishermen's knowledge was cleaned-up or "translated" for use in science and management. Hutchings and Ferguson documented temporal changes in catch rates and fishing effort through interviews with fishermen. In this case, fishermen's knowledge was simply recorded, with fishermen as relatively passive actors in the effort. Most promising is the Fishermen and Scientist Research Society (FSRS) described by Zwanenberg et al, an organization for enabling cooperation and knowledge sharing between fishermen and scientists. Again, these studies document instances where fishermen's knowledge has been collected and/or used by scientists, but fishermen themselves were not key players in all phases of these research projects.

Another notable study that documented fishermen's knowledge is Ted Ames (1997) research on historic (extinct) cod and haddock spawning grounds of inshore Maine. Ames, a fisherman with a science degree, documented "old time" fishermen's local ecological knowledge of historic spawning locations of cod and haddock populations in the Gulf of Maine through the use of oral histories. In this study, retired fishermen provided their knowledge of the locations of cod and haddock spawning grounds, when they were active. This information was needed for a project that aimed to reintroduce groundfish into inshore areas that had long been depleted; these areas were unknown to current fishermen and scientists (Ames 2003). In a related study, scientists used side-scan sonar was used to confirm the accuracy of the fishermen's reports (Barnhardt et al. 1998; Ames 2003). Ames compiled maps of the areas identified by fishermen using a GIS database. However, before producing the maps, Ames used a method for verifying the information. This study is unique in that it contributed directly to management; the State of Maine used this information to close inshore fishing in state waters in 1998 for five years. Ames extended his research on cod and haddock spawning grounds by combining his findings with scientific data from the 1920s and making a case for the existence of localized spawning components that were depleted as a result of "system-wide" assessment and management, and argues for decentralized, hierarchical management at the scale of the cod subpopulations (Ames 2004). More recently, this work has inspired interest in "area-based management" and local management of fisheries in Eastern Maine. The most notable effort is the Downeast Maine Groundfish Project (Treadwell 2006; Schreiber 2007).[12] Lessons learned by Ames about interviewing fishermen include the need to find the best source of information (rather than random sampling), difficulty verifying fishermen's knowledge and integrating it with conventional fisheries data; and the possibility that fishermen using different gear types will provide different information. He also noted that fishermen are often mistrustful of sharing "hard-won knowledge" and are reluctant to participate if information is collected just for the sake of collecting it (i.e., with no purpose for improving the fishery). Fishermen are also hesitant to participate due to concern regarding the potential misuse of the knowledge they provide, especially when knowledge is made public or used in fisheries management (Ames 2003).

Different methods are used by both social scientists and biologists in studies documenting fishermen's knowledge for use in science and management, with most studies relying in some form on interviews with fishermen. Many researchers also rely upon interviews that included a mapping component to document the spatial aspect of fishermen's knowledge (e.g., Neis et al. 1999; Ames 2004). Neis et al. (1999) assembled detailed information from fishermen in Newfoundland through three types of interviews: taxonomy/toponomy, career-history, and follow-up, structured telephone interviews. In addition, they held "feedback meetings" to check findings. They further showed how some of this local knowledge could be quantified for use in quantitative assessments. Hall-Arber and Pederson (1999) conducted a pilot project to systematically collect information about habitat and effects of fishing gear and found that focus groups were better for collecting information than questionnaire and that fishermen's knowledge requires independent verification because different fishermen often expressed different points of view, making it difficult to delineate "fishermen's knowledge." Davis and Wagner (2003) cautions researchers to do a better job at reporting their methodology and should be more systematic in their identification of local experts.

These FEK studies could theoretically be considered "collaborative" or "cooperative" since they include participation by fishermen and scientists. However, they are not considered collaborative in this study, as fishermen are only passive, albeit still important, participants and communication is generally one-way – from fishermen to scientists. In these studies, fishermen rarely have the opportunity to contribute to the design, implementation, or analysis phases of the research. Fishermen can be considered the tools or instruments to gather data on the subject of inquiry (i.e., fishermen's knowledge or the specific type of FK).

The Nature of FEBK

Scholars have also addressed epistemological questions of FEBK and local knowledge. Many studies have focused on understanding differential success of skippers, questioning whether the skipper is significant in explaining differential catches among captains (Jepson, Thomas, and Robbins 1987; Pálsson and Durrenberger 1990; Russell and Alexander 1996; White 1992). Studies have also explored how fishermen make decisions, such as where to fish. While some argue that the process is rational, Gatewood (1983) found that fishermen make decisions regarding where to fish based on hunches that they later describe as rational, as it is not possible to compute a single optimal decision.

Others scholars emphasize that the decision-making process of fishermen is based on experience and knowledge (e.g., Thorlindsson 1994; Pálsson 1994). Most notably, Pálsson likens fishermen enskilment (learning) to "finding one's sea legs" or overcoming sea sickness. Pálsson emphases that learning is a process of immersion in the practical world, and dismisses the view of fishermen's knowledge as culturally transmitted through the internalization and application of a mental script (or a cognitive model). Fishermen's knowledge is then based on practice and experience. Similarly, Thorlindsson (1994) says that fishing success requires reflexive practice and skill, and involves making observations and looking for patterns, developing hypotheses, and limited experimentation. Skipper success depends on the ability of the skipper to develop a good theory on fish behavior, read the environment, and utilize fishing gear skillfully. The learning process that fishermen go through involves observation, discussion with experienced fishermen, and at sea experience; an inductive approach fueled by attention, patience, and creativity (Thorlindsson 1994). This supports the adoption of fishermen's knowledge as "experience-based."

The "experience-based" nature of fishermen's knowledge means that issues of scale significantly influence the nature of fishermen's knowledge, which has implications for the use of FEBK by scientists and in fisheries management. Fishing activities occur across numerous spatial and temporal scales, and thus fishermen experience changes in the marine system at various scales. Since fishermen's knowledge is often related to experience, fishermen with different experiences (due to gear type used, seasons fished, locations fished, etc.) will possess different kinds of knowledge. For example, an inshore lobster fishermen using fixed gear will likely have a different view of nature than a groundfish fishermen using mobile trawl gear. In addition, Murray et al. (2006) note that individual fishermen exist on difference places on a continuum from local knowledge to globalized harvesting knowledge. Thus, fishermen's knowledge is complex and variable over space and time. It is erroneous to view fishermen's knowledge as homogenous or to assume that all fishermen have the same view of nature. Further, Drew (2005) cautions that not every individual in a given community will likely hold (or divulge) the culture's entire knowledge. Thus, as mentioned above, depending on the subject, fishermen will possess different levels of expertise on any given subject ranging from no expertise to interactional expertise to contributory expertise (Collins and Evans 2000).

Related to the issue of scale, knowledge can be distinguished as either anecdotal or systematic (Wilson 2006). Anecdotal knowledge refers to that which cannot be used to characterize phenomena at higher scales, while systematic knowledge is gathered by specific procedures with the purpose of linking observations to higher scales.

Fishermen's experience-based knowledge can be most accurately described as having both tacit and discursive characteristics (Wilson 2003b). Since much of fishermen's knowledge is based on experience and observation, or immersion in the practical world (Pálsson 1998, 1994), it tends to be difficult for fishermen to communicate. Yet some fishermen do communicate aspects of their knowledge to others as well (Stuster 1978; Ruddle 1993; Thorlindsson 1994; Oles 2004). For example, seventy-one percent of those interviewed by Oles (2004) in New Jersey claim to actively teach other fishermen about fishing and seventy-six percent claim to have been taught some of their knowledge by others. In addition, many fishermen keep written records of their knowledge in their logbooks (e.g., Oles 2004; Hall-Arber and Pederson 1999). Thus, fishermen's knowledge can also be in either written or oral form (Wilson 2006).

Thorlindsson (1994) borrows Merton's term "cooperative competition" to describe the production and distribution of fishermen's knowledge. Fishermen tend to be very selective in the sharing of their knowledge, recognizing the advantages and disadvantages of sharing their knowledge. On the one hand, fishermen's knowledge is proprietary information that allows fishermen to be successful in the competitive fishing business. On the other hand they can benefit when others are reciprocal with their knowledge. Wilson (1990) explains how fishermen need to cooperate to learn in complex marine environments. Some fishermen are selective with who they trust to share their knowledge with. For example, many share with individuals from their port or with kin, and some fishermen routinely fish together to increase the likelihood of success, and for safety reasons (Wilson 1990; St. Martin 2001). In some cases, fishermen set up codes for communicating information via radio (Stuster 1978). Thorlindsson (1994) found that fishermen are less secretive about fishing gear and safety knowledge than about catch. In any case, although some degree of sharing occurs between fishermen, many fishermen don't share their knowledge with scientists because they are afraid the information will be used against them in the form of fishing restrictions (Hall-Arber and Pederson 1999).

Due to its diversity and heterogeneity, as well as its anecdotal and tacit nature, fishermen's experience-based knowledge is more difficult to apply to fisheries management problems than is research-based knowledge (Wilson 2006). Scientists feel they must often verify fishermen's knowledge, not necessarily because they think individual fishermen are ignorant or prone to make up observations that are favorable to them (i.e., self-interest maximizing), but because they need to "delink" the experience of an individual fisherman from his knowledge. In other words, they must prove the reality of the observation or knowledge and make it generalizable beyond the local experience of the fisherman. This may involve something as simple as documenting similar observations from numerous fishermen or something as complex as a controlled experiment. The scale of fishermen's knowledge does not always match the scale of scientific questions, which are driven in large part by existing institutions. The comparatively local aspect of fishermen's knowledge is still valid to science and management, which typically focuses at scales larger than the experience of individual fishermen, but the contribution that it has will vary depending on the question or type of knowledge being pursued. For example, St. Martin (2001) suggests fishermen's local knowledge is not easily incorporated into the current large-scale, single species-based fisheries management paradigm, but could be integrated in area-based or community-based management approaches.

Incorporating FEBK into science and management can involve both (1) making the tacit knowledge discursive and (2) increasing trust to encourage the sharing of FEBK by fishermen. Indeed, many social scientists or “FEK researchers” (Holm 2003), seek to collect and clean up FEK to make it complementary to scientific knowledge for management purposes. For example, Hall-Arber and Pederson (1999) reported habitat information collected by fishermen. Mackinson (2001) offers an innovative way of integrating fishermen’s knowledge into science using “fuzzy logic.” Neis et al. (1999) showed how fishermen’s knowledge could be documented for use in stock assessments. Ames (1997) gathered and aggregated fishermen’s knowledge of cod and haddock spawning grounds. According to Holm, translation of fishermen’s knowledge into a form usable by science and policy-making is done through a process of “transcription” or “purification” and this can be problematic. For example, Agrawal (1995) argues that the process of translating EBK can change the knowledge in such a way that it becomes unrecognizable to the resource users. The result is that users are disempowered, as their knowledge is transformed, alienated or distorted as it loses coherence out of context (Maurstad 2002).

In summary, based on a review of the studies of fishermen’s knowledge, I use the term “fishermen’s experience-based knowledge” (FEBK). I acknowledge FEBK to be localized, heterogeneous, and scale-dependent, with both discursive and tacit components. The nature of fishermen’s knowledge as experience-based means fishermen will have varying levels of expertise to contribute to science and management.

Depending on the context of the management problem or research topic, fishermen will have no expertise, interactional expertise, or contributory expertise. I also recognize that the nature of FEBK is such that its incorporation into science and management is challenging and will be context dependent. In this research, I explore the incorporation of FEBK into cooperative research, and then the incorporation of cooperative research results into management in a number of different contexts: involving different species/fisheries, funding sources, and management institutions.

Scientific Research-based Knowledge

Unlike FEBK, fisheries research-based knowledge (RBK) can be considered a form of "certified" expertise. And unlike FEBK, the production of fisheries science and/or fisheries scientists' research-based knowledge (RBK) has received less attention by scholars (but see Finlayson 1994; Wilson 2003a; Wilson et al. 2002; Alcock 2004).

Those who have studied fisheries science and scientists have used different methods and made different contributions to our understanding of fisheries science. For example, Christopher Finlayson's *Fishing for Truth*, examines the role of science in the collapse of the northern cod fishery in Eastern Canada and argues that scientists' dismissal of inshore fishermen's warnings about the health of the resource directly contributed to the collapse of the fishery. Through interviews with Department of Fisheries and Oceans scientists, Finlayson illustrated the cultural, institutional, and political aspects of the "construction" of fisheries advice. Most insightful are quotations imbedded throughout of a DFO scientist's honest reflections on the author's narrative. Finlayson gives both institutional and cultural explanations of the construction of fisheries advice and the fishery collapse. Doug Wilson's (2003) study of bluefish science and management is based on observations of the management process. Wilson found both cultural and institutional influences to be important in explaining the outcome of the disputes (Wilson 2003a). Most interesting, Wilson observed scientists' reluctance to use anecdotal fishermen's knowledge as the "best available science" because of legal mandates, not because they disagreed with its content (Wilson and Degnbol 2002).

Finally, Wilson et al. (2002) conducted a survey of fisheries scientists in the Northeastern U.S. illustrating both similarities and differences among different types of fisheries science. For example, they found that scientists working in management agencies are more positive about working with fishermen than are conservation and academic scientists. These studies illustrate the need to be aware of the cultural and institutional factors that may influence the interaction and use of science, cooperative research, and fishermen's knowledge in various settings.

Alcock (2004) demonstrates how the institutional structure linking fisheries science to policy-making affects perceptions of salience, credibility and legitimacy by stakeholders. He argues that fisheries stock assessment processes that are embedded within policymaking organizations are more influential within those organizations than outside of them, while autonomous assessments are more influential than embedded assessments with a broad range of stakeholders affected by fisheries policies but less influential within the policymaking organizations themselves. Alcock (2004, 136) provides an interesting comparison between the institutional structures found in Canada and the U.S.: "Unlike Newfoundland, where scientists marginalized industry concerns, the situation in New England is reversed. NEFMC and the industry interests that dominate it have long marginalized NMFS scientific recommendations." The Canadian stock assessment process and resulting crisis illustrate the problems with embedded organizations, suggesting that such processes tend to be less transparent and more apt to misreport uncertainty. This reduces the salience, credibility and/or legitimacy of these processes in the eyes of external stakeholders. The U.S. stock assessment process is considered autonomous, and transparent. In the U.S. the separation of knowledge production (by the Northeast Fisheries Science Center) and management (by the New England Fishery Management Council) resulted in the dismissal of scientific advice by managers because it was perceived to be at odds with the perceived interests of council members (mostly fishermen). Unlike managers in Canada, U.S. managers are unable to influence scientific advice, and so they tend to question the salience, credibility and legitimacy of the stock assessments when the advice contradicts a strong policy preference. Cooperative research is perhaps a way that stakeholders can influence the autonomous production of scientific advice, while addressing the issues of salience, credibility, and legitimacy.

Fisheries science in general produces a diversity of different kinds of knowledge about the marine environment and its resources, as well as social and economic data regarding the fisheries and fishing communities that rely on those resources. A complete review of all knowledge produced for fisheries management is outside the scope of this analysis. One can think of fisheries science-based knowledge as ideally produced through the systematic collection of data from the fishery and the marine environment and through experimentation. This systematic collection of data allows processes that happen at higher scales to be understood. Fisheries management is a critical force driving the kinds of research questions, the kind of data collected, and thus, the knowledge produced by fisheries scientists.

Like FEBK, the production of fisheries RBK is a "community" effort in that most of what an individual scientist "knows" is built upon observations or knowledge produced by others, and the process is guided by shared norms and expectations (although many argue that norms and practices have little to do with the content of science). Scientists follow similar intellectual paths of formal learning in academic institutions and through on-the job training, and so they share life experiences. Scientists are supposed to ask questions and be skeptical of ideas. Scientists are supposed to be value free and disinterested in the results (i.e., they should advocate the result because they are based on science, not for personal reasons). Merton's notion of "communism" is especially important for the advancement of science. Most of fisheries science is shared widely throughout the scientific community and the public at large, although scientists, like fishermen, operate under "cooperative competition." In science, there are incentives to be the first to make (and publish) a discovery, which imposes some limits to how much and how often sharing between scientists occur (i.e., there is some competition). However, the rewards for sharing knowledge are perhaps more important in science. Often professional advancement relies on publication of research results. Scientists are also rewarded when others refer to their work, such as in citation. Scientists spend a good deal of their time presenting findings at conferences and then publishing their results in peer-reviewed journals. Jasanoff (1990, 62) discusses peer review as a "social compact created and sustained by the self-centered communal needs of science." Scientists also spend time keeping up with what others are doing and/or did in the past, as they are often expected to build on other scientists' work. Science, thus, produces knowledge primarily for internal consumption (Andrews 2002). Although knowledge sharing is common with fishermen, the level of sharing is unlikely to be as great as it is among the scientific community. This is because of the proprietary nature of the knowledge; sharing too much knowledge with other fishermen (their competitors) could economically and socially disadvantage them (e.g., Stuster 1978; Maunder and Starr 2002).

Another activity that illustrates the "competition" between scientists is writing grants and research proposals to fund their research. This is essentially competition for limited resources necessary to do science. In many, but not all instances, scientific research is limited by the availability of funding. Academic fisheries scientists must write grants to fund their research, unless they are contracted by federal or state governments or by the industry. Government scientists, both state and federal, also work with limited budgets, and the research they do is often directed by the mandates of the agency in which they work, whereas academic scientists can, in theory, have more freedom regarding their work. In some cases, a significant portion of the fisheries scientist's time is spent writing grants and/or securing funding for research. Success in securing funding is related to the ability of the scientists to write grants that "sell" their ideas to the funding agencies and illustrate their expertise and credentials that demonstrate their abilities to do the research, including past research success.

Most importantly, the production of fisheries RBK is influenced by the large-scale and single species focus of fisheries management, and more recently by growing interest in ecosystem-based fisheries management. Most fundamental are the quantitative assessments of the current and future status of fish populations, which are done through the systematic collection of fishery-independent information (i.e., from resource surveys) and fishery-dependent data (i.e., information on catch and effort from the fishery) (Hilborn and Walters 1992; Gulland 1985; Sissenwine, Azarovitz, and Suomala 1983). These data are fed into quantitative stock assessment models used to characterize the status of the population, mainly in terms of biomass and fishing mortality indicators. Because marine environments are highly variable and complex, it is inherently difficult to assess the status of fish populations and predict how they will respond to management intervention. Thus, the bulk of fisheries science, and management based on that science, is plagued by high levels of uncertainty (Ludwig, Hilborn, and Walters 1993). Because much of fisheries science is used for creating fisheries management policy, it is "mandated science" and subject to external scrutiny and deconstruction, and so boundary-making is often seen to try to maintain the authority of science (such as by efforts to separate science from policy and the dismissal of non-scientific, anecdotal knowledge of fishermen).

The Challenge of Integrating FEBK and RBK

Several scholars suggest there are systematic differences between fishermen's knowledge and scientific research-based knowledge. Some view these differences as due to differential experiences and cultural backgrounds which cause them to see the world differently (i.e., that they have different cultural or cognitive models; see Paolisso 2002 and Smith 1995). Others, such as Agrawal (1995), reject the dichotomy between indigenous and western knowledge. It is also important to recognize the divisions that exist within the categories FEBK and RBK; both fisheries science and fishing communities are internally diverse and heterogeneous. For example, within fisheries science there are numerous specializations (e.g., oceanography, biology, ecology, gear technology, stock assessment, etc.) and different scientific institutions (e.g., federal science, academic, and non-profit institutions) (Wilson 2003b). Within “the fishing community” there are numerous place-based (i.e., associated with ports or states) and species or gear-sector communities (e.g., Cape Cod hookers, fixed lobster gear fishermen, trawl fishermen, etc.). The “two cultures” view is an over simplification given that there are in reality many cultures of both fishermen and scientists, and that this approach “disregards the importance of institutions in the creation and definition of the knowledge base for fisheries management” (Wilson 2003a, 492). While recognizing the diversity and complexity of knowledge types and the importance of institutional factors, as well as the limits of simplification, I think it is still important to distinguish between two general types of knowledge without privileging one over the other. One can think of fisheries scientists’ knowledge as research-based, while fishermen’s knowledge as experience-based.

Both FEBK and fisheries RBK are social constructions of nature, and so it is important to consider the ways in which knowledge is created by different groups (Wilson 2006, 2003b). As already noted, the scale of observation is important to how different groups interact with the world - be they different fisheries scientists or fishermen. This creates a potential “divide” between their knowledge. The spatial and temporal scale of scientists’ research-based knowledge differs significantly from knowledge produced by fishermen through their fishing experiences at sea. Fisheries scientists, like fishermen, rely heavily on observations, but they tend to make observations at a different scale than fishermen. Where FEBK tends to be localized, fisheries science produces knowledge about processes occurring across large scales (e.g., Cape Hatteras to Canada). As individuals, scientists do not spend as much time at sea compared to fishermen; they spend most of their time in their offices or labs analyzing data collected from the fishery and the marine environment. So in some ways, scientists make fewer observations compared to fishermen and this varies among scientists. Fishermen's observations are generally made on a smaller spatial scale and a "quicker" temporal scale compared to scientists' observations (i.e., their experience is often localized over years on a daily basis, whereas scientists' experience tends to be more regional, infrequent and over long-time periods). And where FEBK is based on repetitive interactions (e.g., daily), scientists' knowledge is based on intermittent interactions, but over a longer time period. For example, scientists' view of the groundfish resource in the Northeast is based in part on a time series of data collected two times a year for more than 40 years (biannual snapshots), as well as the average experience of hundreds of fishermen fishing throughout the region (i.e., from catch records and logbooks). Few active fishermen today have fished this long, and so their knowledge is based on a shorter time frame, although some aspects of fishermen's knowledge is also historical as it is based on information passed on from previous generations. And there is concern that the timeframe used by scientists may not be sufficient, resulting in the "shifting baselines" syndrome (see Jackson et al. 2001 and Pauly 1995).

As result of their differential experience and interactions with the marine environment, fishermen and scientists often produce differential social constructions of the marine environment. Again, the different scales at which knowledge is produced is critical to these different constructions. Consequently, they often disagree about the status of some fish populations and management goals. Although both are social constructions and partial views, RBK is often positioned as superior to FEBK in the realm of fisheries management. It is considered more broadly applicable compared to fishermen's local knowledge, and it is considered unbiased or not influenced by social and economic circumstances. RBK holds more power as its "discursive, written, and systematic" nature is more easily applied to fisheries management than FEBK's oral, tacit, and anecdotal form (Wilson 2006). However, we know that this view of fisheries science is also idealized because it is "mandated," and science studies illustrates that it is not immune to social, cultural, institutional, and political influences. We also know from the literature on expertise that different scientists will have different levels to contribute depending on the topic of investigation. Like fishermen, scientists will either have no expertise, interactional expertise, or contributory expertise.

Thus, one critical obstacle to the merging of FEBK with RBK is the different scale of experience through which knowledge is produced. Cooperative research, theoretically, could represent a co-construction of Nature by fishermen and scientists. By integrating fishermen's knowledge with scientific knowledge, presumably a more nuanced view of Nature will develop. This, in theory, should lead to greater acceptance (or buy-in) of fisheries science and management and fewer conflicts between these groups. In summary, this research examines the production of fisheries knowledge through cooperative research as a "new construction" of Nature. Does it incorporate fishermen's local and experience-based knowledge into what is otherwise a large-scale research-based knowledge production effort?

Public Participation in Policy-Making

Research Question 5: How does cooperative research function as a form of public participation? Are fishermen and their knowledge meaningfully integrated in the science and policy process?

The literature on public participation in policy-making is too substantial to discuss in its entirety here. Needless to say, there has long been a growing interest in increasing public participation in policy-making, and some suggest this is a result of the declining role of science in society (Ezrahi 1990). Cooperative research can be considered part of this trend: it is on one hand a consequence of increasing public skepticism regarding fisheries science and management and on the other hand a recognition for the need to include stakeholders in fisheries management, such as in calls for increased co-management, or power-sharing between government managers and stakeholder groups (Jentoft and McCay 1995; McCay 2005; Pinkerton 1994).

Frank Fischer (2000) examines the role of citizen participation in complex, technological decision-making and makes a case that ordinary citizens do have something to contribute; in particular; they have local knowledge. Specifically, he argues that "local knowledge plays an important role in problem identification, definition, and legitimation" (217). Fischer (2000) outlines several cases of participatory inquiry or participatory research, of which local knowledge is a primary product. While clearly, there is a place for non-experts in decision-making, Fischer also notes that just because citizens can participate, it doesn't always mean that they should. Citizen participation is valuable in some situations and a hindrance in others. For example, citizen participation can help in the solving of "wicked" or "intractable" problems for which the issue is not well understood, let alone a solution available. On the other hand, in some complex technical cases, participation can "waste a great deal of time and lead nowhere" (144).

Definitional issues complicate the concept of public participation. Public involvement can occur in a number of different ways and levels. There are numerous types and mechanisms of public participation, ranging from "tokenism to collaborative partnerships" and the definition is debated (Chess 2000, 770). Rowe and Frewer (2000) describe public participation as ranging on a continuum from communication between experts and the public to active participation in decision-making. They distinguish between three types of public engagement based on the flow of information: public communication, public consultation, and public participation; where flow of information in these goes from the policy-making institution to the public, from the public to the policy-making institution, and both ways, respectively (255). Rowe and Fewer identify and evaluate eight formalized methods of public participation: referenda, public hearings/inquiries, public opinion surveys, negotiated rule-making, consensus conferences, citizen juries/panels, public advisory committees, and focus groups.

Related to and possibly a variant of public participation, a number of scholars call for public-private *collaborations*, which are defined as processes "in which diverse stakeholders work together to resolve conflict or develop and advance a shared vision" (Koontz and Johnson 2004, 185). Here, collaboration differs from traditional modes of public participation in that it involves citizens early in planning processes, and it brings together different parties, with different interests, for face-to-face discussions (Kootz and Johnson 2004). As with public participation, there are numerous forms and types of collaborations (Kootz and Johnson 2004).

Fischer (2000, 176) defines "collaborative research" as "a deliberative process in which a practitioner(s) and a client system are brought together to solve a problem or to plan a course of action through the process of collective learning." "Collaborative research" as discussed by Fischer is similar to "joint fact-finding" forms of policy-making, as described by Andrews (2002). Fischer offers the Danish consensus conference as a model for "collaborative research" or citizen deliberation on complex social questions. In this model, a panel of ordinary citizens with "no special interest or knowledge in the topic under investigation" is asked to write a consensus report that reflects the various issues and concerns of the parties involved in the conference. The panel members are given materials to review, receive presentations from experts, and then ask questions of the experts about the topic, and thus gain interactional expertise about a subject. The report is distributed to government officials, scientists, special interest groups, and the public at large. These have influenced Danish environmental decision-making. For example, consensus conference recommendations influenced the Parliament's decisions to not fund animal gene technology research, to restrict food irradiation, and to accept a proposal on a tax on private vehicles (Fischer 2000, 237).

Cooperative fisheries research may be considered in the above light as an instance of public participation or public-private collaboration, but with the special feature in that it involves citizens with experience-based knowledge or expertise in the practice of scientific research. This differs from other forms of public participation that emphasize the role of ordinary citizens in making science policy decisions without necessarily engaging in the scientific research process. Here I examine whether cooperative research is an effective form of public participation – specifically whether it provides a mechanism for incorporating citizens and their knowledge in science and management. By exploring cooperative research under a number of different circumstances (e.g., fisheries, funding agencies, management institutions), I hope to gain a better understanding of the social, political, and institutional conditions that contribute to successful cooperative research efforts.

Summary of Research Questions and Organization of Dissertation

In summary, the research questions of this dissertation are organized around major themes in the interdisciplinary study of the production and use of knowledge in policy-making. First is the public understanding of science. Research Question #1 pertains to the public understanding of science: How do stakeholders perceive the meaning of cooperative research? Does involving stakeholders in cooperative research improve stakeholder perceptions of science (i.e., generate buy-in to science policy)? Research Question 2 concerns "mandated science" and boundary-making: What does cooperative research do to the boundaries between non-scientific and scientific knowledge in the context of the fisheries science policy process? What evidence is there of boundary making, spanning, and management as a result of cooperative research? The next research question (#3) is about expertise in policy-making: What kind of expertise is involved in these cooperative research efforts– and what, if any, expertise is shared across the boundary between scientists and non-scientists? Research Question 4 concerns the nature of knowledge and expertise in marine fisheries: Does cooperative research enable the use of fishermen's experience-based knowledge (FEBK) in the science policy process? Does cooperative research enable the integration of local FEBK into the large-scale, research-based knowledge (RBK)-based paradigm of fisheries management? What is the nature of the interaction between FEBK and RBK in cooperative research? Finally, Research Question 5 is about public participation in policy-making: How does cooperative research function as a form of public participation? Are fishermen and their knowledge meaningfully integrated in the science and policy process?

Chapter 2 outlines the methods and sites and foci of this study. Chapter 3 provides the necessary context with which to understand cooperative research in this region, including the history and institutions that contribute to the boundaries observed between fishermen and scientists, and their knowledge. Chapters 4-8 provide case studies of industry-science collaboration. Chapter 9 examines the meaning of cooperative research as reflected in stakeholder discourse. Chapter 10 synthesizes the evidence to answer the research questions regarding whether (and how) cooperative research enables the integration of fishermen and their local FEBK into the large-scale, research-based knowledge (RBK)-based science policy paradigm, thus functioning as an effective form of public participation.

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[1] According to their online database, the Northeast Consortium funded about two hundred projects totaling $23,095,846 from 2000-2006. The NMFS-Cooperative Research Partners Program website boasts funding close to ten million dollars, and lists sixty-four projects funded. This estimate does not include the Mid-Atlantic Research Set-aside projects.

[2] For example, Bernstein and Iudicello (2000) examined seven case studies of cooperative research in the U.S. involving the National Marine Fisheries Service (NMFS), representing four categories most typical of government-industry cooperative research: industry-based surveys, fishery-dependent data collection, gear/bycatch studies, and tagging studies. They defined cooperative research as "more than simple agreements to share the logistical burden of data gathering" but are "cooperative problem solving efforts" (12). Another notable assessment of cooperative research occurred at a two-day symposium held in Anchorage, Alaska in 2006. Over 150 participants contributed to the discussion that is summarized in the symposium proceedings (Reid and Hartley 2006). This event focused on identifying lessons learned, including motivations and factors facilitating success. On the west coast, Harms and Sylvia (2000)explored the feasibility

of cooperative research within the West Coast groundfish fishery using a mail survey. Cooperative research was defined as "the active participation of industry in scientific research" (1). The authors identified several different types of industry-science cooperative efforts: specimen collection, tagging studies, logbooks/observer programs, industry charters, industry-based surveys, bycatch reduction studies, and interviews with fishermen that generate further research. This economic study looked at factors that influence industry's willingness to participate in cooperative research with fishery scientists and found that the industry favors projects that allow them direct involvement and input into the scientific process, while scientists are more hesitant to support greater industry involvement amidst concerns about potential biases and objectivity of the industry. Karp et al. (2001) present three case studies of cooperative research in the North Pacific and discuss factors contributing to success in cooperative research. They suggested that success depends on the ability of the scientists and industry to work together at all levels. They cautioned that cooperative efforts become tested when results are not deemed favorable. They also noted that cooperative efforts are attractive when NMFS allows retention of and sale of fish to fund the research. Finally, success is related to how well the research conditions resemble commercial fishing conditions, which determines the applicability of the results. Conroy and Pomeroy (2006) evaluated the human dimensions of a cooperative fisheries research project in Oregon and California based on a survey of participant motivations, expectations, and experiences, and their attitudes about future participation. They examined one industry-science research effort, the Juvenile Rockfish, Cabezon, and Greenling Collaborative Fisheries Research project. Project participants were satisfied with project and emphasized that meaningful involvement and regular communication were important to them.

[3] However, it is debatable whether the U.S. system can be considered a true "co-management" approach given the high level of oversight and "veto power" retained by the federal government (Loucks, Wilson, and Ginter 2003). One stakeholder from New England expressed disapproval against using the term "co-management" to describe the U.S. system. In his mind, the term is reserved for systems with greater authority given to stakeholders, or what he called "true power-sharing." As examples, he referred to the Maine lobster zone council system, lobster management in Nova Scotia, and the Japanese cooperative system.

[4] Another method used to demarcate science from non-science is associated with Lakatos who distinguished between progressive and degenerative research programs. Progressive science is considered "good" and is characterized by theories and experiments that increase in content, explain the successes of predecessors, and have independent corroboration. However, the boundary between progressive and degenerative is open to negotiation (Gieryn 1995).

[5] I use the term "science studies" to refer to the work of scholars from science studies, sociology of science, science and technology studies, and other scholarly fields that examine the social, cultural, and political dimensions of the production of scientific knowledge, most of which adopt a "social constructivist" view of science.

[6] Michael (1992) makes a useful distinguish between public perceptions of "science-in-general" and "science-in-particular," suggesting the public perception of science is more complicated. In a study on the public perception of risk from radon gas, Michael found that when talking generally about science, citizens exhibited the "traditional view" of science. But distrust about science was also seen regarding "science in particular" – where citizens saw scientists as dismissive of local knowledge or pursuing individual interests. In their study of public perceptions of salmon recovery policy, White and Hall (2006) found that citizens used various discourses based on the traditional, authoritative view of science to support their own positions, but invalidated other views with discourses based on the skeptical-realist understanding of science. This study suggests we need to pay attention to the discourses individuals use in different situations. In my research, fishermen reflect different views of science in general and science in particular; suggesting fishermen's perceptions of science are complex. At times, fishermen praise scientists as hard working and skilled; while at other times scientists are rebuked for being incompetent and ignorant. In addition, fishermen are often skeptical of science and dismiss its use in fisheries management, but nonetheless sometimes cite scientific findings to support their arguments, especially in the realm of fisheries management. Fishermen appear to adopt the traditional of science as a method for identifying the truth, but question the way it is being done by scientists (e.g., it is not objectively or rigorously). Several fishermen explained to me that they less concern with how data are interpreted by scientists, including assessment models, than they do about the competency of the scientists in relation to data collection.

[7] There have been several challenges to the stock assessments in the Northeast. In 1998, the National Research Council peer reviewed the groundfish assessments (NRC 1998b). This review found the assessments valid for fisheries management. More recently, an industry group hired a consultant, Dr. Douglas Butterworth from South Africa, to conduct an alternative stock assessment for several groundfish species. The Butterworth model found that cod is doing better than predicted by the U.S. assessment scientists. In 2003, this model was rejected for use due to its preliminary nature, but will be considered again at the benchmark assessment scheduled for 2008. The New England Fishery Management Council's Science and Statistical Committee also reviewed this model in 2005, but at the time the model still was deemed too preliminary for use in management. In the Mid-Atlantic region, several stock assessments have also been challenged, most notably summer flounder (Terceiro 2002; NRC 2000).

[8] On November 10, 2006, an interesting debate occurred on National Public Radio's *Talk of the Nation* between Dr. Boris Worm (Dalhousie University), Dr. Steve Murawski (NOAA fisheries, formerly Northeast Fisheries Science Center), Dr. Patrick Sullivan (Cornell University, chair of the NEFMC Science and Statistical Committee), and Lee Crockett (Marine Fish Conservation Network). It can be heard at http://www.npr.org/templates/story/story.php?storyId=6469061.

[9] Other scholars have noted the unique nature of science that is produced or used in policy. For example, Alvin Weinberg identified a “grey zone” between science and policy, which he called “transscience” (Weinberg 1972).

[10] There is also “pure” fisheries science that has no immediately recognizable management implications. Principally, here I am concerned with fisheries science aimed to assess resource conditions (e.g., data for stock assessments) or gear technology studies used to inform the selection of management strategies (e.g., when and where specific gear configurations can be used by fishermen). The cooperative research programs that are considered in this research are federally funded programs and, in most cases, having management implications is the criteria used to determine which projects are funded.

[11] Oles (2004), based on ethnographic research conducted in New Jersey and a review of the literature, organizes fishermen’s environmental knowledge into three “knowledge domains”: gear-environment, habitat, and species knowledge. “Gear-environmental” knowledge refers to knowledge of how gear interacts with the environment under different conditions, including knowledge of oceanographic conditions and bottom type. By “habitat” knowledge, Oles is referring to knowledge of fish habitat including water temperature patterns, salinity levels, bottom sedimentation and erosion, and water quality. “Species knowledge” includes knowledge of movements and migration patterns, concentrations, abundance, and behaviors. This is a useful way of looking at fishermen’s environmental knowledge, but does not emphasize certain aspects of their social, economic, and institutional knowledge that are to this study.

[12] For more information about the Downeast Goundfish Initiative see the website provided by the Penobscot East Resource Center, http://www.penobscoteast.org/dei.asp.

CHAPTER 2: METHODS AND DESCRIPTION OF THE PROJECT

Research Questions and Design

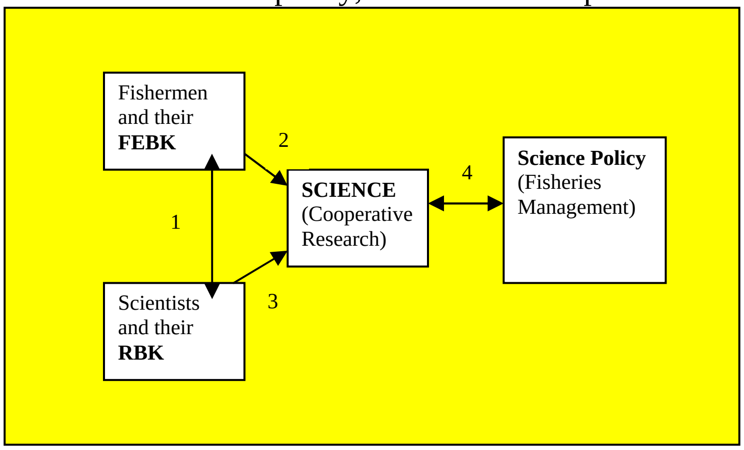
This dissertation aims to evaluate cooperative research as a mechanism for integrating fishermen and their knowledge in scientific-based fisheries management. Based on the review of the literature, the "mandated" nature of fisheries science suggests that boundary-making would occur between traditional science and cooperative research, as it occurs between fishermen's experience-based knowledge and scientific research-based knowledge. In addition, based on the tendency to dismiss fishermen's knowledge as "anecdotal," or biased by fishermen's interests, one would expect that fishermen's knowledge would not contribute significantly to these research efforts. Thus, we might expect that cooperative research would not affect the boundaries between fishermen and scientists, or between their knowledge. Based on Beierle and Cayford's model of public participation (below) it is expected that different types of cooperative research will have different outcomes depending on the nature of the industry-science interaction and the problem the research aims to address (i.e., the context and process).

In order to investigate whether cooperative research does function to integrate fishermen and their knowledge in scientific-based fisheries management, I explore what roles fishermen and scientists play in cooperative research and as well as the fate of cooperative research for fisheries science and management (process and outcome). I examine five different types of industry-science collaborations. In addition to the four most common forms of cooperative research (industry-based surveys, tagging studies, study fleets, and gear selectivity/bycatch studies), I also explore an industry-science advisory committee that is collaborating to improve the collection of fishery-independent data at the traditional scale of fisheries science.

Figure 2-1 depicts the boundaries across which flow is potentially enabled as a result of cooperative research. These flows are examined to answer the following research question: Does cooperative research represent a mechanism for integrating fishermen and their knowledge into science and management? This question is broken into sub-questions based on the review of the literature above:

- R1: How do stakeholders perceive cooperative research? Does involving stakeholders in science improve the perception of science policy?
- R2: What does cooperative research do to the boundaries between science and non-science? (flows 1, 2, and 4)
- R3: What kinds of expertise are involved in cooperative research? Is knowledge shared? (flow 1, 2 and 3)
- R4: Does cooperative research integrate FEBK with scientific-based RBK? (flow 2)

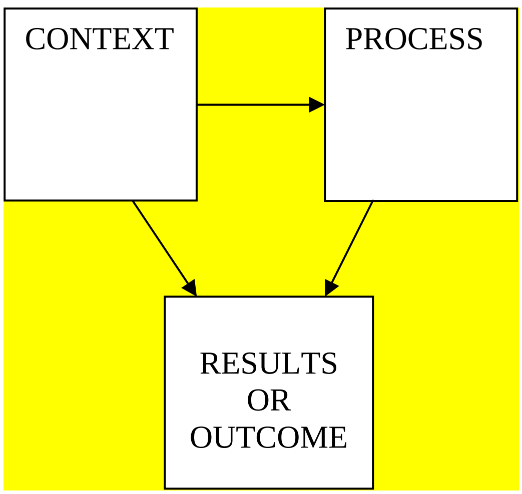
Figure 2-1: Potential Flow across Boundaries in Cooperative Research
Flow 1 is exchange of knowledge or expertise between fishermen and scientists. Flow 2 is the contribution of fishermen and FEBK in cooperative research. Flow 3 is the contribution of scientists and RBK in cooperative research. Flow 4 is the exchange between science and policy, or the use of cooperative research in science policy.



Research Question 5 is: How does cooperative research function as a form of public participation? Are fishermen and their knowledge meaningfully integrated in the science and policy process?

Beierle and Cayford (2002) present a simple conceptual model of public participation that is useful for evaluating the effectiveness of cooperative research as an effective form of public participation. They identify three components of the process that influence the success of public participation: <u>context, process, and results</u>. Figure 2-2 illustrates the conceptual model. Context refers to the situation in which the collaboration is embedded and includes the type of issue, preexisting relationships, and the institutional setting. Process in this model refers to “what happens” and includes the type of public participation mechanism and variable process features. Results are what are produced from a combination of context and process and are defined broadly to include output, relationships and capacity building. This conceptual model guides the evaluation of cooperative research as a form of public participation. In chapter 3, I provide a detailed discussion of the context and history from which cooperative research in this region emerged. Additionally, I provide more specific context in each case study as well. In terms of process, for each case study, I discuss how and what fishermen and scientists contribute in cooperative research. Finally, I examine the fate, or the results, of cooperative research, both on a case study level and for cooperative research as a whole in this region.

Figure 2-2: Beierle and Cayford's Model of Public Participation
Note: Context includes type of issue, preexisting relationships, and the institutional setting. Process (i.e., what happens) includes the type of participation mechanism and variable process features mechanism. Results include the outcome, relationships created, and capacity building.

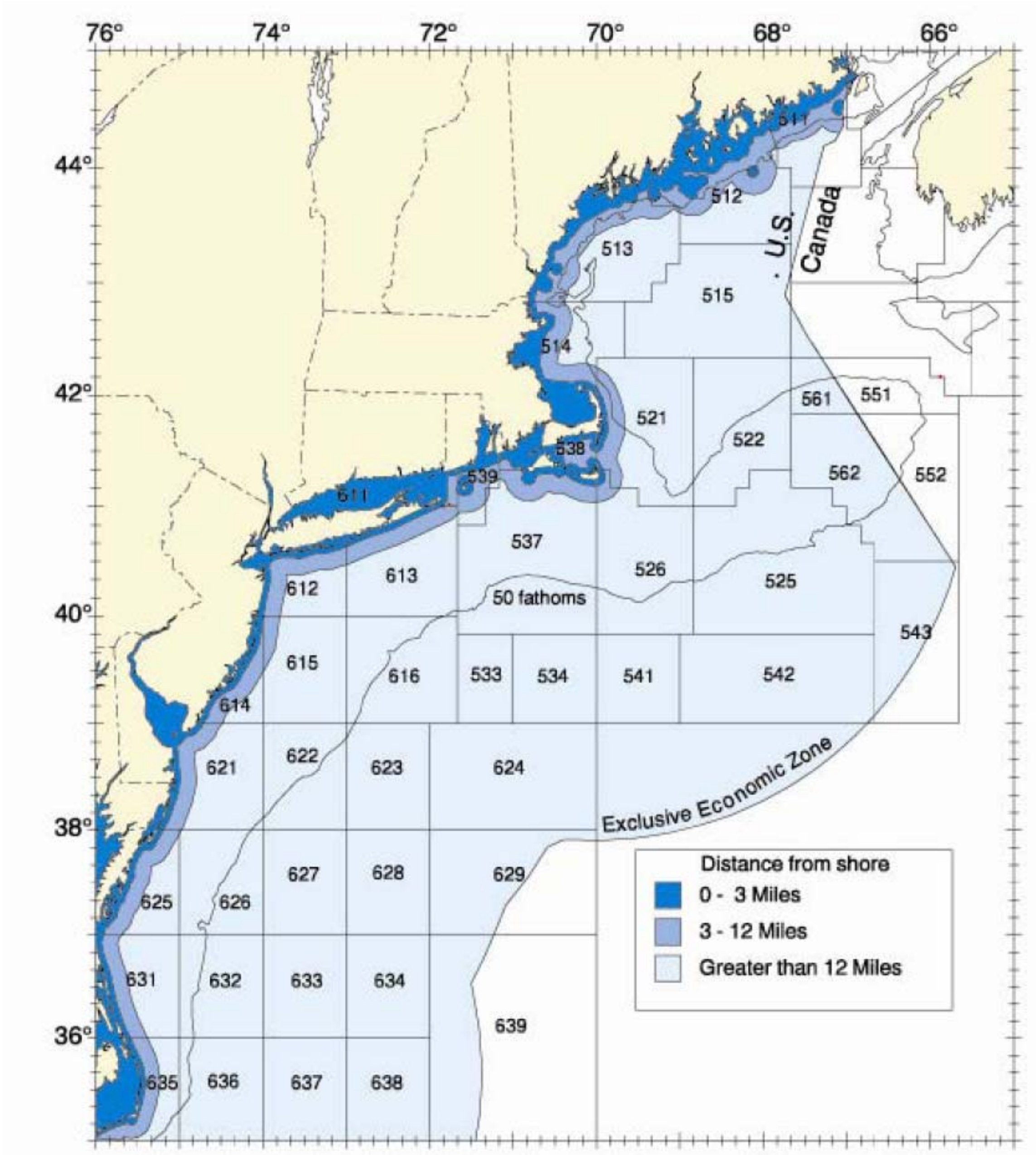


Study Site

This dissertation focuses on industry-science cooperative fisheries research in the Northeastern U.S., from Cape Hatteras to the Gulf of Maine (Figure 2-3). This region consists of two overlapping management regions: New England and the Mid-Atlantic. Federal fisheries science for both regions is the responsibility of the Northeast Fisheries Science Center (NEFSC), centered in Woods Hole, Massachusetts, but two separate regional fishery management councils implement fishery management plans for species in this area. The New England Fishery Management Council (NEFMC) manages the species from Maine to Rhode Island, while the Mid-Atlantic Fishery Management Council (MAFMC) manages species from New York to North Carolina. Ultimately the actions of both regional councils fall under the review of the National Marine Fisheries Service's Northeast Regional Office and the Secretary of Commerce. A description of these management institutions is provided in chapter 2. As I will discuss later in this dissertation, these two regional fishery management councils are structurally similar but institutionally, politically, and culturally different. Consequently, these regions have very different experiences related to the form and outcomes of cooperative research.

In order to limit the scope of this research, I focus on federally funded industry-science cooperative fisheries research that has occurred since 1999 in New England and the Mid-Atlantic. The collaborations occurring since this time are part of what Sissenwine (2001) calls the "new wave" of cooperative research. The federal funding programs that are the focus of this research are the Northeast Consortium (NEC), the Cooperative Research Partners Program (CRPP), and the Mid-Atlantic Research Set-aside program (MA-RSA).[1] This delineation enables the examination of four key types of industry-science cooperative research: industry-based surveys, study fleets, tagging, and gear selectivity studies. Unfortunately, this delineation misses several interesting and innovative industry-science collaborations that occurred either before this time period, with funding outside of these programs, or are non-federal programs. Several collaborations that took place before this "new wave" are part of the context and are thus described in chapter 3. The other collaborations, such as state or university funded or organized research, are outside the scope of this research.

Figure 2-3: Map of the research study site, the Northeastern U.S (from NEFSC 2006, 10)



An Ethnographic Approach to Studying Science

Many science studies scholars focus on the internal practices of science. Such research tends to be characterized by microscopic study of scientific practices, prioritization of *how* questions over *why* questions, and a constructivist perspective (Knorr-Cetina 1981). Rigorous ethnographic studies of science have provided “thick description” of scientific practices.[2] From these ethnographic science studies, we learn the importance of looking critically at both the process and outcomes of scientific research. For the most part, ethnographic studies of science focus on laboratory research.

This dissertation contributes to this field by focusing on scientific research conducted “in the field” rather than in a laboratory. In addition, I focus on what happens to science outside of the lab and outside the field (i.e., in the fisheries science policy process). Unlike typical ethnographers of science, I did not have access to the scientific laboratory, which was in this case most often the deck of a fishing vessel as well as the computer rooms and labs where data were assembled and analyzed. I was, however, often able to observe the planning and dissemination of research results, and I was filled in as to how research is done through extensive interviews with industry and science participants. Thus, the study presented here adopts an ethnographic approach to science studies, but one that does not adopt “participant observation” as a primary method. In this research, an ethnographic description of both the process of cooperative research and its outcomes is critical. This is achieved by observation of the science policy process and extensive interviews with participants in the science policy process. Rather than following scientists in the lab, I tried to follow the use of cooperative research in fishery science and management through interviews, examination of documents, and attendance at key meetings. As I discuss below, interviews and observations sought to understand both what happens in cooperative research, including the roles of the scientists and non-scientists, and what happens to the data or new knowledge produced from these collaborations by tracing where the data go and how (if at all) it is used in the management process.

Case Study Selection and Analysis

This research initially focused primarily on one fishery in each region: (1) Atlantic cod, *Gadus morhua*, in New England and (2) Squid, *Loligo pealeii* and *Illex illecebrosus*, in the Mid-Atlantic. I selected these fisheries/species based on prior knowledge of them being the subject of substantial cooperative research and management controversy. For each fishery/species, I initially identified major cooperative research efforts that have been underway since 1999. From these, I selected seven case studies for exploration that are representative of the key types of cooperative research efforts currently underway in the Northeast: industry-based surveys, study fleets, tagging, and gear selectivity studies. The case studies selected for each fishery are shown in Table 2-1. While gathering data on these case studies (see Data Collection below), I also obtained data related to several other cooperative programs, as well as cooperative research in general, and discuss these as appropriate throughout this dissertation. For each case study, I sought to answer the following questions:

- What and how do fishermen and scientists contribute? (process question)
- What has been the fate of cooperative research in the U.S.? (outcome question)

The first question focuses on the process of doing cooperative research and includes the knowledge and expertise provided and the roles individuals took on in the different stages of the cooperative research process. The second question examines the outcome or results of cooperative research by looking at the fate of the data and whether (and if so how) cooperative research was used at all in science or management. The case studies inform my evaluation of cooperative research in terms of whether it functions to incorporate fishermen and their knowledge into the science policy process.

Table 2-1: Industry-Science Cooperative Research Case Studies

Region/Fishery	Project	Type of Research	Funding
New England cod			
	ME-NH Inshore Trawl Survey	Industry-based Survey	NEC/CRPP
	Cod IBS	Industry-based Survey	CRPP
	Gulf of Maine Whiting Fishery	Gear Selectivity/Bycatch	CRPP
	NE Regional Cod Tagging Program	Tagging Study/Ecological Research	NEC
Mid-Atlantic squid			
	Mid-Atlantic Supplemental Finfish (transect) Survey	Industry-based Survey	MA RSA
	Loligo Selectivity Studies	Gear Selectivity/Bycatch	MA RSA
	Illex Squid Real-Time Data Collection/Management Study	Study Fleet/Real-Time Data Collection	MARFIN Industry funding
Both regions	Trawl Survey Advisory Panel	Fishery-independent survey	NEFSC NEFMC, MAFMC

In addition to the “species-based” case studies, I also examined a cooperative effort involving both New England and the Mid-Atlantic fishermen and scientists: the Trawl Survey Advisory Panel. This “collaboration” is an effort aimed to improve the collection of fishery-independent data used to manage fisheries in both regions. This joint New England and Mid-Atlantic Fishery Management Council panel is composed of council members from New England and the Mid-Atlantic, fishermen from each region, academic scientists, and NEFSC scientists aims to improve the NEFSC trawl survey. The Trawl Survey Advisory Panel is an example of the "public advisory committee" form of public participation (Rowe and Fewer 2000). Although the Panel is not a "true" cooperative research effort since fishermen are not involved in the at-sea data collection, it is nevertheless one of the most cooperative efforts occurring in this region. I attended all trawl survey advisory panel meetings from May 2003 to April 2006, a total of twelve meetings, and I interviewed individuals both on and off the panel. I also attended several public presentations about the panel and reviewed meeting summaries and documents distributed at the meetings.

Data Collection

Data collection primarily consisted of informal and semi-structured interviews and direct observation of the science-policy process conducted from June 2003 to April 2006. A total of forty-five formal, semi-structured interviews were conducted and more than sixty (multiple day) meetings attended. In addition, I reviewed a number of relevant fisheries science and management documents. Data sources and collection are described below. Data for specific case studies are identified more specifically in the individual chapters in which they are presented.

Interviews

This research utilized informal and semi-structured interviews (Bernard 2002, 204-05). Informal interviews took place at fishery management and science meetings, where I informally talked with individuals about a variety of issues related to fishery science and management. These informal interviews were not tape recorded but often led to future semi-structured interviews. This type of interview is especially useful for gaining rapport and uncovering new topics of relevance to the research (Bernard 2002). Semi-structured interviews lasting approximately one hour were conducted with fishermen, industry representatives, scientists (federal, state, and academic), managers, and representatives from non-profit and/or environmental organizations based from North Carolina to Rockland, Maine.[3] Interviews were based on an interview guide but interviews varied significantly according to the informant. Not all questions were asked of each informant due to time constraints, experience or interest on the part of the informant. Informants were asked to share their experiences, observations, and opinions related to cooperative research and the fishery management process. Questions ranged from specific case-study relevant questions to general questions about cooperative research, fishermen's knowledge, fisheries science, and fisheries management. Interviews were tape-recorded and all but a few were transcribed.[4] Interviews took place at locations convenient to the informants, most often at fishery management council meetings or the informant's place of business.

Three types of non-probability sampling were used in this research: purposive (judgment), snow-ball, and opportunistic sampling. Informants were selected based on their involvement in cooperative research, fisheries science, and/or fisheries management process. Effort was made to interview federal, state, and academic scientists and fishermen from a variety of fishing ports and fisheries to ensure a "representative" sample (purposive sampling). Informal interviews relied upon whoever was willing to talk with me (opportunistic or convenience sampling), with most informants recommending other individuals to talk with (snow-ball sampling). Individuals interviewed can be considered “key informants” in the scientific-based fisheries management process (Bernard 2002, 188).

Observations

Throughout this research, I directly observed relevant fisheries science and management meetings and recorded notes of meeting proceedings. No effort was made to conceal myself at these meetings as I openly took notes and, when used, the tape recorder was always visible.[5] There is no evidence to suggest my observation of the process significantly altered the behavior of the participants I was observing. Meetings include fishery management council meetings, council oversight and advisory committee meetings, and public fishery meetings and conferences (e.g., the Northeast Regional Bycatch workshop, Maine Fishermen’s Forum, Rhode Island Fish Expo, American Fisheries Society meeting), and several non-public project-planning meetings (e.g., meetings of those involved in the Mid-Atlantic supplemental finfish survey). Attendance and observation of meetings also functioned as an opportunity to solicit and/or interview informants. Documents distributed at the meetings were obtained and represent data, as described below.

Documents

Verbatim transcripts of the fishery management council meetings were obtained from fishery management council staff from New England and the Mid-Atlantic. In some cases, summary documents of committee meetings were also available, most notably from the NEFMC’s Research Steering Committee (RSC). The Mid-Atlantic FMC also provided summary notes of the Trawl Survey Advisory Committee meetings. Documents distributed to the public at council meetings related to the case studies or cooperative research in general were also obtained for analysis. Summary documents of committee meetings and partial transcripts of the council meetings were included in the qualitative analysis. When available, final reports were obtained from the principal investigators of the projects or the funding agencies. For example, cruise reports were available from the Mid-Atlantic Supplemental Finfish (Transect) Survey through Rutgers University-Haskin Shellfish Research Laboratory staff. Annual reports and a procedures manual of the ME-NH Inshore Survey were available on-line from the Maine Department of Marine Resources. Peer review summaries for the ME-NH Inshore Trawl Survey, the Mid-Atlantic Transect Survey, and the Cod Industry-based Survey were also available. Several published reports based on cooperative research were provided by principal investigators (e.g., Hendrickson 2004; Powell et al. 2004). Additional information sources include project and agency websites, newsletters (e.g., *Collaborations)*, and local and fishery newspapers (e.g., Cape Cod Times, Commercial Fisheries News, and National Fisherman). These various documents primarily informed the case studies.

Qualitative Data Analysis: Grounded Theory and Discourse Analysis

A QSR N6 database was used for storage and quick retrieval of data from interviews and field notes (i.e., observations of meetings), and meeting transcripts and summaries. Information from the database was used to write case studies of cooperative research. The database also functioned as a tool for qualitative analysis. Two qualitative analysis approaches were employed: grounded theory and discourse analysis.

Qualitative analysis through grounded theory occurred through the careful coding and recoding of the data. Grounded theory is a qualitative analysis technique that aims to remove subjectivity and provide a means of systematic analysis of qualitative data

(Glaser and Strauss 1967). In this approach, understanding (or the discovery of patterns) emerges inductively through the close reading of texts (i.e., interviews, transcripts, and field notes) and the assignment of analytical "codes" to the data. Memoing, making notes about coding and potential links between codes and emerging patterns, was also critical to understanding the data. Through the iterative process of coding, grounded theory allows the researcher to become more and more "grounded" in the data. In this research, an understanding of cooperative research emerged from the coding and re-coding of the data.

In addition, interviews, transcripts, and field notes were analyzed within the methodological approach known as discourse analysis. Discourse analysis is based on the close study of naturally occurring interactions and assumes that discourses are manifestations of culture (Bernard 460). Adopting a social constructivist epistemology, this approach assumes that social attributes are a function of the discourses expressed, and so understanding social activities means understanding the discourses which both reflect and shape the culture (Phillips and Hardy 2002). Discourse is considered broadly to mean interrelated texts, "and their practices of production, dissemination, and reception that brings an object into being" (Phillips and Hardy 2002, 3). Discourse is also "a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities" (Hajer 1995). The product of discourse analysis is the description of discursive themes or storylines (Hajer 1995).

In this dissertation, I examine the storylines being produced by stakeholders in the fisheries science policy process related to cooperative research. A storyline is "a generative sort of narrative that allows actors to draw upon various discursive categories to give meaning to specific physical or social phenomenon" (56). Discourse is viewed as facilitating political change through a struggle for discursive hegemony; where actors try to secure support for their construction of reality. This is argumentative struggle and is influenced by credibility, acceptability, and trust. Credibility is necessary to get actors to buy-in to the position the discourse implies; acceptability means making the discourse attractive to others, and trust enables the reduction of doubt and uncertainty about the view and is done by instilling confidence in either the author of the discourse or through the practice through which the construction of reality was achieved. The power of a discourse is not in its consistency but in its multi-interpretability. In addition, new discourses can alter the perceptions of problems and possibilities, creating "space for new, unexpected political coalitions"(Hajer 1995). In this dissertation, I examine the storylines being produced by stakeholders in the fisheries science policy process related to cooperative research.

Overview of Dissertation

In chapter 3, I begin by describing the context of cooperative research in the Northeastern U.S., focusing on the institutional structure and history in which it is embedded, as well as the current cooperative research funding programs and institutions that are the focus of this research. This chapter also provides necessary background for those unfamiliar with marine fisheries science and management.

The case studies of cooperative research are provided in chapters 4-8. First, the *Illex* squid real-time data collection program illustrates the movement of expertise from scientist to fishermen. The Northeast Regional Cod Tagging Program illustrates what happens when there is only selective boundary-spanning. In chapter 6 two instances of gear selectivity research illustrate the institutional barriers to the integration of fishermen's knowledge into science and management. Three cooperative industry-based surveys are discussed as ground-breaking efforts to transform fishermen's local knowledge into something relevant to the large-scale paradigm of fisheries stock assessment and management. I then present the Trawl Survey Advisory Panel as an example of an industry-science collaboration that functions as a boundary organization, linking knowledge to action in fisheries management while enabling communication, translation, and mediation across diverse knowledge boundaries.

Chapter 9 examines critically the meaning of cooperative research through an analysis of the discourse related to cooperative research. In addition, I examine perceptions regarding the outcome of cooperative research. Although it is too soon to know whether cooperative research will create long-term buy-in to fisheries science and management, I offer a preliminary examination into the perception of science conducted cooperatively with the fishing industry and identify several factors that are likely to hinder or enhance buy-in to science and management.

Finally, chapter 10 concludes the dissertation with an analysis of whether cooperative research functions to integrate fishermen and their knowledge into science and management.

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[1] The exception is the *Illex* Squid Real-Time Data Collection Program which was funded by the NEFSC and the squid fishing industry.

[2] For example, Bruno Latour and Steve Woolgar's *Laboratory Life: The construction of scientific facts* (1986) is based on two years of ethnographic fieldwork at the Salk Institute where Latour observed the "discovery" of Thyrotorpin Releasing Factor (TRF).

Drawing on anthropology, Bruno Latour approached the laboratory using the notion of "anthropological strangeness" and required that he "apprehend as strange those aspects of scientific activity which are readily taken for granted" (27). In addition to observing the on-goings in the laboratory, Latour's research included a review of the literature, analysis of citations to the literature, and in-depth interviews with key participants. Karen Knorr-Cetina's *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science* (1981) provides an ethnographic study of a protein chemistry laboratory at the University of California at Berkeley and included observation of scientists at work, interviews with key participants, and an analysis of publications. Sharon Traweek's *Beamtimes and Lifetimes: the world of high energy physicists* (1988) offers a study of the world of high energy physics in the United States and Japan, offering insight into cultural differences of scientific research. In her comparative approach, she relied on key informant interviews to discover systematic cultural differences between U.S. and Japanese scientists regarding laboratory organization, approaches to detector design and building, leadership, and working condition preferences.

[3] Telephone interviews were significantly shorter lasting on average thirty minutes.

[4] For most interviews, an undergraduate or graduate student produced an initial transcription which I then cleaned up for quality assurance. A handful of interviews were not recorded or transcribed as was the preference of the informant or where tape recording was inaudible. In these cases, handwritten notes were transcribed for coding.

[5] Recording at meetings was done on only a few occasions due to the fact that the large rooms and background noise did not permit quality recording. In some, tape-recording was discouraged by meeting organizers and so was not done. Several recordings of the NEFMC's Research Steering Committee meetings were acquired from the council but were not transcribed.

CHAPTER 3: CONTEXT, HISTORY, AND INSTITUTIONS

Introduction

This chapter provides necessary context with which to understand the significance of cooperative research in this region, particularly to those who may be unfamiliar with the U.S. fisheries science policy process. First, I describe the federal fisheries management process and institutions in the Northeastern U.S. (i.e., New England and the Mid-Atlantic), which is the setting of this research. From this description, several barriers and opportunities for industry participation in fisheries management are identified, as are impediments to integrating fishermen's knowledge in the science policy process. I then provide a brief history of industry-science relationships in this region, and how they went from uncooperative to collaborative. That is, it describes the development of boundaries between industry and science followed by, presumably, the opening of those boundaries as a result of cooperative research. This discussion includes several early examples of cooperative research efforts that pre-date the "new wave" of collaborative research beginning circa 1999 that is the focus of this research. As I discuss, these efforts paved the way for the cooperative research that we see now in this region. It should be evident that cooperative research emerged out of a social and ecological crisis and, given the history of industry-science relations, is somewhat unexpected. Finally, I describe the current institutions that enable industry-science collaborative research in the Northeastern U.S. Most notable are the Northeast Consortium, the NMFS Cooperative Research Partners Program, and the Mid-Atlantic Research Set-aside Program.

Federal Fisheries Management Institutions and Processes in the Northeastern U.S.

Marine fisheries management in federal waters (3-200 miles offshore) in the United States falls under the jurisdiction of the National Marine Fisheries Service (NMFS), which is situated within the National Oceanic Atmospheric Administration (NOAA) within the Department of Commerce. Individual coastal states have responsibility for fisheries 0-3 miles offshore. Fisheries are managed in accordance with the Magnuson Stevens Fishery Conservation and Management Act (MSA) of 1976 with amendments made in 1996, known as the Sustainable Fisheries Act. The MSA extended U.S. jurisdiction to two hundred miles and set up eight regional fishery management councils to manage fisheries on a regional basis.[1] The regional fishery management councils (FMCs) are composed primarily of federal and state government officials and appointed members of the public who tend to be from the commercial and recreational fisheries, but may also be members of environmental organizations or the general public. Fishery management plans developed by the regional councils are subject to the MSA's ten National Standards (Table 3-1). Below I discuss these institutions and processes in more detail through a discussion of the New England FMC and the Mid-Atlantic FMC, which manage the fisheries considered in this dissertation. When important, differences between the councils are noted.

New England and the Mid-Atlantic Fishery Management Councils

Two FMCs manage federal water fisheries in the Northeast, the study site of this research. The New England FMC manages the fisheries in the Northeast from Maine to Rhode Island, while the Mid-Atlantic FMC manages the Mid-Atlantic from North Carolina to New York. Each FMC meets about five times a year to develop fishery management plans and regulations to manage fisheries in their jurisdiction. The New England FMC has established eight fishery management plans to manage the fisheries in the region. The Mid-Atlantic FMC has established six FMPs to manage the fisheries in the region.[2] Coordination of marine, estuarine, and anadromous fisheries that occur in state waters (0-3 miles) is done through the Atlantic States Marine Fisheries Commission (ASMFC).[3]

Management Approaches

As noted, each fishery management council has a number of tools with which to manage their fisheries. The use of these tools is at the discretion of each Council, although the Regional Administrator and Secretary of Commerce can decide when certain tools are not appropriate, if they are judged as not meeting one or more of the National Standards.

In general, fisheries management in New England focuses on effort controls including restrictions on the annual number of days at sea (DAS) allowed per vessel, mesh sizes, gear restrictions, size limits, daily and trip possession limits, and area and seasonal closures. Although New England manages primarily on DAS, the total allowable DAS is calculated to achieve biomass and fishing mortality targets (i.e., to meet biological reference points used in overfishing definitions). Mid-Atlantic management focuses on output controls; i.e., total allowable catches (TACs) – allocated to commercial and recreational fishing sectors. They also utilize some effort control rules such as mesh sizes restrictions, gear restrictions, gear restricted areas (GRAs), size limits, daily and trip possession limits, and area and seasonal closures. The Mid-Atlantic does not manage DAS, although some of their fishermen are restricted because of their participation in New England fisheries. In order to ensure that quotas are not exceeded, the Mid-Atlantic has a complex system of allocation among sectors (recreational and commercial) and among states.

These differences influence cooperative research in these regions. As I discuss later, the quota-based management approach in the Mid-Atlantic creates an opportunity to set-aside quota to generate funds for fisheries research that is exceptionally difficult, if not impossible, to do in the mixed fisheries in New England. For example, it is unclear how much "effort" would equal a hundred pounds of quota. In New England, there is a need to calculate the value of research in terms of fish abundance and fishing mortality in order to ensure that conservation goals are achieved (i.e., research does not cause the fishery to exceed its biological targets), whereas this is already taken into account in the Mid-Atlantic with the quota-based system.

Council Structure

Each Council has an Executive Director and administrative and technical staff to assist with its operations. For example, the Council staff takes care of the logistics of the meetings, including reserving meeting rooms at hotels convenient to regional participants), hotel accommodations for the council members, distributing emails and documents to all members, and conducting social, economic, and biological analyses of various fishery management alternatives.

The composition of the councils is similar as specified by the MSA. Both the New England FMC and the Mid-Atlantic FMC are composed of voting and non-voting members. Voting members include the Regional Administrator of the National Marine Fisheries Service (NMFS) (or her designee) and the principal state officials with marine fishery management responsibility (or their designees). For New England, state officials represent Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut. For Mid-Atlantic, state officials represent New York, New Jersey, Pennsylvania, Delaware, Virginia, Maryland, and North Carolina. In addition, each council has voting members nominated by the governors of the States and appointed by the Secretary of Commerce for three-year terms (they may serve a maximum of three consecutive terms). New England has an additional twelve government voting members, while the MAFMC has an additional thirteen non-government voting members. Both councils have four non-voting members who represent the United States Coast Guard, U.S. Fish and Wildlife Service, U.S. Department of State, and the Atlantic States Marine Fisheries Commission. Thus, New England Fishery Management Council is comprised of eighteen voting members and four non-voting members, and the Mid-Atlantic FMC consists of twenty-one voting members and four non-voting members. Additionally, one NEFMC member is generally assigned as a liaison (non-voting) to the Mid-Atlantic FMC, and vice-versa. This representation is necessary because actions taken by one Council may impact the fisheries or fishermen in the other region as well, or may conflict with another management plan in the other region.

The council members annually vote on a chair and vice-chair and establish an Executive Committee. As one would guess, the vice-chair takes over when the chair is not present. The chair is a key individual in the council process, as he/she provides necessary structure to meetings that would otherwise be chaotic. The chair allows individuals to speak in turn, making sure that the discussion stays on topic and progresses forward. There is some discretion given to the chair in terms of how much time he allows for public comment. The chair also ensures that the rules of operation or council conduct are maintained. The Executive Committee determines much about how the meetings are organized, such as developing the agendas for each meeting, and so is one of the most powerful of the council committees.

Committees

Each council member serves on one or more committees. In New England, these committees are called oversight committees. These committees meet regularly to review and discuss individual fishery management plans (FMPs) and framework actions. In New England, they meet in between regularly scheduled Council meetings. These committees develop specific measures that will form the basis of the plan, plan amendment, framework adjustment to an FMP, or annual adjustment/specification. Committee recommendations are forwarded to the full Council for their approval before inclusion in any draft or final version of an FMP. Mid-Atlantic council members are also assigned to committees (species) that function similarly to the “oversight committees.” In the Mid-Atlantic these committees typically meet in conjunction with the full council meetings (i.e., during the same week as the council meets, usually a day before the full council convenes). An informant said that a fundamental difference between NEFMC and the Mid-Atlantic FMC is that the latter does not do as much “committee work” as the former. A council member from the Mid-Atlantic explained that the geographic extent of the council does not permit the committees to meet other than in conjunction with the full council. The Council simply cannot afford to pay for all of the committee members to travel throughout the region more than they already do (i.e., to attend the general meeting). In any case, holding the full council and committee meetings together has one advantage: it provides consistency and predictability to the management process. This enables participants (both on and off the council) to better schedule time to participate in the process because they know when and where the meetings will occur. In New England, it is a little more difficult to keep up with all of the committee work that goes on (personal observation). However, in the Mid-Atlantic the geographic scope of the region may make it more difficult for non-council participants to attend all of the meetings, where in New England the geographic area required for traveling is not as extensive (although still significant for some).[4]

Advisory Panels

In addition, each council has established Advisory Panels made up of knowledgeable members from the commercial and recreational fishing industry, scientists, environmental advocates, and others knowledgeable about fisheries issues. These generally correspond to the oversight or species committees. The advisors meet separately, or jointly, with the relevant committee and provide input and assistance in developing management plan measures. Advisors are generally appointed every three years following a public solicitation for candidates. After reviewing applications, the respective committee chairman selects new or returning advisors. The Council's Executive Committee provides the final approval of advisory panel members. According to one informant, the Mid-Atlantic does not use the advisors as much as in New England, with the exception of the advisors for surfclams/quahogs and squid/mackerel/butterfish.

In a few rare instances the Councils have committees composed of both Council members and outside experts. For example, in New England the Research Steering Committee (RSC) and, for a short period, an Ad Hoc Bycatch Committee were composed of council members, industry experts, and scientists. There is also a joint-MAFMC and NEFMC Trawl Survey Advisory Panel composed of council members, industry gear experts, and scientists. The Trawl Survey Advisory Panel is presented in chapter 8.

Technical Committees

In New England, for each species there is a Plan Development Team (PDT) made up of scientists, managers and other experts with knowledge and experience related to the biology and/or management of a particular species. Individuals serve as an extension of the Council staff. PDTs meet regularly to respond to any direction provided by the oversight committee or Council, to provide analysis of species-related information and to develop issue papers, alternatives, and other documents as appropriate. A member of the Council staff generally chairs each PDT, and the team members are from state, federal, academic or other institutions.

The Mid-Atlantic FMC relies on Monitoring Committees for each of its fishery management plans. These are composed of scientists experienced with the biology and/or management of a particular species or complex. The committee is composed mostly of state biologists, but also includes at least one NMFS biologist and MAFMC staff member. Typically, the NMFS scientist is the chair of the working group that handles the species of concern. The committee reviews data from the previous year (e.g., removals and effort) to develop annual specifications for each stock (i.e., total allowable landings, commercial and recreational quotas, size restrictions, gear restrictions, etc.). The council staff member responsible typically compiles the new scientific information and makes a preliminary recommendation, which is reviewed by the committee. The Monitoring Committee recommendation, determined with a vote, is forwarded to the species committees and then to the full council for use in management. One observer of the process felt that many of those on the committee are not real experts, but play a role as the state's guardian. In my observation, I was surprised that few questions were asked by the Monitoring Committee members about the preliminary recommendation. Experts from the fishing industry were on hand in the audience to provide insight and assist with the recommendation making. For example, some data needed to be interpreted in light of industry behavioral responses to market conditions.

In addition, both councils have technical expert committees: science and statistical committees (SSCs). This is a requirement of the MSA, although regional fishery management councils utilize their SSCs differently (Miller 1987). In New England there are two scientific expert advisory panels: the Science and Statistical Committee and the Social Science Advisory Panel. In the Mid-Atlantic there is just one science and statistical committee with both natural and social scientists. These provide technical advice to the council. The role of the Science and Statistical Committee is currently a hot topic of discussion regarding how to strengthen the role of science in federal fisheries management. An informant reluctantly admitted that the SSC in the Mid-Atlantic is typically not used. Similarly, during this research, the SSC in New England met only two times. At the two SSC meetings that I attended in New England, there was industry representation in the form of an industry group representative or a scientist consultant. However, I did not feel that they contributed significantly to the discussion. In lieu of relying on the SSCs, as some councils do, the NEFMC and the MAFMC rely on the Stock Assessment Review Process (SAW/SARC), discussed below, and the PDT/MCs to review the quality of information available for decision-making.

Council Process

Following other government agencies, federal fisheries management emphasizes public input and transparency. Options or alternatives identified are sent out to the public for comment. After a period of public comment, by hand, voice, or roll-count vote the Council selects a management strategy to achieve the identified objectives. This is forwarded to the Regional Administrator who makes the final determination to approve or disapprove the action. The final say belongs to the Secretary of Commerce. In keeping with the U.S. democratic process, transparency of the process is emphasized at all stages. All Council, committee, and technical committee meetings are open to the public for comment. Members of the public can express their views in person at one of these meetings or through writing.

The main objective of the FMCs is to prevent overfishing while achieving the optimum yield from the fishery (National Standard 1). In essence, the Council receives scientific advice regarding appropriate fishing mortality and catch levels (i.e., biological reference points) that if achieved will (or should) prevent (or end) overfishing and/or rebuild overfished populations. The Council is charged with developing fishery management plans (FMPs), amendments to those plans, and framework actions to meet conservation objectives. In some cases, the council may be considering management options to address a specific management problem (e.g., bycatch reduction) rather than achieving harvesting targets. Each council has a variety of tools with which they can manage their fisheries. The Council's Oversight/Species Committees and Advisory Committees recommend strategies for meeting objectives. The council receives technical advice from plan development teams (PDTs) or species monitoring committees and science and statistical committees. For each species within each FMP, overfishing definitions are approved that are used to measure the status of the fishery. The overfishing definitions specify when a fishery is considered “overfished” and when “overfishing” is occurring. The overfished status is related to the biomass target that will achieve sustainable use of the resource in the long term (i.e., what the current biomass is relative to the target biomass), and the “overfishing” status refers to the current fishing mortality level as it relates to the biomass levels (i.e., the desire is to prevent fish stocks from becoming overfished). Ideally, the managers want stocks to be of the status “not overfished” and “overfishing not occurring.” The determination of whether a stock is overfished is based on stock assessments prepared by regional science centers. Again, the MSA requires that when fisheries are overfished that the FMCs must within one year develop a rebuilding plan and end overfishing when occurring. Typically, rebuilding plans must rebuild stocks within ten years.

Once the Council creates an FMP, adjustments can be made using one of two distinct mechanisms: the amendment and the framework adjustment. The amendment generally takes longer to implement since it is generally associated with a significant shift in management strategy and is subject to the rigors of the National Environmental Policy Act (NEPA), including a full environmental impact statement and public hearings. The EIS process includes substantial public involvement: initial scoping meetings, public hearings, and the collection of written and oral comments over a 45-day period. The framework adjustment, on the other hand, can ideally be implemented more quickly, as it is not associated with significant impacts and so is not subject to the full EIS process under NEPA. Butler, Steele, and Robertson (2001) raise concerns that the framework adjustment process may not provide for sufficient opportunities for public participation and may hinder the assessment of cumulative impacts. The framework process allows the council to react (or adapt) quickly to management needs, but this may be at the expense of public participation.

Thus, the U.S. management process is driven by the need to rebuild overfished stocks and/or prevent overfishing. Quantitative information is required to determine the status of fish populations relative to these overfishing definitions. The determinations of overfishing and overfished are based on the "best scientific information available" as provided by NMFS regional science centers. As I will discuss later, fishermen's anecdotal and experiential information is difficult to integrate into the quantitative stock assessment process that fishery management decisions are ultimately based upon. Fishermen's knowledge does become important in allocation discussions and in the development of tools to meet conservation criteria (i.e., overfishing definitions).

Federal Oversight: National Marine Fisheries Service

As noted, responsibility of the nation's fisheries rests with the National Marine Fisheries Service of NOAA (or "NOAA Fisheries"), which is overseen by the Secretary of Commerce. The NMFS is structured hierarchically, like other government bureaucracies. The main offices are in Washington D.C., and are often referred to as "Headquarters." Each region is affiliated with a regional office and a science center, which may be responsible for one or more of the regional fishery management councils. In the Northeast, the Northeast Regional Office (NERO) and the Northeast Fisheries Science Center (NEFSC) work with the fisheries managed by the New England and Mid-Atlantic Fishery Management Councils.

Northeast Regional Office

Although the regional fishery management councils develop fishery management plans and regulations, the NMFS Regional Office (RO) is responsible with ensuring that they meet federal requirements, as well as monitoring and enforcing the plans. The Regional Office's Administrator (RA) has power to disapprove decisions made by the regional councils. In the Northeast, the RO is located in Gloucester, MA. The RA is a voting member of the regional fishery management council. The Secretary of Commerce ultimately can disapprove a plan that the RO has approved if it is not in accordance with federal law. Another important role of the Northeast RO is to provide necessary permits for experimental fisheries and scientific research. This is discussed later in this chapter as an important institution enabling cooperative research in this region.

The Northeast Fisheries Science Center

In all regions of the U.S. fishery stock assessment advice provided by regional science centers is a vital component of the fisheries management process (NRC 1998a). More specifically, scientists at the Northeast Fisheries Science Center (NEFSC) are charged with monitoring abundance and productivity of more than two hundred exploited and non-exploited populations and providing fisheries management with quantitative evaluation of the potential consequences of alternative management options to meet management objectives (NRC 1998b). The NEFSC is responsible for an extensive area of the ocean, the Northeast Continental Shelf Ecosystem from the Gulf of Maine to Cape Hatteras (Figure 2-3), and produces stock assessments for about fifty-one managed species/stocks (NMFS 2001). The NEFSC has a long history as having the oldest survey in the country and the second oldest in the world (Sissenwine, Azarovitz, and Suomala

1983). The Center's objectives are carried out through coordinated research efforts conducted at research facilities located in Massachusetts, Rhode Island, Connecticut, New Jersey, and Washington, DC. The "base" of the NEFSC is located in Woods Hole, MA, which is also where the two primary research vessels, R/V Albatross IV and R/V Delaware II, are docked. The NEFSC is organized hierarchically, organized into "divisions" and "branches" with responsibilities for certain areas of scientific investigation.[5]

Stock assessments are done by the Population Dynamics Branch of the Resource Assessment and Evaluation Division. This process requires quantitative information on the relative abundance of fish populations, estimates of total removals from the fishery (landings, discards, fishing related mortality), and life history data (growth rates, age of sexual maturity, maximum longevity, natural mortality) (NMFS 2001). The stock assessment process consists of five steps: (1) stock definition, (2) choice of data collection procedures and data collection, (3) choice of assessment model and conducting of assessments, (4) evaluation of alternative management actions and specification of performance indicators, and the (5) presentation of results (NRC 1998a). Enhancing the quality of stock assessments primarily involves improving the quality of input data on catches, abundance, and life history (NMFS 2001). There are two types of data collection; fishery-dependent and fishery-independent. Fishery-dependent data collection is used to assess fishery removals and includes dealer landings reports and fishermen's logbooks.[6] Fishery-independent data collection is typically done through standardized sampling gear (e.g., the NEFSC bottom trawl survey) and provides information on abundance, distribution, and the biology/life history of species. Once prepared, most stock assessments are peer reviewed through the Northeast Regional Stock Assessment Workshop (SAW) process by the Stock Assessment Review Committee (SARC).

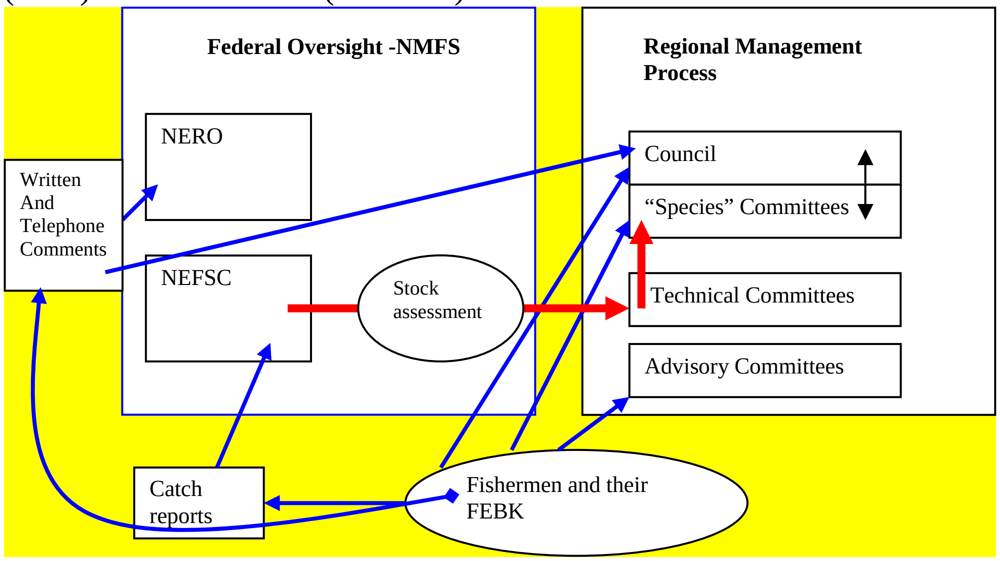
As will be discussed, fishermen have long been skeptical about the ability of NEFSC stock assessment scientists to forecast fish population dynamics and establish sound management advice. Numerous peer-reviews and lawsuits regarding specific stock assessments or the general stock assessment process have occurred whose findings generally favor the NEFSC and/or NMFS (e.g., NRC 1998a, 1998b). However, fishermen continue to question the science behind the stock assessments. Thus, as we will discuss, much of the impetus of collaborative research has been on improving stock assessments and creating industry “buy-in” to stock assessment advice.

Co-Management and the Role of Fishermen and FEBK in Fisheries Management

The U.S. fisheries management system resembles a form of “co-management,” where managers and users share in decision-making responsibilities (Jentoft and McCay 1995; Jentoft 1989; Pinkerton 1989). The intent is to give those who harvest resources a say in the management of those resources in order to foster stewardship necessary for long-term sustainable use of the resources. By including users in creating management rules, those rules are expected to be viewed as more legitimate by stakeholders and therefore self-enforcing (or at least require lower enforcement costs). Co-management is also an improvement over “top-down” management because it draws upon the knowledge that exists in the fishing community (Pinkerton 1989). In the U.S. fisheries management system much effort is made to ensure that the process is as transparent and open to the public as possible, and seeks to be fair and equitable to all stakeholders through representation. Council members are expected to vote for their constituents and in a manner consistent with the Magnuson Stevens Act's 10 National Standards.

Numerous opportunities exist for public participation which theoretically should allow fishermen and their knowledge to enter the scientific-based fisheries management process (Figure 3-1). First, fishermen directly participate in the management process as both council members and advisors. Fishermen also participate as members of the public by attending and making comments at the council and committee meetings, or by writing letters or telephoning in their comments regarding proposed management actions. Some fishermen also participate by expressing their concerns to their, often very sympathetic, congressional representatives.[7] Fishermen also participate to a small degree in the stock assessment process, at the working group meetings and/or the SAW/SARC process, and at the scientific technical committees, although this is considered a recent development. Fishermen also "participate" through a third party. A growing trend seen in the U.S. is that rather than attend fishery management meetings themselves, fishing industry groups send representatives to speak on their behalf. For example, in New England representatives for the Associated Fisheries of Maine, the Northeast Seafood Coalition, and the Fishermen's Survival Fund are always visible at fishery management council meetings on behalf of their members. In the Mid-Atlantic, representatives for the Garden State Seafood Association, National Fisheries Institute, and various recreational fishing groups are often visible at the meetings. In addition, many industry groups have hired scientific consultants and lawyers to represent their interests in the process. As I discuss later, these individuals are critical boundary spanners.

Figure 3-1: Depiction of the Opportunities for Fishermen and their Knowledge to Enter the Science Policy Process. The flow of scientific research-based knowledge (RBK) is also illustrated (Red lines).



Despite these opportunities, the National Research Council (NRC) identified several important "flaws" in the public participation aspect of this "open" and "transparent" process (NRC 2004). One is that even though the meetings are open and accessible to the public, many fishermen cannot attend because they cannot afford the time away from fishing or the travel expenses associated with attending meetings. The NRC also noted problems due to a lack of communication or information flow between fishermen and scientists. The report noted that scientific presentations are "replete with complex terminology, methodologies, and theoretical concepts" and that "many fishermen lack this expertise." They found that in some regions, fishermen have a difficult time participating in stock assessments reviews because they do not understand stock assessment methods. In practice, councils also sometimes delay action and/or disregard the advice of peer reviewed stock assessments and other advisory bodies. The NRC recommended that scientists should communicate more effectively to the public and the regional councils. The NRC also found that problems arise when methods of data selection and analysis are not transparent or the limitations of the data are not acknowledged. These challenges to getting stakeholder input in the fishery management process could, in theory, be addressed in part through cooperative research (i.e., involving fishermen in the scientific collection of information used in fisheries management).

Alternatively, some non-fishery related stakeholders, mainly those representing the environmental community, feel that fishermen have too much control in the fisheries management process (Eagle, Newkirk, and Jr. 2003; Corkett 2005; Daley 2003). Not only do they feel that there is insufficient public representation (i.e., non-industry) on the councils, they also feel there is a conflict of interest when fishermen are allowed to vote on and make management decisions regarding their livelihood, especially when there are financial incentives involved. At the Managing Our Nations Fisheries Part 2 Conference in Washington D.C. (Witherell 2005) there was significant debate regarding the composition of the councils: some saying that there was too much industry representation, while others arguing the benefits of industry involvement. To be sure, fisherman have significantly influenced management, but generally today these concerns are treated secondary to legal mandates to prevent overfishing and rebuild overfished stocks. In any case, whether the councils provide an adequate level of participation for all stakeholders remains debated.

Given that scientific advice is formulated at the regional science centers and then translated into fishery management options through the councils’ technical committees (PDTs or MCs), one may question where fishermen’s knowledge enters the process. The council votes on various fishery management options or rules that will achieve scientific-based targets while minimizing social and economic impacts in the fishery in a way that is most equitable to the industry. In my experience, this is where fishermen most often come into the process. The most frequent type of "knowledge" seen shared by fishermen (or through their representatives) in the council process is that related to potential social and economic impacts of fishery regulations. This knowledge is situated in the local experiences of the fishermen, and is based in part on past experience. For example, many fishermen predict certain management measures (e.g., trip limits, size limits) will result in increased discarding and waste and often cite past failures of certain management measures. For example, in New England fishermen often speak out against hard caps (quotas) given their experience with them in the 1980s that led to massive discards and erratic fishery closures. In recent years, Mid-Atlantic fishermen have argued repeatedly to lower the minimum size of scup in order to reduce discarding, a problem plaguing that fishery, but to no avail. Many of the debates focus around allocation and equity of management measures. For example, emergency action implemented by the NMFS to reduce fishing mortality on weak groundfish stocks was argued as unfair to a large sector of the fishery. The fishing industry by and large has long felt that their knowledge is not considered that important in the management process. Fishermen are allowed to question the equity and effectiveness of certain management measures, but the underlying foundation of the management process remains off limits to negotiation and discussion (i.e., scientific-based biomass and fishing mortality targets).

A quick review of the ten National Standards provides additional insight into the way fisheries are managed and the role of fishermen's knowledge in this process (Table

3-1). Although there is some debate over how they should be treated, National Standard 1 requiring that management prevent overfishing is generally thought to be the most pivotal of the standards. Generally, social and economic considerations or impacts to fishery dependent communities (i.e., National Standards 5 and 8) are treated secondary to the requirements to prevent/end overfishing and rebuild overfished stocks. National Standard 2 requires that the "best scientific information available" be used, but the definition of "best available science" has been debated (NRC 2004). The NOAA fisheries science centers view best available information as "data systematically collected through established procedures and analytical products based on commonly accepted statistical techniques or models developed specifically for resource management" (NRC 2004, 25). The regional councils view "best scientific information available" as "the most recent and relevant information available to them at the time of FMP development, typically as it appears in stock assessments and other reports generated through the science centers" (NRC 2004, 26). The councils do not collect scientific data themselves, but rely on the science centers. The councils do collect verbal and written "anecdotal and experiential information, opinions and recommendations from stakeholders and the interested public" for use in the development of FMPs. The councils "often rely on the experiential information from fishermen as a means of corroborating scientific information, determining changes in stock distributions, and revealing data discrepancies" (NRC 2004, 27). However, when fishermen's reports and science conflict, "councils report that they more often than not defer to the scientific information" (NRC 2004, 27). Thus, fishermen's knowledge is viewed as important, but in the end expert scientific knowledge serves as the basis of policy-making.

Table 3-1: 10 National Standards Guiding Fisheries Management in the U.S.

#	National Standard Description
1	Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.
2	Conservation and management measures shall be based upon the best scientific information available.
3	To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.
4	Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be: Fair and equitable to all such fishermen; Reasonably calculated to promote conservation; and Carried out in such a manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5	Conservation and management measures shall, where practicable, consider efficiency in the utilization of the fishery resources; except that no such measure shall have economic allocation as its sole purpose
6	Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.
7	Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
8	Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities.
9	Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.
10	Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea

Although managers feel fishermen are critical to successful fisheries management, many express difficulty in using fishermen's knowledge in the process due to its interest-based and localized nature. In my research, managers, including industry members, explain how that they have to "be careful" when using fishermen's knowledge because some fishermen are not thought to be honest or as knowledgeable as they claim to be. There are significant economic incentives for providing misleading information in this process. Therefore, council members must figure out what information provided from the industry is reliable. For example, when asked about using fishermen's knowledge, one fisherman on the council responded:

> "Some is good and some is bad, and you have to know how to read through it. That's why…I think having a fisherman on the council is so important because you can tell when somebody's bullshitting…Managers don't necessarily know that."

Thus, when provided, fishermen's knowledge theoretically must be reviewed or "translated" for use in the management process. My discussion of fishermen's knowledge in chapter 1 detailed several reasons why the incorporation of fishermen's knowledge into science and management is difficult. Because fishermen's knowledge tends to be qualitative, localized, and anecdotal, verification and/or aggregation may be necessary for its use in science and management. Scientific-based fisheries management relies mainly on quantitative information about single species at rather large scales provided through quantitative stock assessments. Fishermen's qualitative knowledge is difficult to incorporate into this paradigm (St. Martin 2001). Recent ecosystem-based, area-based, and community-based initiatives may require the collection of more localized knowledge from fishermen (St. Martin et al. 2007). At the same time, there is also increasing demand to limit the use of "non-scientific" or non-peer reviewed knowledge in the science policy process (e.g., the 2000 Data Quality and Information Act). This most likely means that fishermen's knowledge will have an even more difficult time influencing management. On the other hand, collaborative research may be a mechanism to integrate fishermen and their FEBK into the science policy process. If effective at this task, cooperative research may achieve the benefits often attributed to co-management – i.e., "buy-in" to fisheries management and more legitimate and effective governance of marine resources. In addition to creating a sense of stewardship in the resource, and long-term commitments to sustainability, cooperative research may create a sense of ownership and investment in scientific research. This has happened, for example, in the Mid-Atlantic surfclam and ocean quahog fishery.

History of Industry-Science Relations and Cooperative Research in the Northeast

Early Years of Collaboration between Science and the Industry

Cooperative research, if defined as science involving fishermen to any degree, has been on-going for a very long time.[8] Cooperation between fishermen and scientists in the U.S. existed when fisheries science began in the 1870s with the birth of the U.S. Fish and Fisheries Commission (NRC 2004). Spencer Baird was pivotal in the establishment of the Commission in 1871, which was founded in part to investigate fishermen's complaints about declining fish populations (Weber 2002). In 1886, the ninety-foot fishing schooner *Grampus* was converted to a research vessel for use by Spencer Baird and colleagues at the research station in Woods Hole, MA. These early research efforts made use of the knowledge that existed in the fishing community (NRC 2004). Baird also set the precedent for linking research for scientific understanding with research that benefits the fishing industry, and when possible communicated information to the fishing industry to assist with their efforts (Weber 2002). The Bureau of Fisheries, directed by Congress, would later follow Baird's lead and directly sought to locate new species or fish populations for the fishing industry through the 1950s and 1960s.

One of the earliest and most widely celebrated examples of how fishermen contributed to scientific research can be found in the work of Henry Bryant Bigelow and William Schroeder, conducted on the R/V Grampus in the early twentieth century. Their book, *Fishes of the Gulf of Maine*, first published in 1925 and then in 1953, made use of the "anecdotal" observations of fishermen to describe the natural history of what at the time was a *mare incognitum*. In their book, the authors expressed their "hearty thanks to the many commercial fishermen and to the many salt water anglers" who have "supplied us with a vast amount of first-hand knowledge on the habits, distribution, and abundance of commercial and game fishes, which could be had from no other source." [9]

In his book, *The Great Gulf: Fishermen, Scientists and the Struggle to Revive the World's Greatest Fishery*, David Dobbs begins with a look at Henry Bryant Bigelow and his early explorations of the Gulf of Maine in the early twentieth century. He provides a fascinating account of Bigelow's life and work, emphasizing the cooperative relationships between fishermen and scientists at that time. For example, Bigelow and Welsh (with whom he wrote the first version of Fishes of the Gulf of Maine) "grilled knowledgeable fishermen about where the fish were and how thick they were running" (Dobbs 2000, 36). In a memo, Bigelow instructed a scientist who was to conduct a cruise in his place to identify two localities where haddock were spawning that were suitable for trawling, and added that "the precise spots can only be determined after consulting the local fishermen" (H. Bigelow, in Dobbs 2000 pg. 37).

In the early years, fisheries science relied on fishery-dependent information collected from fishery, mainly landings statistics. Sissenwine (2001) described early collaborations between stock assessment scientists and the fishing industry in the early 20th century. One of the first stock assessments, for Georges Bank haddock, relied on the fishing industry to collect data on catch rates and related observations for use in tracking changes in abundance over time.

> "As early as the 1920s and 1930s, Woods Hole scientists recognized the importance of systematically documenting observations made from fishing vessels for use in assessments. They established what was known as a "study fleet" of vessels from the once mighty Boston haddock fleet. The study fleet was made up of selected fishing people who agreed to cooperate with scientists so that their catch rates and related observations could be tracked over time. The spirit of cooperation was very strong, as indicated by a letter written in 1933 by the Captain of the fishing vessel Breeze, who wrote "...let us know if you would like any further information, and if our present data is proving of any interest. It certainly takes up some of my dead time, which is a great help to me" (Sissenwine 2001, 2-3).

Boundary Formation between Industry-Science

The Role of Modern Fisheries Science

After World War II, the fisheries management paradigm of maximum sustainable yield (MSY) took hold (Larkin 1978), drawing on the work of Gordon (1954), Schaefer (1957), and Graham (1935).[10] The idea was to determine the maximum catch that could be harvested continuously over time. This necessitated a fisheries science that aimed at collecting detailed fishery statistics of populations and the development models for prediction and assessment of changes in fish population dynamics.

Two distinct approaches were developed for modeling exploited fish population dynamics. The first was based on the Pearl-Verhulst "logistic" curve. Graham (1935) applied this theory to the Northwest fisheries. Schaefer (1957) expanded on Graham's work, and built upon the work of economist H. Scott Gordon (1954), who argued that the problem of rational fishing was an economic problem and fisheries science had thus far failed to adequately account for the costs of fishing and the behavior of fishermen. The Gordon-Schafer bioeconomic model related yield to effort, and argues for maximizing economic yield rather than maximum yield. The second approach, which also remains prominent today, is to disentangle the processes of fishery population dynamics (growth, fishing mortality, recruitment, and natural mortality) and reassemble them into a model to describe population dynamics. Two of the most widely accepted models of this approach are Ricker (1954) and Beverton and Holt (1957). A critical assumption of these models is a theoretical relationship between stock and recruitment, which has been criticized for not matching data from real-world populations (e.g., Larkin 1977; Frank and Leggett 1994).

Fisheries science then aims to determine the current status of fish populations and also how they will respond to various levels of fishing mortality or harvest. Critical to this objective was the establishment of systematic fishery-independent resource surveys in the 1960s (Sissenwine, Azarovitz, and Suomala 1983). To avoid statistical problems associated with using fishery-dependent data, surveys monitor trends in fish populations. In 1963, the longest running survey program was launched in New England. These surveys received little support from the fishing industry, politicians, and fishery managers (Weber 2002). For example, the methodology of randomly selected areas for sampling meant that samples were sometimes taken in areas that were not fished, which fishermen did not understand. This combined with the small number of samples that could be taken rendered the results of the surveys as “irrelevant” to fishermen. In addition, this type of research did not provide immediate economic and political return to the fishing industry as did product development and research to find new fish populations. The development of these surveys contributed to widening the divide between fishermen and scientists. Industry criticisms of the survey are described in chapter 7. Even today, many fishermen do not feel that assessments based on these surveys reflect true resource conditions.

The “modernist” fisheries management paradigm based on these theories of fish population dynamics prevails today, although in a slightly more sophisticated form. The aim of fisheries management is to control fishing effort or total catch to ensure a sufficient level of spawning stock biomass that will provide sufficient recruitment to replenish the population in the future. Various rules are implemented to achieve the appropriate level of fishing mortality or annual total catch, and these levels are derived from the quantitative, single-species stock assessment models. The shift in management focus on maximizing catch and/or controlling fishing mortality (effort) has had a tremendous impact on fisheries management and industry-science relationships. Pol Dengbol (2003) describes the development of fisheries science over the last 100 years with its focus on the “stock concept” as widening the gap between fishermen’s knowledge and the knowledge used in science; and between fishermen and management. St. Martin (2001) illustrated how the bioeconomic discourse of fisheries management, based on the Gordon-Schafer view of the fishery, produces management solutions that diverge from fishermen’s perceptions of the resource and their desired fishery management solutions. The scientific-based management approach developed in the 1950s has been criticized for its simplification of fish populations and marine ecosystems, as well as fishermen behavior and economic systems, and scholars have advocated instead for ecosystem-based and area-based approaches (Larkin 1996; Wilson 2006).

The Role of Fisheries Management

Perhaps the most fundamental factor in the break down of relations between fishermen and scientists was the establishment of domestic fisheries management. This began with the passage of the Fishery Conservation and Management Act that extended U.S. jurisdiction to 200 miles in 1976, now known as the Magnuson Stevens Act (hereafter MSA). Prior to the passage of the MSA in 1976, domestic fisheries were virtually unmanaged and the focus of management was on foreign fishing (Weber 2002). Below I discuss how the failure of the government to control foreign fishing and then domestic fishing contributed to the poor industry-science relationships that predate the recent development of cooperative research.

Foreign Fishing and the Failure of ICNAF: 1960s

Foreign fishing became the principal concern of the fishing industry beginning in the early 1960s, whereas before that the focus was on addressing the economic conditions of the U.S. fleet (Dewar 1983).[11] In 1961, there were one hundred foreign fishing vessels, mostly from Russia, on Georges Bank, and then by August 1963 three hundred Russian vessels on Georges Bank and in the Gulf of Maine. The vessels were much larger than American vessels, and other nations were sending their vessels to this region too. These vessels were not only bigger, but they had better technology (e.g., stern trawls and better gear) and were more effective at catching fish. These vessels first targeted species of little importance to U.S. fishermen, but then shifted to haddock in 1965 to fish the large 1963 year class, and then targeted yellowtail flounder. By 1970, fishermen were talking about the “haddock crisis.” In 1969, the lowest harvest of haddock in memory (at that time) was landed. And whiting in southern New England had been depleted. After these resources began to decline, foreign fishing shifted towards mackerel, herring, and squid. By the mid-1960s fishermen were warning the government that the fisheries were being depleted by foreign fishing, and in 1966 New Bedford, Point Judith, and other fishing groups were calling for a two hundred mile zone to protect their fisheries. At that time, the administration was opposed to the two hundred mile limit and tried to control fishing through multi-lateral agreements. At that time, the U.S. was trying to handle foreign fishing through the international conference of the Law of the Sea.

Beginning in 1950, fisheries management had been managed under ICNAF, International Commission for the Northwest Atlantic Fisheries. ICNAF was a response to the depletion of important fish populations in the 1940s. ICNAF was formed to provide international cooperation in the collection and analysis of fisheries information for this region and to sustain the yield from these fish stocks. Science was a fundamental part of ICNAF, which set up a Committee on Research and Statistics that was responsible for recommending better research programs and statistical procedures and for providing regular stock assessments (Dewar 1983). In the early years, the most important management tool implemented under ICNAF was regulated mesh sizes. ICNAF faced no major problems until the early 1960s when foreign fleets began to target fish resources on Georges Bank. Problems with enforcement quickly arose as member states were responsible for ensuring their fishermen followed ICNAF rules. ICNAF proved to be a slow process, as rules were implemented several years after initially proposed. ICNAF began imposing annual quotas in 1970, first for the haddock fishery on Georges Bank and

Browns Bank, and also closed spawning areas. ICNAF quotas often exceeded the fishery levels recommended by biologists. Again, quotas were difficult to enforce and violations were rampant. New England fishermen objected to ICNAF, mainly because it was the first time they had experience real regulation and they felt that reducing their catch without regulating the foreign fishing was incorrigible. New England fishermen began protesting ICNAF management. In addition, fishermen did not want to be engaged in discarding fish to stay within ICNAF limits. Despite opposition to ICNAF and desires by the fishing community to extend U.S. jurisdiction to two hundred miles, the U.S. tried to work within the Law of the Sea Conference. It wasn't until 1976, after it was clear that the Law of the Sea Conference would not reach an agreement, that the U.S. decide to unilaterally extend its jurisdiction over fisheries management to two hundred miles. Eventually such extended jurisdiction was incorporated into a new Convention on the Law of the Sea.

In 1976, the Fishery Conservation and Management Act addressed the industry's concerns over foreign fishing, but introduced a new era of fisheries management. This is the regional fishery management council process that exists today, as described in Part 1. At that time fishermen disliked and distrusted NMFS and NOAA due to what happened during ICNAF. According to Dewar (1983), the industry's dislike of NMFS scientists was because they had made the fish stock assessments that led to the lowering of ICNAF quotas, which meant U.S. fishermen could not harvest as much as they wanted. They also felt that NMFS scientists gave fish to the Russians, and were also the ones enforcing the rules in the U.S. fishery (when other nation's violations were not enforced). They also felt that NMFS/NOAA did not do enough for the U.S. fishermen during ICNAF negotiations. Fishermen became resentful of the “academics” and “bureaucrats” that were hurting the fishermen, which referred mainly to NMFS scientists and economists and NMFS staff in Washington D.C. and in the regional offices. Fishermen felt that these scientists and bureaucrats were just out to expand their own jobs and didn’t care about the fishing industry. These sentiments would continue as the new fisheries management process was implemented. The fishing industry was ecstatic that foreign fishing had been eliminated and had thought very little about how the fisheries management process that would replace it would mean to them. Despite wide acceptance that ICNAF management had failed miserably, both the U.S. and Canada adopted with little alteration the single species scientific paradigm and large scale fisheries management approach that had developed under ICNAF. This “intellectual path dependency” still persists today (Wilson 2002).

Domestic Management: U.S. Federal Fisheries Management 1977 to 1990s

Attempts to manage the groundfish fishing industry failed in the early years of management. Regulations were put into effect in March of 1977 to manage cod, haddock, and yellowtail flounder. There were no restrictions on entry, as anyone who wanted a groundfish license could get one. Management at this time focused on seasonal quotas and trip limits. The result of this management approach proved detrimental to both the resource and industry-management relationships. Both seasonal quotas and trip limits resulted in discarding, misreporting, or the illegal sale of fish. The fishery was shut down repeatedly due to the fishery reaching the seasonal quota. In July 1977, after only four months of regulations, the cod quota was reached and the fishery was closed, ostensibly for the remainder of the year. On November 9, 1977, quotas for all groundfish were raised due to political pressure and cod fishing was allowed again. On December 1, 1977, all groundfish fishing was prohibited for one more month. In January 1978, in an effort to allow for year round fishing, quotas were established for three months. The pattern of opening and closing the fishery continued. If that were not enough, there was some change in the groundfish regulations at least once a month (Acheson 1984). Much of this rapid change of management regulations and the opening and closing of the fishery was due to political intervention by the fishing industry. When management action took place, "there was a good deal of political agitation involving visits from Congressmen, lobbying activity, letters to public officials, heated hearings, and the like" (Acheson 1984, 321). After 1979, as a result of intense political pressure, the Council seemingly gave up and avoided the closures (Acheson 1984).

Dr. James Acheson, of the University of Maine, conducted a study on attitudes of groundfish fishermen during these early years of management (Acheson 1984). In a survey done in 1987 of 318 owners and captains of fin-fishing vessels in Maine, New Hampshire, Massachusetts, and Rhode Island, not a single respondent approved of the way the federal government was managing the Gulf of Maine fisheries. A "good many" respondents went into "long tirades about the "government" and is bungling attempts at fisheries management. This question further produced a good many anecdotes to the effect that federal biologists whose figures and assessments influenced management decisions did not know what they were doing. This finding illustrates the developing distrust that fishermen had with federal fisheries scientists. Starting at this time, federal scientists were no longer viewed as disinterested scientists looking to discover the truth about the marine environment and its resources. In fishermen's minds, the scientists were now equated with the managers who were in their minds mismanaging the fishery, and both NMFS managers and NMFS scientists were “out to get them.” The result was growing distrust with scientists and the growing fear that any information that fishermen provided, the scientists would use against them in the form of management regulations. Fishermen responded to this distrust by claiming that the science was bad and/or refusing to accurately report their catches. Scientists then became distrustful of the fishermen. As more management actions were implemented, the industry’s distrust of science increased, as did the conflict between fishermen and scientists.

Acheson (1984) also found high levels of uncertainty within the fishing community regarding what they felt was the best way to manage the fisheries. Interestingly, the vast majority favored some kind of regulation but most (97%) did not favor the quota system that was in place at the time. Peterson and Smith (1982) also found that a great deal of uncertainty resulted from the initial efforts to mange groundfish in New England. The uncertainty and frustration with fisheries management led to serious conflicts between the industry and NMFS and the Council. Some fishermen blatantly violated rules and there were episodes of violence and conflict in the fishing community (Miller and Maanen 1979).

After 1979, as a result of intense political pressure the Council gave up and avoided closures and did little to manage the fishery (Anthony 1990). An Interim Fishery Management Plan went into effect in 1982 because the original Groundfish Plan was not working. The Interim Plan stated that “…a quota-based management program no longer is necessary for rebuilding the resources” (Anthony 1990, 180). This plan focused on effort controls rather than output controls. This plan was supposed to be in effect for only three years, but it wasn’t until 1987 that the Council implemented the Northeast Multispecies Fishery Management Plan. Management changed little with these new management plans (Anthony 1990). As a result of the council’s inability to implement fisheries management regulations to protect the groundfish resource and reduce fishing mortality, effort in the New England groundfish fishery continued to escalate and the fish stocks were depleted (Boreman et al. 1997). They were able to get away with this in the early years in part due to strong year classes of fish in 1979, 1980, and 1981. Rather than implement the effort reductions as recommended by scientists, managers questioned the validity of the science and cited scientific uncertainty to justify no action (Wilson 2002). A result was a push by NMFS and environmental groups to insulate the regulatory process from scientific uncertainty through efforts to separate scientific decisions from allocation, or policy decisions (Wilson 2002). Later, amendments to the MSA in 1996, known as the Sustainable Fisheries Act, essentially mandated that decisions be based on quantitative data (i.e., requirements to develop quantitative overfishing definitions for stocks and that management must prevent overfishing and/or rebuild overfished stocks in relation to these definitions).

What really changed the Council’s course of action? Political intervention, via lawsuits, by environmental groups (i.e., CLF) against NMFS claimed that the government had failed to protect traditional groundfish species (cod, haddock, and yellowtail flounder). In response to these lawsuits, the NEFMC implemented Amendment 5 and then soon after Amendment 7 to the Northeast Multispecies Fishery Management Plan in 1994 that was the first of a series of severe effort restrictions in this fishery. These amendments limited access to the fishery, reduced effort by limiting Days-at-Sea (DAS) fishermen are allowed to fish, required mandatory vessel trip reports, and closed large areas of the ocean to fishing. The management of Days-At-Sea has been a controversial management tool, with some believing that it does not adequately control fishing mortality. The New England fishing community and its managers have long preferred so-called "effort controls" over numerical controls such as quotas and ITQs, most likely due to failed efforts to implement seasonal and trip quotas in the late-70s. There are conflicting accounts of whether Amendments 5 and 7 were enough to rebuild the overfished fish stocks. In 1996, the Sustainable Fisheries Act was passed with more management requirements that the NEFMC has been struggling to meet. Environmental groups continue to put pressure on the NEFMC to manage the groundfish resources. Numerous management attempts have been made over the last ten years to manage this fishery, most notable rolling closures in the Gulf of Maine, very low trip limits, and reduced DAS allowances.

The initial round of effort reductions that occurred with Amendments 5 and 7 resulted in several funding opportunities for "cooperative" research, much of which was in the form of economic assistance to the fishing industry. These are described below.

Early "Cooperative" Research Funding Programs

Here, I describe several "early" cooperative research funding opportunities that aimed to address management concerns in the mid-1990s, before the "new wave" of cooperative research that is the subject of this dissertation.[12] These early efforts differed in that the involvement of the industry was significantly less in terms of quality and quantity of participation. In particular these programs didn't always require the involvement of fishermen or their knowledge. Many of these represented the chartering of fishermen's vessels as research platforms. The point here is simply is to recognize that the recent growth of cooperative research came out of earlier attempts at collaboration with the industry.

Fishing Industry Grants (FIGs) (1995)

In response to Amendments 5 and 7 to the Northeast Multispecies Groundfish Fishery Management Plan, Congress passed the Emergency Supplemental Appropriations Act of 1994 (Public Law 103-211) providing thirty million dollars to the U.S. Department of Commerce (Department) for the Northeast Fisheries Assistance Program (NFAP) to address the needs of those directly affected by the decline of the traditional groundfish fisheries in New England. Of the total package, eighteen million dollars was designated to the Economic Development Administration to provide economic adjustment assistance to communities; twelve million dollars went to NMFS for direct industry assistance in the form of (1) loan guarantees under the Fisheries Obligation Guarantee Program to help restructure existing debt, (2) grants to assist the fishing industry affected by the decline of the traditional groundfish and scallop fisheries and, (3) Fishing Family Assistance Centers in the Northeast to serve as clearinghouses for all possible assistance available from Federal and state sources. Of the twelve million dollars in NFAP funds administered by NMFS nine million dollars was provided directly to the private sector through grants under the FIG (Fishing Industry Grant) Program. These grants were provided in two rounds. A total of $4.5 million was available for the first round. In response to that notice, 201 proposals were received, of which twenty-eight were recommended for funding. Eleven of the twenty-eight projects focused on the development of commercial fisheries and markets for underexploited finfish and shellfish species; nine focused on aquaculture as a method for enhancing natural production of groundfish and shellfish stocks, and also as a commercial enterprise; and eight explored various aspects of new business opportunities for displaced fishermen. Federal support for these projects ranges from $20,000 to $654,900, with an average Federal funding level of $160,714. As a result of an increasing decline in the groundfish resources, the second round of $4.5 million emphasized short-term assistance for those directly dependent upon groundfish and other traditional Northeast fisheries, such as developing new economic opportunities, promoting the development of fisheries and markets for underexploited species, and developing methods to reduce or eliminate inadvertent capture of non-targeted, protected, or prohibited species (i.e., bycatch studies).

Saltonstall-Kennedy Grants (1980 to 2004)

Before and after the FIG program, there was the Saltonstall-Kennedy Grant Program (S-K grants) that enabled cooperative research, which began in 1980. The American Fisheries Promotion Act (AFPA) of 1980 authorized a grants program for fisheries research and development projects and a National Fisheries Research and Development Program to be carried out with Saltonstall-Kennedy (S-K) funds, which are derived from duties on imported fisheries products.

The S-K Grant Program was created as a competitive grants program administered by NMFS. Grants and cooperative agreements were made annually on a competitive basis (subject to funding) to assist in carrying out projects related to U.S. commercial and recreational fisheries. When funds are available, NMFS solicited proposals through a notice published in the Federal Register once during each year for which grant funds have been allocated. The notice described the program’s priorities (variable from year to year), eligibility requirements, instructions and format for submitting proposals, and selection criteria. Grant applications are reviewed by technical experts for scientific and technical merit and by Constituency Panel members for usefulness to stakeholders. The Assistant Administrator for Fisheries used the input from stakeholders in making funding decisions. For example, in New England and the Mid-Atlantic, “fishery development foundations” were created, composed of the fishing industry, to aid in the distribution of S-K funds. According to one foundation member, these foundations got together and agreed on what research projects they felt were most valuable to the industry.

Initially, the program aimed to develop underutilized fisheries within the U.S. EEZ, as the Magnuson-Stevens Act aimed to provide the domestic fishing industry with priority access to the U.S. EEZ. Thus, the S-K program originally focused on stimulating the development of underutilized fisheries within the U.S. EEZ, through fisheries development and marketing. After the domestic fleet was at overcapacity and the fish stocks began to be overfished, the emphasis of the program shifted towards conservation, management, and aquaculture. Two major events in recent years led NMFS to significantly overhaul the program's emphasis again. One was the passage of the Sustainable Fisheries Act in 1996, which addressed stock rebuilding and industry impact issues. This resulted in a shift in the S-K program to focus on addressing the current condition of the fisheries. And then in the late 1990s, program priorities also emphasized projects that addressed the needs of fishery dependent communities, as defined by the MSA. The other major event was the 1998 update of NOAA’s Strategic Plan, which included a goal of building sustainable fisheries through meeting several objectives. The

S-K program's priorities included projects aimed at helping fishing communities to resolve issues that affect their ability to fish, make full use of currently managed species or explore the potential development of new fisheries, provide environmentally sound aquaculture, and address socio-economic impacts of overfishing and excess harvest capacity.

In the Northeast, the S-K program has funded over 250 projects worth about thirty million dollars since 1980 (Beal and Stritzel-Thomson 2005). The program more often funded academic researchers and state fishery agencies, but a few went to members of the fishing industry. In 2004, this program was discontinued due to insufficient funding.

Examples of "Early" Cooperative Research Projects

Before discussing the "new wave" of cooperative research, which according to Sissenwine (2001) began in 1999, I now briefly mention some of the forerunners of cooperative research in this region. These projects essentially paved the way for the collaborations seen today. I discuss the three most commonly cited examples of industry-science collaboration that began before the "new wave" of cooperative research, but which nevertheless were critical to the development of cooperative research in New England and the Mid-Atlantic. These projects are also notable in that they are examples of the successful integration of cooperative research into science and management.

In the northern shrimp fishery, fishermen and scientists tested the feasibility of the Nordmore grate to reduce bycatch of groundfish. This example illustrates the implementation of gear research into management. In the mid-1990s, Mid-Atlantic, the surfclam and ocean quahog fishery worked closely with NEFSC scientists to improve the collection of fishery independent data used in the stock assessments that formed the basis of quota allocation for their fishery. Finally, in the scallop fishery cooperative research in the late 1990s allowed controlled access to the groundfish closures on Georges Bank.

Development of the Nordmore Grate in the Shrimp Fishery

One of the earliest "cooperative" research efforts in the Northeast was the research that led to the wide use of the Nordmore grate in the shrimp fishery. Perhaps one could best think of it as a time when cooperative research tended to be "for-hire" research, where fishermen's vessels were used as research platforms. Fishermen, at least in New England, had little to do with the design and little say in whether it was implemented.

In the early 1980s, the New England groundfish resources were visibly declining and people began to identify the shrimp fishery as a potential culprit. As a small mesh fishery, the shrimp fishery was blamed for catching too many juvenile fish and causing the groundfish decline. Shrimp managers became interested in finding ways to continue shrimp fishing by reducing bycatch of groundfish. At that time a number of gear technical groups began devising and testing different ways to reduce groundfish bycatch in the shrimp fishery.

One of the scientists heavily involved in these efforts was Dr. Daniel Schick at the Maine Department of Marine Resources, who was the shrimp assessment biologist at that time. He received a Saltonstall-Kennedy grant to look at several fish escapement elements in a shrimp trawl. Part of that grant included significant funds to essentially have fishermen propose ideas for gear changes that they thought would release fish and then they would test those ideas. Fishermen were basically coming up with research questions and hypotheses, which they would test with scientists. Or, perhaps better stated, the scientists would test for them. This work went on through the mid to late 80's and early 1990's. Their best separation with all of the different elements they tried had gotten about a thirty percent separation of some species of fish, but not all of them.

Then around 1991, a few fishermen from Nordmore County, Norway came up with an idea for getting rid of fish in their shrimp fishery. This became the Nordmore Grate. It was a hard panel of bars that would exclude from the net anything that was too large to go through the bars. They mounted that at an angle back in the extension and provided an escape hole for everything that could not go through the bars. It worked well. The Nordmore Grate got rid of over ninety-five percent of all fish and retained over ninety-five percent of all shrimp. As one observer noted: “It was just it was a magic device compared to anything we'd seen and it blew us all out of the water. So we just all said 'Okay...you win. We're going to use that.'”

Not all fishermen in New England embraced this new device. For example, a sector of the groundfish fleet, mostly large boats out of Gloucester, depended significantly on the bycatch of groundfish in their shrimp fishery to keep their boats going. In addition to economic reasons, there was a mentality at that time that one wasn’t a good fisherman unless they landed a huge bag of fish. In some ways, the shrimp were a bycatch in the shrimp fishery (i.e., they were really targeting groundfish with these small meshes). The result was that a lot of these fishermen simply left the shrimp fishery.

The use of the Nordmore grate was a learning process and continued to evolve. Initially there has always been a lot of skepticism about how much shrimp actually escape. More studies were done to assess this. They found that successful use of the grate had a lot to do with the rigging. As one scientist explained:

> "If you mounted that grate at the right angle and it stayed that way under tow then no, you didn't lose many shrimp. If that was mounted so that it was a lot steeper or less steep then it should be or that the way it fit essentially then it was much more of a straight shot for shrimp to go out the hole rather then go down through the bars."

One fisherman explained that although the gear modification is a success, it was poorly implemented: "When they implemented the Nordmore Grate, we didn't even have an English interpretation on how to put them into the god damn net." He described the effort as not cooperative but "dictated" because they were simply told to use this gear that was developed elsewhere. Fishermen were provided with only one way to rig their grate, with the hole at the top. Fishermen were having trouble with the grate because after 15-20 minutes into a tow skates would wrap their wings around the grate and just hang on, clogging the grate. They tried everything to get the grate to work and nothing worked. One fisherman contacted someone at the University of North Carolina and learned that they had to turn the grate upside down. After turning it around, the grate worked fine, although it didn't catch as many shrimp.

But once they began to use it fishermen quickly came to recognize its benefits. Fishermen avoided or reduced a very unpleasant part of the shrimp fishery for them: they didn't have to be on their knees in freezing weather picking fish out one by one from the catch and pitching them overboard. In addition, the reduction in time spent culling fish got to the point where they could actually do with one less deck person on a shrimp trip and still get the work done. Personnel expenses went way down and the crew very quickly dispatched a catch of shrimp in terms of getting it boxed up and cleaned. So it was a time and labor saving device, and made the fishing a little more pleasant for them. Despite feeling like the effort wasn't really cooperative but dictated, the same fisherman felt that "…if we define success as something positive happening in the fishery then the Nordmore grate would have to be up with the top of a success story…They still say you're going to use this or you're not going to go, but it is a huge success for the fish." In recent years, as part of the new cooperative research movement, studies have tested the use of the Nordmore grate in the whiting fishery, where it reduces discards of groundfish. One example is discussed in chapter 6.

Mid-Atlantic Surfclam and Ocean Quahog Cooperative Surveys (1995-present)

While New England was developing cooperative research from monies dedicated from Congress, the Mid-Atlantic was initiating significant industry-led cooperative work in the surfclam and ocean quahog fishery. This set an example of cooperative research in this region.

The surfclam and ocean quahog fishery became the nation's first fishery managed under individual transferable quotas (ITQs) in 1990 (McCay and Brandt 2001). By creating property rights in this fishery, owners of ITQ presumably have a greater interest in the future of this resource. Those in the surfclam and ocean quahog fishery have a vested interest in ensuring that the fishery is managed with the best science available. As David Wallace, a representative of the North Atlantic Clam Association, said, "It is important to the fishing industry that the clam population studies are based on the highest quality data that can be gathered" (Griffin 2002).

Like many other cooperative efforts, research done in collaboration between the surfclam and quahog fishery and the NEFSC rose out of conflict. In 1994, the hydraulic dredge survey used to determine abundance of clams found that there were 2-3 times more surfclams than previous surveys, which differed significantly from what scientists thought existed. Scientists considered the results of the survey an anomaly and recommended a ten percent reduction in total allowable catch. Later, it was discovered that the voltage on the NMFS survey dredge was high, explaining the “atypical” results. The industry followed with a lawsuit claiming that the results of the survey were invalid. Although the court favored NMFS in the law suit, a collaborative relationship emerged between the industry, academia, and the NEFSC, largely through the cooperative research involved.

Around this time, the clam industry hired a scientific consultant, Dr. Eric Powell, of Rutgers Haskin Shellfish Lab, to help them in their effort to show that the dredge efficiency used in the assessments was overestimated. They decided to use industry vessels to measure the dredge efficiency. The research was ultimately funded by the industry itself in the form of financial resources and boats. The National Fisheries Institute (NFI), a non-profit organization, was given accounting responsibilities to avoid potential legal issues, or charges of mismanagement.

In 1997, in the first of many collaborative efforts, clam industry vessels conducted tows side-by-side with the federal research vessel as well as depletion studies to estimate the dredge efficiency of the vessel used to assess the abundance of clams. These studies continued in 1999, 2002, 2004, and 2005. The depletion studies involved the industry following the same area towed by the research vessel to find out what the research vessel didn’t catch. Basically they were using the industry boats to find out how many clams the research vessel missed when they towed with their dredge. In addition, as part of the cooperative research effort, the research vessels are using a state of the art sensor packages to monitor the dredge. The sensor packages cost about thirty thousand dollars:

the program needed two of them, so the industry bought one of them. The data collected from these efforts was incorporated directly into the assessment process. Like other cases examined in this dissertation, one element of success was the involvement of the stock assessment scientists in the effort. Their involvement in the collaboration facilitated the use of the data in the assessment.

The cooperative surveys and collaboration between NEFSC scientists and the industry continue today. For example, at the stock assessment review meeting (SARC) in June 2003, there was evidence of a massive die off of clams in the southern area. The industry wanted to do another survey the next year instead of waiting for the next one scheduled for 2005. The industry met during lunch at the SARC with NEFSC scientists to discuss the survey. They planned the survey over the course of a few more meetings and conducted the survey in July 2004. This probably would not have happened without the history of cooperation between these scientists and the surfclam industry. According to one NEFSC scientist, the industry-based survey for surfclam and ocean quahogs will most likely take over the task of collecting fishery-independent data for this fishery.

Scallop Cooperative Research (1999)

Another early successful example of cooperative research occurred in New England with the industry based surveys in the Atlantic sea scallop fishery. Four large groundfish closures on Georges Bank were implemented in 1994 to protect the depleted New England groundfish stocks. These closures prohibited the use of any gear capable of catching groundfish, including scallop dredges. Combined with effort limitations in the scallop industry implemented at that time, this resulted in a significant reduction in effort on scallop stocks. Nevertheless, landings continued to decline and managers called for more reductions in DAS. Effort from the closed areas was displaced to the remaining open areas and on Mid-Atlantic populations. Additional areas in the Mid-Atlantic were later closed to scalloping. Meanwhile, the scallop resource flourished within the closed areas, a somewhat unexpected outcome of this effort to protect and rebuild groundfish. In the first twenty months of the groundfish closures, sea scallop biomass tripled. The scallop industry became interested in exploring these areas. Several attempts were made by the industry to acquire experimental fishing permits (EFPs) to fish in these closed areas, but applications were rejected due to poor scientific design. As Paul Rago, scientist at the NEFSC, said: “They were not well thought out and there was no expectation that the design was sufficient to answer the questions. Some of them just looked like fishing expeditions” (Bernstein and Iudicello 2000, 67).

In 1998, the fishing industry, represented by the Fishermen’s Survival Fund, collaborated with Dr. Brian Rothschild of CMAST and worked with NMFS scientists to design a feasibility study to do a dredge survey in Closed Area 2. The research objectives included finding out if there were sufficient scallops of a large size to warrant opening the area to fishing. In order to estimate abundance, they need to calibrate the industry’s vessels with each other and with the NOAA research vessel, the R/V Albatross IV. They also needed to measure the efficiency of the dredge tow to convert estimates of relative abundance to absolute abundance. In addition, NMFS also wanted to know how much bycatch of flounders and other groundfish occurred during scalloping, as the closures were created to protect these resources. Their research confirmed a huge biomass of scallops in Closed Area 2 and contributed to additional scallop openings in 1999 worth thirty-six million dollars to the industry. Since then an area-based management approach involving rolling closures has been used to manage the scallop resources. Today, the scallop resource is exceptionally abundant and is one of the most valuable fisheries in the United States (Hart, personal communication).

One of the most important contributors to the success of this project was industry organization through the Fishermen's Survival Fund, a New Bedford and Fairhaven industry association formed to protect the interest of scallop fishermen. One of the most important steps this group took was to hire a Washington-based lawyer to represent them. His job was initially twofold: support CMAST's request for an EFP and file a petition for rule-making to open the closed areas to fishing. He was able to make the process work for the industry that fishermen alone could not have done. The industry provided their vessels and scallop gear. CMAST provided scientists. The NEFSC provided electronic equipment and supported the salary of a post-doc at CMAST. The fishing industry was compensated by being allowed to keep and sell ten thousand pounds of scallops and not having their DAS counted against them for time doing research. The rest of the catch was pooled to generate revenue to cover CMAST's research costs, observers, and expenses of the vessels.

As one of the early cooperative research efforts, these efforts were not without conflict. The research design process and the research itself went fairly smoothly. Problems arose during the analysis of the data. There had been different expectations about peer review and release of the data. One major obstacle to the cooperative effort occurred when Dr. Rothschild "stepped over the government and announced how much product was offshore…before the government could finish processing the data" (Bernstein and Iudicello 2000, 70). There was a bit of debate over how to interpret the data. There was debate over how long the dredge was on the bottom and the rate of efficiency of the tows. Different values of when the dredge starts and stops fishing made a twenty percent difference in the biomass estimates. The CMAST scientists estimated sixteen percent dredge efficiency, while NMFS estimated it at forty percent. There was also conflict between the CMAST and NMFS scientists, as CMAST scientists felt that NMFS was trying to control the research and data collection. Another source of conflict, common to most surveys, involved the need to avoid damaging fixed gear, in this case from the lobster industry. They were able to work with the lobstermen to reduce damage of the lobster pots.

This pilot was followed by a project to assess the numbers and size of scallops in the remaining closed areas: Closed Area 1 and Nantucket Lightship. Again, this project also sought to evaluate the level of bycatch in the scallop dredges. There was significant concern regarding bycatch since the closures were after all designed to protect groundfish. A joint survey was conducted from August 6 to September 1, 1999. Two scallop vessels were chosen by lottery to participate in the biomass survey portion of the project, while two other vessels were chosen by lottery to do the bycatch portion of the project. The scallop vessels used their allocated DAS and retained fourteen thousand pounds of scallops from their ten day trips, which was then sold. This had a value of about eighty thousand dollars. The vessels only had to count DAS that were actually used during the survey tows. As with the pilot survey, the NEFSC was responsible for the survey design, the industry provided crew and vessels, and CMAST and VIMS provided researchers and scientific assistance. These cooperative research efforts proved to be a significant success for the industry. The results allowed managers to devise bycatch reduction measures and enable additional openings into these closed areas, resulting in thirty-six million dollars worth of landed scallop meats. Today, as result of this cooperative research, scallops are managed with a rotational management strategy.

“Trawl Gate” and the R/V Henry Bigelow

A discussion of the context of cooperative research in the Northeast would not be complete without mention of “Trawl Gate” – which had important implications for industry and science relationships in this region. This is briefly described below and presented again in chapter 8, when I discuss the Trawl Survey Advisory Panel.

In September 2002, the Northeast Fisheries Science Center announced the miscalibration of the research gear used on the NEFSC bottom trawl survey (Malakoff 2002). The trawl warps connecting the doors to the nets had been mismeasured and so were not of equal length when towed, making the survey net fish improperly. The gear had been mismeasured for two years or for eight bottom trawl surveys. A local fisherman had first noticed that the warps were mismarked and reported this to the NEFSC, which confirmed the error two years later. This error was dubbed “trawl gate” by members of the fishing industry, and skepticism quickly emerged regarding the validity of stock assessments and proposed management measures based on those assessments. In addition to the calibration issues, a number of additional concerns regarding the gear and operation of the survey were identified when six fishermen observed the survey in operation after the trawl warp error was identified. In addition to its “scientific” response (i.e., analyzing the data and conducting calibration experiments), the NEFSC also pledged to improve the survey and respond to stakeholder concerns. Although two peer reviews of the survey concluded that the trawl warp miscalibration had no effect on the results of the survey (and no impact on stock assessments)[13], the NEFSC and the industry agreed that some changes were necessary. To be sure, many fishermen remain skeptical about the survey and its implications for fisheries management. Establishing trust in or "buy-in" the survey will take time and effort on the part of the government science center.

Coincident with "trawl gate," Congress appropriated funds for a new, state of the art scientific research vessel. At 208-feet, the new research vessel, the *R/V Henry Bigelow*, is much larger and more powerful than the vessel it replaces, the 187-foot *R/V Albatross IV* which has been used in the survey since its inception in 1963.

With the new vessel, there was a pragmatic need to develop a new survey trawl system. In addition, the size of the new research vessel will preclude sampling in some inshore areas, making data collected by cooperative industry-based surveys critical. Thus, these two events influenced several cooperative research efforts. An industry-science advisory committee, the Trawl Survey Advisory Panel was created to provide advice to the NEFSC regarding it trawl survey (chapter 8). And several industry-based surveys are being conducted that will supplement data collected by the R/V Bigelow in the future (chapter 7).

Summary

Distrust between fishermen and NMFS scientists began during ICNAF management and worsened during early years of U.S. management under the Magnusson Act. Throughout the history of groundfish management, fishermen and managers have questioned the validity of the science upon which these management measures were based, often suggesting that there are more fish out there than assessments predict. Until

Amendment 5 and 7, scientific recommendations to reduce fishing mortality were ignored in favor of status quo fishing. This has been attributed to differential views of the resource (Smith 1995; Dobbs 2000). According to Dobbs (2000 5), “the rift between fishermen and NMFS scientists over how to look at the ocean and think about fish fostered a level of discord, doubt, and mistrust that made it almost impossible to convince fishermen and regulators to curb overfishing.”

Fishermen continued to question the science used in fisheries management. New England fishermen rallied political support for their cause through their congressional representatives. Several peer reviews emerged from these complaints, including a review of the groundfish assessments (NRC 1998b). A similar review occurred of stock assessments of summer flounder in the Mid-Atlantic (NRC 2000). As I discuss later, beginning in 1999 Congress responded by encouraging and funding industry-science cooperative research. The Northeast Consortium and the NMFS-Cooperative Research Partners Initiative were created with federal funds to provide cooperative research opportunities related to groundfish.

Thus, cooperative research in the Northeast can be viewed as a response to overfishing practices and mismanagement that developed after the Magnuson Act in 1976. These efforts aim to improve management and address the socioeconomic impacts of management on fishing communities. A more recent crisis in fisheries science occurred in 2002 when the NEFSC acknowledged errors in its bottom trawl survey, known as “trawl gate.” From this crisis additional industry-science collaborations have emerged, most notably the Trawl Survey Advisory Panel and several industry-based surveys.

Current Institutions Enabling Cooperative Research in the Northeast

Today, several federally funded or managed cooperative research programs exist in the Northeast. In New England, these are the Northeast Consortium and the NMFS-Cooperative Research Partners Program, both created in 1999. [14] These programs represent action taken by Congress to mitigate social and economic impacts to New England fishing communities resulting from fishing regulations in the multi-species groundfish fishery. In the Mid-Atlantic, the Research Set-Aside quota program was set up by the Mid-Atlantic FMC as a way to provide funds for cooperative research in their region, as no direct funding from Congress was available as is the case for New England. In addition to these federal programs, other cooperative efforts have been funded by federal, state, or industry programs, but these are not the focus of this research, such as the MARFIN program and the S-K grant program. Related to these three funding programs for cooperative research, I also briefly describe three critical management institutions related to cooperative research process in New England and the Mid-Atlantic – (1) the NEFMC's Research Steering Committee (RSC), (2) the NMFS-Northeast Regional Office and (3) the Northeast Fisheries Science Center.

<u>The Northeast Consortium</u>

The Northeast Consortium was established in 1999 to administer federal funds allocated by Congress for cooperative research. Hartley and Robertson (2006,11) describe the Northeast Consortium as "a multistakeholder-driven process, open to all fishermen, encouraging and facilitating partnerships, promoting the transfer of findings to managers and other end-users, and monitoring progress to ensure that it would remain fair, inclusive, and credible." The Consortium is a group of four research institutions, the

University of Maine, University of New Hampshire, MIT Sea grant, and Woods Hole Oceanographic Institution. The University of New Hampshire is the fiduciary agent, which receives the grant and administers the program. Each of the four institutions has a representative, the Sea Grant director. This four-person body makes the final decisions on which projects to fund.

Like the Cooperative Research Partners Program discussed below, the Consortium was created in response to a round of fishery regulations that many viewed as going to lead to severe social and economic impacts in the fishing communities. The New England fishing industry approached their political leaders for assistance. Some of the senators in the Northern states of Maine and New Hampshire, who happen to be Republicans, were not particularly fond of subsidy programs that would essentially pay fishermen not to fish, just as they are not fond of agricultural subsidy approaches that pay a farmer not to farm or harvest. At the same time, fishermen did not want to receive a handout and did not like the notion of a welfare program for fishermen. As fisherman explained:

> "We had pitched the collaborative research to Congress as an investment in the fishing industry and so rather than just kick back and say it's a given that the government should give us money, [we] wanted to stop and find a way to say thank you."

An industry member on the New England Fishery Management Council explained the history of the cooperative research programs in New England:

> "I mean it's an interesting phenomenon what happened. We were making these initial very Draconian cuts in fishing effort in response to the sustainable fisheries Act. This was like in 1997-98 period and the industry was going to the Congressmen saying, 'What is the government doing to us? And why are they doing it?' And the Congress' response was "Let's throw some money at them." And it was welfare money…And then when it came down figuring how to hand that money out; first of all there wasn't enough money even though it was

> millions of dollars, there really wasn't enough money there to go around to affect anybody's fishing business in any really significant way…But it basically came down to was, there was no fair way to hand the money out. And it felt too much like welfare. And so some industry people came up with a good idea. 'Let's get people to do something for the money.'"

In the first year, the NEC received two million dollars, but since then has received five million dollars each year to fund cooperative research. Four million goes directly into competitive research projects. This program differs from the Cooperative Research Partner Program (CRPP) in that it explicitly requires that seventy-five percent of the funds go to the fishing industry and twenty-five percent to research. This is to ensure that the collaborations involve more significant relationships than simply scientists chartering fishermen's boats as research platforms. According to their data base, the Northeast Consortium funded about two hundred projects totaling $23,095,846 from 2000-2006. This program has funded gear/conservation engineering, ecological, environmental, monitoring, and stock assessment related projects.

Like other funding programs, the NEC solicits Request for Proposals (RFPs). The NEC runs two RFPs ach year. The more substantial RFP is for one and two year projects ranging in from $50,000 to $250,000, depending on the question and the number of partners.[15] The process begins with a planning letter. An advisory committee of about 25-30 individuals representing all stakeholder perspectives (i.e., fishermen, scientists, state and federal regulators, environmental groups, NGOs) makes up a review panel.[16] This panel looks at individual proposals and evaluates them according to specific evaluation criteria. In terms of the planning letters, they simply recommend to develop a full proposal or not. This is followed by a plenary session where the whole advisory panel meets as a large group for a fuller discussion. The Sea Grant representatives make the final decision, but generally follow the panel's recommendations. Based on this meeting, the proposing investigators receive a response letter from the Consortium that summarizes the panel's comments and the decision of the representative. Typically, it will either encourage them or discourage them to generate a full proposal. The review of full proposals is similar to the pre-proposal process with an advisory committee breaking down into small groups for consensus and then a recommendation being made by the full committee, and the representatives making the final decision. Generally, they encourage about forty proposals and then fund about twenty projects. Again, the Consortium sends out response letters informing proposers if they have been funded or not. When not funded, whenever possible, constructive feedback is provided on how to improve the proposal.

The Northeast Consortium differs from other cooperative research programs in that it does not seek specific types of projects and there is less of an emphasis that projects should address management questions (Hartley and Robertson 2006).

A NEC staff member explained:

> "We don't set priorities specifically on what topic areas to fund…So rather than say, 'Oh, we are going to fund only gear research in this RFP, or something.' We say, 'We'll fund anything you guys propose, but here is the criteria.' And it's things like: What are really important questions for fisheries science and fisheries management and fishermen? What is the technical merit of that proposal put forward? Is it good science? Is it done well? Does it put practical activities on a fishing vessel too? The quality of that partnership, the end user impacts, and the connection to that end user? Is this a product that is going to make a difference in an applied practical sense? We don't tend to be funding too much basic research, as much as more applied research. What's the past experience, past performance of the team? And then, the team composition itself, the capacity of this team."

The remainder of funds left after funding the competitive projects, about one million dollars, is used for administration and outreach activities. The NEC has contracts with local organizations. These organizations include the Gulf of Maine Research Institute in Portland, ME and the Massachusetts Fishermen's Partnership in Gloucester, MA. These organizations have cooperative research contact persons and they run workshops and one-on-one consultations. They try to facilitate matchmaking between fishermen and scientists, trying to help fishermen take their idea and cast it in a scientific hypothesis, help them put a proposal together when the deadlines come up for their RFP's.

Outreach is critical to the Northeast Consortium's success. The program sponsors an annual Participants Meeting. At these meetings cooperative research projects are presented, often by the industry partners, to facilitate learning. These meetings have been important in identifying the challenges that arise in cooperative research, such as delays in permitting. They also have a communications contract with NAMA, the Northwest Atlantic Marine Alliance, which received funds to hire a cooperative research reporter to generate a newsletter called *Collaborations* that tells stories about cooperative research. These readable essays function to get the word out to fishermen about cooperative research and hopefully to get more fishermen involved in becoming involved. Another function of Collaborations is to inform members of Congress, especially those from New England who worked hard to get funding for cooperative research.

NMFS Cooperative Research Partners Program

In 1999 the Northeast Regional Office of the National Marine Fisheries Service (NMFS) created the Cooperative Research Partners Initiative to manage a cooperative research program in New England. This program is supported by more than twenty-five million dollars that Congress has allocated since 1999 to support cooperative research. In

2005, the name of this program was changed to Cooperative Research Partners Program (CRPP). Since the program was established, over nineteen million dollars has been spent on cooperative research projects.

Again, this program developed in response to the need to provide funding to fishing communities affected by the New England groundfish crisis. One CRPP administrator described how the program came about:

> “In 1998, I think it was about five million dollars, and in 1999 it was another couple of million dollars, up to four million dollars, [Congress] put funds that went to "disaster relief." And those funds were distributed directly to fishermen, based on their fishing history. And they were earmarked to provide disaster relief to help fishermen through the tough years when management regulations were heavily impacting their economic viability. And those two programs, or those two funding sources, are really what {were} the impetus for developing this program. It came about sort of in an anecdotal story. The fishermen basically just did not want to just receive free handouts. They didn't want it to be a welfare type program. They wanted to do something in return, and provide something back to the government and the taxpayers. And so, in the beginning, they said, "What can we do to respond to the money that we have received?"

The NMFS initially provided fishermen with two ways to “earn” the money marked for disaster relief. The first was to participate in a whale disentanglement program, where fishermen volunteered to assist in the logistics of releasing a humpback or right whale caught in fishing gear. One option was the “Take a Manager to Sea” program, which was less successful. The final option was to participate in a socioeconomic study, which included providing one year of their IRS information and filing out a socioeconomic survey form. Those options were available for about a year until the formal cooperative research program was established. The CRPP program sponsors both long-term and short-term cooperative research projects.

To develop the long-term projects, NMFS hired three organizations to conduct scoping meetings between 1999 and 2000 along the New England coast from Maine to

Rhode Island. The Gulf of Maine Aquarium (now Gulf of Maine Research Institute) was contracted to conduct seven workshops on industry-based surveys and study fleets. The New England Aquarium was contracted to conduct planning meetings to design a cod-tagging program. The outcome of these meetings included several long-term cooperative research programs. These include two Industry-Based Surveys (Cod and Yellowtail Flounder), the Northeast Regional Cod Tagging Program, and the Study Fleet program. The Cod IBS and the NE regional cod tagging programs are discussed in chapters 7 and 5, respectively.

In addition to the long-term programs, as of June 2005, the CRPP program had funded forty-three short-term projects totaling over nine million dollars. These were primarily gear conservation studies, but also included a whiting stock identification study and a social science study. Additionally, the CRPP has taken turns with the Northeast Consortium in funding years of the Maine-New Hampshire Inshore trawl survey, an industry-based survey of state waters, which is discussed in chapter 7.

Short-term research is funded in consideration with recommendations made to the NMFS by the NEFMC’s Research Steering Committee (RSC), discussed later. On an annual basis, for the short-term research projects, the RSC sits down and looks at a prioritized list of research needs. And then the RSC makes recommendations to the National Marine Fisheries Service regarding what the annual solicitations (RFPs) should be. These are published and proposals are received after a six or eight week period. An evaluation team is comprised of several members of the RSC, some of NMFS staff, and other experts. The composition of the evaluation team changes annually and depends on the topics being solicited for research. For example, in 2003 the solicitation was for habitat proposals, and thus the evaluation team included several habitat and marine ecologists. To protect the integrity of the process, the identities of the evaluation team members are not made public. Similarly, the proposals are considered proprietary information, belonging to the principal investigator, and are confidential. Once funded, however, the proposals are considered public and NMFS can post them on the Internet or make them publicly available.

Proposals are ranked based on the evaluation criteria, which includes the soundness of the design, the need for that information for management purposes, the expertise that they have listed that they are going to use (i.e., what scientists or what fishermen are going to be used), the overall potential for success with the team between the scientist and fisherman, and the overall cost, although the cost is only a secondary valuation criteria. The evaluation committee comes up with a recommendation that is given to the Regional Administrator, who makes the final decision on what projects are funded. In the beginning of the program, the solicitations were fairly broad and have become focused in recent years. For example, in 2004 solicitations were specific to habitat proposals. In 2004, there was an RFP for research addressing the development of Special Access Programs (SAPs) and the use of "B" Days-at-Sea (DAS) in the Northeast Multispecies Fishery.

One staff member of the CRPP program described the evaluation criteria and the process for selecting the projects to be funded.

> “They include things like the soundness of the design, the need for that information for management purposes, the expertise that they have listed that they are going to use, what scientists or what fishermen are going to be used, the overall potential for success with the team, between this scientist and this fisherman, and then, the overall cost. The cost is really a secondary valuation criteria. The proposals are then looked at, and we come up with a

> recommendation that we give to the Regional Administrator, and she makes the decision on what projects get funded."

Once the evaluation is complete, if the proposal authors want to get some feedback from their proposal, they can contact NMFS and then they can provide comments that the evaluation team made anonymously back to the proposal author. This is valuable to those not funded as it may help them improve the proposal's funding changes in the future. At first the program would typically receive 60-70 proposals and so it was impossible for NMFS to provide feedback about all proposals. In recent years, proposal solicitations have been really narrowly defined, which has effectively decreased the number of proposals received on an annual basis. This allows NMFS to send out comments to everybody.

<u>Mid-Atlantic Research Set-Aside Program</u>

Cooperative research is also growing in momentum in the Mid-Atlantic, beginning with the cooperative surfclam and ocean quahog studies. These cooperative studies continue today with funding shared by the industry and the NEFSC and are considered one of the most successful cooperative efforts in the Northeast. Fortunately, the clam industry is lucrative enough that the industry willingly contributes towards paying for the scientific research that they need to support their fishery. Unlike New England, the Mid-Atlantic has not received direct Congressional funding for cooperative research. Thus, doing cooperative fisheries research in the Mid-Atlantic has proved more challenging than in New England.

In response to a lack of direct funding for fisheries research, the Mid-Atlantic FMC established the Research Set-aside (RSA) Program in August 2001 to fund cooperative research in this region.[17] The program allows up to three percent of the total allowable catch of certain species to be set aside as compensation for cooperative research. Funds generated from the sale of the RSA quota can be used to cover the cost of the research activities, including vessel costs, gear modifications, monitoring equipment, additional provisions (e.g., fuel, ice, food for scientists), or the salaries of research personnel. The vessel owner can retain any additional funds generated above the cost of the research activities (or excess program income) as compensation for the use of the vessel.

The species for which quota is available for set aside research include summer flounder, scup, black sea bass, *Illex* squid, and *Loligo* squid, Atlantic mackerel, butterfish, bluefish, and tilefish. Set aside for each species is primarily to be utilized for research related to that species. However, because in some cases not enough funds can be generated from a single species (or a low market valued species), individual research projects can also request quota allocations for several other species (up to twenty-five percent of the RSA quota for those species).

Each year when the annual specifications are made in June and August, the council votes on what percentage of quota (0-3%) for each species to set aside for research. This is done separately for each species and is based in part on how much quota has been requested in proposals accepted in the RSA program (i.e., approved by NMFS). An RFP is typically made available around April and proposals are submitted around May of each year. The final decision of how much quota to set aside and which projects to approve is made by NMFS. NMFS can choose to adopt less than three percent of the total allowable landings as a set-aside or decide not to adopt any set-aside for a given fishery.

Like in New England, the MAFMC also created a special committee to deal with the research set-aside program. The Research Set-aside committee is also involved in the prioritization of research. The committee meets annually to identify research priorities for the next funding cycle, based in part on recommendations for species committees. This is the basis for an RFP that is sent out to the public by NMFS. For example, in October 2005, the RSA committee prioritized research needs for 2007, an RFP was available in late December 2005, and proposals were due February 21, 2006. Proposals are submitted to NMFS, which includes an expected budget for the project and how the research-set aside will be used to achieve that budget (i.e., how much money the quota requested from the RSA will produce). NMFS solicits written technical evaluations from anonymous experts to score the proposals using specified criteria. Following completion of the technical evaluation, NMFS then convenes a review panel, including members of the RSA and Ecosystems committees and other technical, to review and individually critique the scored proposals to enhance NOAA's understanding of the proposals. NMFS then makes the final decision regarding which proposals to approve. NMFS can select a proposal out of rank (i.e., highest ranking proposals may not be funded).

One of the most fundamental challenges of this program has been “turning fish into money” to pay for research. Again, no federal funds are made available for this program; all money for research is based on the sale of fish. There is a significant amount of risk and uncertainty associated with this program. Changing market conditions and resource availability may impede the ability of the project to harvest the landings as expected (i.e., quota set aside may not be fully utilized and/or not landed at prices anticipated to pay for research). It is very difficult for research to go ahead without some money or security of money beforehand. For example, some scientists need to secure funding to pay for their time (e.g., soft-money scientists) and/or have equipment purchased in advance of the project. Similarly, fishermen whose boats are being chartered need to know that they will be compensated to pay for crew, fuel, operating costs, and lost fishing opportunities. In 2006, an industry group and Rutgers University had to proceed with the Mid-Atlantic supplemental finfish survey without receiving fish allocated to them under an RSA grant due to the process.

The way the program works ideally is that once a project is approved, the scientists and fishermen participating in the program receive permits from NMFS to conduct the research. Permits are needed to land and sell fish for research and when fishing takes place during times or in places that are otherwise closed to fishing (e.g., closed seasons, closed areas) or when the project violates other fishing regulations (e.g., size restrictions, time/area closures, mesh regulations). NMFS will issue an Exempted Fishing Permit (EFP) or Letter of Acknowledgement (LOA) to provide special fishing privileges for research proposals selected for funding. In reality, however, the permitting process has been an obstacle to doing cooperative research. Delays in obtaining permits have in some cases delayed the ability of the researchers to conduct the research as proposed. For example, a project wanting to test a gear configuration for use in a gear restricted area (GRA) needs to have the permits in time to enter the GRA during the times it is in effect. In cases where the RSA quota is being landed and sold before the project commences, then without necessary permits, funding for the project may not become available in time to conduct the research. Most of the research is time sensitive, so delays significantly impede the ability of the project to be completed as expected. The permitting process is crucial to all cooperative research programs, so a more detailed discussion is provided in the following section. In the Mid-Atlantic, a number of projects approved by the NMFS were not able to go forward as planned because the investigators could not turn the quota into dollars.

However, one industry organization has had significant success in using RSA quota to pay for research: the National Fisheries Institute Scientific Monitoring Committee (NFI-SMC). The NFI-SMC, founded in 1997, is made up of about forty member boats, as well as eight docks and a number of processors from Massachusetts to North Carolina (Stevens 2005). The group aims to promote and foster cooperative research that enhances the science used by the Mid-Atlantic FMC. The NFI-SMC, along with Rutgers University, was awarded nine research set-aside allocations through the RSA program since 2000. Four of these have been *Loligo* net selectivity studies (chapter 6). The other five projects were approved to conduct a supplemental finfish survey in the Mid-Atlantic (chapter 7).

The NFI-SMC auctions off the quota that it receives from the MAFMC RSA program to generate funds for research. Vessels submit bids (price per lb) on lots of the quota and those with the highest bids win the opportunity to harvest that quota. Vessels must also have no NMFS violations. The vessels then must pay their bid to NFI-SMC, which uses the funds to pay boat costs, scientists and observers during the actual research experiments. Only those fishermen who contribute to the NFI-SMC are welcome to bid in the auction. They ask vessels to donate two thousand dollars or one-half percent of their gross income from Mid-Atlantic species, whichever is greater. All fishermen are invited to join the NFI-SMC and auction process.

The auction has proven extremely successful in generating funds for cooperative research in the Mid-Atlantic. For example, on April 11, 2003, a telephone auction of 579,444 pounds of set-aside quota raised $246,917.42 (Cohen 2003). On January 10, 2005, NFI-SMC raised over $700,000 from twenty-six vessels to fund cooperative research in the Mid-Atlantic by auctioning off rights to harvest bluefish (297,750 lbs), black sea bass (91,500 lbs), *Loligo* squid (562,350 lbs), summer flounder (353,917 lbs), and scup (240,000 lbs) (Stevens 2005). On December 18, 2006, the fifth NFI-SMC auction raised more than $800,000 by auctioning off bluefish (363,677 lbs), black sea bass (101,858), *Loligo* squid (973,157), summer flounder (360,677 lbs), and scup (320,000 lbs) to about forty-three vessels from Rhode Island, Massachusetts, Connecticut, New York, and New Jersey (NFI-SMC auction of Mid-Atlantic quota raises record $$ 2007).

There are significant incentives to participate in the auction. On the one hand, the auction is a way for fishermen to participate in science (and improve the science upon which management decision are based) without necessarily participating in data collection. As one bidding fisherman stated, “we're gonna make the 'best available' {science} one helluva lot better!” (Cohen 2003). All of the funds raised go directly to research as there are no administrative costs. However, perhaps the most important incentives are financial. The RSA quota can be fished outside of regulatory trip limits and season closures under Exempted Fishing Permits. This allows fishermen to capitalize on higher prices. An industry member representing NFI-SMC explained:

> "Set-aside quota is only valuable when it can be landed outside of the regular trip limits or season. For instance, why would anyone bid on scup that would only return $.40 per pound? But those boats who won the scup quota in the last

> auction were able to wait until the season closed and it was worth substantially more before actually harvesting the set-aside." (Stevens 2005).

In this way, the set-aside program shares a goal or outcome with the programs in New England: providing economic assistance to fishermen.

The other major incentive or benefit of the RSA to fishermen is that it helps them reduce discards. Fishermen would normally have to discard all fish that they catch above their trip limit. In places like New York where trip limits are low, this can mean significant discarding. One industry member who is involved in running the auction explained:

> "New York is the discard capital of the country because of state-by-state quota management plans. If the boats make ten cents over what they bid today, they're ahead of the game. If they break even, so be it, but at least they don't have to throw the fish over" (Cohen 2003).

Fishermen detest discarding perfectly valuable fish, so they are ecstatic to be able to land these fish that they would otherwise shovel overboard. In this way, the set-aside program can also be considered a conservation tool that can reduce regulatory discarding, as required by National Standard 9.

Since the program began in 2002, a total of seventeen projects have been approved (to 2005). Of those, four were withdrawn. The withdrawals were due mostly to either permitting problems and/or not being able to effectively turn the quota into research dollars. Of those approved, eleven were gear selectivity or bycatch studies and the four were surveys. Seven of the projects went to the NFI-SMC to fund the Mid-Atlantic Supplemental finfish survey (3) and *Loligo* squid gear selectivity studies (4). Five proposals from URI researchers were approved, one of which was withdrawn. Other successful organizations with one approved project include Cornell, Virginia Institute of

Marine Science, United Boatmen, Massachusetts Division of Marine Fisheries, and Wizard Enterprises (however, the latter three organization's projects were withdrawn). As of September 30, 2004, only four projects had been completed with final reports submitted to the Council and five were in active status. The remaining projects were either withdrawn (4) or pending funding (4).

At a workshop in Ronkonkoma, NY in 2004 a NMFS-Northeast RO staff person described the RSA program as innovative, unique, not easy to implement, not fun to administer, not attracting a wide variety of applicants, and not a poster child for future research. Additionally, he said the jury is still out as to whether it is a successful program. It is considered an innovating and unique way to generate funds for research, but has been plagued with other problems. It is a difficult program to implement because of the need for timely access to Experimental Fishing Permits (EFPs) necessary to conduct the research and/or sell the fish to generate research funds. Again, gear and survey research often require that fishing be done in specific areas at specific times of the year, and so if permits are not available when needed the project goals cannot be fulfilled.

Most informants interviewed believe that the administration of the RSA program as a competitive "grants program" is a fundamental flaw of the program. As a competitive process, NMFS and the Council cannot tell applicants how to improve their grants for success. They are not allowed to discuss the proposals with the applicants before they are submitted. In some cases, simple changes could have been made to ensure a project was approved, but NMFS could not offer suggestions to the proposers. After the proposal is accepted, they can discuss and plan the project in order to approve its outcomes, but not before the project is submitted for consideration. As a result, the program has not been able to attract as many participants as desired, particularly from the fishing industry. It is difficult for fishermen to submit a proposal himself and compete with proposals submitted by research institutes or universities, who are more experienced at grant writing and administration. As noted above, the most successful organizations funded are NFI-SCM/Rutgers and URI. The program has also had a very difficult time finding a way to fund recreational fishing related projects, or fund recreational groups. This was the topic of discussion at the workshop held in Ronkonkoma, NY in October 2004. Only one recreational fishing research project has been funded, but it relies heavily on the support of NFI-SMC to work. As of January 2006, this project had not yet gotten underway. Several observers and participants in the fisheries management process in this region raised concerns to me regarding the equity of this program, whereas there is a perception that NFI-SMC/Rutgers seems to be getting all of the research opportunities from the set-aside program. This issue of who participates in cooperative research is important and is discussed later.

The projects funded through the MAFMC RSA program that are discussed in this dissertation include the *Loligo*-scup selectivity studies (chapter 6) and the Mid-Atlantic supplemental finfish survey program (chapter 7), both conducted by NFI-SMC and Rutgers University.

NEFMC’s Research Steering Committee

Coincident with the establishment of the Northeast Consortium and Cooperative Research Partner’s Initiative, the New England Fishery Management Council (NEFMC) established the Research Steering Committee (RSC) in 1999 to better integrate management information needs with research efforts and to foster the participation of fishermen in cooperative fisheries science.[18] The RSC is composed of about eight members, including Council members, fishermen, and scientific experts. In this way, it functions as an "extended peer review" process. The RSC works in conjunction with NMFS' CRPP program, although NEC projects are also discussed. The committee conducts three major tasks: prioritizing research needs for the CRPP program, reviewing proposals submitted to the CRPP program, and funneling research results into management. These are discussed below.

Prioritizing Research Needs

As noted earlier, one of the key tasks of the RSC is to prioritize annual research needs and assist in the development of request for proposals (RFPs), based on recommendations from the Council's species committees. The Council's species committees submit a list of research needs and priorities to the RSC. This is reviewed by the committee and recommendations are forwarded to NMFS, which with "in house" input sends out an RFP. Typically an RFP is sent out annually. The RSC has also assisted in the design of research projects, or at least the stimulation of research ideas. For example, the RSC identified the need for a tagging study, industry-based surveys, and a study fleet. They recommended to NMFS to fund a series of meetings to solicit input into the development of such programs. For example, the New England Aquarium was contracted to facilitate meetings to discuss a tagging program. The Gulf of Maine Research Institute (GOMRI) held meetings to solicit ideas about industry-based surveys and study fleets. Manomet Center for Conservation Sciences was hired to hold port meetings to discuss bycatch and gear conservation engineering studies. The use of "port meetings" to solicit ideas and discussion was a way to gather ideas that existed within the fishing community. Another example is a series of scoping meetings to identify habitat research needs. NMFS hires a facilitator to run these meetings, typically held in 5-6 fishing communities throughout New England. These meetings result in an RFP being sent out by NMFS for cooperative research proposals related to habitat. The committee often reviews the RFP to make sure it is reflective of the Council's research priorities.

Reviewing Proposals

As described above, the RSC is involved in the review of proposals submitted for funding, which is part of the peer review process established for cooperative research. Once an RFP is submitted the public is allowed to respond, which is at least thirty days and is stated in the RFP. The proposals come back to NMFS and are reviewed by an evaluation team comprised of NMFS staff and scientists, outside technical experts, and members of the RSC. Again, NMFS gets the final say as to what projects are funded and which are not.

As initially set up, final reports are forwarded to NMFS for technical review and then the Research Steering Committee reviews the reports to (a) determine that they have had appropriate technical review and (b) provide any additional "value added" comments to direct the results for use in management. The RSC then forwards their findings to the relevant people, such as Plan Development Teams or species committees, and a summary is reported to the full FMC. As part of this process, the RSC initially identified three levels of cooperative research, requiring different reviews. A Level 1 project, defined as ongoing and lacking final reports, can in "rare" cases be made available to the Council's PDTs for use in management. An example of a Level 1 project is the research conducted by the Manomet Center for Conservation Sciences that provided preliminary data that formed the basis of the Closed Area II yellowtail flounder special access program. On June 23, 2005, the NEFMC agreed with the RSC's recommendation to eliminate the Level 1 cooperative research category, as discussed in a moment. Level 2 projects, which are completed with final reports, undergo the RSC review described above. Most projects fall under Level 2 cooperative research. Level 3 projects are long-term or unique projects that would be integrated into the management database and would likely be reviewed through the SARC process or a similar formal review process. Examples of Level 3 include the industry-based surveys, study fleets, and tagging programs. The RSC review process is considered by one member as "a work in progress."

On May 25, 2005, the first four final reports were reviewed by the RSC (Table 3-2). Here I discuss this review meeting to illustrate the challenges that have arisen with trying to incorporate cooperative research into science and management, as well as the learning that is taking place regarding this peer review process.

Table 3-2: First Projects Reviewed by the NEFMC's RSC in May 2005

Project Title	Summary of Review
Fishery Independent Hydroacoustic Survey of the Inshore Gulf of Maine Atlantic Herring	• Not useful for stock surveys • Data did not form a time series • Forward to Habitat and Herring PDTs • Lessons learned
Effects of Mesh Size and Shape on Size Selectivity in the Multispecies Fishery	• Insufficient experimental design • Learning process
Fishermen-designed Electronic Logbook System for the Northeast Multispecies Fishery	• Incorporated into other study fleet effort • Not forward to management
Expanding the Use of the Sweepless Raised Footrope Trawl Fishery in Small Mesh Whiting Fisheries	• Mixed reviews • Some conclusions not supported by data • Fluid goals objects, so difficult to evaluate • Industry member shared expertise, wouldn't recommend it due to mixed results achieved

The first report reviewed was a series of herring acoustic surveys funded by the Northeast Consortium and conducted by the Gulf of Maine Aquarium, now Gulf of Maine Research Institute. This project received an independent peer review with funding by the Northeast Consortium. This project review is unique because there was a significant amount of funding available to have a very formal review of this project. The Northeast Consortium operates relatively independently of the RSC, unlike CRPP projects which always go through the RSC review process. Also, the Northeast Consortium has established its own technical review process that does not rely as heavily on NMFS, but establishes an expert technical review panel. This review process differs also in that reviews are not made public but provided on a “need to know basis” to appropriate end users (e.g., NMFS, NEFMC, ASMFC, commercial fishing groups, etc.). The RSC reported to the full council that

> “{T}he technical reviews for this indicated that the information as a time series was not -- at this point is not actually useful for doing stock surveys and thought that there might be some useful information from this research that could be forwarded to the SARC/SAW process” (NEFMC 2005).

The technical reviews basically said that data did not form a consistent time series to be comparable from year to year, but the RSC found that “there were a lot of valuable lessons to be learned from the series of the surveys that's been conducted and the number of interesting questions that they opened up.” This report was forwarded to the Habitat PDT and the Herring PDT with questions aimed to advise the RSC regarding the future design of herring survey capabilities (i.e., what to do or not do next time).

The second project reviewed was an NMFS-CRPP project and also did not yield information that could be used. The RSC reported that technical reviews of the second final report, “*Effects of mesh size and shape on the size selectivity in the multispecies fishery*,” found that

> “{T}he experimental design was not sufficient to really yield useful information…that too many different gear innovations were attempting to be investigated so that the result was that the sample size was insufficient to support meaningful conclusions.” The RSC concluded that “information contained within should not be used in management decision-making…”

One RSC council member, and former fisherman, emphasized that this was one of the first cooperative research projects to be funded and “it was a very good project for introducing the fishing industry to the scientists and introducing the fishing industry to some of this experimentation.” Although this report was not forwarded to the management system, several RSC members expressed interest in future work related to this project but recommended that these types of projects should be supported as project development grants. This project illustrates a view often articulated that cooperative research projects can be valuable even if they do not produce results for management.

The third final report reviewed by the RSC, a fisherman designed electronic logbook, has already been incorporated into other research projects, namely the Study Fleet program being coordinated by NMFS. NMFS noted that although technical problems were identified, they plan to revisit the project with the Cape Cod Hook Fishermen’s Association (CCCHFA 2005). Some of the components of this project were deemed usable to help the committee understand the direction of electronic logbook development. The RSC recommended that this electronic technology should be developed to create a timely system for data acquisition, not only for the study fleets but also further monitoring projects. The RSC further recommended that the report be supplied to the NMFS Enforcement Division and the NMFS Regional Office's Statistical Branch.

The fourth final report reviewed by the RSC, “Expanding the use of the sweepless raised footrope trawl (SRFT) in the small mesh whiting fisheries,” submitted by Massachusetts Division of Marine Fisheries, received mixed reviews from technical reviewers. NMFS approved the report as it met the revised goal of the project; improve adoption of the SRFT. However, one reviewer noted that the goals and objectives seem to have been fluid and so it was difficult to tell if they were achieved. The technical review found that some of the conclusions stated in the report were not substantiated by the data. For example, the review questioned the rationale behind supporting the use of the SRFT without more data and some positive results. Additional concerns included that data presented in the text, tables, and figures did not match and there were some conflicting statements in the report regarding the effectiveness of the SRFT. Overall the RSC agreed that "the research indicated that the raised footrope trawl is working as expected, at least in the experimental use, there were some concerns that the results were mixed in this experiment and that there were some problems with the experimental design." One RSC member noted that the RFT (not sweepless) works well under reasonable weather conditions in Closed Area 1 and the net maintains shape reasonably well when turning, but fishermen have reported that the SRFT does not maintain shape while turning and under ideal weather conditions. Thus, the RSC concluded that these two conditions would have to be investigated before the industry would accept this gear. One RSC member commented that based on his personal fishing experience he would not recommend the SRFT as a management tool because of inconsistent whiting and red hake catch rates and that the gear has not been shown to achieve bycatch levels achieved by the RFT. Another member recommended more rigorous field-testing of this gear and that the report provides a basis upon which to continue future gear research. The RSC recommended that the PIs address concerns raised in the technical review in a revised report to the NEFMC Groundfish Committee and Groundfish PDT. Most interesting with this review is that fishermen on the RSC were able to bring in their expertise in the review process.

This first attempt to review final reports, which had received technical reviews, was useful in identifying issues with the process that the RSC had developed for getting cooperative research into management. The RSC was unhappy that in many cases only NEFSC scientists, or non-scientists within NMFS RO's and the Cooperative Research Partners Initiative, had provided technical reviews of the final reports. The RSC recommended that each report reviewed by them should be accompanied by at least two technical reviews. The RSC noted that comments received during reviews of interim reports might be valuable to the RSC review process. The RSC identified a problem "with the timing of receipt of final reports relative to making useful comments to management." One scientist noted that it was disheartening to scientists to have to review projects that in some cases were more than a year old. Delays in the receipt of the final report included late submission by PI's, gaps in time between receipt of final reports and technical review, and the intermittent nature of RSC meetings. The CRPI now utilizes a tracking system that should address some of these problems. The RSC recommended that final reports include a statement of the objectives in order to be able to evaluate if project objectives have been met. The committee also recommended that final reports and technical reviews be submitted in a standardized format to facilitate review. The review process itself proved logistically challenging (i.e., getting all of the reviews done in a timely manner), especially since it requires significant contributions of time and energy from the committee members. As of December 2005, only four final reports of cooperative research projects had been reviewed by the RSC. Thus there is a significant "backlog" of final reports that the committee is going to have to review just to catch up. This process takes time and some stakeholders are concerned that it may further hinder the use of cooperative research in fisheries management.

However, the most significant issue raised during the first attempt at the RSC review process was that many scientists (or projects) were bypassing this committee, and results from cooperative research were being used in management without this review. That is, most cooperative research was using the "Level 1" loophole that allowed preliminary data to be considered by the PDT for use in fisheries management without a review of the final report. Again, the Level 1 pathway was only to be used on rare occasions, but in reality it was being used all of the time. For example, Framework 42 to the groundfish management plan included changes to the Closed Area 1 hook gear haddock SAP and modification of the Western Gulf of Maine rod and reel haddock SAP to include longline gear. In addition, one other fisherman was petitioning to have the preliminary results of a project that was unfinished considered by the Groundfish PDT, for possible inclusion in Framework 42. Two RSC members noted that at a recent Groundfish committee meeting results of “un-reviewed” (by the RSC) cooperative research data were being cited. One member asked what the point of the RSC review was (especially considering the time involved in the process) when data from cooperative research was getting into management without review. Paul Howard, Director of the NEFMC, explained the problem:

> As you know, the PDT's are extremely busy. You've seen the list for groundfish with all the actions that have to be completed in a couple months over the summer, and all our actions are -- you know, quite lengthy in terms of documentation and everything. And to throw on right before the actions and doing all this research, to have fishermen and scientists deal directly with the PDT and petition the PDT to include this information is not a good process. It's unfair to the PDT and it's unfair to the RSC to be making those decisions. It's unfair to the Council. I think it's a very gray policy to have researchers deal directly with the PDT on uncompleted research. You're just put in an awkward position. So, I think we have to have a very black and white policy that says only final reports will be utilized.

In addition to the burden placed on the PDT, this was also an issue of data quality. The RSC reiterated its position that “results generally are not considered reliable until research projects are completed, all the available data has been analyzed and reports have been subject to technical review.” Scientists from the NEFSC agreed that this was not a good practice and conflicted with the process that they had in place for using data. Dr. John Boreman, Director of the NEFSC, suggested it wasn't fair for there to be two standards with regards to using data in management:

> "We in the Northeast Fisheries Science Center are bound by the Information Quality Act, that any information that we put forward that goes into management advice goes through a sufficient peer review process. So, in this case it looks like we're being held to a higher standard than those outside the government. Whether you call it a higher standard or not, I don't know, but I think it's a better standard, and I think that we should maintain some consistency in terms of the level of peer review that data and information are subjected to before they appear before this body."

Tom Hill, vice-chairman of the NEFMC, summarized one side of the argument for the need to only use final reports (i.e., finished research).

> "The idea of influencing millions of dollars, if not hundreds of millions of dollars worth of activity in the fishery, and not being sure that the information that you're using is clear, unequivocal and to the best of our ability be accurate in my opinion lays us open to charges of incompetence. And secondly, if there is a problem with the development of technical information and the time line that it takes, the answer is not to then accept partially completed experiments and/or technical information, but is to address how to get that technical information to the Council in a more rapid form. I don't believe in the final analysis that creating an environment where if you're politically savvy or extraordinarily articulate with the ability to present partially completed information, that that should be the criteria under which we should approve using partially completed experiments. Having been around long enough, why, I have seen it where what appears to be the case and what is the case are two entirely different things."

On the other side of the argument were individuals who were concerned that by eliminating the "streamlined" Level 1 pathway, the use of data from cooperative research would be delayed significantly and would represent "missed opportunities." Phil Ruhle, RSC member, explained this view:

> "But this is not the perfect world we live in, because if you look at any of the time lines that are associated with any of these projects, you're in a year and a half, two years, before you get the damn project out the door, before you even start. And I mean we sit around this table starving for some kind of information, and we're basically starving for information on this stuff; and you're talking about putting in

> a system where you're three to four years from getting information. I mean you're looking at a minimum -- I mean when I sit in the back and look, it's not like watching paint dry. It's like watching paint disappear. You know, it just -- it's unbelievable how long it's taken. And I mean I agree, a perfect world we need to have a system that's done that way, that we can sit there and say okay, it's been finalized, it's been up, it's been there. This is what we need to have. But we also need -- as Council members, need the information. So, I have a little problem in eliminating that because I kind of feel like you're standing in the back sticking your finger in the dike, and the problem's way up in front of you."

The Council passed the motion to eliminate Level 1 pathway for using cooperative research in management. The Council was divided; the final vote was 10-7. Before this action, most of the cooperative research that was incorporated into management involved gear selectivity or bycatch reduction studies. The removal of the Level 1 pathway will delay the incorporation of cooperative research into management but will prevent premature management actions from being implemented. For example, it will prevent a gear from being exempted that does not meet necessary bycatch standards. Again, one of the fundamental challenges facing the council is balancing the need to protect weak stocks, like cod, and allow fishermen to harvest "healthy" stocks. Such fishing opportunities will only come through cooperative research that "proves" a fishing gear or fishery can operate without harming the weak stocks. The review process in place for cooperative research may inevitably result in lost fishing opportunities, at a time when the fishing industry is struggling to just get by. This is a difficult issue to resolve: how to incorporate cooperative research into management, much of which could create fishing opportunities and/or conserve weak fish stocks, while at the same time ensuring the necessary protection of the weak stocks (and management of a public resource) by guaranteeing that management is based on high quality data. As I argue later in this dissertation, balancing data quality and timeliness of data availability is one of the most fundamental challenges to incorporating cooperative research into management. The NEFMC RSC considers this a "pilot program" and is still grappling with the issue of balancing data quality standards with timely availability for managers.

This process is part of a complex "extended peer review" process for cooperative research. It aims to be transparent, independent, while allowing multiple stakeholders to participate in the process. Whereas traditional peer review typically involves only scientists, this process also includes industry and management stakeholders, as well as the public. Not only are projects reviewed for their scientific merit, but they are also reviewed for management relevancy. Also, this committee participates in both the review of proposals and knowledge produced. I discuss the peer review process as a boundary management process in chapter 10.

NMFS Northeast Regional Office: Permitting Process

Another boundary process that is critical to all cooperative research programs is the NMFS permitting process.[19] When funded for research, most participants must obtain necessary permits to do the research. This process can be one of the most time consuming aspects of the project. Permits are obtained from the National Marine Fisheries Service Regional Office. In some case permits must be obtained from State agencies to allow fish to be landed and sold in their state. This is necessary because the majority of cooperative research takes place during times or places that are otherwise closed to fishing (e.g., closed seasons, closed areas) and may violate fishing regulations (e.g., size restrictions, time/area closures, mesh regulations). In addition, some cooperative projects require the landing and selling of fish that are caught during the course of the research (e.g., with research set-asides).

“Fishing” is defined in the MSA as any activity other than scientific research conducted by a scientific research vessel that involves catching, taking, or harvesting of fish, as well as the attempt to so, or any activity that can be expected to result in the catching, taking, or harvesting of fish (Perra 2004). Under the MSA, scientific research with a sound scientific plan conducted aboard a scientific research vessel is considered exempt from fishing regulations (e.g., size restrictions, mesh requirements, and time/area closures). Letters of Acknowledgement (LOAs) or scientific research permits are issued to conduct such scientific research. Research conducted by the National Marine Fisheries Service (e.g., the NEFSC bottom trawl surveys) receives scientific research permits. Non-NMFS scientific research receives letters of acknowledgement (LOA) to conduct research activities. The review process for receiving an LOA is quite simple. It involves a simple notification to law enforcement stating the activities are legal under the MSA.

Scientific research is defined not to include gear testing, research related to product development, market or public display, or the collection and retention of fish outside the scope of the research plan. Research activities that fall outside the scope of LOAs or scientific research permits require an Exempted Experimental Fishing Permit (EFP). The EFP process is complicated and lengthy. The process takes a minimum of sixty days to complete. An application is submitted to the RO. The application requires the following information: project goals and purpose, list of exemptions requested and their justification, number of participating vessels, experiment duration, definition of the study area, species that will be harvested (those caught and those that may be caught incidentally), disposition of the catch, potential impacts to marine mammals and protected species, specification of the gear to be used (type, size, and amount), and how the data collected with be disposed. Paul Perra (2004) explained that a complete application will demonstrate sound scientific design, address all questions regarding methodology and procedures, and address any need for observer coverage. Part of this process involves an environmental impact assessment necessary to meet the requirements of NEPA.

In interviews with participants, permitting issues were the most often cited hindrance to doing cooperative research. One of the most important consequences of the permitting process is that research is delayed. This is particularly important when timing of research is a key element of the research design. For example, if a study is testing a particular gear design to be used in an area that is closed during a specific time of the year, the research should be done in that time. One participant explained:

> "In the beginning, when the agency didn't have that much experience with these exempted fishing permits. It was hard to get them. It took a long time. Some projects got frustrated. They missed their window. They missed their funding window, or they missed seasonal weather or fish availability windows because they couldn't get their permits in place."

Another example of the permitting process affecting research was described by Dr. Chris Glass to an audience at the Maine Fishermen's Forum in 2004. Dr. Glass described a cooperative effort in Closed Area 2 to demonstrate that fishing could occur in that area on yellowtail flounder with minimal bycatch of cod and haddock. This research counted as gear research and took place in a closed area, so it required an experimental fishing permit. There was a delay in getting the permits. This influenced the project because it created a delay in funding availability and so the participating boats could not get paid. They were forced to let some of the boats go. The boats worked without getting paid for one month. Dr. Glass explained how this made it difficult to do cooperative research. He said that some kinds of projects are being avoided because of the time and energy required to get the appropriate permits. There was a discussion of the problem with several members of the audience. Dr. Glass suggested that permits should be part of the funding process; i.e., that if funded it should be assumed that the project will receive appropriate permits. Dr. John Boreman, Director of the NEFSC, reflected on the dilemma – on one hand they want to be about to do cooperative research quickly to address issues at a moment's notice, but there are legal reasons that this cannot be done. He noted that the system for determining permits was set up a long time ago, before recent cooperative efforts. He suggested that the Regional office should be delegated more authority for permitting. Don Perkins, director of GMRI, challenged the group to make dealing with the permitting problem a goal for next year – that by Fishermen's Forum 2005, they will have addressed this concern. A year later in the very same location, a coordinator from a regional research institution lamented that the permitting process remains a challenge to doing cooperative research effectively.

Northeast Fisheries Science Center

The Northeast Fisheries Science Center is actively engaged in cooperative research at several levels. Given that NEFSC scientists will often be critical users of the data produced from cooperative research as they make their way into fisheries management, it makes sense that the NEFSC would have an active role in the process. Most important are the long-term, large-scale programs such as the industry-based surveys, the study fleets, and the tagging programs. In addition, the NEFSC is working closely with the industry as part of the Trawl Survey Advisory Panel's efforts to improve the survey.

In 2003, the NEFSC hired a scientist to coordinate the cooperative research activities involving the NEFSC. In addition, several other dedicated hires have gone to cooperative research. In addition to taking care of logistical aspects such as labor and equipment procurement, the coordinator is responsible for budget formulation and strategic planning. Several of the new hires for cooperative research work jointly with the cooperative research coordinator and the Chief of the Ecosystems Surveys Branch, as they are principally at-sea field technicians.

In addition, the NEFSC has also had to deal with the influx of new data coming in from cooperative research. The database management staff of the NEFSC has worked to integrate that data in their database so that it can be utilized by their scientists. This is challenging because the data are often collected in very different ways than their research surveys. Most critical are data that will be used in stock assessments, as in most cases NEFSC scientists are responsible for conducting stock assessments for peer review. The scientists need to know the circumstances in which the data were collected, such as vessel characteristics, gear configurations, and gear deployment.

Finally, NEFSC scientists are critical contributors to the technical reviews of cooperative research proposal and final reports. This is a task given to them in addition to their regular work, although sometimes it is voluntary. In addition, an NEFSC scientist sits on the NEFSC’s Research Steering Committee, which reviews proposals and final reports for the CRPP program and functions to direct cooperative research into management.

Conclusion

In this chapter I situated cooperative research within the existing fisheries management structure that exists in the Northeast, provided context surrounding the growth of cooperative research in this region, and described the principal cooperative research institutions that are the subject of this research.

The historical narrative of industry-science cooperative research provided here parallels that provided by Hartley and Robertson (2006), although they did not discuss early precursors to the “new wave” of cooperative research (i.e., Saltonstall-Kennedy and Fishing Industry Grants) and did not consider the Mid-Atlantic research set-aside program. The decline in the fish stocks can be attributed to overfishing, due to the inability of the fisheries management process to constrain fishing effort. This led to socioeconomic hardship being inflicted on the fishing industry. And an adversarial climate rose in part because of the socioeconomic hardship created by fisheries management, but also because the management process pitted fishermen against government (managers and scientists) and these groups failed to communicate effectively. A lack of communication between fishermen and scientists creating the “adversarial climate” was due to differential experiences and language barriers, as well as an institutional preference for scientific knowledge rather than fishermen’s “anecdotal” knowledge.

To be sure, most cooperative research efforts can be viewed as a response to some “crisis” in the fishery. For the shrimp fishery, it was a crisis in the groundfish fishery that would have shut their fishery down. For the surfclam fishery it was a crisis involving the stock assessment. In the scallop fishery, it was a crisis related to getting access to resources that would otherwise be wasted. The Fishing Industry Grants program was a direct response to social and economic impacts resulting from Amendment 5 and 7 to the groundfish fishery management plan, as well as the ecological impacts of overfishing that necessitated management action. As the groundfish crisis continued, so did the movement in cooperative research, cumulating in the creation of the NEC and the CRPP. In the Mid-Atlantic the crisis created by the establishment of large gear restricted areas (GRAs) contributed to the more recent growth in cooperative research in that region.

The political dimension of cooperative research is also critical to explaining its reemergence. Cooperative research in New England appears to be a response to years of poor management and the particular efforts exist today can be explained by the political strength of the New England fishing community. The New England fishing community lobbied the government to help deal with the crisis (which they believed was due to ineffective science), but did not want a direct financial handout. This is likely a result of the cultural and political identity emphasizing independence found throughout the New England fishing community. Alternatively, cooperative research in the Mid-Atlantic, with the research set-aside program, is a response to a lack of political strength or attention to Mid-Atlantic fisheries, as they never received funding from Congress. The institutions that have been created are very different, but try to achieve similar goals. In both regions, providing financial benefits to the industry is an important goal and outcome of cooperative research. The Mid-Atlantic program is not as explicit about putting money into fishermen’s pockets, but nevertheless does this.

Institutional factors also influence the types of cooperative research programs that emerged in this region. The system of the research set-asides makes sense with the Mid-

Atlantic fisheries because management is “quota-based,” but this would be more difficult to implement in multispecies fisheries where management focuses on effort controls, such as the case of the New England groundfish fishery. In mixed fisheries, it is difficult to control and monitor catch limits, especially given high frequencies of bycatch. Of course, as I discussed, set-asides represent a challenging way to generate funds for research. Direct funding, as occurs in New England, would be easier to implement. Mid-Atlantic would certainly welcome direct funding for fisheries research. In fact, on numerous occasions I witnessed Mid-Atlantic industry and science participants lamenting that they are ineligible to apply for the federal cooperative research funding dedicated to New England fisheries. They often remark on this as an injustice and ask: “Why does New England continue to receive federal assistance when they continue to over harvest their fisheries?” They feel the Mid-Atlantic is snubbed despite what they feel is a better management record.

Finally, institutional mandates such as requirements for peer review and data quality standards influence the way that cooperative research is done and how it becomes incorporated into management. The permitting process is perhaps the most obvious example. Legal mandates requiring environmental impact assessments to be done before permits are issued have affected the success of projects. The grants system that has been set up for cooperative research is another institutional barrier to doing effective cooperative research, as explained by many informants in this research. In addition, results of cooperative research must undergo a significant review process before being integrated into management (such as through the NEFMC’s RSC). The peer review process as a boundary managing process is discussed in chapters 9 and 10.

The personal and institutional investment in cooperative research has been significant. A diversity of institutions emerged related to cooperative research. These include the principal funding institutions (Northeast Consortium, NMFS-CRPP, and Mid-Atlantic set aside program) and management institutions to incorporate cooperative research into management (i.e., the RSC). In addition, we see groups like the National Fisheries Institute and the Gulf of Maine Research Institute becoming key organizations that span the boundaries between the funding organizations, the scientists and the fishermen.[20] The NFI-SMC has been essential to the majority of the cooperative research that has occurred in the Mid-Atlantic. The GOMRI has coordinated numerous cooperative research efforts, including the large-scale regional cod tagging program. These groups help promote and coordinate cooperative research. Finally, state and academic institutions are also active in cooperative research and are discussed throughout this dissertation, including the Maine Department of Marine Resources (GOM grated raised footrope whiting fishery and ME-NH Inshore Trawl Survey), Massachusetts DMF (Cod IBS), and Rutgers University (Mid-Atlantic transect survey, *Loligo*-Scup selectivity studies, *Illex* Real-Time Management study).

These institutions are boundary spanners linking citizens (i.e., fishermen), scientists (state, federal, academic), and policy (NMFS and the regional fishery management councils). They perform key boundary-spanning roles by acting as intermediaries between scientists and the industry (and between science and policy), have responsibilities to groups on both sides of the boundaries, and provide a forum to enable the co-production of information by actors across the boundary. They facilitate communication, translation, and mediation across the boundary. As I discuss in this dissertation, cooperative research is the process through which boundaries between science/expertise and non-science/policy are spanned, and these groups and individuals are critical to this process.

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[1] The system was designed to accommodate regional differences. As expected, each FMC takes a different approach to decision-making and management. This can be seen in the structure of the councils, as well as how they respond to uncertainty, and how they utilize scientific advisors (Miller 1987).

[2] The fishery management plans developed by the NEFMC include (1) northeast multispecies groundfish, (2) scallops, (3) monkfish, (4) small mesh multispecies, (5) red crab, (6) skates, (7) herring, (8) Atlantic salmon. The fishery management plans developed by the MAFMC include (1) squid, mackerel, butterfish, (2) summer flounder, scup, and black sea bass, (3) dogfish, (4) surfclam and ocean quahog (5), bluefish, and (6) tilefish. Responsibility over monkfish and dogfish are shared; New England has taken the lead on monkfish, Mid-Atlantic has taken the lead on dogfish. There is current discussion about separating these joint plans and giving sole authority to the region currently "leading" the fishery management plan.

[3] The role of the ASMFC should not be overlooked in this discussion, although it plays a small role in the principal case studies explored in this dissertation (i.e., Atlantic cod and squid). The ASMFC is composed of "commissioners" from its member states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida. Each state has three members: the State Director of marine fisheries management, a state legislator, and an individual appointed by the governor. The ASMFC works on a "one state-one vote" concept. Thus, the three appointed members for each state must agree on each vote.

[4] For example, in New England most of the committee meetings are held in the greater Boston area, convenient to most of the region, except for example fishermen from Mid-coast or Downeast Maine. Regular meets are held only as far north as Portland, Maine and south as far as Newport, Rhode Island. Mid-Atlantic council meeting are held throughout the Mid-Atlantic region, from North Carolina to Long-Island New York.

[5] For example, the Fisheries and Ecosystems Monitoring and Analysis Division consists of the Population Biology Branch, the Ecosystems Surveys Branch, and the Fisheries Sampling Branch. The Resource Assessment and Evaluation Division is a key division in charge with planning and conducting research to assess the current and future status of marine resources, evaluate social and economic impacts of humans on marine fisheries, protected species, and marine habitats, and understand and protect dynamics of marine mammal and other protected species.

[6] At-sea observers are used to verify data collected from fishermen's logbooks, which are often suspect, as a direct comparison between dealer data and fishermen's logbooks is not possible.

[7] This is a strategy that works well in New England where the industry's congressional representatives are considered among the most powerful and influential. Many pointed out that this strategy does not work as well in the Mid-Atlantic since their representatives "have other things to worry about."

[8] Dr. Mike Sissenwine, former Director of the NEFSC, explained to Congress that "{i]n many ways, people who fished were the first fishery scientists…Fishing people are students of fish distributions, the factors that influence fish movements, and what fish eat" (Sissenwine 2001).

[9] Electronic access to Bigelow and Schroeder (1953) has been made available by the Gulf of Maine Aquarium (now the Gulf of Maine Research Institute) at http://www.gma.org/fogm. This passage quoted comes from the introduction.

[10] Important to these developments are the works of Russell (1931) and Hjort (1914) in the 1930s, which built upon work in ecology by Lotka (1925), Volterra (1928), and Pearl and Reed (1920). Although interesting, a detailed history of the development of modern fisheries science is beyond the scope of this discussion. However, the reader is encouraged to read Smith's *Scaling Fisheries: the Science of Measuring the Effects of Fishing, 1855-1955*. Shorter discussions of early fisheries science can also be found in Larkin (1978) and Frank and Leggett (1994).

[11] Margaret Dewar (1993) describes a long history of government intervention in the fisheries, often in response to industry demands for economic assistance. Before the 1950s, tariff protection was the most common form of government aid and after that time the government programs tried to assist by increasing demand and decreasing the cost of production. For example, the Saltonstall-Kennedy Act in 1954 tried to encourage distribution of fishery products. In 1954, the New England Fisheries Committee was formed with members of the fishing community and state/local government representatives to outline an agenda for research. In 1956, the Fish and Wildlife Act provided loans to replace, maintain, or repair vessels and gear. In the 1960s, there were various subsidies to aid in vessel construction. In 1965, the Commercial Fisheries Research and Development Act provided federal money to match state funds for research. Most of the research during these early years was related to increasing demand (e.g., product development) and decreasing the cost of production (e.g., gear and vessel construction and maintenance programs) rather than scientific research.

[12] Another important program or institution crucial to developments in collaborative research is the Sea Grant program. In 1965, Senator Claiborne Pell (Rhode Island) introduced legislation to establish Sea Grant colleges on campuses nationwide as centers of excellence in marine and coastal studies. The following year the National Sea Grant College Act was adoption. In 1970, the Sea Grant becomes part of NOAA. This created a

unique academic, industry, and government partnership aimed to produce high quality research in response to the needs of the fishing industry and marine environmental problems. The Sea Grant program became involved early on in the management of fishing communities after the passage of the Magnuson Act. Today, Sea Grant staff participates in numerous cooperative research projects. In fact, the Northeast Consortium is an association of the sea grant universities in New England directed to implement cooperative research in New England.

[13] The GARM (Groundfish Assessment Review Meeting) is a regional peer review process of stock assessments for the groundfish resources. In 2002, the GARM provided an update assessment and evaluated the potential effects of the trawl survey warp offset. In early 2003, a Groundfish Science Peer Review was conducted by independent experts arranged through the Center for Independent Experts (CEI).

[14] This program began as the Cooperative Research Partners Initiative, but changed to the Cooperative Research Partners Program in 2005, as it was no longer an initiative but a fully developed program.

[15] The second RFP is for project development funds. This process runs in a similar way as the full collaborative research projects. However, there is not a polling letter but a proposal letter, about a five-page proposal, which the panel reviews and makes decisions based on. These projects are twenty-five thousand dollar awards and usually about a dozen of these projects are funded each year.

[16] The panel meets at an all-day meeting. The panel typically gets 50-89 planning letters, increasing each year pretty dramatically, so to make things manageable, the panel is broken down into smaller subgroups based on their expertise. For example, there may be a sub-group looking at just planning letters related to gear projects and another might look at fisheries biology-type proposals. Generally, the small groups will meet in the morning and are asked to reach a consensus by rating the proposals. The small groups report to a large group everybody back together, and each of the small groups report out and say about the proposals they were responsible for, but anybody else has any opportunity to comment and make contributions.

[17] The MAFMC research set-aside program was established through Framework Adjustment 1 and the RSA provisions of the Tilefish Fishery Management Plan (FMP). Framework 1 established a procedure through which RSA amounts would be set annually as part of the MAFMC's quota-setting process.

[18] This discussion is based on personal observation at four RSC meetings (dates: Nov 2004, May 2005, March 2006, May 2006), as well as a review of documents and audio recordings produced by the committee. NEFMC staff provided meeting summaries and audio tapes for important meetings that I could either not attend or occurred before this research began. Committee summaries were also available at full council meetings. More

recently, meeting summaries and audio files of committee reports to the full council have been available on the NEFMC website (www.nefmc.org).

[19] This discussion of the permitting process is based on a presentation given by Paul Perra of the NMFS Northeast Regional Office to the Mid-Atlantic Fishery Management Council on October 5, 2004, in Ronkonkoma, New York. Mr. Perra provided me with a copy of his PowerPoint presentation and the transcript of the meeting is available from the Mid-Atlantic Fishery Management Council.

[20] Other notable groups embracing the real and expected benefits of cooperative research as is evidenced in their participation in a growing number of projects and active promotion of cooperative research include the Cape Cod Commercial Hook Fishermen's Association and the Northwest Atlantic Marine Alliance. These groups help link fishermen to science by coordinating and promoting collaborations. They provide forums for discussion and learning that are critical for capacity building.

CHAPTER 4: COOPERATIVE FISHERY-DEPENDENT DATA COLLECTION IN THE *ILLEX* SQUID FISHERY

Introduction

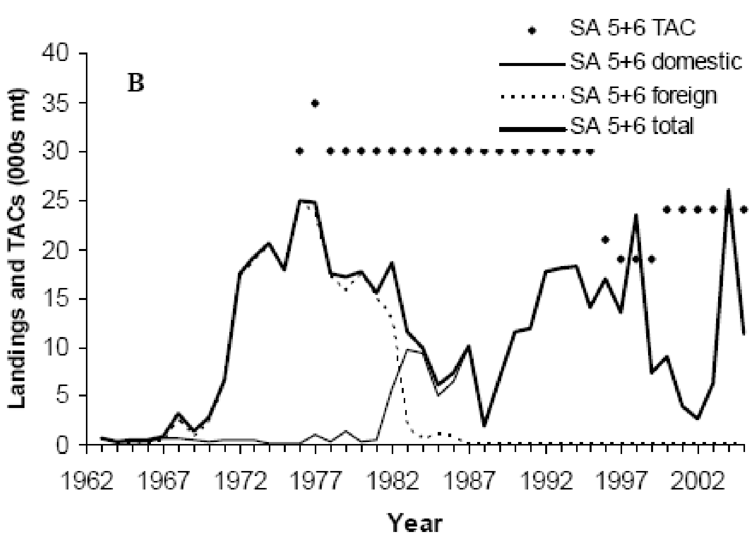
In this chapter, I present a case study of a citizen or participatory science initiative that seeks to involve citizens with experience-based expertise (EBK) in the production of scientific information used in policy-making. Specifically, I examine a citizen or participatory science initiative aimed to improve the science used to manage the *Illex* squid (*Illex illecebrosus*) fishery in the Northeastern U.S. through the collection of real-time, fishery-dependent data by fishermen for use ultimately in real-time management.[1] The case provides an opportunity to explore the research questions, particularly what happens to the boundaries between FEBK and RBK as a result of industry-science collaboration in scientific research. I draw on the typology of expertise presented by Collins and Evans (2000) to illustrate that participation in cooperative research can allow fishermen to shift from having *no expertise* to *interactional expertise*, and what that means for participation in the science policy process. I begin by describing the context of the collaboration, and then describe the case study. In keeping with the larger objective of the dissertation, I also reflect on the role of fishermen and their knowledge and the fate of this collaborative effort.

Case Study: Real-time Data Collection in the *Illex* Squid fishery

<u>Management Context: Status of the *Illex* Fishery and Rationale for Real-Time Data Collection</u>

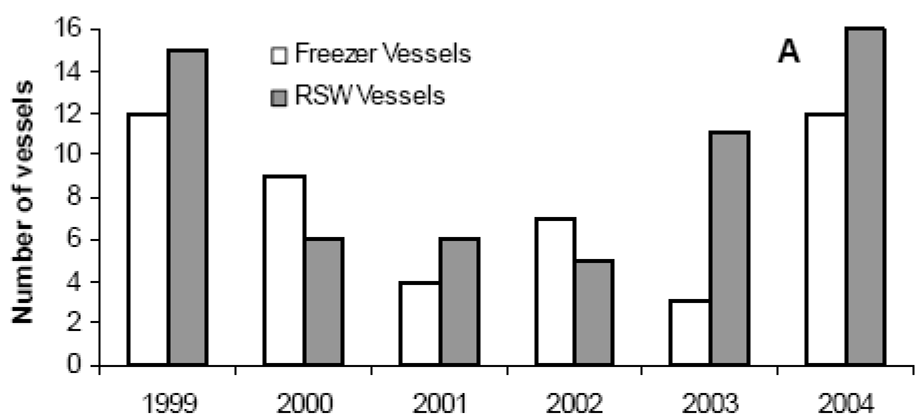
A bait fishery for squid originated in U.S. waters during the late 1800s. International fishing fleets began to target squid in U.S. waters during 1968 and in Canadian waters (NAFO Subareas 3+4) during 1976. Landings of *Illex* in U.S. waters from 1964 to 2005 are shown in Figure 4-1. Prior to the passage of the Magnuson Stevens Act in 1976, the *Illex* squid fishery was prosecuted almost exclusively by foreign vessels off the U.S. coast. The U.S. fishery began in 1982, and since 1986 landings in the *Illex* squid fishery have been completely domestic. During 1928-1967, squid landings (including *Loligo pealeii*) ranged between 500-2,000 mt annually. Total landings from all areas, including Canada, rose from 1,600 mt in 1969 to a peak of 179,300 mt in 1979. In the early 1980s, the stock shifted to a low productivity regime. In 1998, U.S. EEZ landings (22,700 mt) reached their highest levels since 1977. In that year, the annual quota (19,000 mt) was exceeded for the first time. U.S. landings declined and reached their lowest level in 2002 (2,750 mt). In 2003, U.S. landings increased to 6, 389 mt and then reached their highest level on record in 2004 (26,087 mt). This resulted again in the closure of the fishery when the quota (24,000 mt) was exceeded. In 2005, landings declined to 11,718 mt and the fishery was open for the entire fishing year (MAFMC 2006).

Figure 4-1: Landings of *Illex* squid in the U.S. EEZ (NAFO Subareas 5+6), with respect to annual TACs, during 1963-2005 (from NEFSC 2006, 347).



The *Illex* squid fishery is a large vessel offshore fishery comprised of about fifty vessels, of which only 15-20 fish regularly.[2] Participation in the fishery varies annually according to market demand and abundance. During 1999 and 2004, participation in the fishery was high (27-28 vessels) compared to participation in 2000-2003 (10-14 vessels, Figure 4-2). In 2005, participation in the fishery was high again (about thirty vessels). Two fleet sectors make up the directed fishery; refrigerated seawater system trawlers (RSW vessels) and freezer trawlers (FT vessels). The RSW vessels tend to be smaller size than the freezer trawlers and store their catches in chilled seawater. This results in shorter trips (less than four days). On the other hand, FT vessels which freeze their catch and are larger take up to fourteen-day trips. FT vessels are from North Kingston and Point Judith, Rhode Island and Cape May, New Jersey, while most RT vessels port in Cape May, NJ, Wanchese, NC, Hampton Roads, Virginia and other Rhode Island ports (NEFSC 2006).

Figure 4-2: Number of vessels in the directed *Illex* squid fishery from 1999-2004 (from NEFSC 2006; page 258)



The purpose of cooperative research in this case is improving the collection of fishery-dependent information, especially at a finer spatial and temporal resolution (i.e., on a tow by tow basis in real-time). Fishery-dependent data, typically from dealer landings reports and fishermen's logbooks/vessel trip reports, are critical to the stock assessment process, as it is used to assess fishery removals and effort (Hilborn and Walters 1992; NRC 1998). However, many scientists question the veracity of the data reported by fishermen in mandatory vessel trip reports.

There are many incentives for fishermen to misreport how much and especially where they catch (NRC 2000). Many fishermen fear data will be used against them through area closures, gear restrictions, trip limits, etc.[3] Others view their knowledge as proprietary and worry that if it is shared with other fishermen it will put them at an economic and social disadvantage in the future. Due to this perceived deceit and distrust with logbook data, at-sea observers are used to monitor the catch, which represents a significant cost to either the industry or the government. The information reported is also reported on a temporally coarse basis (i.e., trip by trip rather than tow by tow). In addition, hard copy log-books filled out by the industry must be keypunched into computers and then audited for errors. This creates a time lag that hinders stock assessment and management. In many cases, several tows are made during any given trip but only a summary of the entire trip is reported. The reporting of only one location when fishing occurred in multiple areas and the use of large statistical reporting blocks means that data are also spatially coarse. In addition, filling out the mandatory, hard copy logbooks is a burden to fishermen. Thus, there has been significant interest in improving the collection of fishery-dependent information, especially at a finer spatial and temporal resolution (i.e., on a tow by tow basis in real-time). In the Northeastern U.S. there are several other initiatives to collect fishery-dependent data in real-time.[4]

Real-time data collection and management in this fishery is appropriate given the life history of *Illex* squid. The northern short-fin squid, *Illex illecebrosus* (hereafter *Illex* squid), is a highly migratory species inhabiting offshore continental shelf and slope waters in the western Atlantic from Florida to Labrador, and is of highest abundance from Cape Hatteras to Nova Scotia (NEFSC 2006). The species is considered to be a unit stock throughout its range of commercial exploitation, from Cape Hatteras to Newfoundland (Dawe and Hendrickson 1998; NEFSC 2006). Individuals from as far north as Newfoundland undergo a lengthy spawning migration in the fall to warmer waters south of Cape Hatteras (Hendrickson 2000). Juveniles move onto the continental shelf in late spring and summer, where they feed and grow (Hendrickson and Holmes 2004). *Illex* squid growth is rapid (NEFSC 2006) *Illex* squid are also short-lived, with recent advances in aging of squid that indicate that they live for only one year (Hendrickson 2004). *Illex* squid are semelparous and females spawn and die within several days of mating; therefore natural mortality increases with age for the age range where spawning occurs (NEFSC 2006). In addition, fishing mortality and spawning mortality occur simultaneously (NEFSC 2006). An understanding of the stock structure is complicated by the overlap of seasonal cohorts (NEFSC 2006).

Indices of abundance from bottom trawl surveys are highly variable and incomplete, as NEFSC bottom trawl surveys do not cover the entire habitat range of this species (NEFSC 2006). In addition, the survey gear used is considered inefficient for catching *Illex* squid (*Illex* fisherman, pers. comm.). It is unknown whether the survey indices measure relative abundance or availability to the survey gear (NEFSC 2003b). Since *Illex* squid are highly migratory, an unknown fraction of the stock may reside offshore and outside of the area exploited by the fishery or sampled during NEFSC bottom trawl surveys at any given time. Distribution of this species is also strongly influenced by oceanographic factors. U.S. fisheries data is of coarse temporal and spatial resolution, and age and growth information is lacking for the U.S. stock component (NEFSC 2003b). For these reasons, it is difficult to monitor trends in this resource. The nature of the species life history and an unreliable estimate of abundance make it difficult to conduct a reliable assessment for this species. Although progress has been made, the last assessment conducted in 2005 concluded that “due to the lack of adequate data regarding fishing mortality rates and absolute biomass, stock status could not be determined for 2003 or 2004” (NEFSC 2006, 203).

The U.S. fishery is managed by the Mid-Atlantic Fishery Management Council (MAFMC), under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan (MAFMC 1998). Management measures for *Illex* squid include limited entry, annual quota specifications, and trip limits when 95% of the annual quota is reached. Management is based on the idea that in order to have a sustainable *Illex* squid fishery, a sufficient number of spawners must be allowed to survive to produce the next year’s squid population. Management with annual quotas requires that managers have a good idea of how much resource is available for harvest in a given year. However, since *Illex* squid lives only 1 year and the abundance indices are highly variable, it is difficult for managers to know the status of the squid populations prior to the fishing season. Since 2000, the quota or “domestic annual harvest” has been set at 24,000 metric tons, mainly because no new information is available. During 1998, the quota of 19,000 metric tons was harvested completely, and for the first time, the fishery was closed before the season ended. The fishery was again closed prematurely in 2004 when the quota was exceeded again.

One issue that causes the delay is that mangers have a difficult time tracking landings and so they do not close the fishery down in time to prevent the fishery from exceeding the annual quota. In addition, managers have a difficult time anticipating abundance levels due to the annual variability of the resource and so the quota may not reflect the abundance of the resource. The most significant management issue related to the *Illex* squid fishery is the need to allow the fishery to adapt to the variably available abundance of the species and avoid unnecessary fishery closures and/or the unintentional overharvest of the resource. Ideally, managers feel the resource abundance should be assessed annually and landings should be monitored in real-time to ensure an appropriate level of harvest.

Thus, there is a recognized need to manage this species on a real-time basis. There is precedence for real-time management (RTM) as it has been implemented in the Falkland Islands *Illex argentinus* fishery since 1987 (Agnew et al. 1998). However, the management infrastructure and fleet composition are very different from that occurring in the U.S.. The 1996 Stock Assessment Review Committee (SARC) noted the potential of RTM to preserve SSB and to maximize yields in this species (NEFSC 1999). Since then cooperative efforts between the squid industry, the NEFSC, and Rutgers University have been underway to implement real-time management in this fishery (NEFSC 2003b, 2006).

Description of the Collaboration

Like many other cooperative research efforts, real-time data collection in the *Illex* squid fishery was initiated after a “crisis” in the fishery. In 1998, approximately thirty boats in the squid fishery, as well as the squid processors, were severely affected when the fishery was shut down early in August after the quota was filled for the first time ever. A Mid-Atlantic squid fisherman stated at the time “We had two arguments with the [Northeast Fisheries Science] Center. We knew there were nowhere near as many mackerel as they said there were and we knew that there were considerably more squid” (Stevens 2000). There were two related issues that bothered fishermen and managers: one was the science driving the stock assessment that set the quota too low that year and the other was the management process driven by that science (rules that required that the fishery be shut despite information that there were squid available for harvest). The industry responded by organizing and putting their own money up to do a cooperative research project to address some of the management concerns with squid. The National Fisheries Institute-Science Monitoring Committee (NFI-SMC), the squid boats and processors set up a system to raise money from squid landings to pay for research. This included hiring scientists from Rutgers University’s Haskin Shellfish Research Laboratory as science consultants to help them plan and conduct research needed for real-time management.

At the same time, the NEFSC was also looking to improve their assessment of *Illex* squid. At the time, little was known about the *Illex* squid fishery. The NEFSC lead biologist started working collaboratively with the squid industry in 1997 by simply visiting the processors and going out squid fishing to observe fishing practices. Because

Illex squid is a data poor stock, any data that could be collected was valuable. After a period of building rapport, fishermen began to provide valuable biological data (i.e., length and weight information). The NEFSC lead scientist began to work closely with a squid captain and MAFMC council member from North Carolina. This captain was the first fishermen to take the scientists fishing and allow the collection of whatever data was needed.

Later, the fisherman would joke that the mistake he made was “bringing her back in.” Nonetheless, the captain has been instrumental and quite vocal in his efforts to get other fishermen to participate in the real time data collection effort. The lead scientist relied upon NEFSC’s observer methodology and collected tow-based information and simply observed the captain’s fishing activity (how he set the net, where he fished, which direction he towed, what the bycatch was, etc.). Prior to that time the NEFSC didn't have tow-based data unless an observer had been on a squid vessel. It is notable that the Captain allowed the collection of this data. Most squid fishermen are concerned about the observer program since the large, small-mesh nets they use have the potential to catch marine mammals and create regulatory discards (catching fish that are undersize or otherwise restricted).[5] Fisherman generally would not want to risk being caught catching a marine mammal since it could shut down or impose severe restrictions in their fishery. There are also long-standing concerns that data collected in any form may be used against fishermen in the development of fishing regulations. In general, fishermen in this fishery are hesitant about having observers on their boats.

In 1999, an *Illex* squid Real Time Management (RTM) feasibility study was conducted from June-September. This study was a cooperative effort between the

NEFSC, Rutgers University and the squid industry (including NFI-SMC). The NEFSC's lead *Illex* squid assessment scientist led the effort. Scientists from Rutgers University's Haskin Shellfish Research Laboratory were supported by the industry to coordinate the data collection. Twelve vessel captains agreed to keep detailed records of their squid catches and provide them to the NEFSC. Other captains volunteered to participate, but ended up not fishing during 1999 due to inconsistent availability of squid in the Mid-Atlantic fishery area. This study involved the collection of tow-based fisheries data on hardcopy logbook forms. For each tow, the participating captain recorded its location, where the net went in and where it came out, length of tow, total number of pounds caught, any discards, water temperature, and depth towed. Data represented a total of seventy-one trips and 1,146 tows. The data collected in hardcopy form was digitized by Rutgers University staff.

In the feasibility study, the squid captains also packed up sub-samples of the catch, which processors weighed and measured for the study. Processors also provided weight and length information they collect for marketing purposes during pack-out from 1995-1998. Processor staff provided dorsal mantle length and body weight measurements for 14,450 squid.

After the feasibility study was completed, a workshop was held in December 1999 to discuss implications for real-time management in this fishery. Due to inclement weather participation at this workshop was minimal. This meeting was attended by seven scientists, one manager, and four fishermen and other industry representatives. At that meeting they agreed that real-time data collection is feasible, but the feasibility of real-time management could not yet be determined. Participants recommended that the program be continued.

May 2000 Illex squid Survey

Fishermen's knowledge regarding where and when to catch squid was important to this cooperative effort. At the December 1999 meeting they also decided to plan a survey for May 2000. There was also a bit of discussion at this time about doing an acoustic survey, but it ended up requiring more money than was available. The program continued pretty much the same way in 2000, and a survey was planned for May 2000. At that meeting, industry members told the scientists that *Illex* squid are captured in May in specific areas and at specific times of the day and agreed to assist in the design of an industry survey.

Consequently, in May 2000, the lead NEFSC scientist collaborated with the squid industry and consultants from Rutgers University on an *Illex* squid pilot *s*urvey. Two freezer trawlers were chartered: the F/V *Relentless* fishing out of Davisville, Rhode Island and the F/V *Flicka* which fishes out of Cape May, New Jersey. Using commercial gear, the vessels sampled from May 19 to May 29 from Georges Bank to Cape Hatteras. Funding for the pilot program was provided by the NOAA Fisheries' Marine Fisheries Initiative (MARFIN) program and the squid fishing industry. Eighty random stations were sampled at depths of 60-200 fathom. Data that were collected include species catch weight, gear mensuration data, vessel speed and location, water temperature, and depth. Biological data, such as weight, length, and sexual maturing, were collected from more than 1000 individual squid. To measure the performance of the trawl gear, sensors were mounted on the gear to indicate how widely the net is opened during the tow, which combined with information about trawl speed, can be used to calculate the area of the bottom and volume of water sampled. The resulting information could be useful to scientists to estimate the abundance of squid.

This was the only survey that has been conducted, but it proved very useful. It provided valuable biological information about *Illex* squid that was incorporated into the stock assessment in 2003 and 2005, as discussed later. According to one squid fisherman interviewed, there is interest in conducting future industry-based, “pre-season” surveys for the use in real-time management and for stock assessment purposes, and the industry is considering funding this themselves. As I discuss later, this is evidence of capacity building that has occurred as a result of cooperative research in this fishery. The involvement of fishermen in the real-time data collection effort and the survey, coupled with the communication that occurred regarding the value and importance of such data to assessment and management, produced an environment where fishermen are willing to invest in a future survey.

Electronic Data Reporting

The time lag involved in relying on hard-copy data was addressed when, in 2002, the NEFSC introduced electronic reporting of the fisheries data (Hendrickson 2003). This is the next step towards real-time data collection for possible use in conducting in-season stock assessments of *Illex* squid. Real-time, at-sea data collection utilized a GPS satellite service provider (SSP), a marine-quality transceiver/antenna, and hardware capable of email. Data collection macros designed by the NEFSC were programmed and uploaded to the vessels by the SSP. Fishermen entered data into two separate macros, a tow macro and a catch macro. Data were transmitted directly to the NEFSC via email. The NEFSC scientist had promoted electronic logbook reporting from the beginning of the project in 1999 but the industry and the Rutgers consultants felt more comfortable with hard copies, which was why it was not begun until 2002. The NEFSC paid for the emails that the boats sent.

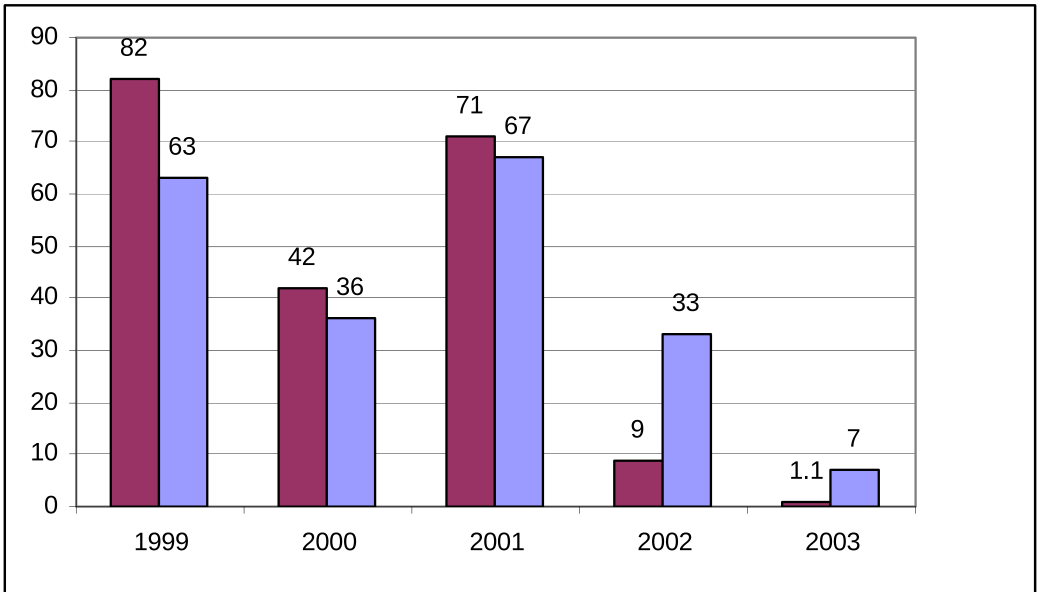
As an incentive to participate, the lead NEFSC scientist offered to have the management requirement to submit hard copy logbooks waived. Logbooks are mandatory and can be a hassle to fishermen. This is especially a hassle to those who are already submitting this same information electronically at-sea. The electronic system can provide the VTR data from the fishermen. When fishermen participating electronically come into dock they connect to the internet, and a menu interface comes on screen and asks the fishermen to verify that the data are correct; showing the fishermen what was sent on a tow by tow basis. The fishermen can then add any other data required in the logbooks, such as mesh size, foot rope length, etc. Then in the background this program sums everything and puts it into the exact format required in the vessel trip report, which he can send instantly, signed with an electronic signature. The data are stored on a personal website which the fisherman can access. Hard copies of the data can then be printed for a single tow, the whole trip, or two months.

There was a significant decline in participation in this program since its inception in 1999 (Figure 4-3). In 1999, twelve boats participated in the program, representing (sixty-three percent of the *Illex* fleet). In 2000 this shrank almost in half to only thirty-six percent of the fleet. In 2001, participation increased again (sixty-seven percent participation), only to drop by about half again in 2002 (thirty-three percent). By 2003, only seven percent of the *Illex* fleet had participated in the program, representing only

1.1% of *Illex* landings for that year. According to Dr. Lisa Hendrickson of the NEFSC (email, July 13, 2006), the annual decline was partly because of lower catches; it was associated with a decline in the catch rates, which was confirmed by the industry. In addition, informants suggested that the initial decline was due to mistrust that arose after the MAFMC implemented gear restricted areas to protect another species, scup (*Stenotomus chrysops).* These seasonally closed areas affected the *Loligo* squid fishery, which meant many of the same fishermen who participate in the *Illex* squid fishery. Other informants believed the issue was that fishermen were concerned that such a system would result in quota reductions. Other informants suggest that the failure of NMFS to waive the hardcopy logbook requirements also reduced participation. Initially the lead NEFSC scientist received a nod that the regional office of the agency would waive the hardcopy requirement, but this did not happen. Participation declined. The regional office (NERO) agreed to waive it in 2005, but the waiver was not made official and has yet to be granted.

The lack of sufficient participation has impeded success in this program. The stock assessment model that has been developed for this fishery, a real-time, in-season assessment model, requires greater participation by the fleet. If only a small percentage of the fleet report their landings, the model is not useful nor is real-time management feasible.

Figure 4-3: Participation in the *Illex* squid Real-time Data Collection Program (1999-2003).



*Based on Unpublished NEFSC data (Hendrickson, pers. comm., July 13, 2006).

While some fishermen bought into the effort and recognize the benefits that this data collection can provide to the industry, others remain skeptical and distrustful of the scientific motivations of the study, as well as fearful of future implications of this research (intended or not). A few are contributing data despite their distrust of the NMFS scientists.

Fate of the Research and Appraisal

This program can be considered a success when compared to many other industry-science collaborations that have been implemented in this region over the last few years. These cooperative data collection efforts between the NEFSC and the squid fishery have contributed to improving the stock assessment process. In 2003, most of the May 2000 survey was incorporated directly into the assessment, especially the model that was developed (NEFSC 2003b). As part of SARC 37, a new in-season assessment model was developed that estimates weekly fishing mortality rates and stock size and unlike the previous model incorporates recruitment and spawning and non-spawning estimates of natural mortality estimates. The model and results from that model were considered preliminary, requiring more rigorous testing (NEFSC 2003b). Nevertheless, the government's stock assessment report included the following special comments indicating that the *Illex* cooperative research projects implemented since SARC 29 "have resulted in improvements in the data available for the current assessment…and should continue" (NEFSC 2003a, 41).

In 2005, the *Illex* assessment built upon the data collected from this on-going cooperative research effort. Yet, progress with the new stock assessment modeling effort lags due to low participation and thus a lack of data. The SARC chair noted that "although significant progress has been made towards developing such an improved assessment, the uncertainty generated by the current data limitation precludes its immediate use as a provider of management-usable values of *F* and stock biomass." In particular, the chair noted that more and better data are needed to calculate seasonal growth rate and maturity. In addition, more participation in the program is needed, as discussed. There are currently discussions underway to gather some of the necessary data from the Mid-Atlantic Supplemental Finfish Survey, another industry-science cooperative effort, and there is interest within the industry for funding a pre-season survey.

In addition to the benefits that this research provided to management and stock assessment, this cooperative effort also generated long-lasting and invaluable biological knowledge about the species. In particular, the May 2000 *Illex* survey enabled Hendrickson (2004) to characterize growth, maturity, and age structure of the *Illex* population. Two findings were particularly valuable. Prior to this study, spawning areas had not been identified because few juveniles and mature females had never been landed and the neutrally buoyant, gelatinous egg balloons had never been found in nature (O'Dor and Balch, 1985 and O'Dor and Dawe, 1998). Statolith-based age analyses were lacking for squid from the U.S. shelf and for the population prior to the start of the fisheries. The May 2000 survey with industry boats provided the first evidence to indicate that *Illex* squid spawning actually occurs on the continental shelf in U.S. waters.

In addition, the study was also the first time the animal was aged. Hendrickson (2004, 264) indicated that the use of commercial vessels in this fishery "offered the advantage of improved catchability in conjunction with a standardized, random sampling design…{and] sampling the population prior to the start of the fisheries reduced potential sampling biases resulting from size-selective fishery removals." Thus, by working with the industry, catchability was improved by utilizing the industry's vessels and gear and their abilities to catch *Illex* and enabled research at the most appropriate time, which is presumably an improvement over what is could be done using the federal fishery-independent survey.

Another outcome of this effort is that real-time management in this fishery is seemingly becoming a reality. Ideally, real-time fishery management of the squid fishery would combine a pre-fishery season survey, like the one done in 2000, to assess resource abundance at the start of the fishing year, with real-time data collection, as they have been doing since 1999 and electronically since 2002. Catches in real-time would be subtracted from the projected abundance until the optimal TAC was reached. This would "better equip managers and the industry in identifying optimal harvest goals and adjusting harvest strategy when necessary” (MAFMC 2007, xvi). Further, this would avoid unnecessarily shutting down the squid fishery when the estimated TAC was achieved but more squid could have been sustainably harvested, as happened in 1998 and 2004. Additional participation, or mandatory real-time data reporting, would be required to monitor the fishery in-season. Mandatory real-time reporting is now being considered by fishery managers (MAFMC 2007).

Despite its success, institutional constraints make it still difficult to implement real-time data management. The management system is not structured for this kind of adaptive process. The former director of the NEFSC explained his frustration:

> “Right now, management cannot accommodate real-time biological information. There are just too many requirements for public input, reviews and so on, so it just takes months if not years to get real-time scientific information incorporated into the process. It's just a question of flexibility right now.”

The director is referring to two fundamental aspects of the fishery management process: transparency and public participation. The process requires that the public be given opportunity to participate and that decisions are made in an open, transparent process. This includes public comments periods and advance notice and public access to meetings. This adds on a layer of complexity to the process making it difficult for managers to react to new sources of information. Thus, one problem that impedes the realization of RTM is institutional inflexibility. This is something that can be developed and implemented, but just had not been done yet. However, the MAFMC is working towards this goal. One fishery manager expects real-time data reporting to be mandatory in Amendment 11 to the SMB FMP. In addition, the season start date may change to June 1 to accommodate a pre-season survey.

Role of Scientists

The way the government assessment scientist acted in this effort was critical to the success of this project. The lead NEFSC assessment (government) scientist initiated the early discussion with the industry that led to the development of the effort. By simply asking questions and taking the time to learn about the fishery, through observation at-sea, she was able to build trust and communicate with the industry. As we see in most cooperative efforts, trust and communication are critical factors for success. The NEFSC scientist also provided her expertise regarding what kind of data and how to best collect that data as needed to improve the assessment. She developed the forms that structured the collection of the data, both hardcopy and electronic forms. Again, her involvement from the very beginning was essential to ensure the use of the information produced from this collaboration.

Thus, to generalize, a factor critical to the utility of cooperative research programs in the management process is the inclusion of those who are most likely to use the data, in this case the lead stock assessment scientist. Those doing the assessments know best what kinds of data are most needed and how that data should be collected. Not all data can be incorporated readily into very structured and quantitative assessments, and therefore, if data from cooperative efforts are to be used in assessments, it is critical that the assessment scientists be involved or at least consulted. If those on the scientists' side of the boundary are not included in the project, the data generated in the collaboration may not be incorporated into the assessments or management. This means that the knowledge that fishermen contributed to the effort would not be included in science or management, and so the boundaries between fishermen's knowledge and scientific knowledge would be maintained. In this case study, the involvement of the lead assessment scientists facilitated the use of the cooperative research data in the assessment and efforts to create real-time management. In other cooperative projects, such as the NE Regional Cod Tagging Program (chapter 5), we see that such critical scientists are not brought into the effort, often for political reasons. Industry distrust with federal scientists results in the alienation of these scientists from these efforts. Interestingly, although the literature often talks about boundary creation by scientists, in that case we see boundaries maintained by fishermen and the scientists with whom they cooperate.

Another key to the success of this effort was the involvement of non-governmental scientists or industry consultants. [6] The “consultant scientist” provided technicians to go at sea with fishermen to test the feasibility of the data collection program and during the 2000 survey. Students (i.e. young scientists) from Virginia Institute of Marine Science and Rutgers also participated. The consultants helped foster trust and buy-in to the program because they provided the industry with a voice in the process. These consultant scientists perform an important function in these efforts, as they provide a mechanism for communication between scientists and the industry. They also bring legitimacy to these efforts through their representation of the industry.

They are boundary spanners. These scientists can communicate to other scientists the concerns of the industry better than the industry might be able, simply because they understand stock assessments and the scientific culture. For example, the industry consultant can emphasize aspects of the fleet’s behavior that other scientists who do not interact with the squid industry may not be aware of or recognize as important. This is due in part to language proficiency; he knows the scientific terminology that is often unfamiliar to fishermen. In this way, these scientists perform critical boundary spanning functions. In addition, these scientists are outside the establishment (i.e., federal government) and so are more likely to question assumptions and think "outside the box." Today, the squid industry and their consultant scientists have an extremely close working relationship. One consultant scientist in particular is very much involved in the assessment process, representing the interests of the industry through science in a way that was not done before. I would argue that he is not an advocate for the squid industry (i.e., he isn't out to try to increase the quota for the industry), but simply brings more insight into the scientific discussion because of his interaction with the industry.

Roles of Fishermen and their Knowledge

In many ways, the role of the industry and the use of FEBK might be considered minimal in this cooperative effort, simply due to the nature of the project (i.e., fishery-dependent data collection). Fishermen are not required to do anything different in their fishing activities. They were simply asked to report their catch on a tow by tow basis and collect some biological samples while fishing as they normally would. The type of data that were collected (and hence the research design) was dictated by the needs of the stock assessment and drew upon existing data collection methods used in the observer (sea-sampling) program, and so the stock assessment scientists designed the data collection forms (both hard copy logbook and electronic). Fishermen contributed their time and energy in collecting the data and samples, but from what I understand it was not a terrible burden to them. So, fishermen occupied a role similar to field technicians who collect data to be analyzed by other scientists back at the lab.

However, fishermen are critical because use of the data in stock assessment and potentially in real-time management requires that the majority, if not all, of the fleet participate. As of now, the program is fully voluntary and tends toward a public goods collective action dilemma, where the efforts of a few can benefit the many, and the many have little incentive to try (Olson 1965). Those who do participate are contributing valuable information that is needed to improve the assessment and management of this fishery. This data cannot be collected without them. Getting participation is facilitated when fishermen encourage other fishermen to get involved in the effort. The squid captain (and council member) mentioned earlier, in particular, has worked hard to get others in the industry to buy into the cooperative effort. Fishermen are more likely to "buy-in" to a cooperative program, and management based on that program, when other fishermen promote it.

Some fishermen are boundary spanners, too, and this is critical to the success of the programs. The fisherman often promoting this effort himself was "sold" on the program as a result of being involved since the program's inception and because he communicated often and openly with scientists. As a council member and thus manager, he is also exceptionally well informed about the complex issues of management and science, and how they interact to impact the fishery. As a participant in the fishery, he was aware of the impacts of traditional annual TAC management had on the industry (i.e., early closures), and so he saw the benefits of the industry participating in this program. Therefore, this fisherman brings to this cooperative effort his *contributory expertise* regarding the squid fishery and his *interactional expertise* related to fisheries science and management. This fisherman acquired this interactional expertise from his involvement in the cooperative effort and as a participant in the fishery management process. This is another example of capacity building.

Another aspect of this program, the May 2000 *Illex* survey, may have utilized more of the industry's ecological knowledge related to when and where to catch fish (i.e. temporal and spatial knowledge of fish distributions), and certainly how to catch fish (i.e., technical knowledge). As noted, the design of the 2000 *Illex* survey was random, so fishermen did not pick the tow locations. But they did operate their gear and vessels in a way that was more efficient at catching squid than the federal research survey. And the fishermen did suggest the time and general area where they knew squid would be (i.e., in the month of May), but the specific areas towed in that area and time were random. In terms of finding the resource, fishermen have *contributory expertise* to offer.

A surprising place to see fishermen contributing their knowledge is in the stock assessment process, which could be thought of as one venue where data from this cooperative effort are analyzed solely by certified scientific experts. I observed fishermen providing insight at a working group meeting for the 2005 *Illex* assessment, providing scientists with a better understanding (or explanation) of fleet dynamics and industry behavior. I observed fishermen confirm to the scientists their knowledge of the spatial and temporal distribution of the resource. For example, at one of the stock assessment meetings, the fishermen said that they can tell ahead of time when it is going to be a "good" fishing year. One *Illex* fisherman also attended the peer review of the assessment, again providing insight regarding the assessment. The captain informed scientists that they were missing valuable information (i.e., that squid were smaller this year or did not grow), which he knew based on his fishing experience and he felt could be confirmed by

2005 data, which were not yet available to the scientists. This kind of knowledge that the industry can provide is important in verifying and/or explaining the data collected by the scientists. At the time, however, the assessment was already complete (i.e., in the final peer review stage) and so the fishermen's insight was not incorporated into the assessment.

Thus, we do see fishermen's knowledge being included in this cooperative effort, but perhaps not directly. Their knowledge is filtered though a scientific assessment model and aggregated with other fishermen's knowledge. This project utilized fishermen's knowledge of fishing gear and operations, and indirectly, the spatial and temporal locations of the squid. However, the most critical place where we see fishermen's knowledge becoming important is in the assessment process. A select group of fishermen were "at the table" with the scientists, contributing their knowledge and insight regarding the fishery.

Conclusion: Boundary Spanning and Capacity Building

Much of the literature on incorporating fishermen's knowledge in science and management focuses on moving fishermen's knowledge from its social and cultural location across the boundary so that it can be used by scientists and managers. Holm (2003) refers to this process as the "radical decontextualization" of fishermen's knowledge through its translation, which "cleans out all cultural and political baggage." While this is also going on in this case study, we also see here, as in other cooperative research efforts, expertise moving from scientist to fishermen (and vice versa), resulting in capacity building for more effective involvement in science and management. For example, as a result of cooperative research, fishermen in the U.S. are becoming more active contributors to the stock assessment process. In the *Illex* squid case, three fishermen participated directly in the stock assessment working group that I observed and at least one was present at the peer review of the final assessment. Fishermen are able to participate in stock assessment because they have gained a new form of expertise. By engaging with scientists in cooperative research, fishermen develop a better understanding of science, including scientific data collection and procedures and how data are used in assessments and management. This *interactional expertise* (Collins and Evans 2002) related to the scientific process includes not just an understanding of the data and how it is used in the assessments, but more importantly how to communicate in the process. In many ways, they gain an understanding of the language (and norms) of a different knowledge culture which allows them to communicate more than they were able to in the past. To be sure, fishermen would not be expected to conduct stock assessments on their own, so they cannot be said to have acquired “contributory expertise” nor can they be said to be fluent in this culture’s language.

This capacity building allows fishermen and their knowledge to span the boundary and participate in the science and management process. Capacity building creates a feeling of intellectual ownership and of greater access to fisheries information among fishermen. This access to information represents a resource for them to draw on in the science policy process. This new expertise gives them power in the process that they would not have otherwise since scientific knowledge is the currency in this arena. This shift in knowledge or expertise from scientists to fishermen is especially valuable in the long-term because it enables future exchanges across the boundary. This learning or capacity building may reduce conflicts between fishermen and scientists over the science used in fisheries management, and thus create “buy-in” to regulations based on that science. This can lead to management rules being viewed as more legitimate by stakeholders. Perhaps most importantly, this new “interactional expertise” related to assessments and science allows them to contribute their contributory expertise (i.e., experience-based knowledge) by being able to communicate and translate their knowledge to scientists, effectively allowing fishermen and their knowledge to span the boundary.

Cooperative research appears to go beyond other forms of citizen science. The flow from scientist to fishermen is qualitatively different than merely educating the lay public about science with the aim to improve the public’s understanding of science, which is the case for most participatory, civil, citizen, civic, stakeholder and democratic science initiatives. Here, the transfer from scientist to fishermen includes expertise. Moreover, it is different due to the nature of the citizens. Fishermen are not by any means “ordinary” and so at the start already have knowledge to contribute; experience-based knowledge. And unlike most ordinary citizens who participate in a citizen science initiative, fishermen become pseudo-scientists, engaged in both the collection and analysis/interpretation of scientific data. Again, this capacity building (the acquisition of expertise) is critical for managing the boundaries between science and non-science, and for integrating fishermen’s knowledge in the science policy process.

Finally, capacity building also means providing resources and infrastructure needed for fisheries science and management and for the fishing industry in general. As we saw in this case of *Illex* squid, there is now an electronic data collection system in place to collect critical data for assessment and management. This system can be thought of as also collecting fishermen's knowledge. There is now a preliminary assessment model that has been developed that will be valuable as more data become available. Fishermen have been taught how to collect data on a tow-by-tow basis. An industry funded pre-season survey is in discussion and may be available in the future. In the Mid-Atlantic squid fishery, these together have created the capacity for real-time data collection, which is needed for real-time, in-season management. This innovative approach to fisheries management would not be possible without collaboration between industry and science. Thus, capacity building both translates fishermen's knowledge for use in science and management and enables the translation of scientific expertise to fishermen.

In this way, cooperative research functions as a boundary institution, one that negotiates the boundary between science and policy and is responsible to both sides of the boundary (Cash 2006; Guston 1996). Cooperative research is expected to maintain scientific standards while being relevant to science policy. Cooperative research also allows for the integration of scientists and non-scientists (and their knowledge) while still demarcating between these different knowledge cultures. Boundary institutions are also considered sites of "co-production," which is the simultaneous production of knowledge and social order by facilitating collaboration between scientists and nonscientists (Jasanoff 2004). In cooperative research, fishermen and scientists are able to collaborate on important science policy issues and scientific questions while still maintaining their unique identities, which are shaped by their experience and expertise. Fishermen do not become scientists, nor do scientists become fishermen. Yet both fishermen and scientists are able to span the boundary between science and non-science.

[1] The *Illex* squid real-time management case study is based on extensive interviews with fishermen, scientists, and managers, as well as informal discussions, observation at fishery management council meetings and stock assessment meetings, and a review of Council transcripts, reports and media articles. This research was conducted from May 2003 to August 2006. A total of thirteen interviews were conducted with key informants related to *Illex* squid science and management. Formal interviews were transcribed and entered into a QSR-N6 database for storage and qualitative analysis. A total of five meetings were directly observed related to *Illex* squid. In June 203, I attended the 2003 peer review of the *Illex* squid stock assessment (SARC 37) in New Bedford, MA. In 2005, I attended both an *Illex* squid stock assessment working group meeting (October) and the peer review of that assessment (November), both held at the NEFSC in Woods Hole, MA. In June 2005, I observed MAFMC squid, mackerel, butterfish committee meeting and the subsequent council's annual specification for *Illex* squid in Wilmington, DE. I also attended numerous meetings of the Mid-Atlantic supplemental trawl survey, at which issues with the *Illex* squid assessment were discussed, most notably after the last assessment in December 2005 and April 2006. Notes from these meetings were entered into a QSR-N6 database for storage and qualitative analysis. Numerous documents and websites related to the *Illex* squid assessment and cooperative research program were reviewed. Documents include published, peer-reviewed journal articles, fishery newspaper articles, stock assessment reports, and other technical documents. Websites include the one created by the NEFSC (http://www.nefsc.noaa.gov/read/popdy/rtm99/) and one from Rutgers University (http://www.hsrl.rutgers.edu/squid.html).

[2] According to unpublished NMFS permit file data (MAFMC 2006), there were seventy-seven vessels with *Illex* moratorium permits in 2005. Only thirty-eight percent of the vessels with *Illex* moratorium permits in 2005 landed *Illex*, but those vessels account for virtually all landings. Thus, although the majority of the *Illex* fleet was inactive in the 2005, participation was high compared to other years (e.g., 2000-2003). The fishery was not closed as the quota was not exceeded.

[3] For example, one fisherman claimed that in the Northeast groundfish fishery accurately reported their catch information in logbooks until they resulted in area closures: "They took all the information we gave them and used it against us. They closed every place we said we fished. This is a great debate in the industry over what to report. There is terrific distrust" (Cook and Daley 2003).

[4] In New England there is a pilot cooperative effort to improve the collection of fishery-dependent data in the multispecies groundfish fishery. This program was funded through the NMFS-Cooperative Research Partners Program. A study fleet of vessels was established to test the feasibility of several different electronic logbooks. Note, the purpose of study fleets differs from efforts to collect vessel trip report data electronically in real-time, such as is the purpose of the *Illex* squid program. The study fleet represents a sample of the fleet so the entire fleet is not expected to participate. The multispecies groundfish fleet with hundreds of boats is more complex than the fairly small single species *Illex* fishery. The program remains in a pilot stage, but progress has been made as technological improvements continue. A related effort involves the Cape Cod

Commercial Hook Fishermen’s Association which is working with the NEFSC to develop the collection of VTR data electronically and in lieu of hard copy reporting, which is considered a burden to the fleet.

[5] The Northeast Fishery Observer Program (NEFOP) collects data and biological samples during commercial fishing trips. These data are either not typically recorded by fishermen or incentives exist for misreporting. Most important are data on discards, marine mammal/protected species takes, and biological samples. More information on the observer program can be found on the following website. http://www.nefsc.noaa.gov/fsb/.

[6] This illustrates a growing trend where fishermen solicit scientific representation in the science and management process. For example, both the scallop industry and the surfclam and ocean quahog fishery hired science consultants to represent them. While some may feel that scientific consultants to the industry are inherently biased because they receive funding from the industry, this I believe is a naïve view. The participants in these programs, are genuinely interested in these scientific questions, and from my observations and discussions with participating scientists, the majority of the funding received goes towards implementing the scientific research programs, such as chartering the vessel, hiring technicians for data collection and analysis, paying for supplies, travel to attend meetings, etc. To be sure, scientists are also benefiting, as they are allowed to pursue research questions that would otherwise remain unfunded. There is a shortage of funding for fisheries research, particularly in the Mid-Atlantic, and so funding from the industry allows scientists to maintain staff, as well as research facilities, that would otherwise have to be let go and without them, and much of this work could not be done. This is part of capacity building. An important question is raised, but not addressed in this study: what does it mean for fishermen’s knowledge when fishermen must seek representation by scientists, rather than providing their knowledge themselves. Does this happen because existing institutions do not allow for the use of FEBK and this is how the industry has responded?

CHAPTER 5: COOPERATIVE TAGGING STUDIES: NORTHEAST REGIONAL COD TAGGING PROGRAM

Introduction

This chapter continues from the previous chapter by examining what happens to the boundaries between science and non-science in the science policy process when involving experience-based experts in citizen science efforts. Here I examine a cooperative fish tagging study aimed to provide information about the movement patterns of Atlantic cod, *Gadus morhua*: The Northeast Regional Cod Tagging Program.[1] I begin by describing the case, and, in keeping with the larger focus of this dissertation, I also reflect on the role of fishermen and their knowledge and the fate of this collaborative effort. Unlike the *Illex* squid real-time data collection program, the cod tagging study illustrates the dangers of too much boundary maintenance, or only selective boundary spanning. In this case, cooperative research did not function as effectively as a boundary spanning institution because the process did not include all relevant actors.

Case Study: The Northeast Regional Cod Tagging Program

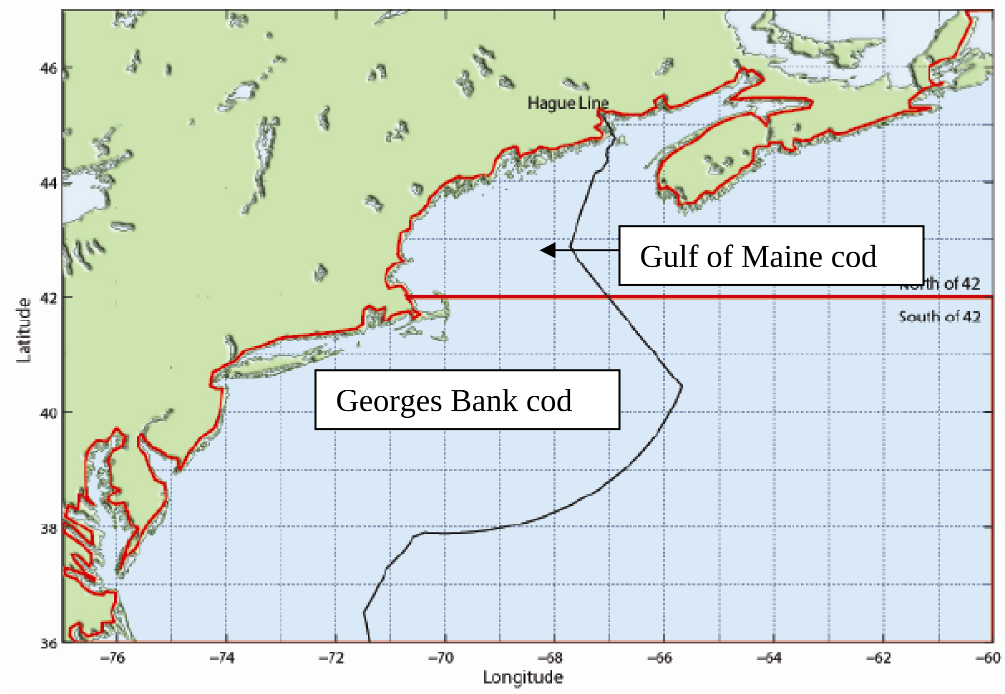
Management Context

Atlantic cod, *Gadus morhua*, is found on both sides of the North Atlantic. In the Northwest Atlantic cod ranges from Greenland to North Carolina. In the U.S., cod is managed by the New England Fishery Management Council as part of the multi-species groundfish fishery, which includes fifteen different species and twenty-six different stocks of demersal finfish. It is also assessed and managed as two stocks: Gulf of Maine cod and Georges Bank cod. According to NEFSC stock assessment scientists, the two stocks exhibit different growth rates, with growth traditionally slower in the Gulf of

Maine, but this has been increasing in recent years (Mayo and O'Brien 2000). The so-called "two-stocks theory," originally based on tagging data that was available in the 1950s, is a source of debate among scientists and members of the fishing community. For example, there are questions regarding migration patterns, the extent of mixing between these two stocks and if the population is more complex than assumed (e.g., Ames 2004; Hunt von Herbing et al. 1997).

These questions have important implications for the management of Atlantic cod, particularly regarding the rebuilding of these stocks after years of overfishing and the impact of closed areas. The migration patterns of cod from wintering grounds into summer spawning and feeding grounds may take them across a number of fishing grounds fished by different fishing fleets. This complicates an assessment of how much fishing mortality occurs on each stock. Moreover, as currently assessed, the fishery is managed with separate trip limits for the two cod stocks. Gulf of Maine cod has been declared seriously overfished and so is managed with strict quotas (four hundred pounds per day at sea). Georges Bank cod, defined as cod caught south of the 42° line, are considered to be in better shape and so fishermen are allowed to land as much as two thousand pounds per day at sea (Figure 5-1). There is concern that the appropriateness of differential trip limits that allows some fishermen to land more fish depending on which side of the line they are fishing on – when in fact fishermen may be fishing on the same stock. In this case, the geographic location of the boundary between the two stocks is questioned. Similar questions are raised regarding the influence of mixing on the effectiveness of the closed areas as a management tool (Hall-Arber 2002a).

Figure 5-1: Map of the 42° line demarcating the two stocks of Atlantic cod managed by the NEFMC (adapted from Tallack 2006).



In addition, there are concerns that go beyond this and speculate that the cod resource is comprised of numerous local stocks. This speculation is supported by fishermen and scientist Ted Ames' work in the inshore Gulf of Maine that revealed numerous inshore, discrete spawning stocks of Atlantic cod and haddock that were depleted in the 1950s (Ames 1997; Ames 2004). A large conference on localized stocks held in 1997 raised similar questions (Hunt von Herbing et al. 1997). Genetic work has begun to answer some of these questions, but significant levels of uncertainty remain (e.g., Lage, Kuhn, and Kornfield 2004). Such questions regarding stock structure raise issues with the appropriate scale of management (Wilson et al. 1999). Many question whether the current large-scale approach to management is able to deal with ecosystem complexities and the potential localized nature of the cod populations and call for a more localized, area-based approach to management (Hunt von Herbing et al. 1997; Kenchington, Heino, and Nielsen 2003). Although questions regarding stock structure were not the primary objective of this cooperative study, the Northeast Regional Cod Tagging program emerged from this debate.

Description of the Collaboration

The Northeast Regional Cod Tagging Program is a long-term cooperative program funded under the NMFS-Cooperative Research Partners Program (CRPP). This program was originally funded for two years, but was extended until June 2006. This project received about $3.6 million from the CRPP since 2002. Although there have been numerous small-scale tagging programs involving Atlantic cod, not since 1959 has there been a regional-wide, federally-funded tagging effort in U.S. waters (Mooney-Seus 2001). The program was considered “precedent setting” as it was “the first time the fishing industry, using industry vessels, would participate as partners in such a broad-scale data collection effort” (Mooney-Seus 2001, 7). Further, recommendations for the design of the program highlighted the belief that “existing communication barriers over data collection and usage can be overcome and relationships can be established between fishermen and governmental scientists based on trust and mutual understanding” (Mooney-Seus 2001, 7).

The program was designed through a participatory process with support from the non-governmental sector. In 2000, a series of eight meetings was organized along the coast of New England by the New England Aquarium (NEA) with funds from the NMFS-CRPI program. These meetings focused on identifying key research questions and design characteristics for a regional cod tagging program. The NEA received $110,786 to organize the meetings, which were held in Portland, Maine, Point Judith, Rhode Island. New Bedford, Massachusetts, Gloucester, Massachusetts, Chatham, Massachusetts, Scituate, Massachusetts, Ellsworth, Maine, and Portsmouth, New Hampshire. These meetings were attended by fishermen, scientists, and mangers. Based on the recommendations contained in the final report by the New England Aquarium (Mooney-Seus 2001), a large-scale cooperative tagging program was developed. The scientific focus of the project examines whether there has been a shift in the distribution and migration patterns of Atlantic cod, as theorized by scientists. Despite growing interest and questions, the project does not attempt to answer questions regarding the stock structure of Atlantic cod.

The Northeast Regional Cod Tagging Program is the largest tagging program in history on the East coast. The magnitude of this research endeavor is ambitious. The primary goal was to tag 100,000 Atlantic cod, from inshore Gulf of Maine to Georges Bank and south (Figure 5-1). The technical objectives were to identify migration patterns of cod throughout the GOM and neighboring U.S. and Canada waters, identify the extent of mixing between cod, obtain in situ growth increment information, and investigate the roles of temperature, depth and reproductive condition on migration and growth. Again, understanding stock structure was not a formal goal of the program. The other major goal was to achieve international collaboration between fishermen and scientists.

The program is coordinated by the Gulf of Maine Research Institute (GMRI), one of the leaders in collaborative research in this region. In addition five other locally-based groups were contracted as part of this program to oversee tagging in specifically assigned areas. The groups contracted to do the tagging were the Cape Cod Commercial Hook Fishermen’s Association (CCCHFA), the Island Institute, the Maine Department of Marine Resources (ME DMR), School of Marine and Science Technology (SMAST), and to a minor degree Manomet Center for Conservation Sciences. These groups contracted commercial and recreational fishermen to find, catch, tag, and release Atlantic cod. Additionally, this project collaborated with Canadian scientists from the Department of Fisheries and Oceans (DFO) who were conducting a tagging study in Canadian waters. The DFO started their cod tagging effort before the U.S. participants (Hall-Arber 2002c).

The CCCHFA members are primarily hook fishermen from Cape Cod who fish close to the "boundary" between Gulf of Maine and Georges Bank cod. The hook fishermen depend socially and economically on a healthy cod fishery. The CCCHFA coordinator worked mostly with members of the CCCHFA, but also reached out to non-members in the fishing community. The coordinator held workshops with fishermen interested in participating in the cod tagging program where he showed them how to tag and release the fish to increase survivorship. He trained fishermen so that they could go out and do the tagging themselves. The CCCHFA was one of the most successful tagging organizations, as they included fifty-seven boats and tagged 60,224 fish (Tallack 2006a). They also built upon what they had learned from this cod tagging effort to develop and implement a haddock tagging project (CCCHFA 2005).

The Island Institute was given the responsibility of tagging on a very small scale off the Maine coast. This organization has long been interested in questions regarding the stock structure of Atlantic cod. In fact, Ames (1997) worked at the Island Institute when he published his now widely recognized research documenting historic, and now extinct, local cod and haddock spawning grounds in inshore Maine waters. The impetus for tagging in these inshore waters was Ames' work. The Island Institute's coordinator worked closely with sports-fishermen on charter boats, handliners, and lobstermen to tag cod inshore. They primarily relied on charters and hand-liners and were tagging around 50-100 fish per day. One problem related to using sports fishing boats was that if the fish were legal, fishermen wanted to keep them, so they ended up only tagging small fish on these boats. The most significant problem they faced was a lack of fish. Although they were expected to tag five thousand fish, they were only able to tag 2,637 fish (Tallack 2006a).

The State of Maine's DMR is the only state government agency involved. The ME DMR has experience doing tagging projects. They conducted a small scale cod tagging study in the 1990s that did not involve the industry. The ME DMR hired thirteen large industry trawlers to catch cod for them to tag in order to get offshore. A total of 23,622 fish were tagged.

SMAST had been involved in a cod tagging study before this large program developed and so is an important partner in this program (Hall-Arber 2002b). This group was responsible for offshore Georges Bank and worked mainly with the trawl vessels from New Bedford. This group utilized eleven industry vessels to tag 20,884 fish (Tallack 2006a).

In addition, federal scientists from the NEFSC are also involved in the program, albeit only to a limited degree. According to one participant, the lack of trust between the fishing industry and the Science Center required that the federal scientists only play a low key role. Their role could be seen as advisory. Interestingly, the NEFSC scientist assigned to this project does not specialize in cod and so contributed only "interactional expertise" related to fish assessments. The role of the NEFSC cod scientists, those with more “contributory expertise,” will likely become more important when data are analyzed for potential use in management and stock assessments.

Each of the “tagging organizations” hired a coordinator that was responsible for overseeing fish tagging in their assigned area. These individuals were the on-the-ground liaisons who recruited and trained fishermen, paid the fishermen for their time or vessel, and typically did a bulk of the tagging as well. These individuals tend to work very closely with the industry, and the coordinators that I spoke with clearly were well regarded in the fishing community. In other words, these are individuals that the industry trusts. They can be considered boundary spanners.

Fishermen were critical to the first phase of research which involved fish capture and tagging. A variety of methods were used to capture the fish for tagging. These include otter trawls (short tow duration), commercial hook gear (hand line and manual rod and reel), lobster traps, and gillnet. Fish were caught within assigned sub-regions. Once the fish were caught and landed, they were put into holding tanks to increase the survival of the fish post-release. The location and length of each fish was recorded. Yellow T-bar anchor tags are applied either by the fishermen or by the on-board researcher. A gun similar to those used in department stores to insert price tags is used to insert the tag into the dorsal fin of the codfish. On each tag is the name of the program “Northeast Regional Cod Tagging Program,” an ID #, and a 1-800 number for people to call in a captured cod. Several participants involved in the design said it was important that the tags did not say NMFS, the federal agency funding the project, because it was felt that if they did individuals would be less likely to return them. Again this is because of the traditionally poor relationship between fishermen and federal fisheries science and managers. Costing about twenty cents each, these are very inexpensive tags compared to the more sophisticated satellite or archival tags, which can cost up to a hundred dollars a piece. The scale of this program was such that these inexpensive tags were more appropriate. The way the cod were tagged and released, what some might call opportunistically, is a potential problem with the study, as discussed later. There was a trade off between getting as many in the industry involved and the statistical robustness of the data.

Fishermen are also critical to the recapture phase of this project. Recaptures are also reported by processors and scientists. Ideally, the program would like individuals to report 1) tag number, 2) date of capture, 3) capture location and 4) the fish length. If the individual reports all of this information they are entered into a cash lottery. In addition, any one who returns a tag receives their choice (when possible) of a cap, mug, or t-shirt. Tag returns are necessary to achieve the scientific goals of the program. Thus, public outreach about the program and incentives to encourage individuals to return their tags are key elements of this program. GMRI and the other tagging organizations have made important efforts to get the word out to the public and fishing industry. For example, they send out mass mailings, present or display posters at various industry forums and tradeshows, as well as fisheries or marine related conferences. There is also a very accessible website sponsored by GMRI.

Industry participation in this program has been exceptional, although it varied by tagging organization (Table 5-1). More than one hundred vessels participated in the tagging effort (Table 5-1). The program estimated that this included about 250 fishermen (Tallack 2006). This program is unique compared to other cooperative efforts because of its inclusion of recreational fishermen as well as commercial fishermen. As of June 2006, nearly 1,500 industry members participated in the recapture phase (Tallack 2006a).

Table 5-1: Number of vessels by tagging organization that participated in the release of tagged cod (from Tallack 2006a, 17).

Vessel type	CCCHFA	DFO	DMR	II	GMRI / Manomet	SMAST	Total	Program total %
Commercial	33	1	13	9	1	11	**68**	63.6%
Recreational	5	-	-	10	-	-	**15**	14.0%
Recreational & Commercial	19	-	-	1	-	-	**20**	18.7%
Research	-	3	-	-	-	-	**3**	2.8%
Other	-	-	-	1	-	-	**1**	0.9%
Total	**57**	**4**	**13**	**21**	**1**	**11**	**107**	

The final phase of this tagging program is data analysis. Data are entered into a database and then edited by GMRI. One of the explicit goals is to make sure that the data is available to the public. The data will eventually be stored in the NMFS database, enabling its use in stock assessment and management. However, public access to the data are also available through an interactive website that provides a direct link to a GIS interface for mapping the data. The idea is to make the website accessible to anyone who wants to map cod movement – based on the tag releases and returns. Again, ensuring that the data were available to the public was important to the industry acceptance of this cooperative program.

The Role of Fishermen and Their Knowledge

In this effort, fishermen contributed their local knowledge of where, when and how to fish. Specifically, fishermen provided their knowledge regarding fishing locations (both spatial and temporal knowledge), catching fish (technical knowledge of gear and vessel operations), and in some cases handling fish (by recreational fisherman). The division of labor in the effort reflected their local expertise. For example, fishermen who fish primarily on Georges Bank may not be as knowledgeable at finding fish in the coastal waters of the Gulf of Maine, and vice-versa.

Fishermen were involved in this research from the beginning, including hypothesis generation. This and other cod tagging efforts were initiated by concerns in the fishing industry regarding the movement and potential mixing of two cod stocks; as well as questions whether they are in fact really two stocks. In this way, fishermen were important “hypothesis generators” in this research, although they are not the only ones who questioned the two stocks theory. To be sure, it was not that scientists did not know that there was mixing of these stocks in certain areas, but given available data that suggested two different stocks in these regions, they were satisfied with the simplification (i.e., drawing a hard boundary between the areas). The industry’s concerns were based on their observations of cod movement patterns. Fishermen not only found and captured fish to be tagged; the program relies primarily on fishermen to catch and report tag returns. Therefore, fishermen are the primary recorders of data for the project. In some cases, fishermen received training to do the tagging themselves in the absence of scientists on board. These are some examples of capacity building that is occurring as a result of cooperative research (i.e., fishermen gaining scientific expertise).

The contribution of fishermen to finding and catching the fish is knowledge that is not trivial. These programs can be costly without the involvement of fishermen, although some informants questioned the cost effectiveness and efficiency of the way the cod were tagged. That is, some informants suggested using fewer, but larger boats would have been more cost effective than chartering a hundred or so boats. Regardless, fishermen are critical to getting data from the tag returns back. Yet, because fishermen are generally skeptical of fishery scientists, they often do not return tags when caught. There are stories of fishermen steaming around the ocean with coffee cans full of tags that they refuse to report. As one industry member stated: “I know that there’s a certain segment of the industry on Cape Cod that is refusing to send in any tags. [laughs] The most significant catchers of cod, and I wonder why that is? [laughs].” However, recent efforts are showing seemingly greater success rates due to the outreach and involvement of the industry which has generated buy-in to these programs.[2] This again is part of the capacity building that occurs with cooperative research.

In some respects, tagging can be considered a for-hire type of cooperative research (i.e., chartering fishermen’s boats) or using fishermen as field technicians rather than as an equal partnership. One industry member explained: “I view the part of the industry that’s hired to go out and tag…as that’s providing them with a job. It’s not really…Their knowledge isn’t really helping.” Nevertheless, I would argue that recent efforts go beyond this since fishermen and their knowledge are critical to all stages of this effort. In the past tagging programs more often than not used fishermen’s vessels exclusively as research platforms, where scientists told the fishermen where to go and when to fish. In other cases, like the State of Maine tagging effort in the 1990s (Perkins, Chenoweth, and Langton 1997), tagging programs didn’t use fishermen or their vessels at all to tag fish, and instead utilized more costly research vessels.

Fate of the Research and Appraisal

Tagging ended in July 2005, with 114,000 tagged Atlantic cod in the water. Now the future success of the program lies in fishermen reporting the tags and associated data when caught. This is the most critical stage of the program. If they do not receive a sufficient number of recaptures, they will not be able to say much about migration patterns, stock mixing, stock structure, or anything else. As of June 2006, fishermen had recaptured over 5,866 cod tags; about a 5.1% return rate (Tallack 2006a). Again, outreach is critical at this point. Incentives are needed to encourage fishermen to report the information from the recaptured cod. There is also a need to maintain the infrastructure that exists within the GMRI so that fishermen have a place to call to report the recaptured tags. To this end, funding for the program was extended until June 2006 to allow for tag returns and preliminary data analysis.

The program has already had some administrative success and certainly achieved some of its original goals. The program achieved and even exceeded its goal of tagging 100,000 cod. A high level of participation was achieved with over one hundred vessels and about 250 fishermen throughout the region, including commercial and recreational fishermen with representation of multiple gear types. Consequently, a broad range of fishermen received supplemental income from this project. Participants indicate that valuable and hopefully long-lasting relationships have been established between fishermen and scientists. However, like any tagging study, the "scientific" success of the program can only be determined after several years of recaptures.

A tagging workshop was organized in October 2004 to review several tagging programs in place in the Northeast, including the Northeast Regional Cod Tagging Program (Workshop Organizing Committee 2005).[3] This kind of "extended peer review" is similar to those being done for other long-term programs funded through the CRPP program, such as the industry-based surveys and the study fleet program. The meeting included participation by two independent experts, program coordinators, and a number of state, federal, and non-governmental scientists. Several recommendations were made regarding the project, some of which were implemented. These include increasing double tagging to investigate tag loss and use of gloves during tagging to improve standardization. Over all, the workshop was positive and provided an opportunity for collective learning among various tagging programs.

There is still concern that some of the expectations related to the use of the data from this project may not be met. One expectation I found often articulated was that the program aimed to answer stock structure questions related to cod. For example, one council member and former fisherman stated optimistically:

> “The cod tagging program has been several years getting to the point where they've gotten one hundred thousand tags in the water and now they are starting to get returns on those. That's going to be very important for addressing some basic stock structure, management questions for cod...We are managing codfish under a two stocks model that was developed in the 1950s on a limited amount of data. And the industry has been saying that that is much too simplistic and it's creating simplistic management approaches that may do more harm then good in some ways. So that is something; that information is slowly feeding into the process and…it'll make changes in the management gradually.”

Scientists not directly involved in the effort have similar beliefs regarding the goal of the program. After a presentation of the program at an industry forum, a year after the program was initiated, one academic scientist questioned whether the design of the project will be able to meet its objectives. He cautioned that to identify different stocks, only spawning fish should be tagged. Another Canadian scientist echoed his concern in another seminar on localized fish stocks. Organizers of the program responded by emphasizing that one of the major goals was to simply have as much collaboration as possible. This goal necessitated the design used. Later, the program administers would make it more explicit that the goal of the program was not to address stock structure questions, but rather movement and migration patterns.

One federal scientist reiterated the uncertainty and potential disappointment that some may feel about the project results:

> "As far as maybe some people in management {or] industry who expected to see a large change in our perception of cod as a result of this work, they're probably going to be disappointed. But I think people who know something about cod aren't going to be all that surprised. I mean there's always an exchange between the {two] stocks and that's what we're seeing - some degree of exchange. And the question is: is it a significant magnitude, enough magnitude to really change the way we handle the assessment?"

One barrier to utilizing the results of this effort is that during the planning and design of the program key NEFSC cod assessment scientists were not consulted. This was because participants felt fishermen would not participate in an effort with the NEFSC due to trust issues. According to one assessment scientist working with cod, it is not clear how they will utilize this data in the cod assessment.

> "I don't know how I would use it in the assessment…Part of the problem {was] that {it] wasn't set up initially as a way of to make any direct calculations. It was more kind of qualitative information…It's not going to provide a quantitative type of information that you would use in the assessment…It was really kind of the industry wanted to go out and tag fish, and it really wasn't set up on 'how can you use this in the end in the assessment?' It's just something they wanted to go out and do. They didn't want NMFS input really."

One industry representative involved in the management process also remains skeptical. Rather than being overly impressed by the fact that so many cod were tagged and that it included significant participation by the industry, she would like to see results: "I guess you could say they have been successful in getting a lot of cod tagged, but what does that mean? So what that they tagged a bunch of fish. What did they learn from it?"

Similarly, there is disagreement over whether this effort is a meaningful cooperative effort or just a way to get income to the industry. Although one industry member viewed the tagging program valuable, they were hesitant to call it a cooperative effort. This industry person viewed the tagging as merely providing fishermen with supplemental income while the real industry contribution came from the return of the tags.

> "I don't care who tags the cod, I don't care whether it's recreational fishermen, whether it's people that they hire on some kind of cooperative venture, whether it's scientists on a cruise. That makes no difference to me. They get the tags out there. Fine. When one says that's cooperative, I view the part of the industry that's hired to go out and tag… as that's providing them with a job. It's not really…their knowledge isn't really helping. The people who catch them, is {helping]."

In any case, the majority of interviews with observers and participants in the New England indicate that the Northeast Regional Cod Tagging Program is viewed as one of the most successful cooperative research projects funded under this "new wave" of cooperative research. Most informants tend to express a level of optimism about the program, perceiving it as a long-term study that will make a difference to management. When asked about projects considered successful, one New England fisherman and council member said, "The cod-tagging program hopefully is heading into management. Management is aware that it is there."

However, despite expectations, it remains somewhat unclear what will become of the data collected and how it might be used in stock assessments or management. Ideally, some data will be used in the next stock assessment that is scheduled for 2008, but it is not clear how that will happen. According to the program's review, data analysis has focused on size relationships, growth rates, distance and direction of movements, seasonal displacement, recapture reporting rate, and method of reporting tags (implications for outreach efficacy). One scientist suggested that if the data are able to calculate mortality rates, it would only be down the road when more sophisticated models exist.

The fate of this cooperative program will likely unfold over the course of a few years. As for now, the results are mixed as whether it can be considered a success. An important question to ask is what will happen to the collaboration if some of the more technical and applied expectations are not met? Will the benefits that have been gained in terms of improved relationships be negated? Some stakeholders in the region do not agree that it is enough to just demonstrate cooperative research and improve relationships between industry and science. These individuals want to see results, particularly when there is a limited amount of funding for research and pressing management concerns.

Unmet expectations may impact the larger collaborative spirit seen in the region. At the tagging workshop the linkage between the various tagging programs was obvious since they all rely on fishermen for reporting. This means that what happens with one program will influence how other programs are viewed by association. For example, if one program fails to pay the rewards promised for the returned tags, fishermen are unlikely to return tags in the future from any program. This is likely true for cooperative research in general. The failure of certain cooperative research projects may thwart efforts in other projects and the gains of trust and buy-in from cooperative research could be lost.

Conclusion: Selective Boundary Spanning and Boundary Maintenance

Although the program is a successful integration of fishermen in scientific research, it is arguable whether their knowledge was critical. In many ways, this effort can be considered an example of a “for-hire” relationship – fishermen were hired mainly to provide a research platform and to collect data for science. To be sure, fishermen’s knowledge and skills were valuable to finding fish efficiently and the industry’s skepticism regarding the assessment and management of Atlantic cod was a driving force for the program, although scientists too agreed with the validity of their questions. Yet, like other citizen science efforts, the cod tagging program could have been conducted without the industry and in fact typically was done that way in the past. Fishermen were given some freedom as to where to tag the fish within an assigned geographic area, but program scientists ultimately controlled the design (i.e., what data to record and how many fish to tag) and the analysis of the data. Of course, the scientific value of the program cannot be realized unless fishermen cooperate by returning tags, which they can easily do if they so wish. This cooperation should not create a severe burden to them since they are bound to find a tagged fish while fishing. It is not as if the program is asking fishermen to go out of their way to find the tags for them. Thus, this program falls into the “for-hire” cooperative effort that also serves to provide disaster relief to a small segment of the fishing industry.

Despite what might be considered minimal contribution of their knowledge, this effort has resulted in capacity building that is critical for achieving some of the broader goals of larger cooperative research. As a result of this effort many fishermen were exposed to and learned about the scientific research process. For example, fishermen not only learned how to tag and release fish (i.e., mark and recapture), but also how to measure fish, take samples, and record data. They learned to appreciate the scientific need for standardization, as well as the importance of getting tag returns. These skills at data recording and a general understanding of standardization may be useful in other research projects in the future. It is not clear, however, how much expertise was gained from the interactions in this effort. If anything, fishermen may have gained some "interactional expertise" related to data collection, but not expertise that would make them able to interpret data themselves or participate in the assessment process.

In this effort, despite being considered a poster child for cooperative research, the boundaries between fishermen's knowledge and scientific knowledge were maintained. The interactions that did occur, the sharing of expertise, occurred between a select group of fishermen and scientists. The fishermen were those chartered by the tagging organizations and the scientists involved were from the tagging organizations (mainly NGO or state scientists). The project neglected to include an important "knowledge culture" –the federal stock assessment scientists. The federal assessment scientists were seemingly purposefully excluded from participation. The project included a NMFS stock assessment scientist, but only to a minimal degree and not one of the scientists directly involved in the assessment of Atlantic cod. There was a perception that the inclusion of NMFS/NEFSC scientists would discourage industry participation in the effort because of the traditionally poor relationship between fishermen and federal fisheries science and managers. The assessment scientists most critical were not brought into the effort due to political reasons (i.e. industry distrust with federal scientists). This means that the benefits of the cooperation, such as improved relationships, shared understandings, knowledge sharing did not occur across one of the most important boundaries – that between the industry and the federal assessment scientists. Without their inclusion, it is unclear how the knowledge produced will impact the science policy process.

Although the literature often simplifies the problem of incorporating fishermen's knowledge into science and management as being the result of a divide between two knowledge cultures (i.e., science and local knowledge), we see here that when thinking about cooperative research, we are reminded that there are more than just two knowledge cultures. Just as there are many different kinds of fishermen, there are different kinds of fishery scientists (Wilson et al. 2002; Wilson 2003). In this research, NGO/academic scientists, state government scientists, and federal scientists have very different relationships with fishermen. In this case, there are "divides" between non-governmental scientists (e.g., academics, NGOs, etc...) and federal scientists. In some cases, the "divide" between fishermen and scientists is insignificant, such as between fisherman and the NGO groups and state scientists in this project. We also see "divides" within the fishing community. Some fishermen described the cod tagging project as the most important and successful project, i.e., a true collaboration, where other industry members questioned the significance of the project both in terms of its outcome and the level of industry participation. The alienation of the federal assessment scientists from this project illustrates this. Based on the literature, we would expect boundary work (Gieryn 1995) to be done by scientists, but in this case (even if unintentional) boundaries were maintained by fishermen and the scientists with whom they cooperated.

This case study underscores the importance of including those who will most likely use the data early in the process. This program included a number of industry and science stakeholders, but lacked early participation by key stock assessment scientists responsible for Atlantic cod. As noted, one assessment scientist working with cod did not expect to be able to utilize the data in the assessment in the way that would make an important contribution. If this assessment scientist had been consulted earlier in the effort, then the program could have been designed in a way that would certainly have provided data for use in the assessment. For example, mortality and growth rate data would make a valuable contribution to the assessment, if collected in a way that was usable in the assessment model. It is still possible that the data will be useful for assessment, but such uncertainty could have been avoided simply by having a short discussion at the outset with the assessment scientists. For example, it is anticipated that data collected in the yellowtail flounder tagging data will be incorporated directly into the assessment since the lead assessment scientist was a principal participant in the design and implementation of that effort (NEFSC scientist pers. comm.).

The boundary that was maintained between federal scientists and fishermen is especially problematic here given that expectations are high due to the political nature of the problems being addressed (and just the political nature of the cod fishery in general). If in the end the results are not useful for science and/or management, then stakeholders may develop additional distrust with scientists and science in general. Given the visibility of this effort, this may negate all of the purported benefits of making it an extensive collaborative effort. It is important in these politically charged situations to temper expectations or make the objectives and potential use of the data clear from the beginning. Given the fiscal investment in this effort, many industry stakeholders are now becoming skeptical about the value of this effort (other than a few fishermen having received supplemental income, paid for by tax dollars). This is especially true for long-term and high investment projects like tagging studies and industry-based surveys.

However, one should not underestimate the value of the relationships generated in this effort, as they facilitate mutual understanding and exchange. The shared understandings, abilities to communicate, and personal relationships facilitate future interactions between these groups, as they are now better able to communicate and translate each other's views. For example, an industry organization, the Cape Cod Commercial Hook Fishermen's Association, built upon what they learned from the cod tagging program to implement a tagging project for haddock (Stevens 2006; CCCHFA 2005). The Hook fishermen brought to this new project their experience and the knowledge about tagging that they gained through the cod tagging effort. The new project also relied on the relationships that they had fostered with the GOMRI, which is their scientific partner in the haddock tagging project. The CCCHFA has also become a leader in cooperative research and a strong advocate for their fishermen in the management process. Interviews with fishermen and scientists who participated in this project reflect the positive, working relationships that emerged from these collaborations, as well as shared understandings generated through these interactions. In some cases, mutual respect and trust developed as each learned more about the other. Both personal relationships and shared understandings were possible because the project created an opportunity for communication or exchange to occur between these groups.

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[1] This case study is based on extensive interviews with fishermen, scientists, and managers, including informal discussions, observation at fishery management council meetings, and a review of various reports and media articles. This research was conducted from May 2003 to August 2006. A total of eighteen interviews were conducted with key informants related to cod tagging program and cod management. The majority

of these were formal interviews lasting between 1-2 hours. The remaining interviews were short informal discussion at various science and management meetings. Representatives from each of the organizations involved in the program were interviewed, including several fishermen who had been involved in tagging. Numerous meetings were attended relative to the cod tagging program, where presentations or posters were presented. On March 5, 2004, I observed a panel discussion on the tagging program at the Maine Fishermen's Forum in Rockport, Maine. I also observed a joint presentation about the program at the 4th Annual Conference on Responsible Fishing in Providence, RI on September 29, 2004, by Dr. Shelly Tallack and Tom Rudolph. In September 2005, Tom Rudolph presented at the American Fisheries Society Annual meeting in Anchorage, AK (Rudolph 2006). Dr. Tallack presented posters at the Maine Fishermen's Forum (March 2003), the Managing Our Nations Fisheries Conference Part II (Tallack 2005), and the American Fisheries Society Annual meeting in Anchorage, AK (Tallack 2006b). Additionally, numerous documents and websites related to the NE Regional Cod Tagging Program were reviewed. Documents include the final report (Tallack 2006a), program annual reports and newsletters, fishery newspaper articles, a peer review workshop document (Workshop Organizing Committee 2005). Websites include the program website created by the Gulf of Maine Research Institute (http://codresearch.org/), including an interactive interface to look at the data and track tagged cod, and sites provided by the tagging organizations. The GMRI website of the program provided access to newsletters, bi-monthly updates, annual meeting reports, and posters.

[2] Numerous fishermen have suggested that certain gillnet fishermen out of Cape Cod not report all of the tags they capture. However, the reporting rate from gillnetters in the Cape Cod area increased due to the CCCHFA offering to assist this gillnet fleet with the preparation of a sector allocation application, on the condition that they start turning in tags. Nevertheless, information reported is still often incomplete from these individuals since the tags are hoarded and then been batch-reported, with little if any information other than the tag number.

[3] The three major tagging programs reviewed were Atlantic cod, yellowtail flounder, and black sea bass. Other tagging programs that were discussed at the workshop included Atlantic sharks, striped bass, herring, salmon, and haddock.

CHAPTER 6: COOPERATIVE GEAR RESEARCH AND BYCATCH STUDIES

Introduction

In this chapter, I examine the contribution of citizens and their experience-based knowledge in science when their expertise is accepted as equal to (and often greater) than scientists' knowledge. Fishermen are considered to have "contributory expertise," as defined by Collins and Evans (2000), particularly in regards to fishing gear and vessel operations. I analyze two cooperative gear studies that illustrate the diversity of these kinds of cooperative programs. First, I examine several cooperative efforts trying to address the exclusion of *Loligo* squid fishermen in the Mid-Atlantic from a gear restricted area (GRA) aimed to reduce discards of scup, *Stenotomus chrysops*.[1] The second case study looks at the development of the grated raised footrope whiting trawl that allowed a whiting fishery to occur with minimal catch of cod and other groundfish in the Gulf of Maine.[2] Both case studies illustrate efforts to allow access to a healthy stock while minimizing discards and bycatch of weak stocks. They are both studies that attempt to "prove" fishermen's "hypotheses" (or perhaps knowledge) that fishing can occur in certain places and times with minimal impact on protected species. *Loligo* fishermen needed to prove that their fishery did not produce significant bycatch of scup or show that they could fish in the area with a certain gear configuration with minimal bycatch. The Maine whiting fishermen needed to prove that they could catch whiting while catching minimal amounts of traditional groundfish like cod and various flounders.

For each case study, I describe the cooperative effort and reflect on the role of fishermen and their knowledge and the fate of this collaborative effort. These gear selectivity studies illustrate the institutional aspects of boundary-maintenance that need to be overcome for greater integration of FEBK into the science policy process. Further, these institutional constraints to integration are a result of the differential scales of management and fishermen's knowledge, and imply a need for new opportunities for innovation such as local, area-based management.

Case Study 1: Mid-Atlantic Gear Selectivity Studies in the *Loligo* Squid Fishery

Management Context: Scup Discarding in the *Loligo* Squid Fishery

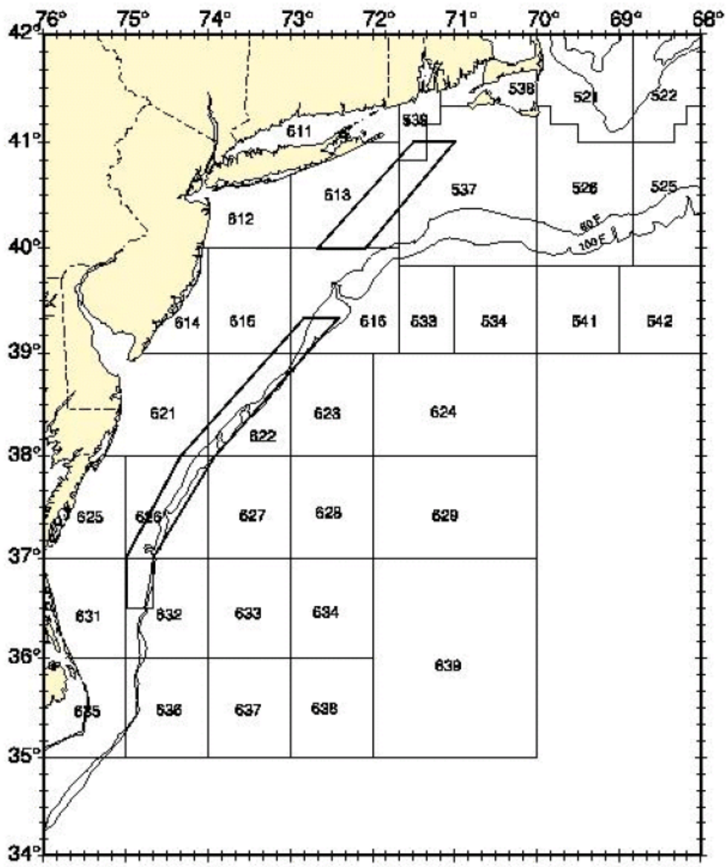
The U.S. squid fishery targets Longfin inshore squid, *Loligo pealeii*, (hereafter *Loligo* squid) along with *Illex* squid, although the two fisheries are very different. The history of the U.S. *Loligo* fishery is similar to that of *Illex* described earlier in chapter 4. The *Loligo* squid fishery is primarily prosecuted with otter trawls using small-meshes, with between $1^{7/8}$ inch and $2^{1/2}$ inch mesh in the cod ends. The Mid-Atlantic Fishery Management Council (MAFMC) manages the *Loligo* squid stock under the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan (FMP). Management measures specified under Amendment 8 to the FMP include a moratorium on permits, seasonal quota specifications and gear restrictions. Amendment 5 imposed gear restrictions to eliminate the waste of *Loligo* that was occurring with the use of small liners. A minimum size restriction was rejected to avoid potential discard problems that would have arisen with such a measure. More recently, beginning in 2000, the most significant and politically-charged management measure impacting the *Loligo* squid fishery was the implementation of Gear Restricted Areas (GRAs) in the Mid-Atlantic, prohibiting the use of less than 4 ½ inch mesh nets in specific areas during certain times of the year.

As a small mesh fishery, discarding of important species is a significant concern for the squid fishery. In the *Loligo* squid fishery, there have been significant concerns regarding the level of discards of scup, *Stenotomus chrysops*. Kennelly (1995) examined the NMFS sea sampling (observer) database consisting of demersal trawler fishing trips working throughout the northeast from 1990 to 1994. He suggested two possible management options to address scup discard problems: time/area closures and gear restrictions, adding that gear restrictions were preferable to a closure strategy as a better way of reducing scup discards throughout the region. Discarding of scup initially became an issue following the 1995 stock assessment of scup, where the Stock Assessment Review Committee (SARC) concluded that scup was overexploited, at a low level of biomass, and that high rates of exploitation of age 0-2 fish should be decreased as much as possible (NEFSC 1995). It has long been suspected that young scup mortality occurs as incidental bycatch and subsequent discarding from demersal trawlers, particularly those targeting *Loligo* squid (Kennelly 1999). The 2000 scup stock assessment concluded that fishing mortality should be substantially reduced and that a reduction of mortality from discards would have the most impact on stock rebuilding (NEFSC 2000). Then the 2002 assessment indicated that scup were no longer overfished, but the status relative to overfishing could not be determined (NEFSC 2002). The SARC concluded that although there was an indication that relative exploitation rates had declined, they couldn't estimate fishing mortality for scup. The 2001 estimate of spawning stock biomass was based on a 3-year moving average of the NEFSC spring survey (2000-2002), and the change in stock status resulted from the extremely high survey index in the spring 2002 survey. Scup is one of the many species for which the NEFSC bottom trawl survey is problematic; often the survey misses them or catches them in high abundance. The SARC recommended that "management should continue efforts to further reduce fishing mortality rates and minimize fishery discards to rebuild the stock" (NEFSC 2002, 17). 2000 was the last time the stock was successfully assessed. Assessments conducted since then have been rejected, principally because of the lack of discard data and poor biomass indices from the NEFSC bottom trawl. According to fishermen interviewed, the industry did not agree that the problem of discards in the scup fishery was due to high levels of discarding in the *Loligo* squid fishery. And they questioned whether the "overfished" status of scup was due to the inadequacy of the NEFSC bottom trawl survey.

In 1999, the MAFMC developed gear restricted areas (GRAs) that closed specific areas at certain times of the year to small-mesh fishing in order to reduce scup mortality from discards in the Mid-Atlantic. The council recommended a series of small GRAs that were to be placed sequentially for two-week periods as part of Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP. NMFS disapproved the Councils scup bycatch provision in Amendment 12 because it did not adequately reduce bycatch or minimize bycatch mortality (NOAA 2000a). On May 24, 2000, NMFS implemented its own GRAs for the scup fishery, which differed significantly from those proposed by the MAFMC (NOAA 2000c). The NMFS GRAs represent two larger areas with restrictions in place for several months (Figure 6-1). A Northern GRA was in effect from November 1 to December 31, and the Southern GRA is in effect from January 1 to March 15. The GRAs prohibited vessels with trawl gear that have a mesh size of 4.5 inch or less in the codend from fishing for *Loligo* squid, black sea bass, mackerel, and silver hake (whiting). This applied to all otter trawl gear unless it was being used in an exempted fishery.

Atlantic herring and Atlantic mackerel small-mesh fisheries were exempt from the GRAs. In 2000, the *Loligo* fishery was given a temporary exemption from the GRAs from November to December 31 (NOAA 2000b). The GRAs were in effect again in 2001, without the exemption for the *Loligo* fishery.

Figure 6-1: Scup Gear Restricted Areas implemented in 2001.
(http://www.nero.noaa.gov/ro/doc/0103.pdf).



The GRAS had a significant impact on many squid fishermen. For example, a Rhode Island fisherman stated at a MAFMC meeting in August 2002:

> "While having this area closed last year I lost two and a half months of fishing there. Those two and a half months that I would have been fishing there, I had to go groundfishing...That was about a quarter of a million dollar hit I took off of this. This is getting a little steep" (MAFMC 2002, 266).

Another fisherman expressed his anger regarding the GRA a year later:

> "I'm a perfect example right here -- the GRA affects me greatly. The GRA in my mind should be a perfect example of what not to do in the future…There's not much about the GRA that makes any sense, honestly…The GRA is totally ridiculous…The GRA is disgusting and to say you can't change it is ridiculous" (MAFMC 2003b, 134-5).

At the start of this process, in anticipation of the need to reduce scup discards in the small-mesh fisheries, the MAFMC convened a scup discard workshop in Atlantic City, NJ in August 1999. At that event, gear specialists and commercial fishermen met to discuss scup discards and whether gear modifications could be used to address these problems. At that meeting, two well known gear scientists from the region shared their research involving inshore testing of small-mesh nets modified for scup escapement. The study found that the behavior pattern of scup allowed the separation of squid from scup and other bycatch species caught in the lower portion of the net (Glass et al. 1999). Although the Mid-Atlantic fishermen were interested in this work, they emphasized that deepwater net use differs from inshore use and so additional experiments would be necessary at various depths and conditions. Following this workshop, a series of related industry-science collaborative studies were conducted to address the problem of scup discards in the *Loligo* squid fishery. Here I discuss several "cooperative" gear selectivity or bycatch studies that were conducted to address the issue of scup discards in the *Loligo* fishery from 2000 to 2005 (Table 6-1).

Description of the Collaborative Efforts

2000-2001 Manomet Modified Loligo Net Testing Study

Responding to requests for additional experimental net testing at various depths and conditions more similar to those experienced in the Mid-Atlantic *Loligo* squid fishery, the MAFMC commissioned the Manomet Center for Conservation Sciences and the Massachusetts Department of Marine Fisheries (DMF) to develop modified fishing gears to reduce bycatch and discard of scup. [3] The MAFMC fully funded the program, with an in-kind match provided by DMF. The project tested four different extension/codend configurations to be used in standard fishing gears. Each design was based either on ideas from the fishing industry or on earlier studies. The project hired five industry vessel boats and conducted research between June 2000 and March 2001. The trials took place in Nantucket Sound, in the waters off Long Island, and in the approaches to Nantucket, as well as in deeper waters around Hudson Canyon in the Mid-Atlantic (Glass 2001).

The research found that the 5-1/2 inch square-mesh extension section configuration (#2) proved to be the most effective arrangement for reducing discard of scup while maintaining target catch. This configuration showed an overall reduction in scup discards of over sixty-six percent. The other nets either showed little difference from the standard small-mesh net in scup discards or lost significant quantities of squid (Glass 2001).

Based on the findings of this study, the MAFMC recommended that vessels using small mesh be allowed into the GRAs in 2002 without NMFS-certified observers, provided they use modified trawl nets with an escapement extension of forty-five meshes of 5.5-inch (13.97-cm) square mesh between the body of the net and the codend. However, this recommendation differed from the one offered by the Council's Scup Monitoring Committee, which, after reviewing the results of the research, considered the data preliminary. In order to gather more information the committee recommended that that vessels be allowed to fish in the GRAs using this modified gear only if they had a

NMFS-certified observer onboard to collect tow-based data. NMFS disapproved the Council's recommendation because they agreed with the Scup Monitoring Committee's finding that the research was too preliminary, citing insufficient sample sizes and sea trials conducted outside the GRAs (NOAA 2001b). They also cited the draft report which had been the basis of the recommendation (NOAA 2001b).

In August 2002, the Council again requested that vessels fishing with the modified gear be allowed access to the GRAs if they carried observers consistent with Atlantic Coastal Cooperative Statistics Program (ACCSP) observer standards. NMFS disapproved this recommendation for the same reasons given previously. However, NMFS agreed to allow access to the GRAs with this gear provided that the vessels carry a NMFS certified observer (i.e., one hundred percent observer coverage). The vessel would be responsible for obtaining and paying for the observer, which was estimated to be approximately six hundred dollars per day in the final rule. Thus, the modified extension recommended by the Manomet study was inserted into the management framework for the *Loligo* squid fishery in 2003. The rule was as follows:

> "Vessels that are subject to the provisions of the Southern and Northern Gear Restricted Areas… may fish… using trawl nets… provided that… the vessel fishes in a GRA only with a specially modified trawl net that has an escapement extension consisting of a minimum of 45 meshes of 5.5 in square (13.97 cm) mesh that is positioned behind the body of the net and in front of the codend" (NOAA 2003).

However, because this exemption program was implemented too late in the fishing season that year, fishermen did not participate. A squid fisherman and council member explained why:

> "Because of the lack of timeliness of getting the observer exemption program, whatever the hell you want to call it -- that thing come up, what, seven, eight days prior to the expiration of GRA. It wasn't any more than two weeks, somewhere in

> that ball park. And I'll be perfectly honest with you. The industry said the hell with it, NOAA, the hell with the Service, we're not going to -- we waited this long, this should have been in place day one. Now that it is in place on the very last -- 11th hour, we're not going to participate. So, they boycotted it. And it was a protest, a silent protest” (MAFMC 2003a, 167).

Rutgers Analysis of the Observer Database

Meanwhile, scientific evidence had become available suggesting that discarding of scup in the *Loligo* fishery was not the main problem, as the industry suggested, but rather the problem was discarding in the directed scup fishery. As part of their final report to the MAFMC’s Research Set-Aside Program, Rutgers University scientists analyzed the NMFS observer data.[4] They estimated that scup discards in the commercial fisheries were 1.91 times scup landings in 2001, with an estimated 2,242,662 kg of scup discarded in 2001. The fisheries primarily responsible for these discards included *Loligo* squid (6.8%), butterfish (18.7%), silver hake (4.7%), scup (56.0%), and black sea bass (12.1%) (Powell, Bonner, and Bochenek 2003). This supported the idea that prohibiting the *Loligo* fishery from the GRAs was an inefficient way to protect scup (Powell, Bonner, and Bochenek 2003).

These findings were communicated to the MAFMC and NMFS in a number of other ways. For example, industry members referenced this study at Council meetings as far back as 2000 (MAFMC 2000, 85). In addition, in comments made to NMFS regarding the GRAs for 2001, four letters referred to the Rutgers study. NMFS disagreed with the way the analysis was done and stated that the analysis required peer review before it could be properly evaluated (NOAA 2001a). In 2002, the industry again suggested that the GRAs were not necessary, citing that they “had a report done by Rutgers showing the minimal bycatch of scup in the *Loligo* fishery of less than two percent” (MAFMC 2002, 268). In 2003, the chair of NFI-SMC reminded the Council again of the Rutgers study and suggested that the minimum size limit in the scup fishery is a better way to address discards of scup. In addition, he suggested that the evidence was being dismissed for political reasons:

> “I think what we've demonstrated through work that's been done through analyzing the NMFS database -- and I think it's confirmed, at least in my opinion, by the work the staff has done for the last number of years, and actually been confirmed by previous votes of the Council and the Commission, is that if we use a non-political evaluation of the *Loligo* fishery, in other words we weren't judging it upon what we think politically needs to be done, but upon what is the mortality cause to the scup fishery by the *Loligo* fishery, that in effect you would make the *Loligo* fishery exempt from any GRAs or actions” (MAFMC 2003b, 121).

Here we see the industry using the Rutgers study as a resource to challenge the GRAs. In a way, they were creating (or perhaps reaffirming) the boundary between science and policy with their reference to this study. They argued that NMFS was being political (and not scientific) in maintaining the GRA. NMFS was also making a boundary around which science was useful for policy making. Perhaps if the Rutgers study had been peer reviewed, NMFS would have accepted it, but perhaps not. It is not clear if the report was rejected due to its content or its applicability.

2003 NFI-SMC/Rutgers Study to Evaluate Effectiveness of the GRAs on Scup Discarding

Then in 2003, scientists from Rutgers University, in collaboration with Manomet Center for Conservation Sciences, conducted studies to “explicitly evaluate the success of the new 2003 net regulations in the *Loligo* squid fishery in achieving a desired reduction in scup discarding” (Powell et al. 2004, 156). A direct test of the effectiveness of GRAs was crucial because tows had not been permitted in these areas to evaluate the probability of high scup discards during GRA times. Because gear performance in commercial operation may differ from gear performance in experimental or research mode, it was important to test the effectiveness of the new regulations by conducting the study within the area–time closures (i.e., the GRA). With funding from the New Jersey Fisheries Information and Development Center (FIDC) and the Mid-Atlantic Research Set-aside program, Rutgers scientists were able to evaluate the potential influence of GRAs on scup discarding, including an evaluation of the gear configuration implemented for management. The study was conducted in both the northern and southern GRAs during closure times. The vessels participating in this study included the F/V Abracadabra, F/V Lady Roslyn, F/V Barbara Joan, and F/V Rionda S. They used an alternate paired tow design, where the vessels alternated between towing (in commercial mode) two different net configurations (a net legal in 2002 and the one required in 2003). Forty tows were observed on two vessels in the northern GRA in November 2002. Thirty-four tows were observed on two vessels in the southern GRA in January–February 2003. Differences between the catches from the different nets were assessed statistically.

In this study, catches in the northern GRA consisted primarily of scup, spiny dogfish, little skate, and summer flounder, while relatively little of the target species, *Loligo* squid, was caught. In contrast, catches in the southern GRA consisted almost exclusively of *Loligo* squid, and no scup were caught. The results of this study disagreed with the results of Glass' research, such that on three of the four vessels when the modified net was used, *Loligo* squid catch was significantly reduced. When scup catch was reduced on the two vessels fishing in the northern GRA, the reduction in scup was explained by the reduction in total catch observed with the modified net. The vessel that did not experience a reduction in *Loligo* squid catch was in the southern GRA, where no scup was found, so the utility of this gear for reducing scup discards could not be determined. The research conducted here suggested that although the modified net implemented in management in 2003 can reduce scup discards without impairing squid catch, the results may not be consistently found (i.e., there is a large vessel-to-vessel variation). In cases where the *Loligo* catch is reduced with the use of the modified net, the captain would likely continue fishing to achieve desired catch rates, and this would negate any positive effect of the modified extension on scup discarding (Powell et al. 2004). They concluded that “implementation of this regulation was likely premature, in that the specification was not adequate to guarantee the desired results on all vessels” (Powell et al. 2004, 166).

2004 NMFS-NEFSC Study

In January 2004, the NEFSC conducted another study to reconcile the Rutgers-Manomet and NFI-SMC/Rutgers studies (Hendrickson 2005). After reviewing both studies, the NEFSC felt there were unanswered questions and decided to do their own study. The most significant difference between the two previous studies was that the Manomet study did not show the gear losing squid, while the NFI-SMC/Rutgers’ study reported the loss of squid at some times but not always. The NEFSC study tested a net similar to that required in the 2003 GRA regulations and utilized a parallel haul method (to compare fishing with and without the square mesh escapement panel). This method differed from the design used in the Manomet and NFI-SMC/Rutgers studies. A total of nineteen stations were completed, out of forty-four planned (ten inside and nine outside the Southern GRA) at depths of 83-155m. By almost all accounts, this effort was neither “successful” nor “cooperative” research.

Two commercial research vessels were chartered for this study: the F/V Sea Breeze and the F/V Iron Horse, both out of Newport, RI. The F/V Sea Breeze had been involved in collaborative research in the past, notably the side-by-side tows with the Albatross following the trawl warp fiasco. Both F/V Sea Breeze and the F/V Iron Horse later participated in a cooperative effort to test a haddock separator trawl, to allow vessels to catch haddock while not catching codfish, done with researchers from URI. The owners of these vessels are active in cooperative research and management. For example, both are also on the Trawl Survey Advisory Panel and one captain is on the NEFMC.

Out of the nineteen tows conducted, it was, according to one observer, "blatantly obvious" that the loss of *Loligo* was upwards of 80% per tow. The final report of the NEFSC found that utilization of the square-mesh panel (modified net) resulted in significantly large losses of *Loligo* (average eighty-eight percent in numbers and eighty-five percent in weight). Thus, it was concluded that "the use of a square-mesh escape panel in the configuration tested is not a reasonable solution to the bycatch problem in the winter *L. pealeii* fishery" (Hendrickson 2005).

It was also "blatantly obvious" to the fishermen at sea that the net didn't work, even before the statistical analysis was complete. The fishermen questioned the need to continue the research because they "knew" the net did not work. According to one scientist on board, it was obvious the fishermen wanted to quit after just a few tows. The scientists tried to explain statistics to the fishermen; that a minimum number of tows were needed to be able to prove this finding statistically, with some measure of probability. One scientist on board expressed surprise that the fishermen were so eager to quit, when they had been hired to do this study. The scientist expected that as long as the fishermen were compensated that they would not mind doing extra tows. However, because of very different views of learning, fishermen could not understand having to continue a study that they knew already was doomed (i.e., the results showed that the net didn't work). There was a significant amount of tension present during the research that took away from its collaborative spirit. In addition to differing views about how the project should proceed, the research was conducted during January 2004, one of the coldest and harshest winter months on record. After the research was over, several participants expressed to me that they were unhappy with the way the "collaborative" effort turned out; not only were the results disappointing, but the relationships between scientist and industry were strained (if even temporarily).

In fact, relationships between the science and industry partners in this effort were strained before the project started. In early January 2004, members of the industry met with Rutgers scientists as a pre-meeting to their *Loligo*-scup study (discussed below). At that time, the plan was to see what happened with the NMFS study and then follow-up as appropriate (meaning make necessary adjustments to the gear based on what that study found). At this meeting, several fishermen expressed concern that the experimental net would not work. One fisherman said that the square mesh escape panel was too big for *Loligo* but a diamond mesh would work better. Another fishermen said that "placement is critical" and that they need "flexibility" to modify the net to get something that works. He felt that the project so far has been "a little too stringent." Another fisherman expressed anxiety over the project, again citing that they have been given "no flexibility" and that he was not happy with how it was going. He felt that his concerns were not getting enough consideration by the scientists directly involved in the study. One NMFS scientist (who was not directly involved) at the meeting explained that the scientists doing the study were "convinced that this rig will work" and "thinks this is a good design." Another scientist not affiliated with the effort noted that they needed to define exactly what they meant by the net "working" and "not working," implying, I believe, a concern that the industry's view of the net working might not be the same as scientists (i.e., scientists may be more willing to let more *Loligo* escape than fishermen). One fisherman was comforted by the fact that this project was being followed-up by another study (i.e., the NFI-Rutgers study). One fisherman asked the NMFS scientist (a manager of cooperative research): if the net is "blatantly not working, can we try something else?" He said he was willing to try the net for a couple of days, but said it was a "tragedy to waste time and money" on something that did not work. The industry wanted a solution to the problem, not necessarily to prove something. One fisherman expressed this in an interview:

> "An experiment to them [scientists] is a success if they prove or disprove the theory. Well, we go off and do an experiment in the industry; we try to get some kind of results. And if by modifying the experiment a little bit…you create the results."

One scientist who observed the research effort felt that the reason the project was "unsuccessful" was because the project was never treated as "collaboration" but instead it was a "for-hire" effort, where scientists treat fishermen as providing vessels for research. In addition, the scientist noted that the goals of the project did not explicitly include building relationships, which has been an explicit goal of most of these recent cooperative efforts. In addition, this effort underscores how personalities are extremely important in successful cooperative research; many felt that the science and industry personalities simply clashed early on and were not suited for "collaboration."

Communication was a barrier to this project since fishermen and scientists failed to articulate their interests to each other in order to create an effort that each agreed with. The communication flow in this project certainly seemed to be "one-way." At least to the industry participants, the scientists refused to really listen to the fishermen. It is most likely that neither side was able to translate their needs to the other.

2004/2005 NFI-SMC/Rutgers Research

After the NMFS project, the NFI-SMC and Rutgers University conducted two other *Loligo* net testing studies in 2004 and 2005, with funding from the Mid-Atlantic Research Set-Aside program (02-RSA-001; 04-RSA-002).[5] Initially, NFI-SMC and Rutgers University planned to build upon the results of the NMFS study that was retesting the Manomet modified net. That study concluded that the Manomet design lost too many squid, making the modified net design ineffective as a bycatch reduction device. Therefore, instead of retesting the Manomet design, NFI-SMC-Rutgers group decided to determine if inserting a funnel in the Manomet extension would increase the retention of *Loligo* squid while still reducing scup bycatch. Also, based on findings from the Mid-Atlantic Supplemental Finfish Survey that showed little overlap of scup and *Loligo* squid within the Southern GRA, they decided to conduct tows inside this area to further evaluate the bycatch of scup during the time the area was closed to the *Loligo* fishery.

Unfortunately, this research encountered several problems. First, the study was delayed and constrained as they waited for the results from the NMFS study. Second, the project was unable to raise as much money as anticipated from the allocated research set-aside quota. This was because the *Loligo* squid fishery did not close in 2003, making the squid not worth enough for the fishermen to harvest. As noted in chapter 3, the research set-aside quota is most valuable when it can be harvested after the fishery is closed when prices are high. Finally, because they failed to complete a sufficient number of tows, only preliminary results could be obtained for analyzing the effect of the funnel insertion in the Manomet extension. In terms of the first objective, the results indicated that the modified extension with the funnel made no difference to scup and *Loligo* catches compared to the Manomet design. In terms of the second objective, the results of the eighteen tows taken in the Southern GRA supported the recent movement of the Southern GRA boundary in 2005, which had been made as a result of the recognition of a spatial separation of scup and *Loligo* in this area. The PIs concluded additional work on net configurations aimed at scup bycatch reduction in the *Loligo* fishery is no longer warranted.

The Role of Fishermen and their Knowledge

In general, although these gear studies can be considered a type of “for-hire” research, where scientists charter fishermen’s vessels as research platforms, they were also very collaborative and comparable to other “for-hire” research efforts like the *Illex* squid “study fleet” and the cod tagging program described in the previous two chapters. In all of the *Loligo*-scup gear studies, fishermen’s vessels were necessary to conduct the selectivity experiments, and the technical skills and expertise of fishermen regarding gear deployment and vessel operation were critical. Fishermen also provided, in some cases, their knowledge of the distribution of species, such as where and when to find scup and *Loligo* together. Thus, fishermen’s knowledge was important to these efforts. The exception is the NMFS study that used fishermen exclusively as providers of research platforms. Again, this effort was criticized for not being collaborative enough despite producing solid results (i.e., and confirming fishermen’s beliefs that the gear configuration was not effective).

These studies can be considered to some degree as testing fishermen's hypotheses. The impetus of this research was the GRAs that were implemented to reduce discards of scup in the small-mesh fisheries. The industry immediately came together in opposition and sought to address this issue, particularly how it negatively and possibly unnecessarily affected *Loligo* squid fishermen. *Loligo* fishermen felt they were being unnecessarily burdened by the GRAs, which they felt were not necessary and failed to achieve intended objectives.

In general, all of these studies, and especially the NFI-SMC and Rutgers research, involved significant levels of industry input into the planning and logistics of the research, including ideas of what might be expected to work. In addition, the NFI-SMC/Rutgers studies were funded with monies generated through the MAFMC Research Set-Aside program, which represents another way fishermen "participated" in this research. Without the support of the industry, the NFI-SMC/Rutgers research would not have been possible.

Fate of the Cooperative Research

As noted, in 2003 the Manomet modified net design was implemented into management to allow fishing in the GRAs. Unfortunately, as was documented clearly in subsequent research (i.e., Powell et al. 2004; Hendrickson 2005), the gear design did not function well as a bycatch reduction device because it resulted in the loss of too many squid. Thus, this case is interesting in that the result of "cooperative research" was implemented into management, and this was later proven to be premature. This underscores the need to ensure that sufficient testing be done before implementing results of collaborative gear studies into management. Of course, one might question the “cooperative” nature of the Manomet research and whether sufficient industry participation occurred such that the problems with the gear would have been identified earlier on. In any case, the incorporation of this device into management was insignificant since fishermen chose not to participate in the exemption program.

The results of the cooperative efforts that followed the Manomet work did not directly result in any management action but did inform management. That is, the subsequent research led to the realization that the gear did not function appropriately as a bycatch reduction tool. This contributed to the termination of the exemption program. To be sure, these cooperative research efforts, particularly those led by NFI-SMC and Rutgers University were integral to the management discussion and did not simply disappear as was the case of many other gear selectivity/bycatch reduction studies. For example, each August, when the MAFMC set annual specifications for the commercial scup fishery, the NFI-SMC/Rutgers research was referenced by members of the industry and the Council. In the 2002 meeting the chairman of NFI-SMC reminded the Council that they “had a report done by Rutgers showing minimal bycatch of scup in the *Loligo* fishery of less than 2 percent” and referred to the upcoming Rutgers/NFI study to test the Manomet design in commercial mode. At the 2003 meeting, Council members were given scientific papers reporting the results of the research done by Manomet and Rutgers related to the GRA, including peer reviews of those papers. Such a public peer review of science is not typical. The Monitoring Committee considered and discussed this research but recommended status quo action. The Council, however, took the information provided by Glass and NFI-SMC/Rutgers and tried to implement an exception program, in part to collect more data to address the issue of whether the exempted gear was appropriate.

Although the Manomet-conducted cooperative research was incorporated into management as an exemption program, fishermen did not participate in the program. So, although the Manomet design was technically incorporated into management, it did not affect the fishery. And, while the research by both Manomet and Rutgers appeared extensively in the fisheries management discussion at science and management meetings, in the end the research results were not incorporated into management, because the resolution of the GRA problem was based on NMFS-NEFSC survey data.

The controversy regarding the GRAs, implemented to reduce scup discards in the small mesh fisheries, inspired numerous cooperative research efforts. Yet in the end the controversy seemed to disappear as quickly as it originated. The outcome was interesting in its reliance on standard data collection (i.e., NEFSC bottom trawl survey data), despite several years of cooperative investigations. One of the principal concerns all along was that the GRAs were arbitrarily placed and did not achieve their objective (reducing scup discards), yet were financially burdensome to the *Loligo* squid industry. In August 2004, the MAFMC approved moving the boundary of the southern GRA 3 minutes to the west beginning with the 2005 fishing season. This movement was important to the *Loligo* fishermen because it opened up areas that would otherwise have been closed to the fishermen. This reduced some of the burden that was forcing fishermen to fish in northern areas, which unfortunately had led to increased scup discarding. Both the Monitoring and the Advisory Committee recommended this redefinition of the Southern GRA. This management change or redefinition was based on data from the NEFSC spring and winter surveys from 2000-2004, which suggested that moving the GRA boundary 3 minutes to the west did not significantly increase scup discards. According to a MAFMC staff analysis, 58.7% of the scup catch occurred within the original boundaries of the southern GRA. Alternatively, 55.8% of the scup catch occurred within the boundaries of the southern GRA positioned three minutes to the west. Thus, this relocation of the boundary only increased the availability of scup to capture by 2.8%, which the staff and Monitoring Committee considered insignificant. In addition to moving the boundary of the GRA, the Council adopted the industry's recommendation to terminate the exemption program that was put into place in 2003, that allowed the use of the Manomet design with one hundred percent observer coverage.

In this case, although cooperative research provided a way to test fishermen's knowledge and demonstrated the value of including fishermen and their knowledge in gear research, in the end the boundaries between science and non-science were maintained. Traditional research-based knowledge was privileged over both fishermen's knowledge and the data produced through cooperative research. Moreover, the research-based knowledge produced through federal government programs was privileged over the research-based knowledge produced by non-government (academic) researchers. When scientific results conflicted, the NEFSC stepped in to provide an "unbiased" assessment of the Manomet design. The Rutgers-NFI analysis of the NMFS observer database was for all purposes dismissed in the discussion in favor of government produced data sources (i.e., the NEFSC bottom trawl survey). The reason for this may very well have been due to the political or "mandated" nature of the research. The government agency is legally responsible for ensuring that only the best scientific information available is utilized in management.

Table 6-1: Summary of *Loligo*-Scup Cooperative Studies 2000-2005

Year	Study	Purpose	FEBK Contribution	Outcome
2000-2001	Manomet Modified *Loligo* Net Testing Study	Tested four different extension/codend configurations to minimize scup discards in *Loligo* fishery	• Gear and vessel operations • Gear-species-environment interactions • Distribution of species	• 5-1/2" square-mesh extension implemented into management as exemption for *Loligo* fishermen; • Not functionally utilized; later proven ineffective
2000-2001	Rutgers Analysis	Analyzed NMFS observer data for scup discards	• N/A	• Showed that most scup discarding was from the directed scup fishery, not the squid fishery
2003	NFI-SMC Rutgers-study	Evaluate the Manomet net exemption	• Gear and vessel operations • Gear-species-environment interactions • Distribution of species	• Showed that the net results were inconsistent/variable; GRA benefits not achieved
2004	NMFS-NEFSC Study	Re-evaluate the Manomet design	• Gear and vessel operations • Gear-species-environment interactions • Distribution of species	• Net lost too many squid; in-effective as a conservation tool • Effort was “not collaborative”; FEBK dismissed
2004-2005	NFI-SMC Rutgers study	• Follow up on NMFS study • Tested alternative bycatch reduction net	• Gear and vessel operations • Gear-species-environment interactions • Distribution/Location of species	• Gear did not work as expected. • Additional scup bycatch research in the fishery is not warranted

Case Study 2: The Gulf of Maine Grated Raised Footrope Whiting Fishery

Management Context: Bycatch in the Small-Mesh Whiting Fishery

Whiting, or silver hake, *Merluccius bilinearis*, a relative of cod, is a traditional small mesh fishery in the North Atlantic. In U.S., there are two stocks of whiting: a northern stock in the Gulf of Maine-northern Georges Bank region and a southern stock occurring from southern Georges Bank to Cape Hatteras, with some mixing between stocks (NEFSC 2006). The research described in this section focuses on the northern whiting stock. Like other small mesh fisheries, there is concern about potential bycatch of the traditional, and severely depleted, New England groundfish stocks in this fishery.

In the 1950s and 1960s, there was a relatively large whiting fishery along the coast of Maine, averaging around eight thousand tons. During World War II, whiting went into fish sticks to feed the military. At this time it was an industrial fishery, where processors handled whiting by the ton. Whiting traditionally was also landed in the shrimp fishery as bycatch and sold for bait, since they are not presentable for human consumption when caught with shrimp. Later, around 1994, a whiting fishery developed that was aimed at smaller fish: an eight inch size that was sold to the Spanish market. When the Spanish and Europeans supplies of whiting began to dry up, they turned to other places for whiting. Traditional whiting fishermen wanted to be able to catch the whiting for this Spanish market using shrimp nets. However, immediately problems arose regarding bycatch of groundfish. As discussed elsewhere, 1994 was the beginning of groundfish management in New England, and substantial efforts were being taken to protect and rebuild the traditional groundfish populations which had been overexploited throughout the 1980s and early 1990. The collaboration discussed below is one case where fishermen and scientists collaborated to test gear that would allow fishing for whiting while minimizing bycatch of groundfish.

Description of the Collaboration

Industry Innovation 1: An Experimental Fishery Using the Nordmore Grate for Whiting

Fishermen first had the idea of using the Nordmore grate to catch whiting without groundfish bycatch. As described in chapter 2, “cooperative research” with the industry led to the use of the Nordmore grate in the shrimp fishery in the 1980s, reducing bycatch of finfish in the shrimp fishery. By 1994, the Nordmore grate was well accepted and the benefits of bycatch reduction had been realized by shrimp fishermen. Fishermen, working with scientists from the Maine Department of Marine Resources, decided to widen the grate bar space in the Nordmore grate from 25 millimeters to forty millimeters to allow for retaining slightly larger whiting and less than five percent of groundfish bycatch. Amendment 5 to the groundfish plan required that small mesh fisheries not land more than five percent bycatch of groundfish, such as cod, haddock, and flounders.

The modification seemed to work, and in 1995, NMFS approved an experimental fishery for a low bycatch whiting fishery to demonstrate that they could land whiting with no more than five percent bycatch of groundfish. Dozens of vessels participated in the experimental fishery. Maine fishermen from Cundys Harbor, Five Islands, Phippsburg, Portland, Sebasco Estates, and several other Maine ports, along with a few fishermen from New Hampshire and Massachusetts participated in this experimental fishery. Landings averaged 948 tons from 1994 to 1997 (Plante 2003). The experimental fishery lasted from 1994 to 1999. Testing of gear modifications using the Nordmore grate in the GOM occurred throughout the experimental fishery period. Maine Department of Marine

Resources led testing, while working with the fishing industry. Some funding for the testing came from the NMFS Fishing Industry Grant (FIG) program in 1996.

However, after five years as an experimental fishery, one participant explained that “We proved it was less then five percent bycatch and we were all literally all set to say, 'Okay let's change this from an experimental fishery into an exempted fishery, an allowed fishery, in the Gulf of Maine.'” However, according to one fisherman, “in 1999 our fishery fell apart” and “for many reasons we were unable to get that as an exempted fishery.” At that time, whiting management was implemented, as Amendment 12 to the Northeast Multispecies Groundfish Plan. When this FMP was implemented it was no longer desirable to harvest the eight inch fish for the Spanish market. In addition, Maine fishermen lost the whiting market when Canada opened the “Whiting Box” off the southeastern end of Nova Scotia to Spanish and Portuguese fishing vessels to harvest whiting. This undercut the prices and made it no longer economically viable for the Maine fishermen. The small mesh multispecies plan tried to encourage the fishery to catch larger fish by restricting vessels fishing less than three inch mesh. The eight inch fish was slightly smaller than the size at first reproduction. Small mesh fishing had been limited to two locations: Small Mesh Area 1 off Cape Ann, MA and Small Mesh Area 2 outside Jeffrey’s Ledge, neither area was accessible to the Maine whiting fleet. In addition, in 2000, Framework 35 to the groundfish plan established a seasonal whiting raised footrope trawl fishery in Upper Cape Cod Bay, but this was also not accessible to the Maine fishery. As a result, landings by the Maine whiting fleet declined significantly; between 1998 and 2001 landings averaged only forty-two tons. Fishermen responded by trying to catch larger whiting.

Initially vessels tested the forty millimeter bar space configuration, but through the years they tested spacing as wide as 64.6 millimeters. Studies showed that using the 63.5 millimeter bar spacing with cod ends up to 2.5 inch diamond mesh and/or 2-5/32 inch knotless square mesh showed low bycatch and brought the fishery into compliance with Amendment 12 by reducing juvenile fishing mortality. In the summer of 1999, four combinations of grate bar spacing and cod end mesh were tested with both control nets towed by paired vessels at the same time and control nets towed by the same vessels on the same day in the same area. The net configurations continued to catch high levels of flatfish, which would go through the grate sideways, preventing them from achieving the five percent bycatch provision.

Industry Innovation 2: Raising the Footrope and Removing the Sweep

The next major innovation came when the collaborators decided to try raising the footrope to allow flatfish to escape below the net. In 2000, the NEFMC adopted Framework 35 that created an exempted seasonal whiting raised footrope trawl fishery in Upper Cape Cod Bay. This was the result of cooperative research between MA DMF and Massachusetts fishermen, which like the Maine fishery started out as an experimental fishery. One fisherman explained that it was a ME-DMR scientist who suggested they try the raised footrope that was used in the Massachusetts fishery. Fishermen were generally hesitant about raising the footrope, which meant shortening the fishing wire and getting it up where it might get hooked on something, but they tried it anyway. Some fishermen also felt that they had already proven low bycatch with the grate during the experimental fishery. So, they gave it a try. They shortened up the fishing wire, lengthened the dropper chains, got the wire over the rollers, and added floats on the net to provide more lift. One participant explained that "that worked fairly well." However, despite dropping the flatfish bycatch by seventy-five percent with the roller frame still in place, the total bycatch of regulated species was "really border line five percent." One scientist involved explained that it wasn't enough: "We just couldn't really straight face guarantee that this net was going to stay under five percent bycatch of regulated species primarily due to the flatfish."

Around that time scientists at MA DMF were experimenting with the sweepless trawl (not using the roller frame). One scientist explained that this worked by taking the chain sweep off and having a little longer (heavier) dropper chains.

> "And what you then have is a dynamic tension between the lift in the balls and the headrope and the weight of the dropping chain and the pull of the door. So you're pulling through the water and you've got these two forces going on and you juggle that weight verses lift in order to get that net to ride where you want it to. It'll rise until the weight of the chains just won't let it rise anymore and then they'll sort of stay there and fish like that till they haul back."

The Maine group learned about this and decided to try it with the grate configuration they had developed. They received a grant from NMFS to test this configuration. And it worked. The net now rides about 2-1/2 to 3 feet above the bottom (if rigged right) and, although they probably do lose some whiting, they have dropped the bycatch down to one or two percent. The testing involved two vessels, the F/V North Star and the F/V Tenacious in October and November 2000 and 2001. Both vessel owners and operators are experienced participants in cooperative research in this region. The F/V North Star also used the sweepless trawl for another twenty days in October and November 2001 to test the gear in commercial mode (catching only 2.5% bycatch of regulated groundfish). These are the months when whiting catches tend to be low and groundfish bycatch high, thus if the gear meets the five percent bycatch provision in these months it can be assured to work with even lower bycatch in the summer months. In 2002, testing occurred again with two vessels at the outer edge of the area tested (because the previous tows were all within fifteen miles of shore). They again landed less than five percent bycatch.

Fate of the Cooperative Research: Implementation into Management

The outcome of this cooperative effort was successfully integrated into management, although this took time. This configuration was initially submitted to the Council for implementation in Framework 37 in November 2002. However, it was taken out of that framework and put into Framework 38 where it was approved in January 2003 (NEFMC 2003b). One reason the fishery was not included in Framework 37 was because it had not had adequate review by the Groundfish PDT or the Groundfish Oversight Committee. This was critical since the issue of concern was groundfish bycatch; the whiting advisory committee was not the appropriate group to determine if groundfish bycatch could be a significant concern (NEFMC 2002). The whiting PDT apparently conducted the analysis quickly, in about six weeks, and the experimental work had not yet been completed. One council member urged the council to postpone including this in the framework until it had received adequate review: “[W]e need to consistently apply the same standards of what level of scientific review, peer review, are appropriate…” (NEFMC 2002, 137). Paul Howard, Executive director of the Council, reiterated the importance of having a process in place for review of this kind of research:

> “The most important thing about all this is for our Research Steering Committee to develop the protocols to review all these experiments and all the research being done under the research grants, TAC set-asides, and Northeast Consortium Funds. We are going to be expected and the expectations from the industry, as soon as research is done, the Council will use it. And we've been told by the National Marine Fisheries Service that we need a -- the same rigors that their science goes

> through, scientific information has to have some type of technical review. The sooner we do that, the sooner we'll have credibility in the science (NEFMC 2002, 143)."

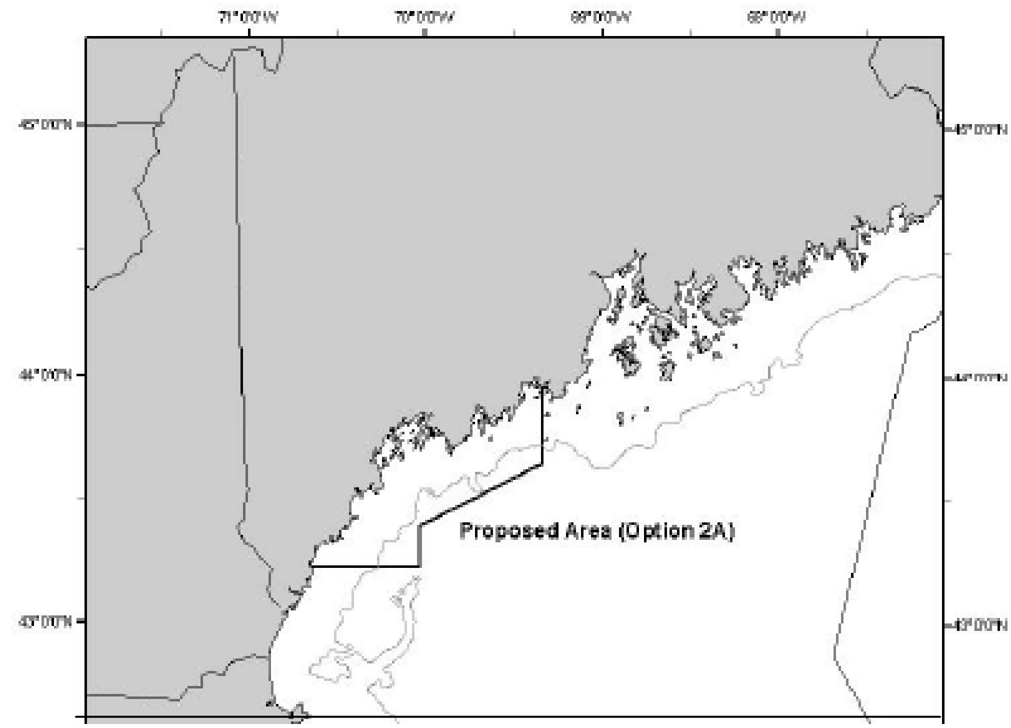
The lead scientist at DMR conducting the research with the industry was disappointed, but confident that the fishery would be implemented. He noted that this additional review "will remove clouds of doubt that may have been lingering about the whiting work" (Daigle 2002). Indeed, by not implementing the exempted fishery at that time, managers allowed the industry and scientist involved in the project to finish collecting the data to substantiate even more that indeed the gear worked as expected.

One observer of the process felt that the reaction by Council members to the proposed exempted fishery was mixed. The participants had to overcome some resentment from industry members on the Council from Massachusetts who did not want to see a whiting fishery in that area. One participant explained: "They had their own whiting fishery, raised footrope fishery down off the Cape and they didn't want the competition, it's that simple." [6] In addition, many fishermen still did not like the idea of the Nordmore grate in a whiting net because most of these fishermen still kept bycatch of finfish and sold it "as shack, essentially sold it under the table, but it was part of their profit for the day." One individual involved suggested that these fishermen "were probably not actively trying to trash our net and fishery…but absolutely no help at all." In addition, the group had to deal with "sort of side long snickering comments about who needs a grate in the net?"

On July 9, 2003, NOAA published the final rule implementing Framework 38 to the Northeast Multispecies Management Plan that established an exempted grated raised footrope whiting fishery in the Gulf of Maine. It took eight years of experimental work by ME DMR and the Maine whiting industry before it was incorporated into management. The exempted grated GOM raised footrope whiting fishery occurs in a specific area (Figure 6-2) from July 1 to November 30 and uses the gear perfected through research trials conducted by the cooperative research done by ME DMR and the industry. The timing of the fishery is based on historical dates of the fishery and the area was chosen to eliminate bycatch of redfish, which tend to be deeper than the area of this fishery. Again, the exempted fishery allows for a specific gear to be used in this time and place: a Nordmore-style grated, sweepless, raised footrope trawl. The gear specifications for this fishery are the same as those used in the Cape Cod Bay raised footrope fishery established in Framework 35, except that it also requires the use of a 50 millimeter grate and a sweepless trawl.

At the time the interviews were conducted the fishery was just getting started. In order to monitor the exempted fishery, the Maine Department of Marine Resources implemented state regulations that allow participation in the exempted whiting fishery only with a state whiting permit. The prerequisite for getting a permit was having their sweepless, Nordmore grate whiting net inspected by the marine patrol to show that it conforms to the regulations in Framework 38. When I spoke the ME DMR at the end of July in 2004, no one had signed up for the program yet. However, there was interest in the fishing community and many fishermen had indicated that they did plan to get the permit and participate. The market perhaps will be the limiting factor for this fishery. There is already an offshore fishery for whiting. One scientist at DMR explained asked the question “how do you go about generating a fishery that is legally in place but really doesn’t have the market?” Despite that the fishery may not be realized, the effort illustrates how fishermen and scientists can successfully collaborate to improve the management of the fishery.

Figure 6-2: Map showing the area of the Gulf of Maine grated raised footrope whiting fishery (adapted from NEFMC 2003a, 6).



Roles of Fishermen and their FEBK

Fishermen were involved throughout the cooperative research process “from the thought process through the final elements,” including asking the questions, designing the gear, testing the gear, and presenting the work to fishery managers. The lead scientist involved explained:

> “They had the ideas to generate a whiting fishery with a grate in the first place and the idea that perhaps we could widen out the bar spaces to make it a whiting fishery rather than just sort of shrimp bycatch…These guys rigged all of that up and thought through what size whiting they wanted and what they might need for bar space and mesh size in order to do that. They constructed all the different elements of the gear and got it out there and fished it…They were there testifying along with me at these hearings for getting Framework 38 approved.”

As in other cooperative gear studies, scientists contributed their knowledge of statistical rigor by setting up the experimental research design to test the gears (in this case paired tows), including making the determination of how many tows to do and what data to collect (i.e., count and measure fish and gear mensuration data). They also went out to sea and collected the data. They analyzed the data and wrote a report necessary to present the findings statistically. They presented their findings in the fishery management process. And they were involved in logistical aspects of doing the research, such as getting permits, assuring observers when needed, and securing funding. The scientist was also important to getting the fishermen to look at using the raised footrope and sweepless trawl, which had come from cooperative work done in Massachusetts.

The fishermen and scientists had a good working relationship in this effort. Again, this effort built upon work done in the 1980s with the Nordmore grate shrimp fishery. The principle scientist involved was one of the leading scientists who had worked with the industry during the implementation of the Nordmore grate and subsequent efforts to use the Nordmore grate to allow for the retention of whiting in the shrimp fishery. He was involved initially when the fishermen wanted to use the Nordmore grate to catch the eight inch whiting for the Spanish market, which led to the experimental fishery that lasted from 1994-1999. And when that fishery went belly up due to market reasons and management intervention, this scientist and the industry worked together to develop and test gear to allow for a large whiting fishery with low groundfish bycatch, which turned into the GOM grated raised footrope fishery.

Conclusion: Institutional Boundary Maintenance

The cooperative gear selectivity studies presented in this chapter are similar in that fishermen and their experience-based knowledge are accepted and considered equal to (and often greater than) scientists and their knowledge. Fishermen in these cases are considered to have “contributory expertise” (Collins and Evans 2000) related to gear and vessel operations and/or ecological knowledge related to the distribution of species and gear-environment-species interactions, and this knowledge was incorporated into the scientific research process. This is generally true for most gear-selectivity or bycatch research. In such rare circumstances where fishermen’s knowledge is privileged over scientific-based knowledge, we might expect that fishermen’s knowledge would have direct and immediate utility for fisheries management. Yet, as the cases studies described in this chapter illustrate, in practice utilizing fishermen’s knowledge remains difficult even under the best of circumstances.

The most critical factor limiting the integration of FEBK into science policy is institutional. Even when fishermen’s knowledge is considered equal and valuable (and perhaps more valuable than research-based knowledge), the institutional nature of the science policy process creates a need to transform fishermen’s experience-based knowledge into scientific, research-based knowledge. First, fisheries management requires that management decisions be based on the best scientific information available. The NOAA fisheries science centers view best available information as “data systematically collected through established procedures and analytical products based on commonly accepted statistical techniques or models developed specifically for resource management” (NRC 2004, 25). Although the decision-making councils “often rely on the experiential information from fishermen as a means of corroborating scientific information, determining changes in stock distributions, and revealing data discrepancies," when fishermen's reports and science conflict, the councils "report that they more often than not defer to the scientific information" (NRC 27). Ultimately, the determination that information is "the best scientific available" is made through the social process of peer review. The peer review process is an additional barrier that cooperative research encounters before being integrated into management. As described in chapter 3, an addition management peer review process occurs in New England through the Research Steering Committee, this further delays the integration of cooperative research into management. To be sure, there is a pragmatic need to verify or confirm fishermen's insights since the government has a responsibility to ensure that management decisions are based on credible information. After all, the government is in charge of protecting a public resource.

Thus, cooperative research attempts to translate fishermen's knowledge into the best scientific information available. By making fishermen's knowledge "scientific" it is viewed as credible and legitimate for use in policy making. In both the *Lolgio* squid and whiting gear selectivity research examples, scientific-based, quantitative data were needed before fishermen's knowledge was considered relevant for management. The Maine whiting fishermen had to prove that they could catch whiting with minimal groundfish bycatch. In this case, "minimal" is defined quantitatively as bycatch less than 5% of the total catch. The whiting fishery required years of testing and had to provide statistical evidence before it was given an exemption in the management process. The *Loligo* squid fishermen similarly had to prove that they could fish in the GRA without catching too much squid. The Rutgers quantitative analysis of the observer database was on attempt to prove this for the fishermen. Interestingly, the Rutgers analysis was rejected as being unconventional despite being peer reviewed, suggesting that even distinguished scientists are limited by institutional factors that limit the kind of data that are utilized in the science policy process. The NMFS and Rutgers field studies were similarly interesting in that they were not only about transforming fishermen's knowledge, but were also about validating (or negating) scientific-based knowledge.

One consequence of the institutional need to translate fishermen's knowledge into scientific knowledge is that it hinders the flow of knowledge into the science policy process. The process through which FEBK is translated (or verified, aggregated, tested, etc.) creates a time lag between when knowledge is available and when it is utilized in management. This can effectively limit the utility of FEBK for management. The dynamic nature of both marine ecosystems and the science policy process means that in some cases, the newly transformed (or proven) FEBK is no longer relevant to the conditions of the fishery. This was seen in the whiting case study, where once the exemption was granted, changes in the market made the fishery irrelevant. Perhaps had the translation (or verification) of FEBK occurred more quickly, the fishermen could have benefited from the fishery when the market was available.

The second institutional reason why fishermen's knowledge is hindered is related to the scale at which management operates. Since the management system is focused at a large scale (i.e., across the range of the species), and fishermen's knowledge is local, it is necessary to make sure that fishermen's knowledge is not inappropriately applied to conditions which it does not apply. That is, a gear that works well as a bycatch reduction device in one area cannot automatically be assumed to work the same in a different area with different environmental conditions; hence the need for quantitative testing in different locations. The NFI-SMC/Rutgers University *Loligo* selectivity research illustrates how a gear configuration may work well in some instances (i.e., for some vessels), but not for others, underscoring the need for adequate testing. Cooperative research, therefore, functions to make FEBK usable at larger scales. This translation is critical to overcoming a key institutional barrier to utilizing fishermen's knowledge in science and management.

In terms of improving the integration of FEBK into the science policy process, the barriers due to legal mandates requiring the best available science, including requirements for peer review, are not something easily altered. Institutional change is incremental – "slow and glacial in character" (North 1990, 6). However, a potential solution to this latter "scalar" barrier to the integration of fishermen's knowledge into the science policy process is to create more opportunities for local scale innovations, in the form of local, area-based management. If the gear configuration is to be used only in a small-geographic area, the data to support its use can be gathered more quickly than if it has to be tested across a large geographic area. This perhaps explains the success of several early examples of cooperative gear studies. For example, research conducted by Manomet Center for Conservation Sciences provided preliminary data that formed the basis of the Closed Area II yellowtail flounder special access area (SAP). Another notable example is cooperative research conducted by the Cape Cod Commercial Hook Fishermen's Association that led to the Closed Area I hook gear haddock SAP. These projects involved a well defined and relatively small geographic area. They were not attempting to prove the validity of these gear configurations throughout the entire range of Atlantic cod, but rather a small area such as a closed area. Thus, area-based approaches to management may enable greater innovation and more effective integration of FEBK into the policy process. Such opportunities are better suited to take advantage of fishermen's local knowledge (i.e., large-scale testing of FEBK would not be necessary).

A final note of caution, although fishermen and their experience-based knowledge are accepted and considered equal to (and often greater than) scientists and their knowledge in terms of their knowledge related to fishing gear and operations, the aforementioned case studies also caution against uncritical assumptions about fishermen's knowledge. Just like we should avoid unnecessarily privileging scientific-based knowledge, we should also not privilege fishermen's knowledge. That is, we should avoid assuming that fishermen can be relied upon to develop a gear configuration without at-sea experimentation. In the *Loligo* studies, several of the innovations (although perhaps not directly designed by fishermen, but created through collaboration with fishermen) did not achieve anticipated results. Similarly, some of the whiting fishermen were skeptical about the feasibility of using a grate in the net and raising the footrope, but this proved effective. Thus, the value of cooperative research is that it involves the integration of two forms of knowledge production and creates knowledge that is viewed as credible and legitimate by both sides of the science/non-science (or science-policy) boundary. To be sure, the outcome is "scientific knowledge" and so RBK remains privileged in the science policy process. This is due to institutional reasons and not necessarily because scientists and managers do not view FEBK as valuable. Nevertheless, cooperative research gives FEBK an opportunity to be utilized in a way that is not possible otherwise due to institutional nature of fisheries management.

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[1] The *Loligo*-scup selectivity case studies are based on formal and informal interviews with fishermen, scientists, and managers, as well as observations at fishery management council and other related meetings and a review of Council transcripts, reports and media articles. Interviews were conducted with key informants related to these cooperative efforts. A total of ten interviews were directly related to this case study. A planning meeting for the NFI-SMC/Rutgers study in January 6, 2004. This meeting included discussion of the NMFS study as the Rutgers study was to build from that effort. At the Northeast Regional Bycatch Workshop in June 2004 (NERO 2004), a MAFMC staff member discussed the Scup GRAs in the *Loligo* fishery. Several published and unpublished reports were available based on data collected from the cooperative efforts (Glass 2001; Powell et al. 2004; Powell, Bonner, and Bochenek 2003; Hendrickson 2005; Glass et al. 1999). In addition, verbatim transcripts from fishery management council meetings provided data for understanding the management issue and outcomes of these various efforts. Most critical were the annual specification meetings for the commercial scup fishery in August from 2000-2004. I also observed a Scup Monitoring Committee meeting and reviewed the report made available at that meeting (dated July 21, 2004). In addition, articles were available from fishery newspapers (i.e., *Commercial Fisheries News* and *The Fishermen's Call*).

[2] The case study of the Gulf of Maine grated raised footrope trawl fishery is based primarily on interviews with key fishermen and scientists and a review of Council transcripts, reports and media articles. The cooperative effort described here took place before the commencement of this dissertation research. This case study was included in this research because it was one of a few examples of a completed gear study, and one cited as a successful example of cooperative research. It should not be confused with the Provincetown raised footrope whiting fishery that does not utilize the Nordmore grate. The principle investigator and one of the lead fishermen in the project were interviewed. In addition, interviews with other fishermen, scientists, and managers not directly involved with the project were also relevant to this effort. Documents include relevant council transcripts from NEFMC meetings (NEFMC 2003b, 2002) and Framework 38 to the Northeast Multispecies Fishery Management Plan (NEFMC 2003a), as well as articles in local newspapers (Plante 2003; Daigle 2002). I also observed presentations of the research at the Maine Fishermen's Forum in March 2004 in Rockport, ME and at the American Fisheries Society Annual meeting in September 2005 in Anchorage, AK (Balzano 2006).

[3] See Glass, C.W., 2002. Mid-Atlantic Small-mesh Research Program, Final Report to the Mid-Atlantic Fisheries Management Council, Manomet Center for Conservation Sciences, Manomet, MA, 7 pp.

[4] This analysis was included in the final report submitted to the MAFMC Research Set Aside Program for grant # 01-RSA-011 "*Loligo* Squid Gear Modification Study."

[5] In 2005, the Rutgers-NFI research continued to explore the issue of discards in the *Loligo* squid fishery. The original proposal include three options for net testing, but discussion with the working group narrowed this down to two options, and then NMFS-NERO prioritized one. Thus, the research team revised the original work statement accordingly and the final plan focused on evaluating different mesh sizes in the *Loligo*-directed fishery to reduce discarding of small squid. The other original options for testing were (1) evaluation of excluder technology in the *Loligo* fishery and (2) the evaluation of different mesh sizes in the scup-directed fishery to reduce discarding of sublegal scup. This represented a shift in objectives, as scup was no longer the principle issue of concern. The Working Group included scientists from NMFS-NEFSC and Rutgers University-Haskin Shellfish Laboratory, and representatives of the fishing industry (including representatives from NFI-SMC and the Garden State Seafood Association. The project was extended thru February 2007 to allow for additional tows to be conducted during Nov/Dec 2006 and Jan/Feb 2007 when the *Loligo* fishery operates offshore. This research is currently ongoing, and consequently, results are not yet available.

[6] A similar exempted raised footrope trawl whiting fishery has also established in Massachusetts; the Provincetown raised footrope whiting fishery (Collins 1997). This exempted fishery was a result of a collaborative effort between fishermen and MA DMF scientists. This is not discussed here but is another example of a cooperative research project that was considered in management.

CHAPTER 7: COOPERATIVE INDUSTRY-BASED SURVEYS

Introduction

In this chapter, I examine three cooperative efforts that use fishermen to conduct standardized resource surveys, known as industry-based surveys (IBSs). As with the other case studies, the citizens in these efforts are more than “ordinary” and have experience-based knowledge to contribute. These surveys collect fishery-independent data that are critical inputs into the stock assessment process. They collect information on abundance, distribution, and the biology/life history of species through the random sampling of stations with standardized gear (e.g., commercial-style otter trawls).

Surveys aiming to provide an unbiased indicator of changes in relative abundance over time have traditionally been independent of fishermen and their knowledge, resulting in firm boundaries between FEBK and RBK. As described in chapter 1, boundaries between FEBK and RBK are due in part to differential scales of experience. While fishermen’s knowledge and experience tends to be local, fishery-independent surveys are typically done at large-scales, i.e., throughout the geographic range of commercial species. As I discuss later in this chapter, Northeast fishermen (and some scientists) have long questioned the credibility of the government fishery-independent survey. These industry-based surveys aim to address industry and scientific concerns regarding fishery-independent data and provide an opportunity to incorporate fishermen’s knowledge into the scientific data collection process. Although data remain “independent,” fishermen make important contributions in these efforts. Through these surveys, fishermen’s knowledge is translated from the local to the regional scale, enabling its use in the science policy process.

This chapter examines three cooperative IBSs in the Northeast: the Cod IBS, the ME-NH inshore trawl survey, and the Mid-Atlantic Supplemental Finfish Transect Survey (Table 7-1).[1] Other notable industry-based surveys not presented in this chapter but informing the analysis include the surfclam and ocean quahog IBS and the scallop IBS described in chapter 3, as well as a Monkfish IBS (Stevens 2002; Bonzek et al. 2006) and a Yellowtail Flounder IBS (Valliere and Pierce 2007). For each IBS case study, I provide a description of the survey, focusing on the survey design and challenges addressed, and discuss the role of fishermen and their knowledge and the fate of each collaborative effort. I examine whether these cooperative research efforts enable the integration of local FEBK into the large-scale, research-based knowledge (RBK) paradigm of fisheries management. I begin by providing the context necessary to understand the significance of these efforts: the NEFSC bottom trawl survey that these IBSs aim to supplement. This context is also critical for understanding the Trawl Survey Advisory Panel case study presented in the next chapter.

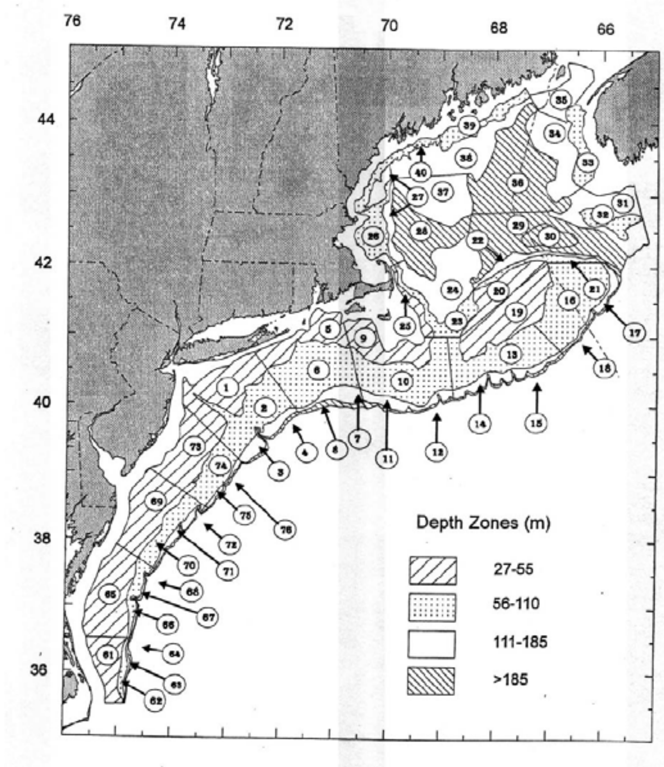
Context: The NEFSC Bottom Trawl Survey

The Northeast Fisheries Science Center (NEFSC) boasts the longest running bottom trawl survey time series in the world, having conducted surveys for more than 40 years (Azarovitz 1981; Sissenwine, Azarovitz, and Suomala 1983).[2] In 1963, the newly built 187 ft. stern trawler R/V Albatross IV arrived at the Woods Hole Laboratory, now the NEFSC. The launching of the RV Albatross IV coincided with a shift in U.S. fisheries science from an emphasis on natural history to quantitative stock assessments (Sissenwine, Azarovitz, and Suomala 1983). A major objective at the time was to provide an annual quantitative accounting of groundfish populations on the northeast continental shelf, primarily for management purposes. From 1963 to 1966, the survey covered the Atlantic continental shelf from western Nova Scotia to just north of Hudson Canyon in depths ranging from 27 to 365 meters (15-200 fathom). The survey was expanded to Cape Hatteras in 1967. Initially, the survey only sampled in the autumn but in 1968 began sampling in the spring as well.[3] Although originally designed for groundfish, the NEFSC bottom trawl survey monitors changes in approximately two hundred species, including demersal and semi-pelagic finfish, flatfish, and invertebrates, and is used for fifty stock assessments.

To meet its objectives, the survey uses a random stratified sampling design. In this sampling strategy, the entire survey region (268,000 km^2) is divided into strata based on depth characteristics, with major strata boundaries at 5, 10, 15, 30, 60, 100, and 200 fathoms. The vessel makes random tows in each strata, with the number of tows in each stratum based roughly on stratum area. About 350 tows in total are made each survey from Cape Hatteras, North Carolina to beyond the Canadian border, which means there is about one tow every 690 km^2 (200 nautical miles) (Sissenwine, Azarovitz, and Suomala 1983). Figure 7-1 shows the spatial extent of the survey.

The survey uses a two-seam trawl: the Yankee 36 trawl (60-foot headrope and 80-foot sweep) equipped with 30-foot bridles and a roller sweep to allow access to rough bottom. When the survey first began, the Yankee 36 net was a standard net used by the fishing industry, but today the gear used on the survey is considered outdated and the industry criticizes it. From 1972 to 1981, the Yankee 41 trawl was used to achieve better sampling of fish in the spring, especially pelagic species. The Yankee 41 trawl is larger and fishes about 2m higher off the ground. In 1985, the survey switched from using wood/steel BMV oval trawl doors to 450 kg Portuguese polyvalent trawl doors. Both trawl net and door changes were calibrated through paired tow experiments to determine differences in catchability.

Figure 7-1: Offshore sampling strata used in NEFSC bottom trawl surveys (NEFSC 2006, 9).



At each station, the vessel makes a 30-minute tow at 3.8 knots, and pulls up what is found in the small-mesh cod-end liner (1/2 inch mesh). Scientists weigh and count fish, and the length composition of the catch is determined by measuring all or a subsample of the fish caught. They also collect aging samples from some of the fish (e.g., otiliths, scales, or fin rays). Additionally, scientist also record sex, state of sexual maturity, stomach contents, and other biological data.

Since their inception, the surveys have been conducted in a standard format with only minor, but necessary, modifications or improvements. Only one other research vessel has been used in the NEFSC bottom trawl surveys: the 155 ft. R/V Delaware II, also a stern trawler. Catch comparability experiments conducted between the R/V Albatross and R/V Delaware II calibrated the statistical differences in catchability between the two vessels. As noted, the aging R/V Albatross IV will be replaced by the R/V Henry B. Bigelow, a large, more technologically sophisticated research vessel. The catchability differences between the two vessels will need to be calibrated in order to maintain the time series of the survey.

Over the years, industry and science stakeholders have criticized numerous aspects of the NEFSC bottom trawl survey. Many of the criticisms arise because, as originally developed, the survey was never meant for as many species or across the spatial range that it covers today. It was originally designed as a groundfish survey in the Gulf of Maine and Georges Bank but now also surveys species throughout the Mid-Atlantic. Consequently, the survey samples some species very well while others are not captured well at all. Below I summarize the most common criticisms that emerged in this research. These were expressed in interviews, at fishery management and Trawl Panel meetings, and documented in a Trawl Survey Workshop sponsored by the NEFSC in October 2002 (NEFSC 2002).

Overall, the most common criticism of the survey relates to the survey gear and its deployment. Fishermen feel the survey uses the wrong gear and tows that gear at the wrong speed, further reducing its already minimal performance. The gear used on the vessel is outdated compared to the gear used by the fishing industry today. In addition, the same net and footgear is fished throughout the range of the survey, which is not viewed as appropriate given the different bottom types and species found in New England and the Mid-Atlantic. According to expert fishermen and gear scientists, the net does not open high enough to sample some of the more pelagic species (e.g., scup and squid) and the roller gear causes the net to "jump" over bottom fish (e.g., flatfish and monkfish). Suggestions to improve the gear were not adopted in the survey due to the need to keep it consistent. According to one fisherman

> "We have been 20 some years trying to get the agency, the Science Center, to reconsider utilizing that net. And they were not going to touch it, would not touch it…We never had the opportunity. We never had it before. We went there before with a lot of ideas and suggestions and people would go out on cruises and coming back and say, 'Boy, this thing is so screwed up, you'll never get it straight. But all you have to do is do this, this, and this and it will work better.'"

More recently, the industry concerns were reaffirmed during a 3-day "exploratory" or "trawl observation" cruise in 2002 when 6 fishermen were invited to observe how the trawl net performed. This cruise was the first of several responses to the miscalibration of the survey gear reported in September 2002. For example, the fishermen observed uneven wear of the doors suggesting the gear was not spreading properly. In one captain's words, the doors "are probably the single most important component of a properly tuned otter trawl rig; having one door not working properly can have a major effect on catch rate, as the spread of the net can be affected." They felt the trawl was "abnormally light" and observed the net leaving the bottom during moderate weather conditions. The fishermen also felt that tow speeds were too high for the net, especially given its light condition. The fishermen also observed a tangle (or snarl) in the net as a few floats on the head rope became tangled with the sweep and footrope on one wing, which went unnoticed by the deck crew. Overall, they felt that the survey gear and its deployment needed improvement and they raised questions about the protocol that was in place that led to the miscalibration and the uneven door wear observed. Based on his observations during this cruise, one fisherman's summarized the industry's recommendations[4]:

> "[T]he best way to change this net would be unhook the shackles that connect the wings to the bridles, remove the tripper rope, and replace the whole net with a newer design net that is more adept at doing the job the trawl survey requires of it. The old net could then be retired to an antique fishing museum where it belongs, and the doors should go with it."

Stakeholders have also criticized the design of the survey. Survey coverage is fairly coarse due to the large geographic area that it covers. The survey makes about 350 tows from Cape Hatteras to beyond the Canadian border, roughly one tow per 690 km^2 (Sissenwine, Azarovitz, and Suomala 1983). Fishermen feel that the survey collects insufficient samples in important places for certain species. Some fishermen feel the survey should be extended into deeper water to better reflect the current distribution of some species. Some fishermen feel that the survey samples at the wrong time of the year for some species. From a scientific viewpoint, samples must be selected randomly or the indices will not reflect changes in relative abundance over time. Additional stations are not possible due to time and financial constraints.

As noted in the introduction, in September 2002 the NEFSC acknowledged that the trawl warps on the R/V Albatross IV had been mismeasured relative to each other since spring 2000. The NEFSC held a trawl survey workshop and invited fishermen to participate in addressing the problem. In addition to the trawl warp miscalibration, fishermen and scientists identified other issues related to the survey. An excerpt of the findings and recommendations of the Trawl Survey Workshop (NEFSC 2002, 27)is below:

> "Further to meet the needs of management…more precise sampling systems (including research vessel and industry based surveys) are required to be deployed over a wider range of habitats. There is an immediate need for NOAA Fisheries, in conjunction with stakeholder groups, to develop and implement these new systems…The new survey design should be calibrated with the current design to ensure compatibility/comparability with that time series. Fishers and other stakeholders should be integrally involved in the planning and implementation of future research surveys. A working group that reflects the diversity of the fishing industry and other stakeholders should be established immediately to assist in the implementation of these recommendations."

Coincidently, Congress appropriated funds to build four new research vessels, one of which was dedicated to the Northeast. The allocation of the new vessel, the R/V Henry B. Bigelow, costing an estimated $38 million, gave the NEFSC and the industry an opportunity to consider and address the various criticisms of the survey. At 208-feet, the R/V Henry B. Bigelow is much larger and more powerful than the vessel it replaces and therefore is both a blessing and a burden. The draft of the R/V Bigelow will not allow it to access some of the inshore stations previously covered by the NEFSC survey, a need that may have to be filled by industry-based surveys. An advisory panel was formed to put the industry and science expertise to the task of improving the survey. The next chapter presents this panel, the Trawl Survey Advisory Panel.

In some cases fishermen's frustrations stem from direct observation of the NEFSC survey when they fished side-by-side with the R/V Albatross. A Maine fisherman said that he volunteered on a NEFSC survey, and the research vessel just happened to be fishing in the area of one of his friends. The two fishermen got on the radio to share stories, and it was obvious to them that the R/V Albatross had missed most of the fish in the area. A Massachusetts fisherman related a similar story to me where he had compared his catch with the survey's catch using the same net in the same area:

> "I was running the boat out here, and the Delaware II was alongside of me, and I had a boat with 165 horsepower and I towed a Yankee 35 net, and I was towing 2 hours and getting 30 baskets of yellowtail. This boat was only 56-foot long, the Delaware II was probably about close to 200 foot long, 150-60 feet anyway, probably had 1,000 HP in it, and he was towing the same 35 net I was. The guy tells me, he says 'Captain, there's no fish around here.' I says, 'What do you mean?' He says, 'Well, we only have 3 baskets.' I was catching 30 baskets.

Another "side-by-side" fishing experience took place, when the F/V Jason and Danielle towed along side the R/V Albatross IV in a "cooperative" effort in 2001. The industry involved in that program also observed that the R/V Albatross IV was not catching the same amount of fish as the commercial vessel, and in the spirit of cooperation they provided some recommendations to the government officials to improve the survey. The "cooperative" effort ended abruptly, but eventually a more lasting and more fruitful cooperative effort developed; the Mid-Atlantic Supplemental Finfish (transect) Survey, discussed in this chapter. These kinds of stories circulate among fishermen quickly. [5]

Table 7-1: Summary of the NEFSC survey and the IBS case studies, the ME-NH Inshore Trawl Survey, the Cod IBS, and the Mid-Atlantic Supplemental Finfish Survey.

	NEFSC Survey	**ME-NH Inshore survey**	**Cod IBS**	**Mid-Atlantic survey**
Sampling Design	• Stratified random	• Stratified Random • Industry selected fixed stations	• Fixed Grid stations • Random Industry stations	• Fixed Transects and stations • Adaptive Stations
Survey Intensity	• 200 stations/area • 400 stations/year • 2 times/year	• 115 stations/area • 230 stations/year • 2 times/year	• 225 stations/area • 1,125 stations/year • 5 times/year	• ~ 28 stations/area • ~112 stations/year • 4 times/year
Funding Sources	• NOAA	• CRPP • NEC	• CRPP	• MA RSA

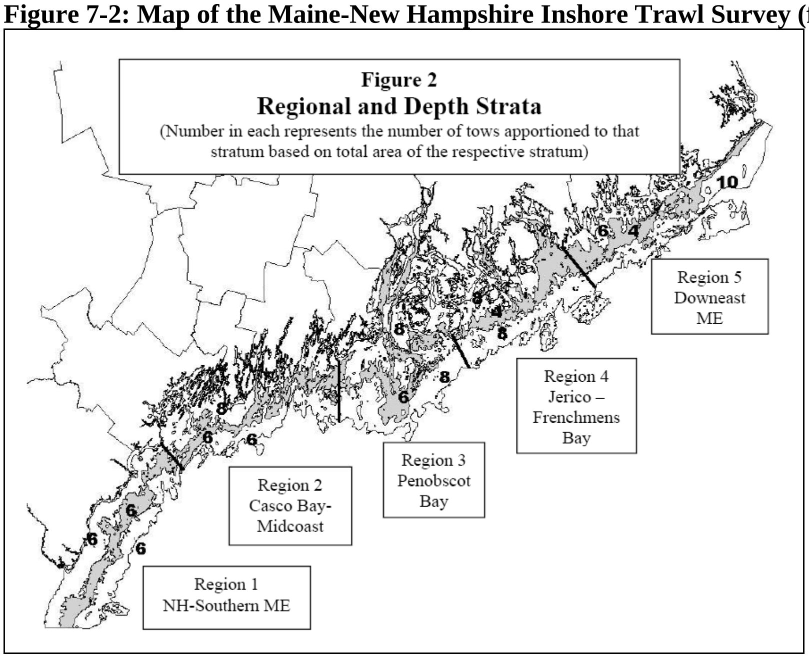
Case Study 1: Maine-New Hampshire Inshore Trawl Survey

Coordinated by the Maine Department of Marine Resources (ME-DMR), the Maine-New Hampshire inshore trawl survey (hereafter ME-NH IBS) began in the fall of 2000 as a fisheries-independent assessment of marine resources within Maine and New Hampshire state waters. Six biannual surveys were conducted from fall 2000 to fall 2006. This survey fills a spatial gap in the NEFSC bottom trawl survey (i.e., inshore within 3 miles of shore), a gap that is expected to expand when the R/V Henry B. Bigelow, the new NOAA research vessel, replaces the R/V Albatross IV, as the new vessel will unlikely be able to survey much of the inshore strata. Federal monies allocated in response to the NE groundfish crisis through the CRPP program and the Northeast Consortium funded this project, although it is not solely a groundfish survey.

<u>Survey Description: ME-NH IBS</u>

The survey uses a stratified random sampling design, with a fixed component. The survey area is broken down into four depth strata and five longitudinal areas based on oceanographic, geologic, and biological features (Figure 7-2). The depth strata are 5-20, 21-35, 36-55, and greater than 56 fathoms. [6] Two surveys are done each year, in the fall and spring, with a target of 115 stations per survey (making the sampling density 1/40 nm^2). Random tows of one nautical mile are computer generated. During the establishment of the tow locations, some grids are *a priori* identified as untowable, based on past experience and local knowledge. After the initial fall 2000 survey, two stations per stratum were designated as fixed stations to be sampled each survey. Fixed stations were determined on the basis of historical importance or being roughly representative of the average catch in the stratum, and some were selected randomly.[7] Two identical 54-ft commercial vessels have been used in this survey. In general, only one vessel is available per survey, while the sistership is available for emergencies to ensure the survey is completed. From fall 2000 to fall 2003, the two vessels alternated between surveys, but starting in spring 2004 the survey has been conducted using the same ship, with the other ship continuing to serve as backup. This again is important to this type of cooperative program because using survey data requires consistency over time; to determine changes in relative abundance. Part of the learning curve of all IBSs has been learning how to make programs consistent over time. The vessel fishes a modified shrimp net designed by the owner of the vessels and a net designer. The net was designed specifically to fish effectively on complex bottom.

Figure 7-2: Map of the Maine-New Hampshire Inshore Trawl Survey (from Sowles et al. 2002, 4)



Challenges and/or Impediments: ME-NH IBS

A significant part of this IBS effort required earning cooperation from the Maine lobster fishermen. Support of the lobstermen is critical to doing the survey because their fixed gear (i.e., lobster pots) is scattered throughout the inshore waters of Maine, making it impossible to tow the survey net in certain locations. From the beginning, there was significant opposition on the part of the lobster industry. In 1999 and 2000, I attended several local Maine Lobster Zone Council meetings where there was a heated discussion between the lobster fishermen and Maine's Commissioner of Marine Resources and his staff. Lobster fishermen were adamantly opposed to trawling in the near shore waters of Maine, especially in the Eastern zones. They were concerned about possible damage to the habitat and their lobsters, especially when egg-bearing lobsters are plentiful close to shore. They also questioned why the State can drag inshore when there is a state law banning dragging within three miles of the coast. The industry's distaste for dragging lobsters has a long history. Many lobstermen also perceived the survey as a "groundfish survey" and so felt the costs and benefits were unevenly distributed (i.e., the groundfish fishermen would benefit while the lobster industry would pay the costs). As one lobster fisherman stated: "I'm pretty disgusted that they would damage a portion of the lobster industry for another industry (ground fishing) that destroyed itself" (cited in Porter 2001). An additional concern was the inconvenience; they had to take the time to move their gear. The DMR gave notice in advance of the locations that they would tow and expected them to move their gear. The scientists took extra steps to ensure a predictable schedule so as not to inconvenience the lobster industry. To alert the industry of when they would be towing an area, the project used numerous means of communication, including a mailing to all permit holders, NOAA weather radio broadcasts, and twenty-four hour toll-free telephone recording. During the first year, there were some tows that could not be made due to the presence of fixed gear, which was the lobster industry's attempt at civil disobedience.

Despite the scientists' attempts at communication and compromise, the lobster industry demonstrated their opposition to the survey through a non-violent, on-the-water protest. On October 22, 2001, a convoy of about 17-30 lobster boats off Corea, ME, surrounded the F/V Robert Michael as it was preparing to conduct the survey. The scientists reported that they "were practically unable to maneuver" while the lobstermen later said they never impeded the research vessel. The protest had not been planned. When they heard the survey vessel was planning to drag despite their attempts at civil disobedience in the form of cluttering up the area with fixed gear (i.e., the scientists were just going to move the gear), they quickly arranged the at-sea protest over the radio. The fishing vessels followed the research vessel from one tow spot to a second one, but the research vessel did not do any dragging. Instead, it just gave up and went into port. The marine patrol officer on the scene called it a "show of solidarity" on part of the lobstermen. One lobsterman explained that it was a statement: "This was a show of disapproval…We don't approve of what you're doing." The DMR scientists were upset that the industry chose this way to communicate their frustrations, stating that "We were blindsided. I would have rather had somebody give me a call and tell me they were upset." In the final report for 2001-2002, the following statement was made about the Fall survey: "All tows in strata 1 and 2 of region 5 were abandoned to appease public dissent (page 11)." The spring survey is less controversial, as it is outside the peak of the lobster season. The spring 2002 survey went off without a hitch, as they were able to make ninety-four out of a possible of one hundred tows (moving or shortening sixteen of them due to presence of gear in the water).

The DMR scientists worked hard thereafter to gain additional support for the survey and to address the lobster industry's concerns. For example, the DMR invited a team of gear experts from the MA DMF conservation engineering program to produce underwater footage of the survey nets towing in the spring 2001 to ease the industry's concerns regarding habitat and lobster damage. The DMR also made changes to onboard handling of lobsters to address the industry's complaints and improved communication with the industry. Another issue that the DMR tried to address was data sharing and making the data available to the industry. Lobster council members raised concerns that fishermen want to see the data and want to know how it will be used. While confidentiality rules prohibit the reporting of individual tows, the information will be available to the industry in aggregate form. DMR releases data in aggregate form to anyone who wants it and final reports are available electronically on their website.

The scientists also tried to convince the lobster industry that they too would benefit from the survey. I heard ME DMR scientists repeat emphatically to lobstermen that "this is more than a groundfish survey." Scientists attended the lobster zone councils and tried to ease the industry's concerns. The chief lobster biologist at ME DMR had developed a good working relationship with the lobstermen so his statements were critical. He was able to explain to them that the only survey used in the lobster assessment was the NEFSC survey conducted outside the fifty fathom line, which was inadequate. As he explained: "In 35 years they have counted a total of about 6,000 lobsters; we counted about 8,000 in five weeks last year" (Plante and Jones 2002).[8] The protests began to diminish after the fall 2001 survey, although the fall survey remains variable in its success rate, measured in achieving the number of desired tows.

The second most important challenge related to this survey has been financial limitations. The ME-NH IBS has lacked predictable funding. The Northeast Consortium and the CRPP program both funded the survey at different times. The project must resubmit grant proposals each year from one of these agencies, making the future of the survey always uncertain. This is a critical concern for surveys because their greatest value is achieved as a time series. Funding the project on an annual basis also makes it difficult to offer job security to scientists, creating a shortage of well trained staff. One ME DMR scientist also noted that the lack of job security makes scientists' working conditions stressful. In addition, time spent chasing dollars means less time available for data analysis. One scientist at DMR explained:

> "One of the reasons why we haven't done more with the data is we're consistently having to write proposals and trying to keep chase after funding to make sure that we're continuing the project. So, that takes up some of the time that we could be doing other things. We've been collecting winter flounder ever since we started this project, because the technical committee asked...They have no age samples especially from eastern Maine, and we've collected them. I just haven't had a chance to look at them because I just don't have the time, you know? We would have the time to perhaps do more of this if we didn't have to keep chasing after money all of the time. And we'd keep three people on staff instead of just two."

<u>Role of Fishermen and their Knowledge: ME-NH IBS</u>

In addition to using industry vessels (and captains and crew), the survey also incorporated fishermen into the early planning phase of the survey. As a "cooperative" effort, project members consulted the groundfish and lobster fishing industries "to understand their interests and concerns and to gain their cooperation." The groundfish industry was concerned about making sure the data were collected professionally so that the "science and methods…used be rigorous and that participation by fishermen not impair the credibility of the data collected." They wanted to make sure that NMFS and the State agencies would use the data. In addition, three planning meetings were held in Ellsworth, Rockland, and Portland to review the proposed tows and determine towability of those locations. If not towable, they asked for the nearest tow to the randomly drawn grid. The scientists also sought help with berthing, navigational problems, and in identifying local experts of the areas to assist them once the survey was underway. At sea, fishermen helped the scientific crew sort and collect data on the catch.

Fate of the Research: ME-NH IBS

According to ME DMR staff, the data from the survey are available for anyone who would like access to them. Final reports are available on-line and are distributed freely when requested. According to the project managers, the data have already started to make a difference. Dr. Yong Chen, a professor at the University of Maine, wrote a paper comparing the ME-HN inshore trawl survey data to NEFSC survey's offshore data and shows how important the inshore component is when considering the total lobster population along the coast of Maine (Chen et al. 2006). The NEFSC survey captures mostly larger adults offshore and misses the recruitment and juvenile lobsters that are more abundant in Maine's inshore waters. Dr. Yong Chen and Carl Wilson used the data from the inshore trawl survey to develop a new lobster model. The SARC will review this new lobster model in the next lobster assessment scheduled for 2007.

In August 2005, a technical peer review of the ME-NH IBS was conducted (Chouinard, Beutel, and Legault 2005). The review panel was asked to review the project using specific criteria. The review panel included three fisheries professionals who displayed expertise in stock assessment, trawl gear design and trawl surveys, fish population dynamics, and fisheries statistics. Overall the panel found that the project has been successful in demonstrating the feasibility of an inshore survey in Maine and NH waters, but also that objectives of the survey need to be simplified and long-term funding is necessary if this survey is to provide a time series of abundance for tuning stock assessments. The most critical issue identified related to survey design (Chouinard, Beutel, and Legault 2005, 5):

> "The current survey design of mixing random stratified sampling with fixed stations needs to be revisited based on the objectives of the program. In particular, the panel recommends that the number of fixed stations be reduced to the bare minimum. In each stratum, the deleted fixed stations would be replaced by random stations. If fixed stations need to be retained for secondary purposes, consideration should be given to adding a corresponding number of random stations to achieve the initial sampling intensity (1 station per 40 sq. nautical miles) so that the primary objective is not compromised"

Other issues were identified. For example, the survey methods need to be documented better for data users. And due to changes in survey design and inappropriate statistical analysis, preliminary results of the time series are incorrect (i.e., the time series is inconsistent and incorrect). However, the panel noted that secondary results of the biological information that have been produced are being used for management purposes, although those uses were not specified in the report. The panel found that data are very accessible. The review members especially praised the partnership aspect of the project (i.e., the collaborative nature of the project with fishermen).

However, they noted that more collaboration with federal scientists would improve the likelihood that results from the project were used in assessments. The reviewers felt that the project should look for alternative, long-term funding rather than relying on the NEC or CRPP programs. In summary, the panel raised issues related to standardization and survey design that could improve the survey. Overall the Panel considered it “an excellent example of cooperative research (Chouinard, Beutel, and Legault 2005, 1).”

Case Study 2: CRPP-Cod Industry-based Survey

The Cod Industry-based Survey (Cod IBS) began as a pilot study in November 2003 with funding from the NMFS-Cooperative Research Partners Program. The State of Massachusetts Department of Marine Fisheries (MA DMF) coordinates the survey, with help from Maine, New Hampshire, and NMFS officials. The pilot program tentatively ended in January 2006 after the completion of two full surveys and one cruise. NMFS sponsored a peer review on August 29, 2006 to determine its utility for science and management (Chouinard, Weinbert, and McGovern 2006). Like other IBSs, the purpose of this survey is to supplement NEFSC bottom trawl survey data. Unlike the NEFSC bottom trawl survey, this industry-based survey targets a single species, Atlantic cod, *Gadus morhua*, in a relatively small geographic area, the Gulf of Maine (Figure 7-3).

Formal goals of the program include improving knowledge of GOM cod distribution, improving stock assessments, and improving relationships between fishermen and scientists. The primary objective of the survey was “to define a broad-scale distribution of cod aggregations in the Gulf of Maine, in space and time, by age and size composition” with a second objective to “provide information on the age/length structure during current rolling closure areas (November, April-May) when fishery-dependent data are unavailable and to provide information on the seasonal distribution and length composition of other groundfish within the GOM where data was [sic] sufficient” (Hoffman et al. 2006, 2). The MA DMF Director described the survey as an opportunity to produce knowledge about the GOM cod fishery and demonstrate fishermen’s knowledge (MA DMF 2003, 1):

> "These surveys represent a very timely opportunity for the states and the federal government to work together to improve our knowledge of GOM cod distribution and to gather information sure to improve cod stock assessments. Involving commercial fishermen at the ground level and using their knowledge of cod movements and net design will be tremendous assets. It will demonstrate to fishermen that those who assess cod abundance and manage their fisheries understand fishermen have a wealth of knowledge to contribute."

Survey Description: Cod IBS

The survey area focuses on the Gulf of Maine from ten to seventy-five fathoms. Unfortunately, this area may not describe the entire cod distribution, which is believed to occur out to ninety fathoms (particularly in the winter). Although the committee considered extending the scope of the survey, this was deemed unfeasible due to financial constraints and the need to continue industry tows. The survey used two independent sampling designs to achieve its objectives. First was a systematic or fixed grid design based on 9-minute blocks generated 145 sampling squares that were sampled in the center during each survey, creating a very high sampling density for a survey. The second design was included to address industry concerns that centers of cod abundance were sampled. This included a random stratified sampling from a selection of 265 industry selected tows (3-minute cells over sixteen strata). The sampling effort was apportioned between these two designs, with sixty-four percent of the effort allocated to the fixed tows and thirty-six percent to the industry selected tows. The survey is conducted five times a year (November, January, March, April, and May) with four different industry vessels. Approximately 225 stations were attempted each cruise, totaling 1,125 stations each year.

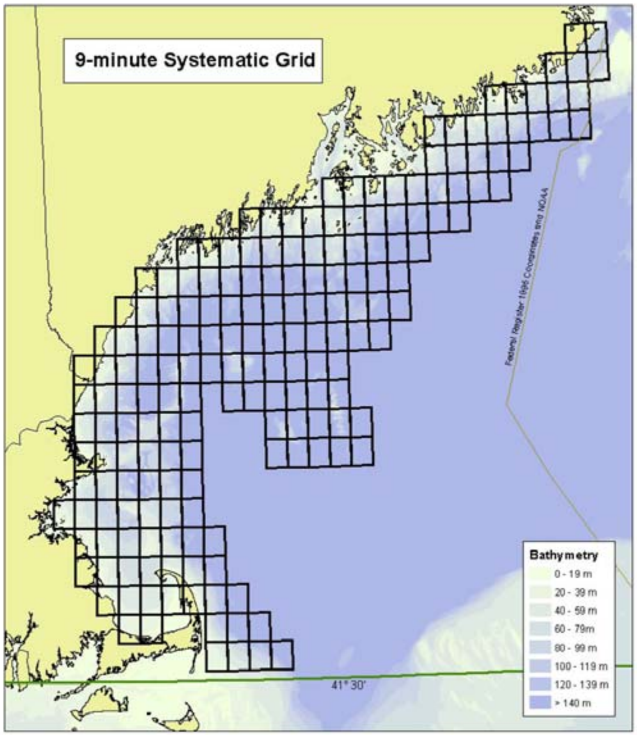
The vessels are of comparable length (67, 66, 56.8, 76 feet) and sail from ports in Maine and Massachusetts. Each vessel tows identical research gear: two standardized trawls, ground cables, Bison #8.5 doors, a net mensuration system, and sea sea-sampling equipment. Although the survey targets cod, scientists sample everything that is caught.

The survey uses a commercial trawl called Reidar's 360. Because of the commercial sized gear, the catches are fairly large, requiring significant sampling labor. Both the scientists and fishermen worked together to tackle large piles of fish according to the survey protocol, which included identifying, sorting, measuring, weighing, and collecting biological information for every species retained. Large catches are a problem for any survey, as they require subsampling, which potentially introduces additional error into the survey data. The trawl is described below:

> "It is a two seam, high-rise net specifically designed to catch a full range of cod year-classes, while targeting the larger, mature fish. The net has a 150-foot fishing circle, 87-foot sweep, and 84-foot headrope. The wings and body of the net are made from 4.5-inch Euro twine tapering in the extension to a 3-inch codend with a 2-inch mesh liner. The sweep is a 14-inch "rockhopper" with 14-inch disks in the belly tapering to12 inches in the wings. Bridals and ground cables are each 15 fathoms. Both bottom leg and ground cable will be rubber cookie-covered to decrease wear and improve a mud cloud effect" (Hoffman 2003, 6).

Gear manufacturers designed and tested this net in collaboration with fishermen. A model of the net was tested in the world's largest flume tank at the Marine Institute of Memorial University in St. John's, Newfoundland. In August 2003, DMF staff and survey participants traveled to Newfoundland to test and refine the net to ensure optimal performance. They found that the sweep had perfect bottom contact and the headrope opened to an impressive 14.4 feet. There they were able to establish the net's optimum geometry and record the dimensions and angles. This data was important for use with the net mensuration equipment necessary to ensure that all nets were fished in a standardized way by each survey vessel (Hoffman 2003).

Figure 7-3: Map of the Cod Industry-based survey area (Hoffman et al. 2006, A1)



Challenges and/or Impediments: Cod IBS

In May 2005, twenty groundfish fishermen from northern Massachusetts and New Hampshire held a meeting to protest the legitimacy of cooperative research (Prybot and Stevens 2005). In particular, they protested two fishing vessels that had been fishing in the rolling closure off New Hampshire. One of these vessels was a participant in the Cod IBS. One fisherman felt it was unfair that certain fishermen benefited by being able to fish in areas closed to the rest of the fleet. He said to a staff member of the Northeast Consortium:

> "You don't know what it's like to be almost broke, have to stay tied to the dock because of the rolling closures, and watch these two boats fish three or four miles off the coast, come in, and sell the fish when we are starving" (Prybot and Stevens 2005, 16A).

Another fisherman reiterated the feeling of inequity regarding the cooperative effort:

> "The government should not be the deciding factor in which fishermen will survive. Allowing vessels lucrative grants to fish largely uninhibited without regulations and splitting the jackpot while others can only watch is unfair" (Prybot and Stevens 2005, 16A).

Unlike most surveys, the vessel sells the legal catch to raise money to fund the project. However, not knowing this, other fishermen thought that these vessels were being allowed to profit from the fish caught during the survey. To be sure, the vessels participating in the IBS receive financial benefits that advantage them compared to those who do not participate. The vessels are charted for a fair price, and when doing the survey the vessels do not have to use their days-at-sea (DAS). The DAS is a scarce and valuable commodity. This means that the vessel is more "active" during the year compared to vessels that do not do cooperative research. There is money coming in to pay for maintenance and the crew that other fishermen do not receive. In an interview, when asked why he participated in the Cod IBS, one vessel owner acknowledged that it was mostly for the financial benefits, i.e., being able to fish more during the year, but then he quickly added that it was also a good project.

<u>Role of Fishermen and Their Knowledge: Cod IBS</u>

The development and design of the program was a collaborative effort between fishermen and scientists. When funding became available in 1999, the NEFMC's Research Steering Committee identified the need for an industry-based survey. In the fall 2000, the Gulf of Maine Aquarium, was contracted to conduct scoping meetings at seven

New England fishing ports (Rockland, Portland, Portsmouth, Gloucester, Chatham, New Bedford, Point Judith). The purpose was to develop a program for utilizing industry vessels for fishery-dependent and fishery-independent survey programs. Then in July 2001, NMFS hired the Gulf of Maine Aquarium again to oversee a committee of scientists, managers, and industry stakeholders to design an IBS fleet to survey areas not currently surveyed. This Industry-Based Survey Committee recommended two “pilot” industry-based surveys; one to survey cod distribution in the GOM and the other to survey yellowtail flounder in southern NE.[9] The committee also produced an extensive final report that detailed the objectives, implementation strategy, and budget for a pilot program (Gulf of Maine Aquarium 2002).

As noted, fishermen also contributed to the design and testing of the survey gear, including flume tank testing at the Marine Institute of Memorial University in St. John’s, Newfoundland. Fishermen also contributed their knowledge and skills of gear and vessel operations. The stations in some cases were selected in areas that are untowable due to boulders or other obstructions. The determination of a site as “untowable” is often made based on fishermen’s local knowledge. In those cases new stations are identified. The survey experienced damage to several of its nets. In one case, a vessel became “hung down” with a wreck and was stuck for several hours. The lead DMF scientist explained that because of the way the trawl was attached, the captain had to be careful to avoid the entire loss of the gear, but after 2 hours of “tactful maneuvers, the Captain was able to finally retrieve the gear.” (Hoffman 2004, 3). Fixed gear still resulted in the loss of some stations. For example, during its first leg in November 2003 off mid-coast Maine, the survey completed only thirty-eight percent of its tows and by the end of the third leg this percentage had increased to only seventy-eight percent. This unfortunately means that there are gaps in the database.

Fate of the Research: Cod IBS

In early 2006, the MA DMF reported on their Cod IBS website that the "project has been temporarily suspended due to financial and contractual issues." The survey was still early in its development (i.e., pilot stage). A final report was written (Hoffman et al. 2006) and the project was peer reviewed in August 2006 (Chouinard, Weinbert, and McGovern 2006).

The peer review panel concluded that the survey provides valuable information on cod in the GOM where no other sources of data are available, including high resolution of data on the spatial and temporal distribution, size composition, maturity and potentially age of cod, while augmenting other surveys. The reviewers found the data to be useful in determining the location and timing of cod in spawning condition, as well as the coincidence of cod spawning with the rolling closures. The reviewers cautioned, however, that the lack of sampling in water deeper than 75 fathoms may not provide an adequate picture of cod distribution, particularly in the winter. Further they cautioned that a significant number of issues would first need examination and resolution before data could be used to derive indices of stock abundance for specific species. They also found that the survey design, while good for the objective of examining cod distribution, was not easily adaptable for other types of common survey analyses. Nevertheless, the NMFS CRPP staff noted that while not useful for indices of abundance, data will likely be used in the 2008 benchmark assessments. The New England Fishery Management Council's Research Steering Committee also reviewed the final report and the peer review document and emphasized the following findings: 1) that fishing industry-selected stations produced results similar to the random stratified stations, hopefully overcoming industry criticism of standard trawl survey methodology; 2) a successfully run IBS can produce useful science as discussed in the peer review; 3) if the survey continues, and given that there are redundancies in the project relative to information from industry-selected stations and the random stratified results, the design may need to be revised to accommodate new management-related research questions and priorities and/or gaps in existing survey coverage of Council-managed species.

Case Study 3: Mid-Atlantic Supplemental Finfish (Transect) Survey

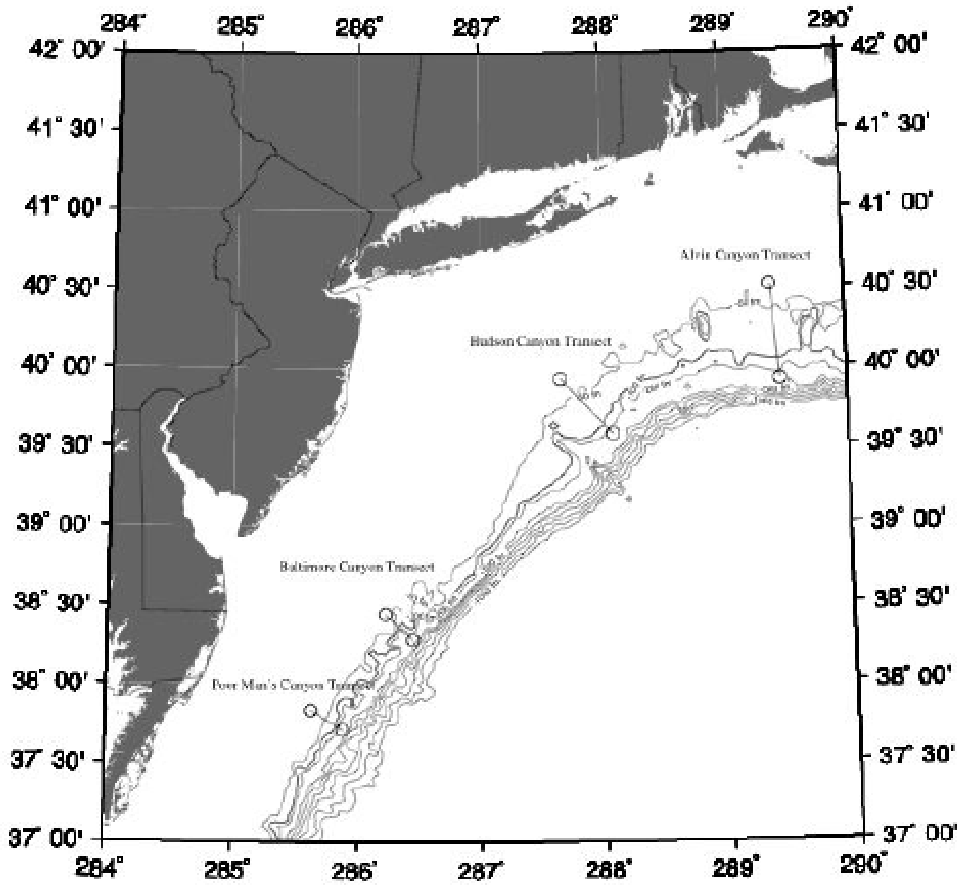
The Mid-Atlantic Supplemental Finfish Survey program has been funded through the Mid-Atlantic Research Set-aside (RSA) Program since March 2003 as a collaborative effort between the National Fisheries Institute (on behalf of the Mid-Atlantic fishing industry), Rutgers University, and the NEFSC (HSRL 2006). The RSA program allows researchers to request, through a competitive grants process, access to part of the quota of certain species with the purpose of using that quota to generate funds for research, with up to three percent of the quota available for select species. The survey targets Mid-Atlantic species that are not sampled well by the NEFSC bottom trawl survey (HSRL 2006). The objectives of the supplemental finfish survey are (1) track seasonal movements of selected species to “supplement the survey database with information on the migratory behaviors of select species, particularly the fall offshore-down coast migration and the spring up coast-onshore migration,” and (2) extend sampling beyond the present NEFSC surveys. The survey is conducted four times a year (January, March, May, and November). From March 2003 to May 2006, thirteen surveys were completed (HSRL 2006).

In considering the significance of this collaborative effort it is important to understand the context from which it emerged. The Mid-Atlantic Supplemental Finfish Survey followed what has been called one of the most “uncooperative” cooperative research projects in the Northeast. In 2001, the Montauk-based fishing vessel F/V Jason and Danielle fished side-by-side the R/V Albatross IV on two separate occasions (February and September 2001) in a “collaborative” effort between the NEFSC, NFI, Rutgers University, and the fishing industry. The major impetus of this cooperative research project was the scup stock assessment, which was the basis of the gear restricted areas described in chapter 6. NMFS uses spring survey data in its scup assessment, and large scup were missing from the spring survey. However, since scup were appearing in the fall survey, industry members and some scientists questioned whether the big fish were simply being missed in the spring survey. More specifically, the formal purpose of this effort was to compare the catchability of the F/V Jason and Danielle with that of the R/V Albatross IV. They were especially looking for any differences in the sizes of the animals that the two vessels caught. On March 4, 2002, the NEFSC abruptly ended the cooperative effort. A press release by the industry stated: “Cooperative Survey Program is Halted by NMFS: National Marine Fisheries Service Says “No Thanks" to Making 'Best Available Science' Better” (NFI-SMC 2002). A year later, in January 2003, the industry, Rutgers, and NEFSC scientists were sitting around a table at the NEFSC lab in Woods Hole making plans for a Mid-Atlantic supplemental finfish survey. Given what happened with the F/V Jason and Danielle survey, it is remarkable that this effort is so successful. It points to the professionalism of both the industry and science partners and their determination to move forward.

Survey Description: Mid-Atlantic Survey

To achieve its objectives, the survey uses a cross-shelf transect design (HSRL 2006), which differs significantly from the typical stratified random sampling design used in most fisheries surveys (e.g., the NEFSC survey, the ME-NH inshore survey, and the Cod IBS). Fixed transects are oriented perpendicular to the average trend in depth contours along fixed transects. The fixed transects sampled vary by survey cruise. The fixed transects identified in a planning meeting are the Hudson Canyon, Baltimore Canyon, and Poor Man's Canyon (Figure 7-4). The Hudson and Baltimore Canyon have been sampled every survey, and the Poor Man's Canyon was sampled in the March 2004 survey. Fixed stations are sampled along at 40, 50, 60, 80, 100, 125, 150, 200, 225, and 250 fathoms on the Hudson Canyon. The same fathom stations are sampled on the Baltimore Canyon, except for the 250 gradient which is too steep to sample. Sampling of the Poor Man's Canyon followed the same fathom stations, but did not include the 225 or 250 fathom stations because of the presence of boulders and steep depth gradient. In addition, the forty and fifty fathom stations were moved away from the transect line to avoid a large wreck. In addition to the fixed stations along the fixed transects, the survey also samples "adaptive stations" that are selected at sea in an unbiased manner. Scientists select adaptive stations based on the target species (summer flounder, scup, black sea bass, monkfish, spiny dogfish, silver and offshore hake, and *Loligo* squid). Scientists first identified fixed stations that provided the highest overall ranking of catches and then chose adaptive stations at one-half depth increments between two fixed stations with the highest combined station ranks. Five adaptive stations are sampled for Hudson Canyon and four are done for Baltimore Canyon and Poor Man's Canyon.

Figure 7-4: Map of the Mid-Atlantic Supplemental Finfish Survey (King 2006, 117).



The survey initially chartered the F/V Jason and Danielle, but after it was sold in the summer of 2004 the F/V Luke and Sarah was used. The Captain of the F/V Jason and Danielle has been intimately involved with all aspects of the research process, including design, planning, and data collection. In fact, he is so dedicated to this survey that he went out on the survey even after his boat was no longer being used. He operated the vessel for the survey in November 2004 and January 2005, after which the captain changed. The exact same gear and sampling protocols have used throughout the program.

The survey uses a 4-seam box net with a standard six centimeter codend (liner). The survey used the F/V Jason and Danielle's fishing gear, and in November 2005 the survey program purchased its own gear of the same configuration. Beginning with the November 2006 survey, the new F/V Jason and Danielle, with the original captain, took over for the F/V Luke and Sarah.

Each station is towed a fixed distance at three knots. Initially the vessel towed two nautical miles, but was reduced to one nautical mile in May 2004 to minimize subsampling and reduce on-deck processing. Issues were raised regarding crew safety because of the time that was required to process the catch in between tows – and subsampling error. To minimize diel variability, stations less than 150 fathoms in depth were sampled during daylight hours only. In addition, a rigid protocol for subsampling is used based on how samples are processed at the NEFSC.

GPS position was logged to 0.01' latitude and longitude every one minute during the tow. The captain logged depth, GMT, and GPS manually every five minutes. Depth and bottom temperature were logged remotely at one minute intervals using a sensor attached to the top of the net behind the headrope. Catch weights were recorded for all species caught, and lengths were taken of the target species summer flounder, scup, BSB, monkfish, spiny dogfish, silver and offshore hake, *Illex* and *Loligo* squid, yellow flounder, winter flounder, bluefish, and American lobster. In addition, starting in January 2004 spiny dogfish were separated by sex prior to analysis. This is a response to conflicting reports by federal scientists and the fishing industry regarding the status of spiny dogfish; in particular the industry does not agree with scientists that there are too few fecund females and that the fishery is severely overfished.

Challenges and/or Impediments: Mid-Atlantic Survey

One of the most significant challenges facing the Mid-Atlantic Supplemental Finfish Survey is that the program is not funded to its full capacity. The program is funded through the MAFMC's Mid-Atlantic Research Set-aside (RSA) Program. The project annually submits a proposal to receive a portion of the set-aside to pay for research. This set-aside is translated into dollars through the NFI-SMC's auction. Fishermen bid on this quota and the proceeds are used to pay for the research. The quota gains value for fishermen when it can be landed when the fishery is otherwise closed. This process is hindered when fishermen are not allowed to harvest the quota, such as when experimental fishery permits are not provided. In addition, the amount of money that is generated during even the best of circumstances from the RSA program is not sufficient to fund the survey as it was intended. As designed, the survey is to sample 4-5 transects, 4 times a year. However, the program has only funded about 2 transects per cruise. This reduces the full potential of the survey for improving stock assessments.

There is momentum within the fishing community to find alternative ways to fund this program besides through the RSA program, such as a line-item in NMFS budget. However, as a scarce resource, competition is significant for such research dollars. The program will compete for such funds with other industry-based surveys, as well as with the NEFSC budget of which has recently been cut significantly. Given the political position of the New England fishing industry, convincing the NEFSC or Congress to fund the Mid-Atlantic survey will be a significant political challenge. However, an important advantage is that this survey is unique whereas there are several surveys that target the New England groundfish resource.

Role of Fishermen and their Knowledge: Mid-Atlantic Survey

Fishermen are critical to the design and implementation of the Mid-Atlantic survey. Most importantly, fishermen's knowledge contributes to the at-sea operation of the survey. Not only does the survey rely on the use of an industry vessel, but also their expertise related to when, where, and how to fish. Fishermen were critical to the creation of the program (i.e., problem identification) and to the survey design (where, when to survey). Another example is illustrated in the following description taken from the March 2004 cruise report that describes the contribution of fishermen's knowledge in locating initial stations for a new transect:

> "A specified location was chosen a priori based on bathymetric charts. The vessel steamed to the location and the Captain was permitted to search an area of approximately 1 nautical mile in diameter to identify a satisfactory location for the tow" (HSRL 2004, 2).

The knowledge and skills of the captain are critical to keeping the program consistent. When the original vessel was sold, the captain was retained to ensure consistency. The original captain trained the replacement captain and crew to assume the survey duties. Later the original captain took over the survey again with his new vessel. When the survey program purchased a new set of gear, identical to that of the original captain's, it did not work as expected by the other replacement vessel. The captain's knowledge of how the gear was rigged was critical to getting the gear to perform the same. In addition, when there was a shortage of scientists, the lead scientists asked the original captain to go out as a scientific crew person. The lead scientists recommended the captain participate given his familiarity with the protocols of data collection. This implies that the fisherman had gained "scientific" expertise, and this expertise was recognized by his scientific partners.

The most important instance of utilizing fishermen's knowledge occurred in January 2003 in Woods Hole at the initial planning meeting for the survey. This meeting included significant input from the fishing industry regarding where transects should be located, as well as the timing of sampling. This was based on their knowledge of the distribution and behavior of these commercial species.

The project also benefits from a supplemental survey planning group that meets in person or via conference calls to plan the survey and improve its implementation. Many of the "pre-cruise" planning meetings are held in conjunction with the Trawl Survey Advisory Panel meetings (chapter 8), which share many of the same participants. The planning committee addresses a variety of issues related to the survey. At a meeting held in July 2003 in Woods Hole, the committee addressed safety issues and subsampling concerns. A safety problem had resulted from the day-night scenario used to avoid diel variability, which forced some of the crew to work about 24 hours straight. The second issue involved subsampling. In September 2005, the group reached a consensus on how to spend some remaining funds related to the survey: they chose to use the money to purchase a 2nd set of trawl gear so that the captain of the F/V Jason and Danielle could get his gear back and so they could have a set for another vessel in the future. At other times, the committee has made similar decisions related to whether to spend available resources on additional tows, transects or surveys. The group also considered requests by interested scientists to collect more data. For example, a NEFSC scientist requested that the project collect more data related to *Illex* squid that would improve the future assessments of those species. As a result, the survey added *Illex* to the target species list starting May 2006 "to determine its usefulness as a pre-season indicator" (HSRL 2006, 3). This data may contribute to cooperative efforts to implement real-time management in the squid fishery (chapter 4). In sum, this “planning committee” has been critical to the success of the project and illustrates how this collaborative effort goes beyond just chartering a vessel for a survey.

In addition, fishermen contribute by generating funds for the research by participating in the NFI Auction. The auction makes research set-aside quota available for fishermen to bid on, generating funds for research. This program was described in chapter 3.

Fate of the Research: Mid-Atlantic Survey

After each survey, a cruise report is sent out to NMFS, NFI-SMC, and interested individuals. Data are eventually available in the NMFS-NEFSC survey database. Rutgers first audits the data and then sends them in a form perfectly compatible with the Science Center’s system. This ensures data are available immediately for use by scientists. NEFSC scientists praised this aspect of the transect survey program.

In March 2006, the NMFS sponsored a peer review of the Mid-Atlantic survey (Bonzek et al. 2006). The review panel found the “domain of inference” for this survey to be very limited since it would only reflect local abundance and patterns for sessile fish and invertebrates rather than population-level trends and is likely to be highly variable for mobile stocks. In addition, as an index, the utility of this survey was viewed as likely to be poor for species that may be at the edges of their distributions. In terms of biological sampling, the review panel did not understand how the allocation of biological sampling was balanced against doing more stations and suggested that a better balance could be determined with better communication with prospective users. In addition, they suggested that a comparative study with NMFS survey data is needed to demonstrate the utility of this survey, i.e. what it offers in addition to the data already collected. The Panel raised concerns that institutional memory, or documentation, was lacking in regards to the data, which may make the use of the data problematic in the future. And they raised questions regarding the utility of the survey for stock assessments:

> "The potential utility of this survey in assessments was not demonstrated…The Panel felt that direct inclusion of these survey results in a standard stock assessment context would require careful consideration and would be unlikely to have a large influence on results. The main utility of this survey within assessments is more likely to provide descriptive or qualitative patterns on seasonal and along shelf distributions. Such patterns may help interpret other survey and fishery data. In particular, species poorly sampled by NMFS survey gear may benefit from the SFS information (e.g., estimates of relative gear efficiency/catchability)" (Bonzek et al. 2006, 2).

However, data from the Mid-Atlantic survey are beginning to be used in the fisheries science and management process. For example, the data informed the 2005 annual specification for scup and was also considered in the *Illex* squid stock assessment in 2005 (Personal observation). And it was discussed heavily in regards to the silver hake (whiting) assessment in 2005, as well (Personal observation). However, the SARC peer review panel rejected the use of the data in the silver hake stock assessment (NEFSC 2006). The NEFSC assessment scientist attempted to calculate a relative efficiency coefficient between the transect survey and the NEFSC spring survey. This coefficient was then applied to the NEFSC survey data to obtain swept-area biomass estimates. The problem with this approach, as identified by the SARC panel, was that locations fished in the supplemental survey are assumed to be random with respect to silver hake distribution (as is the NEFSC spring survey). However, they felt this assumption was inappropriate because the transect locations were selected to have high likelihood of catching fish. The extent to which the tows are “non-random” with respect to silver hake is not known. This creates unknown bias when using the relative efficiency calculations. The panel did not feel this method was scientifically rigorous and thus rejected the resulting fishing mortality and stock biomass estimates. In this case, the SARC rejected how the supplemental transect survey was being used in the assessment (i.e., the assumption that the fixed stations were treated as random). It did not claim that the survey itself was flawed. Nevertheless, the fact that people are already considering these data is significant. The contribution of data collected from this program would likely be greater if it was funded to its full potential.

Conclusion: Integration of FEBK and RBK in IBSs through Translation of Scale

These cooperative industry-based surveys are as much a response to scientific uncertainty and desires to improve the science used in fisheries management as they are politically motivated by fisheries science and management crises. The two New England surveys are motivated by the ecological and political crisis in the groundfish fishery and especially concerns over the assessment and management of Atlantic cod. Most of the industry is not convinced that the severity of management restrictions implemented is warranted or at least based on sound science. Both the ME-NH inshore survey and the Cod IBS are responses to the economic impacts of the groundfish crisis, and vessel owners involved in those surveys openly acknowledge that financial benefits are a major reason for their involvement. The Mid-Atlantic survey can be thought (even if indirectly) as a reaction to management measures (i.e., GRAs) that were implemented based on poor survey data for scup (see chapter 6) and a failed attempt at cooperation (i.e., the F/V Jason and Danielle side-by-side tow survey). The Cod IBS and the Mid-Atlantic survey also came after “trawl gate,” which enabled the industry to politically “sell” the need for improved fishery-independent data collection, while at the same time, the NEFSC was seeking to improve relationships with the industry and trust in their science. In all cases, the fishing industry was dissatisfied with the way the NEFSC survey was conducted and/or disagreed with the resulting assessments based on those assessments (e.g., cod/groundfish and scup). The consensus was that the NEFSC did not reflect fishermen’s experience and knowledge regarding these species’ abundance and/or distribution. These cooperative IBSs emerged from this consensus.

These surveys may address some of the scalar (spatial and temporal) concerns regarding NEFSC survey. The scale and intensity of the IBS efforts differ significantly from the NEFSC survey. For example, all of the IBSs cover a significantly smaller spatial area compared to the NEFSC. The Maine-New Hampshire inshore trawl survey targets inshore coastal waters not sampled well because of difficulties with fixed gear and rocky areas. The Cod IBS provides more intense coverage in areas especially important for cod management. The Mid-Atlantic survey provides data to supplement for species that are not captured well by the NEFSC survey, not only because of the gear used, but also the timing and spatial extent of the survey (i.e., the transect survey covers greater depths and is more likely to hit migrating species when missed by the federal survey). While they cover a smaller area, they also tend to do on average more tows per area.

At the same time, the IBSs do not collect data on as many species as does the NEFSC survey. The NEFSC collects lengths and weights of everything it catches, more than 200 species. In addition, it often collects other biological samples, such as otiliths, scales, ovaries, etc. Unlike the other IBSs and the NEFSC survey, the cod survey is unique in that it is a single species survey rather than a multispecies survey, and data collection focuses on cod, although data are also collected for other species as well. The Mid-Atlantic survey, although a multispecies survey and catch weights are obtained for all species, lengths of only on 10 kinds of fish were recorded (summer flounder, scup, black sea bass, monkfish, spiny dogfish, skates, silver and offshore hake, *Illex* squid and *Loligo* squid). The IBS data will not be replacing what is currently collected by the NEFSC, and that survey will continue to function as it has (with possible exceptions that may arise when the survey is done with the R/V Henry Bigelow that cannot sample inshore waters).

Since management relies on stock assessments (for both effort and quota controls), data from these IBSs will be important to fisheries management so long as they are incorporated into assessments. These data will in theory supplement data collected by the NEFSC. For example, they could be used like a Massachusetts state survey (not discussed) to tune the models, particularly the data provided on recruitment for many species. These data become most valuable when part of a time series, but these surveys have only been going on for a few years now so their value cannot be fully evaluated. Yet, as discussed, data from these IBSs are beginning to be used. For example, data from the ME-NH inshore trawl survey are being used in the current American lobster assessment, and they have been used in herring and shrimp management. The Mid-Atlantic survey was considered in the *Illex* squid and silver hake (whiting) assessments (SARC 2005) and by the Scup Monitoring Committee in making annual specifications for the scup fishery. The Cod IBS is still very preliminary, but NEFSC scientists believe the data will be useful in the 2008 groundfish benchmark assessment, although not for abundance indices. Other industry-based surveys that have been incorporated into stock assessments include surfclam/ocean quahog, scallops, and monkfish. A one-time *Illex* squid industry-based survey has also contributed significantly to the assessment of *Illex* in 2003 and 2005 (NEFSC 2006, 2003). It certainly appears that the data from these IBSs will be valuable for stock assessments in the future, along with the NEFSC survey and various fishery-dependent data sources.

These IBSs represent a mechanism to integrate fishermen and their knowledge into science and management. Fishermen contribute to these industry-based surveys their knowledge of gear/vessel operations and local knowledge about the ocean bottom (gear-environment interactions), as well as in some cases their knowledge of the timing and locations of fish populations (fish movement and behavior). Essentially, they contribute their knowledge regarding when, where, and how to fish, knowledge and skills they have developed while fishing. Although these IBSs seemingly resemble “for-hire” research in that fishermen’s roles appear to be simply providing a research platform, industry participation in these efforts is both substantial and critical.

Fishermen contribute in these projects in different ways. First, the industry was involved in “asking the questions” that were the basis for these studies. The impetus of these IBSs came from the industry, which raised questions about and dissatisfaction with various aspects of the NEFSC survey. And these questions were based on their knowledge. The New England groundfish fishermen have long felt that not enough stations were done in the Gulf of Maine to represent the cod population, hence desires for more survey stations in the GOM. The industry in the Mid-Atlantic was very proactive in questioning the value of the NEFSC survey for catching Mid-Atlantic species like scup and squid. For example, fishermen noted that the variability in the timing of Mid-Atlantic species, as well as their behavior, meant that the federal survey could easily miss them. Mid-Atlantic fishermen pointed out that the NEFSC survey likely missed scup because in some years the survey landed a lot and sometimes landed none. They also knew that the NEFSC survey data did not likely reflect the abundance of pelagic species that were too high in the water column for the survey gear (e.g., squid).

In addition to asking questions, fishermen were also heavily involved in the design of these industry-based surveys. For example, based on when and where they tended to see these species, Mid-Atlantic fishermen knew when and approximately where would be good places to do a survey, and this knowledge factored heavily into the placement of the transects used in the survey. Scientists recommended the design itself, using transects as an alternative to random stratified sampling. In the ME IBS, fishermen were less involved in the design, but did select some of the fixed stations. In each of these studies, fishermen also contributed to the design or selection of the fishing gear used in these studies. For example, in the Mid-Atlantic survey the gear used reflected industry desires to catch more of the pelagic species than are caught by the NEFSC survey gear. The survey used the gear of the vessel that initially conducted the survey. The Cod IBS worked with the industry to design and test (in flume tanks) the gear that it uses. The owner of the vessels used in the ME-NH survey and his gear manufacturer designed the survey gear. Many of the other IBSs not discussed in detail here target a specific species (e.g., yellowtail flounder IBS, monkfish survey, surfclam/quahog survey), and so fishermen provide advice on the gear that best catches those species. For example, the monkfish IBS uses commercial gear and is catching monkfish (something that the NEFSC survey does not do well).

Fishermen also contributed to the design of these projects in the logistical planning phases. For example, the Mid-Atlantic survey had a planning committee composed of fishermen and scientists that met every few months to discuss logistical issues and ways to improve the survey. They have dealt with issues involving such things as what transects to do (involving a tradeoff between spatial coverage and numbers of stations), how to improve at-sea sampling procedures (including what and how to sample), and safety issues. A series of workshops throughout New England allowed fishermen to contribute to the planning of the Cod IBS. Maine lobstermen have been involved in the logistical issues of doing the ME-NH inshore survey that arise due to fixed lobster gear. Scientists at ME DMR attended lobster zone council meetings to help with the planning of where and when to do the survey.

Fishermen contributed to the data collection process, most obviously by providing research platforms, but also as “hands” that helped process the catch. Most fundamentally, all of these surveys used fishermen’s knowledge of gear and vessel operations. The fishermen “drove” the boats and “fished” the gear. The surveys used their local knowledge of bottom type, such as to avoid rocks or hang-ups that would tear the nets. Fishermen were critical in the selection of many tows. For example, fishermen selected about ½ of the stations in the Cod IBS and fishermen identified the fixed stations in the Mid-Atlantic survey (based on where in a specific area was fishable). In the ME-NH survey fishermen did not pick the stations, but their knowledge does factor into decisions about whether the station selected is towable (e.g., if the gear will get caught up on the bottom or in lobster gear).

Another critical role of fishermen in these efforts involves generating buy-in to these programs. Fishermen talk about and spread the word about the project and therefore generate buy-in to the project results. For example, Captain Jim Ruhle is involved in the Mid-Atlantic survey (on the planning committee) and is a member of the MAFMC, and was often heard praising the value of the transect survey. Captain Curt Rice, who runs the F/V Robert Michael, has presented his experiences doing the ME-NH inshore trawl survey to fishermen and other interested stakeholders at the Maine Fishermen's Forum. These captains are important boundary spanners.

Indirect participation is also critical in these efforts, although difficult to quantify. The industry's efforts go beyond those involved in the at-sea operation of the surveys. The Maine DMR is responsible for the ME-NH inshore survey with participation by the fishing vessel owner, captain, and crew. Yet lobster fishermen contribute significantly by either moving their traps when necessary or trying to build up support for the survey within the lobster fishing community. While the contribution of the lobster industry may seem fairly minimal, the survey could not be done without it. Industry participation in the Cod IBS includes those involved in the initial planning workshops organized by GMRI, those on the steering committee, those conducting the research at-sea, and those involved in follow-up workshops aimed to make improvements after almost a year of the survey (i.e., the IBS workshop held in August 2004). The Mid-Atlantic supplemental finfish survey similarly involves the industry both on land and at sea. The planning committee consists of a number of fishermen and has contributed significantly in the development and implementation of the survey program. The industry at-sea contribution consists of the captain and the vessel and its crew. And industry participation in the research set-aside program funds the survey.

IBSs can be considered a way to produce knowledge at a scale that is more compatible with the scale at which FEBK is produced. As traditionally conducted, fishermen's local experiences typically are not reflected by the large-scale NEFSC trawl survey data. For example, the NEFSC survey often does not see "local" changes in the distribution of migratory species noted by Mid-Atlantic fishermen. In the Gulf of Maine, the NEFSC bottom trawl survey does not seem to reflect fishermen's local knowledge of cod distribution and abundance, most likely because the survey samples only a few stations in state waters. In this way, the NEFSC survey misses local phenomenon. By sampling at a smaller scale these IBSs should produce data that is more likely to reflect local processes observed by fishermen.

At the same time, it is also important to reconcile the scale of FEBK, which may miss regional (large scale) phenomenon. For example, although fishermen may believe fish populations to be abundant, scientists note that as fish populations reduce in size, their spatial distribution contracts. This means that fishermen fishing on these smaller concentrations may observe large quantities but this is only true from their scale of observation. A look at these populations from a larger (spatial and temporal) scale is thus also necessary. Ideally, the NEFSC survey and these IBSs should allow scientists and fishermen to construct a more precise picture of the resource.

It can also be considered a translation of fishermen's knowledge into something usable by science and management: RBK. For example, it is insufficient for fishermen to state that they know more scup is available than seen in the survey or predicted in the assessments; science (or quantitative data) must verify this. Fishermen “know” there are more cod than the assessments predict, and this knowledge enters the cooperative research process and then perhaps may be verified by science. Again, as noted elsewhere, the main reason for this barrier is institutional; legal mandates require the use of the best scientific information available. The “best” is typically quantitative and relevant for a much larger spatial scale than can be provided by fishermen’s observations. These and other cooperative efforts give FEBK an opportunity to be used in a way that is not possible otherwise due to the institutional nature of fisheries management.

In addition to the valuable role of the industry partners, scientists were also critical to the success of these programs. Like the IBS captains, these scientists are also boundary spanners. The most important roles of the scientist partners include writing the proposal to fund the research, ensuring the standardized collection of data at sea, dealing with logistical issues such as staffing the survey and acquiring necessary scientific equipment, analyzing data, report writing, and disseminating the results. In the first task, scientists are translating the research question, often posed by fishermen, into a fundable scientific research project. Scientists are needed to ensure that the results are credible by maintaining accepted standards of scientific data collection. The scientists also needed to translate the outcome of the cooperative effort into a form that is both understood and accepted by other scientists and fisheries managers. These tasks require knowledge of what is considered acceptable scientific protocol, as well as skills at statistical data manipulation and presentation. If data are not conveyed effectively and accurately, they are less likely to impact fisheries science or management. Finally, scientists provide the effort with legitimacy and credibility.

In examining these efforts, we see many instances of boundary spanning and capacity building. As discussed, fishermen's knowledge is incorporated into science in these efforts. Fishermen's technical knowledge about gear deployment and vessel operations (and gear design), as well as their local ecological and environmental knowledge related to how different gear configurations interact with specific species or species assemblages in different environments, were incorporated into the scientific process. In this way, the fishery-independent data reflect, at least indirectly, the knowledge of fishermen. This flow from FEBK to RBK is crucial to improving the perception not only of stock assessments, but of management based on those assessments. And fishermen learn from scientists too, suggesting flow both ways across the boundary. Though their participation at-sea, fishermen gain an understanding of how fishery-independent data is used in assessments and management. And they have gained an understanding of survey design, such the rationale for random sampling and why it is the representativeness of the catch that is more important than its quantity. For example, the captain of the Mid-Atlantic survey, and a member of the Trawl Survey Advisory Panel, raised important concerns about the effects of subsampling in the survey, which is a "scientific" problem. Fishermen have learned the challenges of doing science, and have gained an appreciation and respect for the scientific profession. Many captains compliment the scientists' work ethic in these surveys. These examples of capacity building facilitate translation and communication of knowledge and expertise across the Science/Non-science boundary.

[1] These IBS case studies are based on ethnographic research that included informal and semi-structured interviews, direct observation, and a review of documents (Bernard 2002) from May 2003 to August 2006. Semi-structured and informal interviews were conducted with fishermen, scientists, and managers. At a minimum, for each IBS, the chief scientist was interviewed and at least one captain, crew, or vessel owner involved in the survey. At each meeting observed, extensive notes were recorded. From January 2003-April 2006, I observed eight planning meetings for the Mid-Atlantic Transect Survey, most of these were held following the Trawl Survey Advisory Panel meetings. These meetings were typically attended by the principle investigator, the chief scientist, fishermen, and NEFSC scientists. I also observed the two day NMFS sponsored Industry-Based Survey Workshop held in Portsmouth, NH in August 2004, which featured a review of the Cod IBS and some discussion of the ME-NH inshore trawl survey. In addition, the Cod IBS and the ME-NH Inshore Trawl Survey were discussed at several NEFMC Research Steering Committee meetings. Documents reviewed include media reports, technical reports, and transcripts of fishery management councils meetings. The most important of these were the final or cruise reports provided by the Maine Department of Marine Resources and Rutgers University Haskin Shellfish Laboratory for the ME-NH inshore trawl survey and the Mid-Atlantic Transect Survey, respectively. A final report was also available for the Cod IBS (Hoffman et al. 2006). In addition, peer review documents for all three surveys were available (Chouinard, Beutel, and Legault 2005; Chouinard, Weinbert, and McGovern 2006). Posters of depicting the Mid-Atlantic transect survey were on display at several conferences and meetings (King 2005; King, Bochenek, and Powell 2005). The MA DMF provided several short articles about the Cod IBS (Hoffman 2003, 2004) and a PowerPoint presentation of the survey from the IBS workshop. Finally, websites were available for the ME-NH inshore trawl survey (http://www.maine.gov/dmr/rm/trawl/trawl.htm) and the Cod IBS (http://www.mass.gov/dfwele/dmf/programsandprojects/ibsurvey.htm). In addition, there is a public website available to explore and map the data collected from the Cod IBS (http://www.gmamapping.org/trawl/MapIndex.jsp). Also, before this research started, in 1999-2000, I observed several Maine lobster zone council meetings where ME DMR staff was “selling” the Maine-NH inshore trawl survey to lobstermen, asking them for cooperation by moving their fixed gear.

[2] In addition to these references, this discussion of the NEFSC bottom trawl survey is informed by interviews with NEFSC scientists and regional fishermen, as well as documents provided through the Trawl Survey Advisory Panel. In addition, the NEFSC website also describes the survey in detail.

[3] Since1992, a winter survey using a “flat-net” trawl has been used to obtain more representative samples of demersal fish species, including flounders, skates, and goosefish. This survey covers an area from just north of Cape Hatteras to the southern flank of Georges Bank.

[4] Captain Jim Lovgren (2002) from New Jersey, also a member of the Trawl Panel and former MAFMC member, provided an insightful account of his and the other fishermen’s

experience on the observation cruise. Several other fishermen also provided similar accounts of their observations.

[5] One critical source of conflict arises when fishermen believe that catching more fish means that the stock assessments will be higher when in fact it is the representativeness of the sample that counts more than the quantity of fish landed. Interestingly, as is seen in this research, many fishermen now have a greater scientific understanding as a result of their participation in these cooperative surveys. For example, in the Trawl Survey Advisory Panel, fishermen received presentations that described how survey data are used in stock assessments and so have an understanding that quality of the catch (i.e., representativeness) is more important than quantity. Fishermen on the Panel are seen explaining this to other fishermen, as justification for why such a seemingly small net is being recommended for the new research vessel given its large size. As I discuss in this chapter, fishermen participating in the industry-based surveys also learn this and other fundamental aspects of surveys through their participation.

[6] The outer depth stratum was not sampled from Fall 2000-Fall 2002. The outer stratum was added in Spring 2003, expanding the coverage to the area approximately equal to the area covered by the ASMFC and allows more overlap between this survey and the NEFSC survey.

[7] Historical importance was determined in part on previous surveys conducted by the ME DMR.

[8] In interesting aside to this story is that this scientist, Carl Wilson, developed a relationship with the industry as a graduate student with Dr. Robert Steneck at the University of Maine, who is one of the first academic scientists to really involve lobstermen in the collection of scientific data in the lobster industry. Dr. Steneck and Mr. Wilson established a rigorous sea-sampling program that continues today, where scientists spend long hours with fishermen at sea sampling their catch. A recent book by Trevor Corson (2004), *The Secret Life of Lobsters*, describes the collaborations between these scientists and the lobster fishing industry. Dr. Steneck's research with the industry was pivotal to the creation of the Maine lobster zone councils that implement co-management in this fishery.

[9] For more information see the final repot, "Southern New England Industry-Based Yellowtail Flounder Survey, 2003-2005 Pilot Study Report" (Valliere and Pierce 2007).

CHAPTER 8: INDUSTRY-SCIENCE COLLABORATION: THE TRAWL SURVEY ADVISORY PANEL

Introduction

In this chapter, I examine the Trawl Survey Advisory Panel as another case study of integrating fishermen's experience-based knowledge (FEBK) with scientific-based research knowledge (RBK). Like the industry-based surveys (IBS) discussed in the previous chapter, this effort aims to improve the collection of fishery-independent data used as the basis of stock assessments and management and by addressing limitations of the NEFSC survey. While the IBS efforts collect data that will supplement the NEFSC fishery-independent survey data, the Trawl Survey Advisory Panel attempts to address the problems of the survey at its origin. This case also differs from the other case studies in this dissertation in that it does not rely on industry vessels. In this way, it is similar to "collaborative research" defined by Fischer (2000, 176) as "a deliberative process in which a practitioner(s) and a client system are brought together to solve a problem or to plan a course of action through the process of collective learning," although in this case fishermen are by no means "ordinary citizens" but are recognized as having "contributory expertise" (Collins ad Evans 2002). Specifically, they are recognized for their expertise related to gear and vessel operations. The case provides an opportunity to explore what happens to the boundaries between FEBK and RBK as a result of industry-science collaboration in scientific research. The following account describes the Trawl Survey Advisory Panel and its activities from May 2003 to April 2006.[1] I begin by describing the context of the collaboration, and then describe the case study.

Case Study: The Trawl Survey Advisory Panel

Impetus for collaboration: “Trawl Gate” and the R/V Henry B Bigelow

Two events provided the opportunity for fishermen to contribute to improving the NEFSC bottom trawl survey. First, a political need arose in September 2002 when the NEFSC announced the miscalibration of the gear used on the NEFSC trawl survey (Malakoff 2002; NEFSC 2002b). The trawl warps connecting the doors to the nets had been mismeasured and so were of unequal length when towed, making the net fish improperly. A local fisherman first noticed that the warps were mismarked and reported this to the NEFSC, which confirmed the error 2 years later (Cook and Daley 2003). This error – and the delay in confirming it - was dubbed “trawl gate” by fishermen, and skepticism quickly emerged regarding the validity of stock assessments and management (Plante 2002c). Additional concerns regarding the gear and operation of the survey were identified when six fishermen observed the survey in operation (Lovgren 2002; Plante 2002b). In addition to its “scientific” response (i.e., analyzing data and conducting calibration experiments), the NEFSC pledged to improve the survey and respond to stakeholder concerns. Fishermen participated in a trawl survey workshop (NEFSC 2002b) and fishermen and an industry vessel were utilized in a calibration cruise aimed to understand the effects of the warp error (Plante 2002a). Although two peer reviews concluded that the trawl warp miscalibration had no effect on the results of the survey (Payne 2003; NEFSC 2002a), the NEFSC agreed that some changes were necessary. In response to the peer review, the Director of the NEFSC stated:

> “The NEFSC agrees that the current survey design and time series provides useful information for science and management interests, and will not immediately alter the currently employed methodology without careful consideration. However, the NEFSC also recognizes the evolving needs of management and science as outlined in the Findings and Recommendations of the October 2002 Trawl Survey Workshop, and is committed to implementing a strategic process to refine and develop new survey systems. These survey systems will utilize enhanced capabilities of a new research vessel, experience gained through 40 years of surveying, and gear and net mensuration technology to upgrade surveying systems in the near future. A strategic design process will be implemented that includes involvement of fisheries scientists, managers, and a diverse group of stakeholders” (Boreman 2003).

The second precipitating event was the thirty-eight million dollar appropriation by Congress for a new, state of the art scientific research vessel dedicated for the Northeast. At 208.6-feet, the R/V Henry B. Bigelow is much larger and more powerful than the vessel it replaces, the 187-foot R/V Albatross IV, which has conducted the survey since its inception in 1963, described in the previous chapter (Table 8-1). The impending arrival of the new vessel created a pragmatic need for new survey gear. To paraphrase one fisherman, “why put fifty year old gear on a 21st century vessel?” This also was a welcomed opportunity for scientists as well: as one NEFSC scientist explained: “"We don't get to revise our technology very often" (Griffin 2005).

Table 8-1: Comparison of the R/V Henry B. Bigelow vs. R/V Albatross IV

Characteristics	**Henry B. Bigelow**	**Albatross IV**
Launched	July 8, 2005	April 1962
Length	208.6 ft.	187 ft.
Draft	19.4 ft.	16.2 ft.
Speed	14 knots	10 knots
Endurance	40 days	16 days

<u>Description of the Panel and its Activities</u>

The Panel is a unique advisory committee, composed of fishery management council members, fishermen, and expert gear/survey scientists from New England and the

Mid-Atlantic. The Panel consists of two council members and two fishermen from each region, five non-government scientists, and two NEFSC scientists. Three of the four council members are fishermen (Table 8-1). A MAFMC representative chairs the panel, while the vice-chair is a NEFMC representative, and both are fishermen. All members are leaders in cooperative research and management in this region. This translates into a group that understands the complex, technical and scientific problems being addressed and also has the experience, knowledge, and skills with which to communicate.

The charge of the committee is to provide advice to the NEFSC regarding its trawl survey. The Panel met twelve times from May 2003 to April 2006. All but five meetings were held in New England to provide accessibility for the gear vendors and NEFSC scientists. All meetings were open to the public. Overall, attendance by New England members, particularly those chosen to represent the Gulf of Maine, was less consistent than was that of Mid-Atlantic members (Table 8-2).

To illustrate the different levels of participation, I examined attendance by committee members. First, I calculated attendance by region and position category by calculating the percentage of meetings were where *at least one* participant was present for each category and region (Table 8-1). Grades were assigned to each participant category based on these percentages. The lowest grade (i.e., poorest attendance) was given to New England council members (who were also fishermen).

Table 8-2: Composition of the Trawl Survey Advisory Panel and Attendance by Panel Assignment. **Attendance is based on the number of meetings with at least 1 member of the position type present. Grade A = 100-90%; B=80-89%; C=70-79%.**

Region	Participant Category	# of Members	% Attendance at meetings	GRADE
Mid-Atlantic	Council member	2	100	A
	Industry	2	92	A
New England	Council member	2	75	C
	Industry	2	92	A
Mid-Atlantic	Academic Scientist	2	91.7	A
New England	Academic Scientist	2	83.3	B
NEFSC	Federal Scientist	2	100	A

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Next, I explored the attendance of each specific position (Table 8-2). This does not reflect individual attendance since some members switched position categories. For example, one fisherman who was initially a New England industry advisor later became a NEFMC representative when he was appointed to the council. This fisherman attended all meetings. This member did not represent the Gulf of Maine fishermen, but rather Georges Bank and Southern New England fishermen. Again, we see that on average New England participation was lower than Mid-Atlantic, although this varied by position. Note that two New England fishermen that did participate consistently represented Georges Bank and Southern New England fishermen rather than Gulf of Maine fishermen. Interestingly, New England scientists also participated less than Mid-Atlantic scientists. These differences in attendance by region are even more interesting considering that most of the meetings were located in New England.

Table 8-3: Composition of the Trawl Survey Advisory Panel and Attendance Grade by Position and Region. [1] Members appointed to the council member position were also fishermen, except for the non-chair MAFMC council member after year 1. [2] Grading is as follows A=90% or higher; B=80%-89%, C=70%-79%, D=60%-69%, F=below 60%.

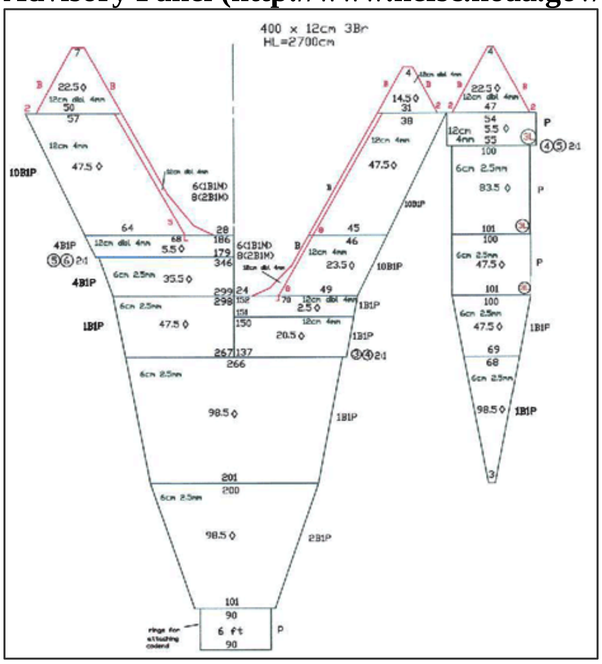
Region	Participant Category[1]	MEETING MISSED	% Attendance	GRADE[2]
Mid-Atlantic	Council member * (Chair)	0	100%	A
	Council member	1	91.7	A
	Industry	2	88.3	B
	Industry	8	33.3	F
	AVERAGE		78.325	C
New England	Council member (Vice-Chair)	3	75	C
	Council member (and Industry)	6	50	F
	Industry	4	67	D
	Industry	5	75	C
	AVERAGE		66.75	D
Mid-Atlantic	Academic Scientist	1	91.7	A
Mid-Atlantic	Academic Scientist	5	58.4	D
	AVERAGE		75.05	C
New England	Academic Scientist	7	41.7	F
New England	Academic Scientist	3	75	C
	AVERAGE		58.35	F
NEFSC	Federal Scientist (Survey chief)	0	100%	A
NEFSC	Federal Scientist	2	88.3	B
	AVERAGE		94.15	A

Principal Task: Designing the Net

The principal challenge of the Panel was to design a new trawl system that would fish consistently and achieve a more representative catch compared to the old survey net, while at the same time not catching too many fish. Because of the timing of the delivery of the new vessel, the Panel was under strict deadlines.

The Panel agreed upon the performance characteristics of a trawl system to be used in the multi-species trawl survey. The Panel also established that industry gear manufacturers would be important in designing a trawl system. They were viewed as having the necessary expertise and skills, and were trusted by the fishing industry. Trust was important in order to design a survey that would produce industry confidence in the survey. After deliberation with the Panel, three trawl gear manufacturers collaborated to develop a 4-seam, 3-bridle net, which was endorsed by the Panel for consideration and testing (Figure 8-1).

Figure 8-1: Proposed trawl survey gear recommended by the Trawl Survey Advisory Panel (http://www.nefsc.noaa.gov/TrawlNet/).



According to one gear manufacturer involved in the design of the net, the intent was to design something recognizable to the industry from Maine to North Carolina, “a familiar net industry wide – something that everyone has seen or wouldn’t have too much opposition to.” The proposed net is based on a net that is about fifteen years old and is similar to what is commonly used in the Mid-Atlantic. The Panel also identified two different sweeps for potential use in the survey to address different habitat types found throughout the region; a cookie or flat sweep and a rock hopper sweep.

Once a preliminary design was adopted, five field cruises and flume tank testing were carried out from fall 2004 to spring 2006. Field tests were conducted by NEFSC scientists aboard the R/V Delaware II because it utilized the same wire size that would be used on the new research vessel. Interestingly, the trawl wire size for the new research vessel was among the first Panel recommendations adopted by the NEFSC. Additional testing on the new vessel is planned, including calibration experiments between the two vessels. A number of tows were done alongside the R/V Albatross IV during its survey for catch comparisons. Flume tank testing was done at Memorial University in Newfoundland, Canada in the spring of 2005. Members of the Panel, both fishermen and scientists, participated in the flume tank testing, which allowed for the determination of optimal gear performance criteria (i.e., door spread, wing spread, and bridle angles).

The Panel contributed significantly to the interpretation of the data. After each cruise, NEFSC scientists reported results to the Panel which generated additional recommendations. The most critical issue that persisted throughout the development of the new net was the overspreading of the net. To address the problem, the Panel recommended several different door types and/or door sizes be tested to try to achieve optimal spreading. Other Panel recommendations included advice regarding how to reduce gilling/meshing, how to prevent twisting of the bridles, where to place net sensors, how to place and distribute weight on the rock hopper sweep, how to measure warp, and how to handle large catches. The Panel provided advice regarding training and expertise of crew on surveys, criteria to determine if a tow is considered acceptable, how to standardize the setting and hauling procedures (i.e., use of Auto Trawl System), how to best conduct outreach efforts with the industry, and how to address fixed gear conflicts.

Overall, testing of the proposed net design indicates that it is a significant improvement on the old survey net. According to one Panel member, “It's just phenomenal, the catchability of this new gear versus old gear.” Compared to the old net, a gear manufacturer said the new trawl “has [the] ability to open up fully and has the ability to spread out more, and maintain its contacts with the sea floor.” Due to the third bridle, the headrope height achieved is expected to improve significantly (about fifteen feet vs. about six feet). Thus, based on the results of several experimental cruises and flume tank testing, the Panel voted nine to one in April 2006 to recommend a modified version of the 3-bridle, 4 seam net design. Approximately eight months later, both regional councils and the NEFSC formally adopted the recommendations of the Panel.

While the Panel was working to design gear for the new research vessel, significant effort was made to ensure an open and transparent process. For example, presentations were made to both regional councils and to industry forums. The NEFSC also discussed the proposed gear with manufacturers not involved in its design. There were also articles in fishery trade papers and a website depicting the proposed trawl system and the Panel process. The website asked for comments and recommendations on the proposed trawl system. However, although there seemed to be interest in what was going on, there was surprisingly little response provoked by the presentations or website. Given the typically outspoken nature of the industry, this might suggest a level of acceptance regarding the Panel’s recommendations, but the new design was not universally accepted and the process did not occur without conflict.

Below I discuss two critical instances of conflict that arose with the Panel. The first was conflict between government scientists and the Panel (mainly industry members). The second instance included conflict between two groups of fishermen.

Conflict 1: The NEFSC Tests Alternate Design

Throughout the process, the NEFSC expressed several concerns regarding the adjustability and complexity of the 4-seam, 3-bridle net proposed by the Panel. The adjustability issue was due to the need to make sure the net is fished the same way each time (i.e., for standardization). There was some concern that the net would have to be adjusted to fish consistently. And there was concern that the net might be too difficult to repair given its complexity. Related to these concerns was the issue of expertise regarding the modern fishing gear, specifically whether the NEFSC scientists and crew on the survey would know how to make repairs and deal with the complexity of the gear. To address these concerns, the NEFSC also tested a 2-bridle version of the Panel's net in February 2005.[2] This was considered a "hybrid" of the Panel's recommendation.

The NEFSC's decision to test a 2-bridle version of the recommended net came with consternation when it was proposed to the Panel in December 2005. The industry Panel members especially voiced their concern that going to a 2-bridle net would reduce significantly the headrope height achieved by the proposed net, a prediction based on their experience and knowledge using both types of nets. As several fisherman pointed out, the net had evolved from a 2-bridle to a 3-bridle net, and so making it into a 2-bridle amounted to "going backwards." There was also the issue that the gear manufacturers who designed the new net for the Panel were not consulted. Several industry members rhetorically told the NEFSC to "go ahead and test the net," expressing confidence that they would be proven right. One fisherman referred to the decision as “cavalier” and “offensive.”

Industry panel members were especially concerned that the NEFSC was abandoning its intention to take seriously stakeholder advice and concerns regarding the trawl survey. In addition, the decision to go ahead and test the 2-bridle net design was considered a dismissal of fishermen’s knowledge. There was a tacit and sometimes explicit acceptance among Panel members that the Science Center lacked expertise regarding fishing gear and fishing operations, which is what made the contribution of the industry so important. To them, ignoring the advice and expertise of the industry members undermined the spirit of the collaboration. In addition, several Panel members objected to the process, dismayed that the decision had come outside of the Panel.

Although the NEFSC felt that it had acted legitimately, as it had approached the Panel before proceeding to test the alternate design, several Panel members were skeptical. At the heart of the issue was the Panel’s feeling of ownership of the process and the context of distrust regarding the NEFSC that existed historically, which had come to a head with “trawl gate” and resulted in the formation of the Panel. The Panel had invested several years at that point in the design of the survey gear, and to have their recommendations seemingly dismissed was viewed as capricious and unjustified. It was obvious that a high level of skepticism and distrust still remained after three years of collaboration, which was exacerbated by poor communication. The distrust surfaced when the NEFSC appeared to make decisions outside of advisory process and to dismiss the advice of the Panel. Until this point, the Panel’s recommendations were essentially translated into action by the Science Center. Yet there is no formal requirement that the

Panel's advice be strictly followed. In these kinds of advisory panels there are often expectations that the governing agency will follow the advice, and when such expectations are not met, the collaboration can disintegrate. One way to avoid this is to communicate expectations throughout the collaboration and provide adequate explanation when advice is not followed. [3]

In this case, the dispute at the meeting settled fairly quickly (within an hour or so) at the next meeting in March 2006. Panel members and the public were given an opportunity to express their views and then the NEFSC representative listened and responded accordingly in a calm and coherent manner. By allowing everyone to communicate honestly and openly, the issues at the core of the conflict were addressed. Another key reason why the conflict was resolved was because the principle issue was no longer relevant: based on the testing in February 2006, the 2-bridle net design was abandoned by the Science Center as it did not meet performance expectations, confirming the industry's predictions.

In summary, the decision by the NEFSC to test an alternate net of its own was not viewed by some Panel members as legitimate because it conflicted with fishermen's knowledge. To them it appeared an outright dismissal of the fishermen's knowledge. Again, a primary impetus for having fishermen on the Panel was to tap into their knowledge regarding fishing and fishing gear. The decision was not considered legitimate because it did not come from the Panel. The discussion initially lacked salience due to the way the decision was presented – i.e., the NEFSC was not asking the Panel to test the gear, but was telling them that it was going to test it. It had not been explicit enough about why it was testing the gear. The impetus for testing the alternate net was unclear initially. As discussed below, some Panel members felt it was due to pressure from stakeholders operating outside of the process, and so felt it was not legitimate. In reality, it was an attempt by the NEFSC to address concerns that had not yet been addressed by the Panel. When communication occurred, the issue was resolved fairly quickly. Thus, at the heart of this conflict was a failure to communicate by both Panel members and the NEFSC.

The need for transparency is often cited in the literature as necessary in policy-making, especially when the public is involved in decision-making. This case shows that transparency is sometimes difficult to achieve. What is transparent to one party may not be to another. The NEFSC felt it had been transparent because it had brought its decision to the Panel before it implemented the decision. The Panel felt that the NEFSC had not been transparent because the decision had emerged outside of the process. The perceived lack of transparency had a direct impact on the levels of trust and legitimacy that Panel members held for the process.

This case study also illustrates how quickly relationships developed through collaboration can be broken down by simple miscommunication as well as conflict over the powers of the collaborating group. The conflict that developed between the NEFSC and the Panel when the former decided to test a net of its own design could have been avoided had there been greater communication between these groups. The panel was able to overcome this conflict by keeping the lines of communication open, especially the face-to-face interaction provided by the Panel meeting. This suggests the need to maintain interactions between collaborating partners. Without sufficient communication across the boundary, these kinds of collaborations cannot effectively manage the boundary between science and policy or science and non-science.

Fortunately, the nature of the process overall and the personal investment that the members had made in the process had created an environment that allowed the Panel to overcome this issue. In this case, the Panel functioned as a boundary institution (Guston 2000; Cash et al. 2004) by enabling communication, translation, and mediation among fishermen, academic scientists, and government scientists. The structure of the meetings provided opportunity for communication between the Panel and the Science Center, the experience and deliberation throughout the Panel process gave fishermen and scientists a shared understanding, and the professional, open nature of the meetings provided an adequate opportunity for conflict resolution. In addition, the inclusion of and active participation by a key NEFSC representative facilitated communication between the Science Center and the Panel.

Conflict 2: Gulf of Maine Fishermen React to Proposed Net Design

The more substantive conflict occurred in September 2005, after two years of deliberation that resulted in the selection of the 4-seam, 3-bridle net, when several New England fishermen, primarily from the Gulf of Maine, expressed concerns about the proposed net. They argued that a 3-bridle net is too complicated for use in a survey. This echoed the initial NEFSC concern regarding the complexity of the net. In addition, fishermen expressed concern that the type of doors considered would not work in both shallow and deep waters. There were concerns about using the net in complex habitat that is prone to gear tear ups and in the mud where they feared the doors would sink. The fishermen also expressed concerns regarding the level of expertise in the NEFSC to handle this new and complex net. An added fear was that the NEFSC might abandon tows that it felt might tear up the net, which would bias the survey. The Gulf of Maine fishermen were also concerned that the original purpose of the “groundfish survey” was being lost in favor of “a Mid-Atlantic survey.” A newly appointed GOM industry representative to the Panel voiced these concerns. These fishermen’s concerns were based on their knowledge of fishing in the Gulf of Maine and their interests in improving the assessments of groundfish. Additionally, a GOM fisherman proposed an alternate net for consideration. Coincidentally, this fisherman was an original Panel member but resigned after one meeting when he disliked the direction the Panel was going.[4]

The other industry Panel members remained unified behind the proposed gear. They emphasized that many of these issues had been addressed. For example, a training program is planned to provide necessary expertise, net sensors are to be utilized, and protocols with “infinite detail” would make the gear “idiot proof.” Further, additional nets can be stored on the larger vessel, so that if gear is torn up it can be easily replaced. They felt that the alternate net proposed was a step backwards and that modern gear was needed for the new survey. The Panel also assured that once fixed, the 3rd bridle would not need further adjustment. Further, based on their own experience, several Panel members believed that the proposed gear would work in the Gulf of Maine. The non-government scientists recommended the alternative net and proposed nets be tested more to resolve this conflict. The government scientist maintained impartiality given his political position.

It also appeared to be a process and legitimacy issue. The Panel members felt that these concerns were being raised too late. The Panel had invested significant effort in making its recommendation under strict deadlines. The Panel noted the absence of New England representation despite meeting locations that often favored this group. In their minds, the process had allowed equal opportunity for the Gulf of Maine fishermen to raise their concerns and contribute. On top of that, two of the fishermen who expressed "serious concerns" regarding the proposed net had been initially appointed to the Panel but had chosen not to participate. Panel members objected that these fishermen expressed their concerns at the end rather than working within the process that had been established.

To be sure, the Mid-Atlantic members dominated the discussion regarding the new gear design. But this was apparently because the Gulf of Maine fishermen chose not to participate. The panel acknowledged the tradeoffs inherent in designing a net to sample such a diversity of species throughout such a large geographic area. They recommended a gear that they believed would work best given the range of the survey and species to be sampled. In addition, the decision was influenced by the expertise of several fishermen on the Panel who fish in both New England and Mid-Atlantic fisheries using gear similar to that proposed for the survey.

In the end, the Panel considered the concerns of the Gulf of Maine fishermen and the alternate net. After discussion with gear manufacturers and the fisherman proposing the net, it was determined that the alternate net could not be scaled down for use in the survey. The March 2006 field experiments tested the 4-seam, 3-bridle net in the Gulf of Maine, but unfortunately not in the mud where fishermen were concerned that the doors would not work. There were plans for additional testing throughout the Gulf of Maine, but this did not occur due to a lack of funding. It will likely occur with the new vessel. Fishermen and gear experts familiar with the proposed gear remain confident that it will catch groundfish in this area. In addition, the Panel is considering the option of using two different sweeps to address regional habitat differences. In theory, the use of two sweeps could maximize catchability throughout the sampling area. Additional testing will occur with the new research vessel.

In December 2006 and February 2007, the MAFMC and the NEFMC both voted to accept the Panel's proposed gear. The NEFSC also formally accepted the gear. The vote included the use of two different sweeps, although it has not yet been decided if in fact two sweeps will be used. Interestingly, little opposition was expressed at the meeting, indicating that the conflict between the two groups has subsided for now.

Understanding this case study requires an appreciation that the "cultures" involved in the collaborative effort were not simply those of "fishermen" and "scientist." Within the fishing industry are very different "cultures." Obviously the designation of these groups as "two cultures" is a simplification because within these groups are numerous other "sub-cultures" (such as ethnic, gear, political, species-based groups). Yet, differences between these two groups may explain the differential responses to the Panel. One critical difference is the fisheries management institutions that manage these fishermen. The two regional fishery management councils are structurally similar but institutionally, culturally, and politically very different. For example, New England management relies upon effort control measures (principally days at sea limits), while the Mid-Atlantic focuses on output controls (i.e., quotas). Early efforts to implement quotas in the New England groundfish fishery proved unproductive as they resulted in frequent closures and openings of the fishery (Acheson 1984), which angered fishermen and wrecked havoc on the market. Instead, New England managers adopted effort controls, such as days at sea limits, area closures, mesh size restrictions, etc. Along with management protests resulting from attempts at quota management, New England fishermen also developed a distrust of scientific advice (Smith 1995; Dobbs 2000), which is simply not seen to the same degree in the Mid-Atlantic (NMFS official, personal communication). This was described in chapter 2. Soon after domestic management began in 1976, Mid-Atlantic managers and fishermen adopted scientific-based, output controls. This implies more acceptance of scientific assessments (although there are notable exceptions, such as the "summer flounder chronicles" (Terceiro 2002)). These different management histories and preferences engender differential relationships between government scientists and fishermen in these two regions. This may explain why Gulf of Maine fishermen are more distrustful and skeptical of government scientists than Mid-Atlantic fishermen, and hence why they were hesitant to participate in the Panel process.

The other consideration is that fisheries are considered more culturally, economically, and politically important in New England than in the Mid-Atlantic. New England is considered to be more typical of a Natural Resource Community (Dyer and McGoodwin 1994; Dyer and Poggie 2000; Dyer and Griffith 1996) than the Mid-Atlantic. For example, comparing the social, economic, and cultural aspects of port profiles found in Hall-Arber et al. (2001) and McCay and Cieri (2000) one can assess important differences between these regions. Perhaps related to the perception of the value of fisheries to the regional economy, New England fisheries management is also more politicized than in the Mid-Atlantic. For example, the New England congressional delegation has often engaged in fishery management disputes for their constituents, which is not as often seen in the Mid-Atlantic. For example, when the NEFMC passed Amendment 13 to the Northeast Multispecies Fishery Management Plant, Senator Susan Collins from Maine placed a rider on an appropriations bill that would effectively prohibit the regulations from being implemented until her demands were addressed (Daley 2003). The political importance of the New England fisheries is also evident in that this region has received millions of dollars in direct funding for cooperative fisheries research, whereas the Mid-Atlantic region was forced to find creative ways to fund such research on its own. To be sure, Mid-Atlantic fishermen note this discrepancy and view it as unjust. One fisherman noted that the difference “gets down to the political aspect of New England who always gets more money than the Mid-Atlantic,” noting that they “have a science consortium and so forth and are much more politically active.” This may explain why Mid-Atlantic fishermen were more likely to embrace this collaborative opportunity. Mid-Atlantic fishermen have fewer opportunities to have their voices heard in science compared to New England fishermen. If New England fishermen do not agree with the outcome of a science or management decision, they have the political resources to bring to the table to voice their opposition. Mid-Atlantic fishermen lack such resources and so when offered a position of power in the form of a seat at a scientific decision-making table, they embraced it. In other words, with few alternatives, Mid-Atlantic fishermen responded to the opportunity, whereas New England fishermen have alternatives and so could afford to not participate.

This instance of conflict also raises questions regarding the meaning of participation, as it appeared to differ for these two groups. For one group, the Mid-Atlantic fishermen, meaningful participation meant physical attendance at the Panel meetings and discussing the issues around a table. For New England fishermen, meaningful participation seemed to involve weighing in on the outcome of the Panel's deliberation and did not require engaging with the other members face-to-face around a table. As an aside, in both regions we see an increasing trend for fishermen to represent themselves in the process through a third party. There are many different industry groups that attend meetings in both regions, and many groups hire their own lawyers and scientists to represent their interests in the management process.

This case further illustrates the challenges associated with incorporating fishermen's knowledge into science and management because of its local and heterogeneous nature. Fishermen's local knowledge and experience translated into different concerns about the survey and created conflict over which type of gear to use. Gulf of Maine fishermen were principally concerned with improving the assessment and survey of groundfish species that are important to them. These fishermen wanted to improve sampling in both rocky and mud habitat and increasing survey tows in places not sampled with the old survey gear. Similarly, Mid-Atlantic fishermen were concerned with the survey's inability to sample "their" species, since it was originally for groundfish. These fishermen were concerned about improving the survey for species found higher in the water column, as well as bottom-dwelling species.

The Panel offers important lessons when attempting to integrate fishermen and their knowledge in science and management, such as in co-management or cooperative research. Rather than treating fishermen's knowledge and science as ideal types, we need to recognize that there are more than just two knowledge cultures (Wilson 2003). We should expect and make an effort to accommodate localized knowledge cultures within fishing communities, making sure to reach out to those less likely to get involved on their own. Different opportunities should be made available to accommodate the different cultures in the industry. The Panel illustrates how difficult this is to achieve.

The structure of the meetings provided opportunity for communication between the Panel and the NEFSC, and between different groups of fishermen. The inclusion and participation by a NEFSC representative was also critical, as it meant that both sides of the boundary were represented. The experience and deliberation throughout the process gave fishermen and scientists a shared understanding, while the professional, open nature of the meetings provided an adequate opportunity for conflict resolution. Even the fishermen who initially chose not to participate were able to share their views in the process, which ultimately should make the process, if not the outcome, more legitimate.

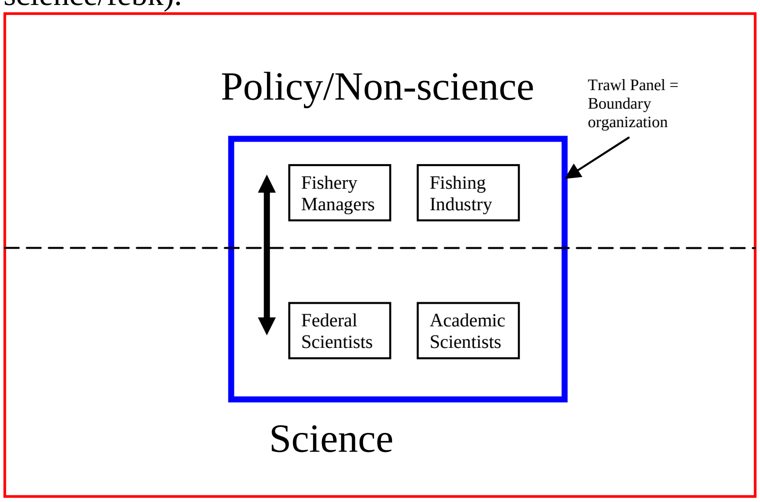
Conclusion: The Importance of Boundary Institution*s*

Institutionally, the Panel exists in between the Regional Fishery Management Councils and the NEFSC. It is technically a sub-committee of the two regional management councils, but is also coordinated by the government science center. The Panel is composed of academic and government scientists, industry members, and fishery council members (several of which fall into the both of these latter categories), as well as two economically and culturally distinct regions. Each Panel member brought their own unique, and often divergent, interests and identities to the Panel, yet in the end they were able to reach a consensus regarding a gear package for the trawl survey. How was the Panel able to overcome its heterogeneous nature and cooperate for the benefit of science, management, and the fishing industry?

The Panel was able to do this by functioning as a boundary institution (Figure 8-2), which negotiates the boundary between science and policy and is responsible to both sides of the boundary (Cash 2006; Guston 1996, 2000). The Panel allowed these groups to negotiate a survey gear package that reflects the interests of both management and science institutions, as well as the needs of the fishing industry. The Panel was able to do this by translating scientific information to fishermen and council members, as well as fishermen's knowledge to science and council members. The result was that fishermen's knowledge was integrated into the scientific research program (i.e., the survey) and scientific understanding was created in the fishing industry. The scientific survey also reflected the needs and concerns of fishery council members responsible for creating fishery science policy.

Although the Panel exists in a space in between the Regional Fishery Management Councils and the NEFSC, it still maintained responsibilities to both groups, as well as to the fishing industry. Additionally, the identities of the individual Panel members were maintained. The Panel members were forced to consider the needs and interests of the other groups on the other sides of the boundaries, yet they were still able to maintain their own identities representing different interests and types of expertise. The fishermen (and council members to a large extent) were responsible for representing the interests of the industry. Fishermen conveyed industry concerns that the survey gear and operations be improved (including the catchability of species), while at the same time they agreed with the "scientific" needs for standardization and representative catches. That is, they were forced to balance the desire of the fishermen that the survey catch more fish, while agreeing that the survey couldn't catch too many fish for logistical and scientific reasons. The scientists were responsible for representing the interests of the scientists who would use the data from the survey. They balanced the need for change with the need for consistency and standardization. All members are held accountable because they ultimately report back to their groups (and face removal from the Panel if necessary). The Panel as an institution risks being disbanded if it does not adequately negotiate both sides of the boundary. That is, if it does not address scientific concerns, the science center will not adopt its recommendations, and if it does not address the concerns of council members or the industry, the survey results and assessments will lack credibility.

Figure 8- 2: Depiction of the Trawl Survey Advisory Panel as a boundary organization that enables flow across the boundary between science and policy (science ad non-science/febk).



In their discussion of boundary organizations (or institutions), Guston (2000) and Cash et al (2004) are concerned with the boundary between science and policy (or knowledge and action). However, in this case study, the science/policy boundary had to be expanded to include fishermen's knowledge, since fishermen are experts as well as council members in the U.S. management system. As a boundary institution, the Panel managed the expertise/policy and the FEBK/RBK boundaries by making use of "boundary objects" and "standardized packages" (Table 8-3, Guston 2000). Boundary objects serve as meeting grounds between actors on both sides of the boundary and can be used by individuals within each for specific purposes without losing their own identity (Star and Griesemer 1989). Standardized packages define a conceptual and technical work space and are considered more robust than boundary objects, as they change practices on both sides of the boundary (Fujimura 1992). In this study, several boundary objects and standardized packages allowed the Panel to effectively manage the boundary between science and policy (and science and non-science) (Table 8-2). Below I discuss some of these boundary objects and standardized packages that contributed to the Panel's success.

Table 8-4: Examples of Boundary Objects and Standardized Packages Used by the Trawl Survey Advisory Panel

Boundary Objects
• Preliminary Net Design
• Flume Tank model
• Net mensuration data (from experimental testing)
• New research vessel
• "Trawl gate"
Standardized Packages
• Optimal performance vs. Standardization/Consistency
• Representative catch (quality) vs. Limited catch size (quantity)

The two most critical boundary objects that held the Panel together were "Trawl gate" and the new research vessel, the R/V Henry B. Bigelow. Each party (scientist, industry, and council member) had an interest in ensuring the credibility of the survey. The acknowledgement that the survey was "broken" at least temporarily challenged the authority and credibility of the science used as the basis of fisheries management, opening the door to negotiation. Scientists responded to "Trawl gate" in order to maintain their credibility and the authority of science. Council members responded that since stock assessments, based in part on this survey, represent the “best scientific information available,” and so a poor survey calls into question the legitimacy of the decisions that they make. Fishermen viewed “Trawl gate” as an opportunity because they felt it validated their claims that the survey did not adequately reflect their knowledge and experience. Whereas scientists wanted to “fix” the survey to preserve scientific credibility of the survey (and the precision and accuracy of assessments), council members and fishermen wanted to “fix” the survey in a way that reflected their interests (e.g., improved the sampling of managed species to better reflect resource conditions). The new research vessel functioned in a similar way, creating an opportunity for these diverse interests to meet and negotiate. Other boundary objects include the preliminary survey design (including flume tank model) and the net mensuration and catch data generated from the at-sea trials and flume tank testing. These served as a meeting ground between the actors on both sides of the boundary, allowing members to work together while still maintaining their disparate identities.

In addition to these boundary objects, several “standardized packages” were critical to the success of this boundary organization. The first package was the goal of optimizing performance of the gear (e.g., headrope height, door spread, wing spread, etc.) while maintaining consistency and standardization needed if data are to be used in assessments. Fishermen wanted to make sure that the gear fished optimally so that the survey results would reflect more closely their observations and experience. They felt that poor gear performance meant that survey catches missed species. The assessment scientists wanted to ensure that fishing was done in a way that ensured consistency over time, since the value of the survey to them is that the catch reflects changes in relative abundance over time, and not changes in fishing selectivity (i.e., its use as a time series).

The second standardized package that guided the Panel's work was the balance recognized between making sure that the catch was representative of the species that were present while not of such a quantity that impeded the scientific goals of the survey. Again, the Panel agreed that they wanted to make sure the survey did a better job catching the species present so that the survey reflected actual resource conditions, but this must be balanced with the logistical issues of the scientific mission (the collection of biological data). That is, these representative catches could not be so large that scientists did not have enough time to record necessary biological data related to the catch. Large catches would translate into fewer stations (samples) or subsampling, both are viewed as unfavorable as they reduce the accuracy and precision of the data. As the Panel deliberated about the results of the experimental testing of the preliminary net, the Panel drew on these standardized packages' guidance.

Boundary spanners were also critical to the success of the Panel and allowed it to function as a boundary institution. As noted, all of the Panel members were leaders in cooperative research and management in this region. These individuals brought important skills and experience to the Panel. They understood the complex, technical and scientific problems being addressed and were able to communicate well with other members of the Panel. They were able to translate their concerns and knowledge into a form that others could understand. They knew how to function in this collaborative environment. Unlike other cases where fishermen and scientist gained expertise and skills as a result of the collaboration, this case was one where members already had participated in cooperative research and so had already gained the expertise needed to contribute in the process. Therefore, this case illustrates the value of the capacity building that occurs with cooperative research.

One impediment to incorporating fishermen and FEBK into science is that they are heterogeneous. Unfortunately, the timing of this research leaves unanswered the ultimate outcome of the conflict between the GOM and Panel regarding the proposed (and later accepted) net. Although the councils and the NEFSC accepted the gear, the GOM fishermen have been silent regarding the new survey (neither vocally supportive nor opposing). This is reminiscent of the Panel's early deliberations. The GOM stakeholders were silent, but not necessarily in agreement. Only time will tell whether the survey will be viewed as credible and the assessment results legitimate. Important questions remain: Will the Panel's work improve the perceptions of the survey and result in greater buy-in to the assessments and management? Does it matter if a minority disagrees with the outcome of collaboration? Does it matter that the dissenting minority has significant power in the process? Will there be a tyranny of the minority or the majority? These latter questions are certainly not novel, they have been long asked by political scientists and other observers of democracy.

Nevertheless, given the role of the NEFSC bottom trawl survey in stock assessments, the foundation of scientific-based management, the regional council's and NEFSC's acceptance of the Panel's recommendations, including the proposed survey net, is perhaps one of the most significant examples of integrating fishermen's knowledge into science and management in the Northeast. Its success is even more remarkable given industry's long-standing distrust of the survey. Each Panel scientist also brought their unique knowledge, experience, and identity to the Panel, including knowledge of gear design/selectivity, fish behavior/biology, survey design and implementation, statistics, and stock assessment. As a boundary institution, the Panel was able to effectively manage the boundaries between the various knowledge groups found in fisheries management. More opportunities like the Panel could improve the exchange of knowledge across the science/non-science boundary as a way of improving the legitimacy and credibility of the fishery science policy process.

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[1] The Trawl Survey Advisory Panel case study is based on ethnographic research conducted in the Northeastern U.S. between May 2003 and September 2006. Data collection primarily consisted of informal and semi-structured interviews (Bernard 2002) and direct observation of public meetings. Interviews included over half of the Panel as well as other industry, management, and scientific stakeholders knowledgeable about the Panel process. Observation included all twelve Trawl Panel meetings during that time, as well as other public presentations of the Panel. For example, I observed presentations made to the NEFMC and the MAFMC, the Maine Fishermen’s Forum, and the RI Fish Expo. Documents were also analyzed, including media reports, public documents, technical reports, and transcripts of Panel (non-verbatim) and fishery management councils meetings (verbatim). Public documents and technical reports include the two peer reviews of the “trawl gate” incident (Payne 2003; NEFSC 2002a), the report of the trawl warp effects workshop (NEFSC 2002b), as well as many other documents provided at the Panel meetings.

[2] This was in addition to other modifications such as extending the 4-seam all of the way to the back to address gilling/meshing problems. The removal of the third bridle was considered the most controversial of the alterations.

[3] At the same time, a heated exchange also occurred between several Panel members and the Science Center regarding the process and expectations of the Panel at the following meeting. The principle issue concerned data availability and access. Several Panel members felt that the data from the gear testing were being withheld from the Panel and that the data were needed for the Panel to make its recommendations. This was the most verbal dispute that surfaced during any of the Panel meetings. The Science Center seemingly misunderstood the urgency or exact nature of the request for data, as they thought they had provided this data in a timely manner. There was a misunderstanding regarding the “rawness” of the data. Panel members thought data could be provided quicker if in a raw form (i.e., before analysis), but the scientists argued that it was raw, but that it simply took time to organize the data for presentation. Data sharing is a

common obstacle that arises in such cooperative research efforts and is related to trust and feelings of ownership.

[4] Specifically, he did not approve of the new research vessel, arguing that it was too big to be used for surveys. He put forth an alternative proposal that involved using industry vessels and even circulated a report by the Office of the Inspector General (OIG 1996) that said NOAA should decommission its ships. At a later date, one federal scientist reminded the group that Congress received the report, and their response was these large, more powerful research vessels. The other members of the Panel acknowledge the issues with the size of the vessel, but realized that the new vessel was a done deal and argued that they needed to make the best of it. They felt that they could design a net that would work, whereas the other fisherman disagreed.

CHAPTER 9: STAKEHOLDER PERCEPTIONS OF COOPERATIVE RESEARCH

Introduction

This chapter examines the perceptions of science, specifically research conducted with the fishing industry (i.e., cooperative research) and its outcome. This is done through an analysis of the discourse produced by stakeholders involved in both cooperative research and the science policy process, which reflects perceptions about cooperative research. I examine statements related both to the meaning and the fate of cooperative research. As described in chapter 3, the emergence of cooperative research in the Northeast over the last decade is a response to poor public perceptions of fisheries science and management and escalating scientific information needs. By involving fishermen in scientific research, cooperative research is expected to improve the public perception of fisheries science and result in scientific advice being taken more seriously in policy-making (Johnson and van Densen 2007). To borrow a phrase often used by stakeholders, cooperative research should generate “buy-in” to science and management on the part of the interested public (especially commercial and recreational fisheries). Unfortunately, it is too early to know how cooperative research will affect the perception of fisheries science and policy in the long-term, or if it will create long-term “buy-in” as is anticipated. For one reason, as I discussed elsewhere in this dissertation, many cooperative research results have not yet been made available for use in the science policy process. Thus, this chapter offers only a preliminary look at expressions of the meanings of cooperative research.

Methods and Analysis

This analysis utilizes the social science method known as discourse analysis, which is based on the close study of naturally occurring interactions and assumes that discourses are manifestations of culture (Bernard 2002, 460). Discourse is “a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities” (Hajer 1995, 44). The product of discourse analysis is the description of discursive themes or storylines (Hajer 1995). A storyline is “a generative sort of narrative that allows actors to draw upon various discursive categories to give meaning to specific physical or social phenomenon” (Hajer 1995, 56). The story lines presented here emerged from a qualitative analysis of interviews, observations, and a review of key documents. [1]

As I discuss, there remains little ambiguity regarding the meaning of cooperative research in this region. Although one federal scientist stated that cooperative research, “means different things to different people,” where stakeholders emphasize different expectations or potential benefits of cooperative research, there appears to be a shared view on most matters. Stakeholders of all kinds refer to cooperative research as “partnerships,” “a joint venture,” and “a full collaboration,” among other similar ways. And most stakeholders view cooperative research as valuable in principle. Yet there are still some story lines that depict skepticism regarding cooperative research, or at least the way that it is being conducted. To be sure, these storylines are expressed by a minority of stakeholders. Here I present story lines related to the meaning of cooperative research in the Northeastern U.S. as reflected in the discourse produced by stakeholders, particularly scientists, policy-makers, and fishermen (Table 9-1, Figure 9-1).

Table 9-1: Summary of Cooperative Research Story Lines

SL#	STORY LINE DESCRIPTION
1	Cooperative research means equal partners and more than chartering vessels
2	Cooperative research allows for the use of fishermen's knowledge
3	Cooperative research devalues fishermen's knowledge
4	Cooperative research is science
5	Data sharing is necessary
6	Data quality assurance and peer review are necessary
7	Cooperative research should be applied research
8	Not enough cooperative research is being used in management
9	It is OK that not much cooperative research has been used
10	Relationships are important too
11	Cooperative research is merely a welfare program

Story lines

<u>Story line 1: Cooperative research means equal partners and more than chartering vessels</u>

The majority of stakeholders make a point of emphasizing that cooperative research requires that fishermen be treated as equal partners and contributors in these efforts. Statements like the following made by two different fishermen illustrate this:

> F1: "I very rarely use the word cooperative. I like the word collaborative better. It may be a technicality and it may be the definition, but in my opinion, I see the government calling it cooperative, and I've always been resentful that it's insinuated that I'm going to cooperate with 'you.' You know, as the government. Whereas, collaboration is really where I started in this project or these ideas, where the idea should resonate from all different aspects. A scientist could have a good idea and a fisherman could have a good idea, and collaboratively, to me as it's my opinion, says we're going to sit down and try and figure out how to do the project. We're going to gather our expertise together and we're going to be equal."

> F2: "Well, I think the general meaning is supposed to mean that cooperation between 2 or 3 interested parties, a full cooperation…Whether it be the science center and the industry, the fisheries service and the industry, or fisheries service and the science body, or even the environmental community, whatever...My opinion of it is that it should be cooperative, an even cooperative, amongst all."

This story line is also found when stakeholders talk about the various roles or contributions of fishermen and scientists. Most emphasize that cooperative research should involve fishermen "from start to finish." One non-government gear scientist described it this way:

> "I see it as being a process where a fishermen/some fishermen and a scientist/some scientists get together, talk about a problem, identify the problem, work together to design a project, and follow it through with equal partnership at all levels right through to the end."

A federal scientist also emphasized that fishermen should be involved throughout the effort:

> "In the spirit of cooperation, it's projects that don't necessarily just get handed off to either the industry or to the scientists to do but rather they are projects that start at the conceptual stage together, as well as work through the scientific design, execution of the project, and interpretation of results."

Reinforcing the "equal partners" story line, cooperative research is often described as going beyond the long-established practice of merely hiring fishermen's vessels for research platforms. According to stakeholders, being "more than just charters" requires that fishermen participate in real and meaningful ways, and in all phases of the scientific research. An academic gear scientist active in cooperative research expressed this in the following statement:

> "Some people think that just by being on a fishing boat that it is cooperative research; I don't see it quite like that. I see it as being a process where a fishermen/some fishermen and a scientist/some scientists get together, talk about a problem, identify the problem, work together to design a project, and follow it through with equal partnership at all levels right through to the end."

An industry representative expressed a similar view:

> "What I think it means is that fishermen should be doing science. They should be actively involved in asking questions, designing experiments, working on science, both in the field and in the lab, and not simply being chartered and having their

> vessels chartered. To me, cooperative science is not a fisherman driving his boat around while a couple of scientists are out on the deck collecting samples."

In this very characteristic statement, in addition to explaining that it is more than using fishermen's vessels as platforms, cooperative research is seen as removing the boundary between scientists and non-scientists. In his view, doing science is not a privileged role open only to scientists, but something that fishermen can do as well. However, this also implies that science itself is useful to fishermen.

Also characteristic from the interviews done are important silences. It is not clear from this passage what he feels is the role of fishermen's knowledge – that is, whether the experience and practice of fishermen produce knowledge of value as well. He is also silent on the issue of whether fishermen's knowledge is qualitatively different than scientific knowledge.

Federal and state scientists also tend to talk about cooperative research as more than "for-hire research." A state scientist referred to cooperative research as "equal partners rather then just hiring them on for purposes of using a boat." A NEFSC scientist engaged in cooperative research similarly described it this way, albeit in the negative: "It's not just something that [we] develop a plan and we hire some fishing boat and then we do the research."

This view of cooperative research is also seen when people discuss the concept of "uncooperative" research. One fisherman explained:

> "Unsuccessful would be either side of the equation monopolizing the equation. Either the fishermen dictating to the scientists 'You do it my way or the highway, it's my boat.' Or somebody coming down and saying 'I just want to charter your boat, I don't need your advice, I don't want to work with you, just take me out to the grounds.' Either one of those is not cooperative research, and usually from my perspective doesn't work."

Funding for fisheries research is a scarce resource, and so framing cooperative research in this way provides a political justification for funding cooperative research. In the recent political and funding context, both fishermen and scientists benefit from cooperative research and have an incentive to promote it.[2]

Financial motivations are important to both sides. Fishermen want to continue to have this opportunity to share their expertise while at the same time maintaining their livelihood or even increasing their incomes (or helping make up for lost incomes as allowable catches decline). Similarly, scientists also want their expertise valued and wish to continue their livelihood, which for some scientists is their primary source of income.[3] They need each other to buy-in to doing cooperative research. Scientists need fishermen to cooperative in order to receive cooperative research funds, while fishermen need to cooperate with scientists to receive the alternative income that this research provides.

Those articulating the “equality” story line appear to be trying to convince others that cooperative research is something credible, that it can be trusted to do the things in which it intends to do, and generally that it is more acceptable than the previous discourse that viewed fisheries science as an activity that should occur in isolation from fishermen and their knowledge. By casting cooperative research as an equal partnership, both groups appear to be trying to convince the other group that this is something they should do. Considering the history of conflict between these groups, where each ultimately dismissed the other’s knowledge, the “equal partners” story line allows the members of these groups to compromise by acknowledging that they are not the only ones with relevant expertise. Again, scientists want fishermen to take the knowledge they produce more seriously, which they feel will occur with increased communication and understanding. Fishermen want their knowledge to be taken seriously in these efforts and not be passive contributors. They want to have some power in the production of the knowledge that ultimately controls the management rules that govern their fishing activities.

Further, the characterization of cooperative research as an "equal" partnership and "more than chartering fishermen's vessels" may be a response to those who view cooperative research as not involving meaningful participation by fishermen, and thus not real collaboration. For example, many scientists and fishermen remain skeptical and view cooperative research as "merely a welfare program," another story line described later. By emphasizing it as meaningful (and equal) participation, science and industry stakeholders can "sell" cooperative research to skeptical stakeholders, including the taxpayers who ultimately fund some of these efforts.

This story line positions cooperative research relative to traditional modes of knowledge production, and generally positions it as different than status quo fisheries research and qualitatively different than past "cooperative" efforts involving the industry. Cooperative research is seen as something better, something new, and something that goes beyond what was done in the past. It requires full engagement by the fishermen involved. It also requires equality on both sides. These themes, therefore, contrast with the fourth story line that considers cooperative research to be no different than science, which typically is characterized by boundaries between science and non-science.

<u>Story line 2: Cooperative research allows for the use of fishermen's knowledge</u>

Cooperative research is often discussed as a way to enable the use of fishermen's knowledge by transforming it into quantitative information useful in the science process.

Scientists and managers often emphasize that despite its value, integrating fishermen's knowledge into science and management is a challenge, especially where it is non-quantitative. For example, one federal scientist noted that it is "difficult for science to evaluate that non-quantitative information versus more, not necessarily correct, but more formalized data collection." As a federal stock assessment scientist remarked:

> "I think a lot of what we hear from fishermen is based on their experience but they don't have a lot of quantitative stuff to bring to the table. This [cooperative research] gives them an opportunity or an avenue to do that. Lots of times fishermen will say something to me and I believe 'em and it would be great to use that information but if it's simply qualitative or recollection or an anecdote, it's difficult to put that into a model and have it make a real impact."

Cooperative research is described as providing a way to merge fishermen's knowledge with scientific knowledge. For example, one NEFSC scientist described cooperative research as joining FEBK with RBK, "We take their particular expertise and meld it with our particular expertise."

By integrating FEBK in science, such as through experimentation, fishermen's knowledge can cross the science and management boundaries. This is an important motivation for fishermen because it addresses their desire to be heard and have power in the system. One fisherman expressed that cooperative research gives fishermen's knowledge power, such as the "validating of fishermen's knowledge" that otherwise is dismissed. To be sure, the outcome of cooperative research is "scientific" – and perhaps qualitatively different than fishermen's knowledge, but on the bright side, it can be incorporated into science and management.

Like the first story line, those who draw on this theme tend to be fishermen and scientists who want to sell the benefits of cooperative research. This story line is often expressed by individuals who represent the fishing community, either fishermen on the councils or representatives of industry organizations. On one hand, they use this story line to get others to "buy-in" to cooperative research. By telling their fellow fishermen that cooperative research empowers their knowledge, they hope to get them to buy-into the process, and into the future management polices based on these collaborations. They are also speaking to scientists and managers who would like to utilize fishermen's knowledge but do not know how, and those industry stakeholders who have not yet signed onto cooperative research, for example those *Illex* squid fishermen who do not yet participate in the real-time data collection program.

Embedded within this story line is the view that fishermen's knowledge should be treated as valuable and even equal to scientific RBK, with something to contribute to science and management. This is certainly not a new view, but it is now heard more often and with more force than in the past. Informants provided numerous examples of the value of fishermen's knowledge to both science and management.

Some fishermen, when arguing that fishermen's knowledge is valuable, emphasize the similarities between fishermen's knowledge and scientific knowledge. By referring to their knowledge as scientific, fishermen are also saying that it also should be used in science policy making. For example, when asked to define fishermen's knowledge one fishermen explained it as:

> "Just the basic knowledge that you accumulate through the experience of fishing itself. Not only what you acquire, but what you hear, what you observe. Empirical data. Empirical information…[gathered] by fishing is science. It is as simple as that. It is science. Science is knowledge learned through...[the] knowledge gained from experience and...Observations…brought forward from fishermen is in fact science. Just doesn't have a PhD on the end of it, but it shouldn't be underestimated."

A federal official similarly noted the similarities between the production of scientific and fishermen's knowledge, specifically that fishermen bring valuable observations to science:

> "Most science - all science is driven initially by some observation. And fishermen are out there. There's thousands of eyes out there observing things, and if we could take those observations and turn them into really good, efficient science, which then would drive more efficient management."

One prominent federal stock assessment scientist explained his view regarding the value of involving fishermen in science:

> "I think the real beauty of having fishermen involved is, # 1 they ask penetrating questions, 'Why are you doing it that way?' It doesn't make sense to them why they are fishing in places where there are no fish. 'Why do you do that?' In one sense they come into it without the burden of unnecessary scientific complication, so they only ask perceptive questions. And also you have people who have been piecing together observations for years - that is how they make a living, they piece together observations about what occurs where, they make all these ancillary observations about well 'the temperature was X when I caught Y' and all that stuff, and so they are a constant wellspring of hypotheses on how things work."

One change reported by several scientists is a conscious decision to stop referring to fishermen's knowledge as "anecdotal." Another federal fisheries scientist explained:

> "One of the phrases we try really hard not to use around here is the phrase "anecdotal information," which has previously been used to refer to information that is non-quantitative information that is provided by commercial and/or recreational fishermen. And that term is ridden with a lot of negative connotations that seems to make it a less effective terminology."

This story line seems to be universally accepted. Fishermen draw on this story line to give them credibility in the process. And as the quote above suggests, it is now politically incorrect to devalue fishermen's knowledge, such as by referring to it as anecdotal. Stakeholders of all kinds draw on this storyline to promote cooperative research.

Like the above story line, the “CR allows FEBK to be used” story line appears to reflect real or perceived power asymmetries between fishermen and scientists and the knowledge they produce. It reflects several underlying impetuses of cooperative research: industry distrust and dismissal of scientists and their RBK, and scientists’ and mangers’ treatment of fishermen’s knowledge as inferior or its dismissal as “anecdotal.” By engaging in cooperative research and promoting the concept of equality, both fishermen and scientists appear to be seeking to legitimize their roles and contribute to the knowledge base of fisheries management. Both groups maintain the hegemony of science, as they both seem to accept that fishermen’s knowledge must be transformed into (or merged with) scientific RBK. This is also seen when fishermen and scientists compare FEBK to RBK: they tend to refer to FEBK as similar to RBK, but not the other way around (although this may be implied).

Story line 3: Cooperative research devalues fishermen’s knowledge

Contradicting the above story line is the story line that cooperative research actually devalues fishermen’s knowledge. This story line is expressed by a minority of individuals, generally members of the fishing industry or others who are skeptical of cooperative research and maintain their skepticism and distrust of scientists and the science policy process. For example, one fisherman felt that in general cooperative research “devalues fishermen’s knowledge because it says you have to have a project with scientists or else what you know is of no value.” They are arguing against those fishermen who argue that cooperative research allows their knowledge to be heard. They imply that those fishermen involved in cooperative research have been co-opted, or even fooled, by scientists. The values and interests of these individuals are not clear. Perhaps they want to completely change (and diminish) the role of science in fisheries management, and by having some fishermen buy-into science this will unlikely happen. Or perhaps they would rather return to a recent past where managers were given the freedom to dismiss scientific knowledge, such as if fishermen's insights provided justification or as potential social and economic impacts warranted. In any case, these individuals tend not to speak out against science as a valid form of knowledge production, but specifically the particular science that the NEFSC produces (based on their surveys and assessments).

Story line 4: Cooperative research is science

Whereas people interviewed often describe cooperative research as something different and perhaps better than historical opportunities for industry involvement in science, many also make a point to reaffirm that cooperative research is not different from other scientific endeavors. These individuals argue that cooperative research data must be treated the same as other scientific data. This story line, "cooperative research is science," is compatible with although not necessarily the same as the view that FEBK is valuable and equal to RBK.

However, different groups seem to have different reasons for insisting that cooperative research be treated the same as science. For example, federal scientists argue that it must be held to the same standards of quality as other scientific knowledge, such as through peer review (Hogarth 2005), which is also story line 6. The NEFMC (managers) institutionalized this position when it voted that the council could only consider cooperative research when provided in final reports that had undergone appropriate technical review, a motion that was offered by an environmentalist on the council. This is a particular concern of the environmental community concerned about interest group bias in "scientific" information. Another example is when an environmental group representative called for more peer review of the cooperative research that formed the basis of the GOM grated raised footrope whiting fishery (chapter 6). He raised concerns regarding the use of data that had not been peer reviewed:

> "[I] just think we need to be thinking every time something like this comes up that in order for us to really create good incentives for people to do the best possible work, to get an idea like this to the table so that we can vote on it, we need to consistently apply the same standards of what level of scientific review, peer review, are appropriate, before we could take action on it…But let's do it right so that the next time an action comes along that shows great initiative and invention by scientists and fishermen that we can move it through without -- with it having the kind of credibility that this needs to have when we finally vote on it. (NEFMC 2002, 137-138).

Similarly, one NEFSC scientist reiterated that cooperative research is science by noting that its results are treated no differently than are any other data:

> "We have not changed any of our peer review process to accommodate cooperative research. We figured that's just another source of information to use…Data are data. The computer treats them all the same."

Scientists and managers need cooperative research to be treated the same as scientific knowledge in order to maintain the credibility and legitimacy of the science policy process. If cooperative research is to be used in management, and it is not considered to be of the same standards as science, then the process loses its legitimacy. Further, this story line reinforces the role of science in the policy process, reaffirming that only knowledge produced through science is credible for use in policy-making.

Fishermen too are often heard describing cooperative research as science, recognizing that for it to be useful in management, it must be recognized as scientific, as in this statement: "Cooperative research—basically, to have any type of validity to it you have to have a Ph.D. attached to it…It really has to follow the correct scientific protocols; otherwise they might as well throw it in the trashcan." This is in response to the concern that the results of cooperative research will not be taken seriously by scientists and managers. That is, they won't count as the legally mandated "best scientific information available."

The "cooperative research is science" story line is also used to explain the lack of impact of cooperative research in management. Some argue that it is simply the nature of scientific research that not everything produced will be useful for policy. For example, many gear selectivity research results were inconclusive or did not meet bycatch requirements and so they were not forwarded to management. As one scientist noted:

> "I think that is the problem with that in many cases, and it's just that nothing has come out of it. That's fair enough in science. That is what happens sometimes; you just don't find anything. I think it is difficult to get the money out faster, the questions, and set up a system that demands something comes from it."

By being scientific, cooperative research is treated as a form of knowledge production equal to research done only by scientists and their technicians. More important, by describing cooperative research as "scientific" both fishermen and scientists are expressing the hope that the outcome, or the construction of reality produced through this effort, is accepted. By being scientific, cooperative research gains credibility, acceptability, and trust. It becomes legitimate for use in fisheries policy.

<u>Story line 5: Data sharing is necessary</u>

Fishermen are often heard drawing on the next storyline: "data sharing is necessary." Both fishermen and scientists emphasize that who "owns" the data and who has access to them are critical to successful cooperative research. The industry's desire to have equal access to the data is rooted in their long history of distrust of scientists. In some cases "data ownership" has been a sticking point for cooperative research. One Maine fisherman explained how important sharing the data is to the industry. He was planning to participate in a cooperative research effort, but when told that he would not have access to the raw data, he backed out of the effort. In his words:

> "We wanted to be able to get the data, and in the scoping process, we were absolutely told that 'No, we couldn't get the data.' Again that's my definition difference between 'collaborative' and 'cooperative.' I was going to cooperate on a program that I didn't have any say in the design? The government was telling me what I was going to do…It's backwards! I think that they are missing a huge opportunity…the whole idea of the people sharing the data was what was supposed to be broken down."

Examples of "data ownership" issues occur on the science side as well. One non-federal scientist felt that sometimes other scientists, particularly federal scientists, tend to control the data analysis process. The scientist claimed that NMFS wants it to be their science, and if it doesn't match up to what they believe, then they dismiss the results as not statistically valid. It is not clear that this actually happens, but this is a perception nonetheless. Another scientist expressed similar views and suggested that this was a way federal scientists continue to exert control and power in this process.

In the case of fisheries cooperative research, data sharing is a political issue. Those who have access to the data control information and so are able to exert "power" in the process. Those with data are able to "speak" in the management process in ways that are viewed as more legitimate than those without data. Fishermen have come to realize this, having experienced their anecdotal knowledge treated inferior to scientific knowledge, and they feel strongly about this aspect of cooperative research. They have experienced management rules based on "science" that have conflicted with their "knowledge" based on their experiences. Although they argue vehemently that they must be given access, it is unclear what, if anything, they would do with the data. While some claim that they would like to do their own analysis, most fishermen wanting to see the data are silent as to exactly why they want to see the data. This suggests that the underlying issue is trust; fishermen want to see the data in case it conflicts with their beliefs because they still do not trust scientists completely.

The story line of data sharing mirrors several of the themes discussed earlier in this chapter. In the first story line, cooperative research is viewed as requiring real and meaningful involvement by fishermen, who are expected to be treated as equals in this process. The data sharing story line reinforces this by saying that meaningful involvement and equal treatment includes data sharing. Thus, involving cooperative research in science can improve the public's perception of science if the collaboration involves real power sharing between non-scientists and scientists. By involving fishermen in cooperative research, the outcome of the science is more transparent, increasing its legitimacy and credibility. When knowledge is produced behind closed doors (or data access is denied), fishermen are more skeptical as to the motives of the scientists, and hence the outcomes of the science.

Mangers and scientists tend to draw on the data sharing story line as a justification for the seemingly low level of use of cooperative research in management. One fishery manager explained that one reason more cooperative research has not been used in management is because scientists do not like to give up their data:

> "Some scientists are very proprietary about their data; getting them to relinquish it is like pulling teeth. Other people are very open in sharing it. I think we are still struggling with setting up some kind of universal way to access data."

The “data sharing” story line is expanded by managers, scientists and cooperative research participants who argue that data must also be shared in a format that is accessible to those that could use it. Again, this story line offers justification or explanation as to why not enough cooperative research as been utilized in the science policy process. Over the years, scientists at the NEFSC have noted that it takes a while to get data from outside the center into its database because in some cases it has to be keypunched in or reformatted to fit their database. One industry member on the RSC stated adamantly,

> “We need a single format for everyone to put the data in. The Science Center [needs to say] ‘This is the format.’ I don't care what projects you're doing, you've got to have the data in this format. If you have to have someone keypunch in all of the information, we'll end up with a 6-8 year delay just getting the information into the data pipe.”

This fisherman, manager, and cooperative research participant recognizes that if the government scientists cannot access the data, they will not be able to use it in the stock assessment process or management. Other fishermen and scientists throughout the region also raised this concern at numerous cooperative research venues (e.g., council meetings and fisheries meetings).

<u>Story line 6: Data quality assurance and peer review are necessary</u>

Contrasting the “data sharing” story line is the story line that emphasizes the need for data quality assurance and peer review, which is often heard in response to the “data sharing is necessary,” “cooperative research is science” and “not enough cooperative research is used in management” story lines (the latter is described later). All proposed management actions, regardless of what knowledge it is based on, must go through a long, complicated process before they can be implemented. Not only does National

Standard 2 require that management decisions be made on the "best available scientific information," but federal government agencies must also meet requirements of the Data Quality Act of 2000. Federal scientists have been given the responsibility of being the "gate keepers" – making sure that only high quality data are used. The determination that data is of high quality is done through the process of peer review. Since they are legally obligated to ensure data quality, federal scientists tend to voice this story line most often. For example, one federal scientist acknowledged the importance of data sharing, but reiterated that they must meet legal mandates:

> "We're by law required to have it go through quality insurance, quality control. There was a new law that was passed and we have to make sure that this stuff has been screened and check for outliers and stuff like that. So we do that then we send the file…Some of the funds have gone to third party groups to display the data so the fishermen can see it right away."

Another NEFSC scientist, speaking of the cooperative industry-based surveys, reiterated that cooperative research should meet the same data quality standards as other forms of science (specifically that produced by the government's survey):

> "How the [industry-based] survey is conducted? How about the procedures? One would hope that those protocols are subjected to the same scrutiny as ours are. You know, because this kind of scrutiny in the era of the trawl warp thing. We had a peer review of a peer review…Outside people that are completely disconnected with this laboratory to sit in judgment of how we've adjusted to that problem and what the problem was…I would hope that…if there's an expectation from industry that data from cooperative research will be used as part of the assessment process, especially as a tuning index, that those surveys get the same kind of scrutiny before they even go out on day one."

This story line competes with the data sharing story line because it implies that data cannot be shared until they have been peer reviewed. At the same time it reiterates that cooperative research must be treated the same as science, and so reinforces the cooperative research is science story line. However, by saying that they two need to be treated the same, the above scientist also hints that perhaps he does not believe that they are treated the same. He seems to differentiate the cooperative survey and “their” survey, suggesting on one level he may not treat cooperative research and traditional research the same.

To be sure, some scientists recognize this and have tried to reconcile this conflict. One federal scientist explained that from the very beginning of cooperative research fishermen were concerned about data sharing and they have tried to accommodate that:

> “When we started cooperative research one of the big things that came out was the fishermen said, ‘Well we're really tired; you guys monitor us then you guys come back and measure our stock and then we never hear anything.’…Most people just say, ‘It's the National Marine Fishery Service; they're doing this to us. And they take our information and they don't tell us anything about it and sometimes we think we sent information and we're not sure they used it or they rejected things’...So one of the mandates or one of the key things was, ‘We'll be involved in these cooperative research projects. We want to see the data and we want to be able to look at it too, and we want to see it quick.’ So we paid to have websites developed…”

Several such web-based data sharing opportunities are notable. The Northeast Regional Cod Tagging Program created an online GIS mapping interface that allows fishermen to explore the data collected in the program. Fishermen can track individual recaptured tagged cod, while also having access to data on how many cod were tagged and released, who tagged the cod and how many have been recaptured. The GIS interface also allows stakeholders to map the locations of the releases and captures. The industry-based surveys targeting cod and yellowtail flounder have a similar online GIS interfaced database that stakeholders can easily access. By creating these data-sharing opportunities, these federal scientists seem to recognize the importance of balancing data sharing with data quality assurance are trying to please both fishermen, managers, and the public (represented by Congress and the environmental community). For these scientists and managers, the “data sharing” and “data quality assurance/peer review” story lines are not incompatible.

The other group that tends to be heard drawing on this story line is the environmental community. For example, in the discussion of how cooperative research should enter the management process, a council member and representative of an environmental organization recommended that the council require projects receive adequate review before being implemented into management by eliminating the Level 1 pathway available for incorporating cooperative research into management (see discussion of RSC in chapter 3):

> “I feel like what happens sometimes is it's like we're in a courtroom and one of the attorneys -- when one of the attorneys makes an argument, knowing that it's going to be ruled out of order, but makes the argument anyway, the judge says to the jury omit this from the record, directs the jury not to consider what they just heard, but of course they've heard it, so it's already -- regardless of what the judge says, it's in the record. So, I think we need to be clearer on what kinds of research we're comfortable with incorporating; and by eliminating this aspect of the research policy, I think we'll be much clearer and on much more solid ground in terms of the research that we're using in our management decisions (NEFMC 2005, 34).

This group is concerned about the credibility and legitimacy of the management system. They are reacting to the past when science was dismissed in favor of industry concerns. This story line is used to ensure that management decisions are based on unbiased and credible information. These groups have a slightly different interest in the fisheries management process. They value marine ecosystems for their intrinsic value, not only as providing economically valuable resources. In the past, their interests were also dismissed in the policy process. It took a number of successful and high profile lawsuits before their interests were taken seriously and they even had a seat at the table. Unlike fishermen, who have experience-based knowledge [and the results of cooperative research] to bring to the science policy process, these individuals tend to promote the role of science as the most appropriate source of knowledge for decision-making.

Story line 7: Cooperative research as applied research

By and large, stakeholders characterize cooperative research as applied research, with applications to science and management problems affecting the fisheries. Most argue that it needs to be relevant to real fisheries management problems, as described by the industry representative who said, “To me the most important part of it is to solve management needs.” A New Jersey fisherman noted: “Knowledge for knowledge sake is always nice but at this point it is not a luxury we can afford.”

Recognizing the value of improved relationships and communication between scientists and fishermen, fishermen nonetheless agree that the results should have management value, as shown in this statement by a Maine fisherman:

> “Everybody wants, ultimately, that the results go someplace. Some projects-- the results were the fact that two, the scientist and the fisherman, got together - that was a huge result. But ultimately, in the crisis mode that we are in with management, people want the data to be applied to management.”

At the same time, stakeholders also recognize the value of doing “pure research” as well, as in this statement by a Maine industry representative:

> “I think that some portion should be pure research and very few, whether it’s, you’re talking about cooperative research or government research, nowadays it’s very little of [pure science], but I think there needs to be, just, ‘This is an interesting question. Why are these weird critters here?’ Or whatever…it’s not that just scientists should do everything, but that isn’t necessarily every kind of research doesn’t necessarily mean the same level of participation of the different types of participants.”

In this story-line, like others, stakeholders seek to maintain the credibility, trust, and acceptance of cooperative research. They feel that if cooperative research is viewed as merely a “good-feel exercise” or a “welfare program” support for it will diminish.

Thus, they frame cooperative research as something that will produce knowledge with which to solve pressing fishery management problems, i.e., something relevant. As mentioned before, stakeholders often note that although it is different than "pure science" in that it is applied research for fisheries management, they nevertheless still consider it real science. Again, this is a way to ensure that it is treated as credible and accepted in the science policy process.

Story line 8: Not enough cooperative research being used in management

Overall, my research suggests that most people involved in the cooperative research process and/or management process do not feel that enough of cooperative research is making its way into the management process, including both the council decision-making and stock assessment processes. Several examples of success, defined in terms of making a difference to stock assessments or management decisions, are commonly noted. The most often cited examples are the surfclam and ocean quahog surveys (chapter 3), the scallop closed area research (chapter 3), use of turtle excluder devices (TEDs), the Maine raised footrope trawl fishery (chapter 6), the Nordmore grate shrimp fishery (3), the research that created the Yellowtail Flounder Closed Area 2 SAP and the Closed Area 2 Haddock SAP. To be sure, other examples have been considered and/or discussed in the management process, but these are the projects cited by stakeholders as having made a difference. Nevertheless, many stakeholders suggest that there is a great disconnect between how much cooperative research has been funded and how much has made its way into management. More than 250 projects have been funded since 2000, yet stakeholders consider only a handful as examples of successful integration in management.

When asked about the fate of cooperative research in the science policy process, one New England academic scientist involved in cooperative research said that the results are:

> “…mostly gathering dust on people's shelves…There are a number of exceptions and things are hopefully changing, but it still is a problem with the system as it is constructed at the moment…If you look at the money that is being spent on cooperative research, very few changes have been made to regulations on the basis of that funding.”

Many would like to see the results and are becoming skeptical as to why not much has influenced management. One industry member explained:

> “I think my biggest concern now is that you never see any of the results. The results don’t seem to…the projects don’t seem to be constructed in a way that the results are particularly useful. And, you know, you hear well, this person was doing this, or that person was doing that, but that’s about all you hear.”

On behalf of eighteen fishing organizations, an industry representative expressed concern to Congress that not enough cooperative research is being utilized in the management process, insinuating that some kind of power struggle was at stake:

> “The major complaint we hear is that collaborative research results are not used in management. The reasons for this may not be as obvious as some may believe. It is not simply a question as to whether or not the science is good, the review was independent, or the information was relevant. There is more to it, and we need to understand it” (Bergeron 2006).

There is a significant amount of uncertainty about how the results are to get implemented into management. One fisherman noted:

> “We've been really trying to figure out what to do with the final report. Where's it go, how do we catalog it? How can people get their hands on it? And then there is this great divide. What do you before it gets to management? How do we bridge that gap and then how does that information become relevant?”

One scientist noted the need for a process for incorporating cooperative research into management, starting with asking management relevant questions. He noted:

> "My view on that is a lot of the funding has not resulted in changes in how we manage our fisheries. That is partly because it has not been set up to do so. Despite the fact that lots of people are saying we need to make sure that something comes out of all this, the management is not terribly clear at the moment as to how this could be better achieved."

This story line is consistent with the previous story line in that stakeholders claim cooperative research should be applied research, but contrasts it by admitting that it really does not get applied. It is also compatible with the following story lines that seem to explain and justify why cooperative research has not been utilized in management.

Story line 9: It is OK that not enough cooperative research has been used

When asked about the fate of cooperative research, most stakeholders explain that not much has been utilized in management (story line 10), but then proceed to explain why that is the case. Stakeholders seek to justify why it has not produced more usable results. For example, stakeholders point out that sometimes there was insufficient money allocated to do the research rigorously enough for the results to be relevant for use in management. For example, in the case of gear studies, in order to implement a gear configuration into management research must show that the fishing gear involved catches no more than 5% bycatch, and this must be shown for all areas and times that the gear will be used. Thus, occasionally, not enough tows were done in enough areas at the appropriate times of the year to meet this requirement and therefore for managers to allow the gear to be used in management. In some cases, insufficient funds were available to analyze the data after the project is complete. One federal scientist noted:

> "I have seen instances where projects have not left enough money on the table to handle the data once it hits the dock. Because they went out and bought all the equipment and hired the boat and built a few things and when they get back to shore there is simply no money left."

Several cooperative research participants point to mundane logistical issues to explain why some efforts have not been utilized in management. For example, a project could not get the necessary experimental fishing permits in time to do the research or could not get approval to conduct the research at times and/or in locations proposed. At times, research could not be finished because of issues with weather and difficulties of coordinating research so as not to interfere with the fishing vessels fishing activities. Finally, long-term projects need multiple years and/or a time series for the results to be relevant for use (e.g., tagging studies and industry-based surveys).

However, the strongest barriers to integrating cooperative research in management are institutional in nature, including the data quality requirements discussed in story line 6. The structure of the process is not flexible enough to allow managers to adapt quickly to new fishery conditions and new information, as noted in the *Illex* squid real-time data collection case study (chapter 4). The Director of the NEFSC described the institutional constraints that limit the use of cooperative research data for *Illex* squid. When asked about the fate of cooperative research, he referred to constraints imposed by the regional council policy-making process and its procedural mandates:

> "Mixed. Some information has gone directly into management…But our squid surveys, that's been frustrating, learning a lot of things about squid, having a good working relationship with the industry, but management is not in a good position to do anything about that. To use that type of information, which is real-time abundance information, we'd have to change our whole management process. Right now, management cannot accommodate real-time biological information. There are just too many requirements for public input, reviews and so on so it just takes months if not years to get real-time scientific information incorporated into the process. It's just a question of flexibility right now."

Consistent with this story line, many stakeholders express optimism that progress is being made. Many emphasize that it is still too early to tell and getting cooperative research results into management is part of the learning curve associated with this new kind of research. One Mid-Atlantic industry Council member explained: “The thing you've got to understand is that it is still in its infant stage. It's a learning curve for us too.” A New England fisherman stated similarly “I think it's been a learning process. No question about it. Just stating that it's a learning process, I think it's been good.”

Many informants cited such a learning curve and are optimistic that progress is being made. Further, they expect that more data from cooperative research will be used in fisheries management. They note that many of these impediments are institutional in nature and cite numerous instances of institutional change (learning) visible regarding cooperative research. For example, the NMFS regional office is doing better getting experimental fishing permits available for the research to be conducted in a timely manner. At a planning meeting for the Mid-Atlantic supplemental finfish survey in January 2004, the participants were pleasantly surprised that the permits were already in place for the survey. There are also instances where data from cooperative research are being shared on a website almost immediately (e.g., cod tagging and industry-based surveys). Data from the Mid-Atlantic Supplemental Finfish Survey are promptly available for use by NEFSC scientists because Rutgers University scientists provide the data in the format most accessible for inclusion in the NEFSC database. And most importantly, the Councils are developing more formal mechanisms to implement cooperative research into management. Both councils have established a committee to deal with cooperative research. In New England, the RSC is fine-tuning a more formal process and the council is being more proactive in filtering cooperative research into management. The Mid-Atlantic FMC on the other hand has not had a federally managed cooperative research program in place as long and therefore is not as far along the learning curve. However, there is evidence that the Mid-Atlantic region is learning from what is going on in New England, such as the need for peer review and a process for filtering cooperative research results into management. For example, several cooperative research presentations have been made directly to the MAFMC at its meetings.

Like other story lines, this story line cautions against giving up on cooperative research just yet. This story line is used to counter those story lines that claim cooperative research is not credible, or functions as nothing more than a welfare program, described below. This story line attempts to sell cooperative research to fishermen and those who may fund cooperative research. This storyline is used to support the story line that it is alright that not enough cooperative research has been used in management. They argue that cooperative research can produce valuable knowledge and is worth participating in and funding. This is reinforced by the following story lines that emphasize benefits that go beyond influencing the decision-making process.

Story line 10: Relationships are important

A story line that reinforces the story line that essentially argues that “it’s OK that not much cooperative research has been used in management” is the “relationships are important” story line. The need to first build relationships between fishermen and scientists is often cited as a valid explanation for why not enough cooperative research has yet been used in management. An industry representative described one New England funding program for cooperative research as focusing very specifically on management needs, while the other funding program has “been more focused on the idea of improving relationships between fishermen and scientists than solving immediate management problems."

Stakeholders explain that when cooperative research was just starting in New England, there was little forward thinking about how results would impact management. Obviously, many of the project proposals were written with statements about their management implications, and improving the knowledge base of fisheries management is an explicit goal of cooperative research, but at that time the focus was getting cooperative research programs off the ground, getting fishermen and scientists working together, and distributing money to the fishing industry. A fisherman explained that the early focus on building relationships was necessary:

> "[I]nitial goals were to break down the barriers between fishermen and scientists. They needed those discussions to be happening. They needed to get people to embrace that scientists know a way of doing things and fishermen know a way of doing things and both have their expertise, and bringing them together was going to be very significant."

A council member representing the fishing industry explained: "We rushed to get money into the hands of fishermen so that they…we weren't particularly concerned with the questions they were asking." A scientist involved in cooperative research similarly emphasized that the focus has been on building relationships and not getting results for management:

> "In general, there is less focus on the fate of the data after the boat gets back to the dock. My personal observation is that the emphasis has been on establishing the research relationships with commercial vessels."

Indeed several people that I spoke to emphasized that having fishermen and scientists working together is an important benefit of cooperative research in and of itself, and if anything else comes from it then it is "gravy."

There is some tension between this story line and the story line that argues for cooperative research as being applied research and those who want to see results be used in management. This story line is contrasted with the story lines that view cooperative research as nothing more than a welfare program, or a feel-good effort. Those who talk up the benefits of building relationships are trying to get others to buy-in to the process, or at least not give up on it quite yet. This is also echoed in the following story line.

Story line 11: Cooperative research is merely a welfare program

Despite the high levels of optimism, a few stakeholders remain skeptical about cooperative research and raise concerns regarding the credibility of the process. This story line refers to cooperative research as “merely a welfare or subsidy program.” One industry representative held this view: “The current cooperative research is, as far as I can tell, is one-third fine, and two-thirds just giving people jobs, and it’s a waste of money.” Another industry representative on the NEMFC explained: “The common opinion that exists with a lot of fronts is that cooperative research, in some cases, is nothing more than a subsidy; just like the farmers get paid not to plant crops or not to harvest crops, fishermen get paid to work with scientists.” Those utilizing this story line tend to question scientists’ and fishermen’s motivations, suggesting that rather than trying to improve the science policy process or utilize fishermen’s knowledge, the process is just about putting money in the hands of a few fishermen. Related to this, some stakeholders question whether the welfare program is equitable, as they feel only a select group of fishermen are benefiting.

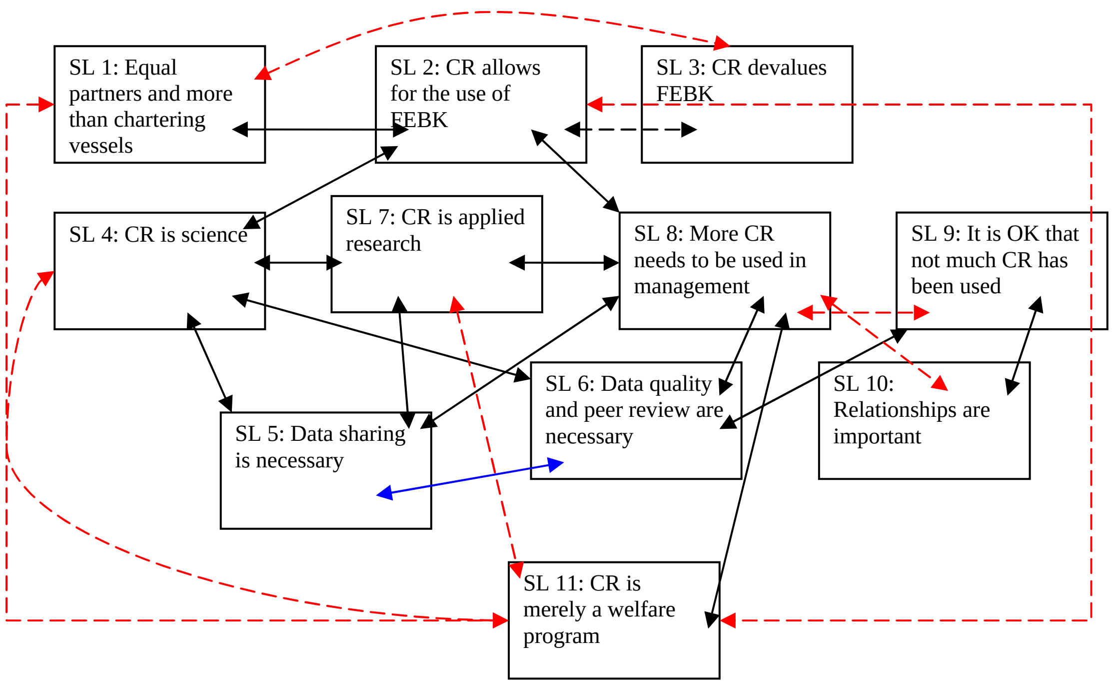
This story line conflicts with the story lines that tend to promote cooperative research (e.g., cooperative research as science and as applied research), as well as the story lines that view cooperative research as empowering fishermen and their knowledge (e.g., the equal partners and more than charting vessels story lines). This story line is compatible with the "not enough cooperative research has been used" story line, since they don't expect that it will produce relevant results since they see it as focusing on getting money to fishermen.

This story line tends to be expressed by individuals who, for whatever reason, have not been active participants in cooperative research or have not been as active as they would like. This is true for both industry and science stakeholders. Some have chosen not to participate, while others have simply been unsuccessful in securing cooperative research grants or otherwise finding opportunities to participate. In the former case, much of the skepticism is due to the long history of industry-science distrust that characterizes this region, as described in chapter 3. The latter cause of skepticism implies that greater effort needs to focus on increasing participation in cooperative research in order to generate the buy-in into science and management that cooperative research aims to achieve.

Conclusion: Summary and Analysis

In the past, the region was characterized by little communication or understanding between fishermen and scientists (Dobbs 2000). One New England fisherman explained, "Years ago we'd walk into a room and you'd go to a fishery management room or a PDT meeting, scientists would sit on one side and fishermen would sit on the other side and nobody would talk to each other." Now many of them have reached across these boundaries and are partners. Although stakeholders do talk about how cooperative research could be improved, it is rarely characterized as a bad concept. Instead, the emergence of a new discourse, cooperative research, seems to have created unexpected alliances between previously adversarial "knowledge cultures" – those relying more on experience-based knowledge—by and large the fishermen-- and those committed to research-based knowledge, mostly the scientists. These new coalitions are reflected in the shared understandings and expectations regarding the meaning and fate of cooperative research. The storylines and their interactions are illustrated in Figure 9-1.

Figure 9-1: Storylines related to cooperative research. Solid (black) lines are related and supportive storylines. Dashed (red) lines are potentially incompatible storylines. Blue lines are both supportive and incompatible.



The first set of story lines indicates a level of shared acceptance regarding the meaning of cooperative research. The first two story linse (SL) position cooperative research relative to traditional modes of knowledge production, and generally position it as something different and an improvement upon status quo fisheries research. At the same time, it is still viewed as a real science (SL 4), and so deserving the same power or status as traditional research. This implies that in order for science to be viewed as legitimate, real and meaningful participation by stakeholders must occur, including shared access to the data (SL 5). It is not enough to simply expose fishermen to science; fishermen need to be engaged in the practice of science. Science is viewed not as something to be left to an elite group of "experts," but rather as something that they all can and should participate in. Or, put another way, certified fishery scientists are viewed as not having a monopoly on the expertise relevant to science and management (SL 2). An example from the case studies that illustrate these themes is the NMFS *Loligo*-scup selectivity research effort (chapter 6), which was cited as a poor example of cooperative research by several industry and science stakeholders because fishermen were treated as "charters" and "unequal partners," and fishermen felt their knowledge was dismissed.

The value of fishermen's experience-based knowledge is widely recognized. This view is embedded in and reinforces the view that cooperative research is a good process because it allows fishermen's knowledge to be used in science policy (SL 2). Some may claim that SL 2 is contradictory because it maintains the privileged role of science. In other words, SL 3 claims that cooperative research devalues fishermen's knowledge because it forces it to be science in order to have validity. However, story line 3 is compatible with the underlying assumption of SL 2 in that it recognizes the value of fishermen's knowledge, but argues that it should be valued as is, not transformed into science.

In response to story line 5 (data sharing is necessary), scientists and environmentalists tend to emphasize the need for quality assurance and peer review. These are not necessarily incompatible storylines. Rather, SL 6 seems to be a response to those asserting SL 5. Rather than disagreeing with SL 5, this story line agrees that data should be shared but disagrees that it must be shared immediately. It is also related to the story line that argues that cooperative research should be treated the same as any other science (SL 4). Furthermore, fishermen are also heard calling for independent peer review of science, including cooperative research.

There is an interesting contradiction that emerges regarding the meaning of cooperative research, particularly for fishermen. These emergent themes appear to condemn boundary-making between scientists and fishermen, and between FEBK and RBK, and they tend to emphasize that cooperative research is something new and different. For example, they speak of equal treatment of fishermen and their knowledge in these efforts. Yet, industry and science stakeholders also stress that the research is still scientific, and must be treated the same as that produced by traditional scientific research efforts. Moreover, fishermen accept and even advocate this continued monopoly over the form that knowledge must take to be used in management. In many cases, they take pride in that they are contributing to science. They use it to confer status on their knowledge.

Fishermen seem to accept the legitimacy of science, but question the credibility of the science currently produced. They also seem to accept the same definition of science as scientists and other members of the public. In fact, they are often heard advocating what could be considered Merton’s norms of science: universalism, disinterestedness, organized skepticism, and communism. This is seen in calls for independent peer review and data sharing. An independent peer review process ideally supports universalism, interestedness, and organized skepticism, while data sharing supports communism. They want the basis of management to be science, but want to expand the definition of who is included in the process.

To be sure, the outcome of cooperative research is scientific, and outcomes are rejected if they do not meet scientific standards. Fishermen's knowledge, therefore, continues to be treated secondary to science. The process ultimately translates (or transforms) fishermen's knowledge into science. Why do fishermen accept the monopoly of science as the form of knowledge used in policy-making? This is a difficult question to answer. On one hand, it may be part of the public's acceptance of science as arbitrator in the political process. Fishermen, after all, are members of the public. And the public by and large accepts the role of science in policy-making. On the other hand, it may be due to the fact that this monopoly is inevitable due to the legal mandates that position science as the basis of policy-making. In participating and promoting cooperative research, perhaps fishermen have adopted the "if you can't beat them, join them" strategy. By participating in cooperative research, fishermen are given an opportunity to share their knowledge and contribute to the science that forms the basis of management. The fact that their knowledge is ultimately translated (or transformed) into science seems to be secondary (if it matters to them at all). They still feel as if their knowledge is making a difference in these efforts. They often take pride when their knowledge has been proven by science.

Story line 7 argues that cooperative research should address real management problems, which may imply that the boundary between science and policy must be spanned in order for science to be effective. The majority of stakeholder held this view. This is echoed in story line 8, which says that not enough cooperative research has made its way into management (suggesting that it should).

Story line 8 relates to the fate of cooperative research, suggesting that, at least at this time, most stakeholders feel that cooperative research's record influencing management is unimpressive. This is consistent with SL 7 that says cooperative research should have management implications, i.e., that it should be applied research. Story lines 9 and 10 illustrate optimism despite story line 8. Eager to provide recommendations for improved success, stakeholders emphasize that learning and progress are being made, and remain optimistic. Storyline 9 gives justification; it essentially says, "It's OK that not much has been used" because doing cooperative research is difficult and learning is necessary." Storyline 10 emphasizes the benefits of building relationships that form as a result of cooperative research, suggesting they are not only an important outcome of cooperative research, but are needed to do cooperative research. The need for these relationships also explains or justifies the lack of impact that cooperative research has made.

Regardless of the optimistic attitude, the fact that very little cooperative research has been used in fisheries science and management is a significant concern. One of the most important goals of cooperative research is to improve the knowledge base of fisheries management. Yet very little of cooperative research is actually influencing management. As one industry representative noted, Congress may begin to ask if this is the best use of the nation's money. In fact, the Northeast Consortium is in danger of disappearing due to a lack of funding. Fishermen also may begin to ask if this is just another way the science and management process is dismissing their knowledge.
Some fishermen, particularly those who do not benefit financially, are questioning the credibility of these programs and view them as merely ways to put money in fishermen's

pockets. Again, the other goal is to create buy-in to fisheries management and improve the relationships between fishermen and scientists. If cooperative research turns out to be just a "feel good" effort and does not find its way into management, then fishermen are likely to feel cheated and relationships may deteriorate.

The last storyline, expressed by only a small group of stakeholders, raises skepticism about the perceived credibility of cooperative research, suggesting that to some it is "merely a welfare program." This opposes storylines 1, 2, 4 and 7 since those story lines consider cooperative research to be a meaningful and valuable process that creates useful knowledge for decision-making, while empowering fishermen and their knowledge. This story line does not disagree with the story line that fishermen's knowledge is valuable, nor does it disagree that cooperative research is a good idea in principle. The economic benefits of doing cooperative research should not be underestimated. The majority of fishermen are financially struggling as a result of regulations and stock depletions. Those who receive extra income from cooperative research are at an advantage.

A "discursive struggle" (Hajer 1995) may be occurring between those who are optimistic about cooperative research and those who remain skeptical. Some stakeholders have embraced industry-science cooperation, while others remain doubtful of the motivations of those participating and the outcomes of these efforts. This was seen most visibly with the Trawl Survey Advisory Panel (chapter 8), where a group of stakeholders declined to participate and rejected the outcome of the process. They remain distrustful of the federal scientists' motivations, and the legitimacy of the process. Similar concerns have been expressed regarding cooperative research in general, with suggestions that it isn't really improving the science or being conducted in an appropriate manner (fair and unbiased). On one hand, they do not support the status quo where fishermen were positioned outside the science process, but nevertheless remain distrustful of the process that includes them. It is not clear what is needed for them to "buy-in" to cooperative research as others have. Thus, it remains to be seen if cooperative research will result in the desired political change, i.e., meaningful participation by stakeholders and improved public understanding and perceptions of science (buy-in). To quote a fisherman, cooperative research "is in an infant stage." We do not know who will "win" the discursive struggle: the advocates or skeptics of cooperative research. And if the skeptics "win" it is not clear what the result would be: will there be a reduction in the role of science in the political process? It seems unlikely at this point that this will happen due to the legal mandates institutionalizing the role of science in policy-making.

This analysis of the discourse reveals several factors as being critical for ensuring the legitimacy of cooperative research and generally improving stakeholder perceptions. The first is the need for transparency. The process must be considered open to fishermen, not conducted behind closed doors by scientists. This means that fishermen must be involved in all stages of cooperative research that is feasible – "from start to finish." Related to this, fishermen and their experience-based knowledge must be treated as equals in these efforts. And participation should be inclusive of the diverse members of the fishing community as much as is feasible. Transparency also requires communication. Open dialogue should occur throughout the project between those participating in the project, as well as with the public at large. This is necessary to ensure that all partners meet expectations. Finally, the perception of science can also be improved when cooperative research data are incorporated into policy-making. Cooperative research, in theory, facilitates this by ensuring that science addresses problems most critical to fisheries management (including stock assessment). Boundary spanning must occur between those conducting cooperative research and those likely to utilize the results (i.e., managers or assessment scientists). Right now, there is optimism regarding cooperative research despite little use in management, yet in the long-term if cooperative research is not viewed as making a difference, the credibility and legitimacy of these efforts may diminish and buy-in to science and management will unlikely occur.

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[1] Data for this analysis were collected from May 2003 to June 2006 and include interviews, observations, and a review of key documents. Semi-structured interviews with scientists, fishermen, and managers were guided by a number of key questions about cooperative research, but were also kept open to ensure that stakeholders were free to discuss issues that were important to them. In addition, informal interviews occurred throughout the research. Observations occurred at fishery management council meetings (and committee meetings), stock assessment working groups and peer review workshops, fishing industry forums, fishery conferences or workshops, and academic conferences. More than sixty meetings were attended, many of which spanned several days. In some cases, summary minutes or recordings were provided by the agency hosting the meeting. Documents included in this analysis include verbatim fishery management council meeting transcripts. Transcribed interviews, field notes, and documents were entered into a QSR-N6 database for qualitative analysis. Data were coded inductively based on the content of the materials.

[2] While fishermen have been affected by the fisheries crisis, particularly in New England, scientists have also experienced a reduction in available funds for research. In particular, I have observed NEFSC scientists struggling with fiscal uncertainties.

[3] This is especially true for scientists who do not have permanent funding sources and are forced to “chase research dollars.” There are some government and non-government scientists whose positions are entirely funded through grants. For example, several institutions were able to hire scientific staff with cooperative research funds, and in the absences of additional funds the institution would not be able to support them. Most government scientists are not funded through grants, but rather from direct allocations to government agencies. Similarly, the salaries of some academic scientists are not directly dependent upon grants, since they are funded by universities or non-government organizations. Yet, in some cases, grants allow these scientists to conduct the research that they would otherwise not be able to pursue.

CHAPTER 10: ANALYSIS AND CONCLUSIONS

Introduction

In the previous chapters, I explored what happens to the boundaries between science and non-science, including different forms of expertise, when citizens with experience-based knowledge (EBK) are included in the science policy process through cooperative research. This study focused on industry-science collaborations between fishermen and fisheries scientists. Five different types of collaborations with fishermen were presented: “study fleets” (chapter 4), fish tagging (chapter 5), gear selectivity/bycatch reduction research (chapter 6), industry-based surveys (chapter 7), and an industry-science advisory panel to improve the government resource survey (chapter 8). These case studies were considered in relation to the research questions posed in chapter 1 (Table 10-1). In addition, chapter 9 examined the discourse produced by stakeholders and revealed insight into stakeholder perceptions regarding the meaning and fate of cooperative research. This final chapter synthesizes the findings presented in the previous chapters to answer the principal research question regarding whether fishermen and their knowledge can be effectively integrated into the science policy process through cooperative research. In particular, I looked for evidence of boundary management, spanning, and maintenance.

In theory, fishermen’s experience-based knowledge (FEBK) and scientists’ research-based knowledge (RBK) are integrated in cooperative research to produce a research outcome (e.g., knowledge, data, etc.) (Figure 10-1, A). The use of this new information in science and management represents a path through which citizen’s local knowledge or expertise (here FEBK) can span the boundary into science-based policy-making (Figure 10-1, B). In sections 1 and 2, I examine the process of cooperative research and highlight instances of boundary management, spanning, and maintenance. I then conclude with a fuller discussion of the theoretical issues related to these boundaries. Specifically, I consider cooperative research as a boundary institution, one that negotiates the boundary between science (here, RBK), and non-science (i.e., FEBK and policy).

Table 10-1: Research Questions

#	Research Questions
1	How do stakeholders perceive the meaning of cooperative research? Does cooperative research improve stakeholder perceptions of science (i.e., generate buy-in to science policy)
2	What does cooperative research do to the boundaries between non-scientific and scientific knowledge in the context of the fisheries science policy process? What evidence is there of boundary making, spanning, and management as a result of cooperative research?
3	What kind of expertise is involved in these cooperative research efforts – and what, if any, expertise is shared across the boundary between scientists and non-scientists?
4	Does cooperative research enable the use of fishermen's experience-based knowledge (FEBK) in the science policy process? Is local FEBK integrated into the large-scale, RBK-based paradigm of fisheries management?
5	Does cooperative research function as a form of public participation?

Figure 10-1: Theoretical process through which Cooperative Research Functions as a Mode of Public Participation and Mechanism for Integrating FEBK into Science and Management

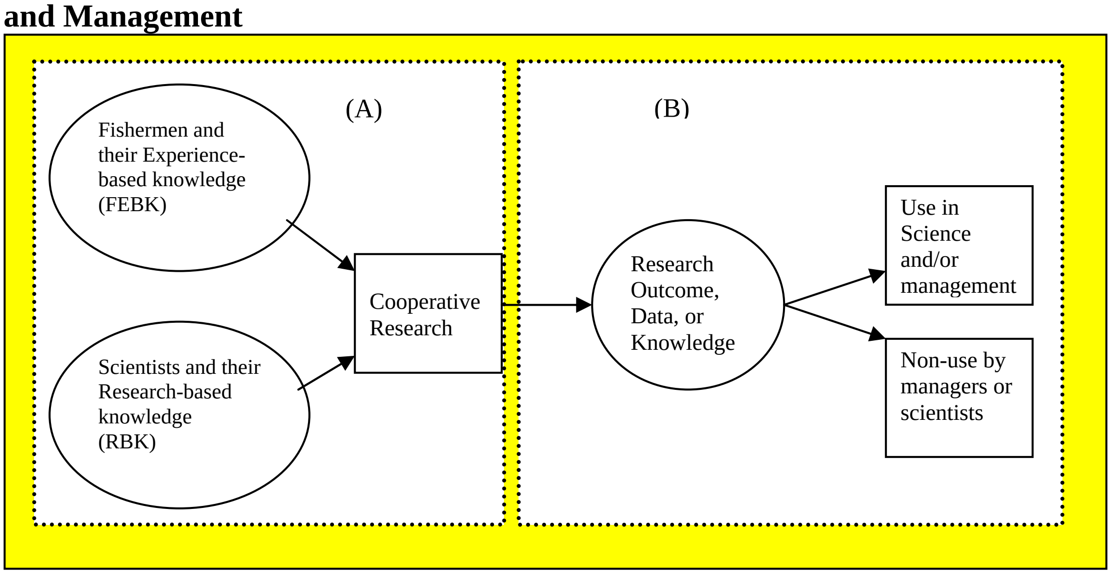

Table 10-2: Summary of Contributions of FEBK by Type of Cooperative Research

Case studies examined	**Type of Research**	**Role of Fishers**	**FEBK Contribution**	**Use in Science Policy**
Loligo-Scup selectivity studies ME grated raised footrope whiting fishery	Gear research	Hypothesis generation Research design Planning/logistics Data collection Use of industry Vessels Analysis of results	Technical knowledge of gear and vessel operations Gear-species-environment interactions Spatial/temporal distribution of species	Special access programs and exempted fisheries created (e.g., whiting fishery, *Loligo* exemption with Manomet design) Relatively easy integration possible in management (but results often inconclusive)
NE Regional Cod Tagging Program	Tagging studies	Hypothesis generation Research design Planning/logistics Data collection Use of industry vessels Outreach	Technical knowledge of gear and vessel operations Gear-species-environment interactions Spatial/temporal distribution of species	Not yet utilized Potential use in stock assessment (i.e., Growth and mortality data possible, but not yet)
Illex Squid Real-time Data Collection Program	Fishery-independent data collection	Data collection Use of industry vessels	Knowledge of the social and economic conditions of the fishery	Data utilized in stock assessment Real-time data collection/managem ent in the works Industry involvement in stock assessment
ME-NH Inshore Trawl Survey; Cod IBS; Mid-Atlantic Supplemental Finfish Survey	Industry-based surveys	Research design Planning/logistics Fixed station selection Data collection Use of industry Vessels	Technical knowledge of gear and vessel operations Gear-species-environment interactions Spatial/temporal distribution of species	Some IBSs utilized in assessments (e.g. SCOQ) Other IBS data considered in assessments, but not yet utilized (MA IBS) Potential to complement NEFSC data (but not yet)
Trawl Survey Advisory Panel	Advisory panel	Hypothesis generation Research design Planning/logistics Data interpretation Distribution of results	Technical knowledge of gear and vessel operations Gear-species-environment interactions Spatial/temporal distribution of species	Accepted by management (NEFMC, MAFMC), and science (NEFSC)

The Role of Fishermen and FEBK in Cooperative Research

To examine how fishermen and their knowledge are incorporated into cooperative research (Figure 10-1, A), I examined two overlapping issues: (1) when (and how) in the cooperative research process are fishermen and their knowledge contributing and what kinds of FEBK are used in the different kinds of cooperative research that is occurring in the Northeast; and (2) related to this, the level and degree of participation by stakeholders in cooperative research. I begin with a review of the cooperative research process based on descriptions provided to me by participants and my own observations, as well as the case studies presented in chapters 4-9 (summarized in Table 10-2). As I discuss these, I highlight instances of boundary management, spanning, and maintenance. I then discuss issues related to the quality and quantity of participation that ultimately influences the success of cooperative research as a boundary spanning process.

<u>The Cooperative Research Process</u>

Observation and Problem Generation

Fishermen and their knowledge contribute significantly to the generation of research questions in cooperative research. Many cooperative research projects are based on hypotheses or questions identified by fishermen based on their experience or knowledge, including their experience with both marine ecosystems and institutional environments (i.e., management arena). For example, the Maine whiting fishermen first hypothesized using the Nordmore grate to eliminate bycatch of groundfish in the whiting fishery. The *Illex* squid real-time data collection effort was based in part on fishermen's observations regarding squid abundance and their experiences with management (i.e., premature fishery closures). The NE Regional Cod Tagging Program is based in part on fishermen's concerns regarding the validity of the two stocks theory and on their observations of cod movement. The industry-based surveys are also based in part on industry's concerns regarding the validity of the NEFSC survey. Gear studies are perhaps the most direct way fishermen propose research questions and ideas, and these are based directly on their experience at-sea and their knowledge of gear-species-environment interactions.

The development of the research question and hypothesis is considered a key part of the process where fishermen's knowledge can contribute most significantly to the scientific process. One scientist reflected on how fishermen contribute to this aspect of the research process:

> "I think the real beauty of having fishermen involved is, number one, they ask penetrating questions: 'Why are you doing it that way?' It doesn't make sense to them why they [scientists] are fishing in places where there are no fish. 'Why do you do that?' In one sense they come into it without the burden of unnecessary scientific complication, so they only ask perceptive questions. And also you have people who have been piecing together observations for years – that is how they make a living, they piece together observations about what occurs where, they make all these ancillary observations about well "the temperature was X when I caught Y" and all that stuff, and so they are a constant wellspring of hypotheses on how things work."

Other research ideas arise out of a joint "brainstorming" session between specific fishermen and scientists who have agreed to do a research project together. Even in this case, the research question that ultimately arises will still be based on the observations and experience of those involved (both scientists and fishermen), either experience on the ocean, in the management arena, or both. For example, many gear scientists explained that they often find themselves making contacts with fishermen who want to do "something" about "something" and *together* they discuss and develop a research project to conduct. Many of the Northeast Consortium research gear selectivity/bycatch projects developed through this collaboration between fishermen and scientists.

Finally, most cooperative research questions emerge directly from the management arena, another site of the presence of fishermen and FEBK. Those fishermen who are members of the regional fishery management councils or otherwise participate in the process inevitably contribute to what "management" asks of science or from cooperative research. In some cases, cooperative research projects developed by fishermen and scientists are responses to a specific "Request for Proposals" (RFP) distributed by the government science and management institutions (NMFS). Both Mid-Atlantic and New England FMCS have committees that prioritize research. For example, in New England the CRPI program works closely with the management process through the Council's Research Steering Committee when it solicits RFPs. The Mid-Atlantic Research Set-aside committee's research prioritizes forms the RFPs for the Research Set-aside Program. This differs from the Northeast Consortium program, which is more removed from the management process. Project ideas emerge from a more "bottom-up" process – where ideas for research come from fishermen, scientists, or both.

Examples of management driven cooperative research include the Northeast Regional Cod Tagging Program (chapter 5), the industry-based surveys (chapter 7), the *Illex* squid real-time data collection program (chapter 4), and most gear selectivity/bycatch reduction projects (chapter 6). With these projects, fishermen and their knowledge have been able to span the boundary between science/non-science, building capacity for the generation of useful knowledge for fisheries science and management.[1]

Research Design Specification and Planning

Once a hypothesis or question has been raised, the research partners must then work together to design a project that will answer it. This requires communication between the fisherman and scientist partners. Again, in the past when fishermen participated in research (i.e., before the new wave of cooperative research), they were typically not involved in this aspect of the science. Experimental design has typically been considered outside the realm of fishermen's expertise. Scientists probably did not consider that fishermen could or would want to participate in this process.

Understanding some of the fundamental aspects of experimental design is often cited as a challenge that fishermen have learned to overcome in these cooperative efforts, or an example of capacity building. According to one experienced manager, more fishermen now understand some of the basic principles of experimental research design. For example, in the past many fishermen did not understand the concept of "random sampling" used by scientists in resource surveys. They questioned why scientists often towed in places where fishermen already knew that fish were unlikely to be found. They also questioned the "standardization" of the survey (i.e., vessel and gear configurations consistent since the 1960s), which many felt caused it to be very inefficient at catching certain species. Because of outreach and educational programs (such as the Marine Research Education Project) and by participating in cooperative research, fishermen today have a greater understanding of scientific methods than they did before.[2] Many fishermen now understand why stations must be random and the need for standardization. This was apparent when I spoke to fishermen about the industry-based surveys. In addition, throughout the work of the Trawl Survey Advisory Panel, in its attempts to improve the standard NEFSC survey, fishermen on the panel are deliberately balancing the need for more technologically efficient gear with the recognition that the survey must be consistent (standardized).

Scientists are also now more willing to include fishermen's views on experimental design. For example, several industry-based surveys represent a compromise between industry and science in that some stations are selected randomly while others were selected by the fishing industry (ME-NH inshore survey, Cod IBS, Yellowtail IBS). This may be an attempt to capture some of observations of fishermen that would otherwise be missing through randomization, although it is also partly done in response to political pressure from the industry. To be sure, fishermen in these projects are not necessarily suggesting how the project should be done from an experimental design perspective, but they are supportive of the need to ensure that the project is done in a way that meets scientific rigor. This is an example of expertise flowing across the boundary from scientist to fishermen, which I refer to as capacity building.

The most important contribution of fishermen is likely seen in the design of gear that is tested in the cooperative gear selectivity studies and the IBSs. Most of the cooperative research that has been done in the Northeast has involved the testing or developing of gear to reduce discards or bycatch. In New England, hundreds of projects have been looking at how to minimize the catch of weak stocks while enabling fishermen to target healthy stocks. The Maine grated raised footrope trawl whiting fishery is an example of this. It was the Maine fishermen who suggested that they could use the Nordmore grate in their whiting net to reduce bycatch of groundfish. Similarly, many gear types that are being tested in cooperative research are gear that the industry already uses, but must be proven to meet the five percent bycatch provision that shows it does not harm protected groundfish species. For example, fishermen and researchers from Rhode Island tested the use of a haddock separator trawl that fishermen already “knew” worked – appropriately named ‘The Eliminator’ (Beutel and Skrobe 2006). Also, fishermen’s knowledge directly contributed to the selection of the gear used in all of the IBS case studies discussed (chapter 7). Most notable is the Cod IBS where fishermen and their knowledge contributed towards the design and testing of the research gear, including participation in flume tank testing. The Trawl Survey Advisory Panel is the best example of utilizing fishermen’s expertise in the design of the gear used as the basis of research (chapter 8). These are important examples of how fishermen’s knowledge is being incorporated into scientific research and illustrate boundary spanning. Here fishermen’s expertise spans the boundary into science.

Proposal Writing and Submission to Funding Agency and Review

Fishermen are not typically involved in the writing of proposals (or final reports). Often scientists write the research/funding grant proposals based on their discussions with the industry partners. This makes sense since scientists are experienced at writing fundable proposals. In fact, some scientists must secure funds via grants processes for all of the work that they do. Most are comfortable sitting in front of a computer writing a paper, which is typically not part of the normal daily activities of average fishermen.[3] Although the contribution of fishermen at this stage is typically minimal, some fishermen sometimes contribute to this stage by reviewing and commenting on drafts. While scientists write most proposals, there have been some examples, most notably with the

Northeast Consortium program, where fishermen have submitted preliminary proposals themselves. These rare instances are a sign of the learning that has taken place.

Fishermen do participate in the review of proposals. In the cooperative programs that I focus on in this research, the proposals are reviewed in a competitive process. Funds are limited such that not every proposed project will be funded. Most funding programs operate with a review panel or committee that reads, ranks, and recommends which projects the program will fund. These panels or committees typically include industry representation. The programs have a list of guidelines or criteria that are used to judge the proposals. There is a conflict of interest requirement that prohibits anyone who is involved in any of the projects being funded from participating in the proposal review. Involving fishermen in the review process means that they contribute, even if indirectly, in the selection of which projects are funded by participating in proposal review. In this way, cooperative research differs from non-CR fisheries science. This is another example of boundary-spanning and capacity building.

However, the boundary between science and non-science is managed and maintained. The review always starts with a scientific technical review by the experts and the final decision is always left to NMFS officials. The NMFS ensures that a technical review is done of the proposals on top of any other reviews done as part of the competitive process involving federal funds. Typically, scientists within and outside of NMFS look at the proposals and make sure that the project is technically sound. The review committee's recommendations are forwarded to another place where the final decision is made, usually NMFS. With the Northeast Consortium funds, the four Sea Grant partners make the final decision. In the CRPI program and the Mid-Atlantic Set-

Aside program, the final determination is made by the NMFS regional administrator at the Regional Office. After the projects have been approved (or rejected) for funding, the proposers receive a letter acknowledging whether or not they will be funded. In some cases (e.g., NE consortium and CRPI) the program will offer a critique as to why a project was not funded in order to allow the proposers to improve and resubmit in the future. Ideally, funds are then quickly distributed to the research partners to conduct the research.

Permitting Process

One barrier to spanning the boundary is the permitting process. In a presentation to the Mid-Atlantic Fishery Management Council on October 5, 2004, Paul Perra of NMFS described the permitting process as it relates to cooperative research. In most cases, project participants must obtain necessary permits before the project can commence. Permits are obtained from the NMFS Regional Office, and in some case must also be obtained from State agencies. These are necessary because the majority of cooperative research takes place during times or places that are otherwise closed to fishing (e.g., closed seasons, closed areas) and may violate fishing regulations (e.g., size restrictions, time/area closures, mesh regulations). In addition, some cooperative projects require the landing and selling of fish that are caught during the course of the research (e.g., with research set-asides). As part of the permitting process, NMFS must also evaluate the environmental impacts of the project in accordance with NEPA regulations. Under the MSA, scientific research with a sound scientific plan conducted aboard a scientific research vessel is considered exempt from fishing regulations (e.g., size restrictions, mesh requirements, and time/area closures). Fishing is defined in the MSA as any activity other than scientific research conducted by a scientific research vessel that involves catching, taking, or harvesting of fish; the attempt to so; or any activity that can be expected to result in the catching, taking, or harvesting of fish. Letters of Acknowledgement (LOAs) or scientific research permits are issued to conduct such scientific research. Non-NMFS scientific research receives LOAs to conduct research activities. The review process for receiving an LOA is quite simple. It involves a simple notification to law enforcement stating the activities are legal under the MSA. However, most cooperative research falls outside the scope of LOAs and requires an Exempted Experimental Fishing Permit (EFP). However, by definition scientific research does not include gear testing, research related to product development, market or public display, or the collection and retention of fish outside the scope of the research plan.

The EFP process is complicated and lengthy and consists of quite a bit of paperwork. The process takes a minimum of sixty days to complete. An application is submitted to the Regional Office. The application requires the following information: project goals and purpose, list of exemptions requested and their justification, number of participating vessels, experiment duration, definition of the study area, species that will be harvested (those caught and those that may be caught incidentally), disposition of the catch, potential impacts to marine mammals and protected species, specification of the gear to be used (type, size, and amount), and how the data collected with be disposed. According to a NERO official, a complete application will demonstrate sound scientific design, address all questions regarding methodology and procedures, and address any need for observer coverage. Project managers and/or scientists, rather than fishermen, conduct the bulk of the work of compiling the information.

The permitting process functions to maintain (and may even create) a boundary between science and policy and non-science (and between scientists and fishermen) by distinguishing what activities counts as science and what activities are not science. Again, the definition of "scientific research" excludes activities conducted by industry vessels. The process also distinguishes between government science and other science, since non-NMFS science goes through a different process.

Data Collection

In most of these projects, fishermen are critical participants in the at-sea data collection, as most involve the use of industry vessels. The actual research activities, as well as the contribution of fishermen and FEBK, will vary according to the objectives and type of project. This is probably the most significant site where fishermen and their knowledge contribute to research. Here I discuss fishermen's contributions to gear conservation engineering/bycatch studies, stock assessment related studies, and tagging studies as were revealed in the case studies (chapter 4-8).

Gear selectivity and bycatch research

Chapter 6 presented two case studies of cooperative gear selectivity research. The case studies presented were similar in that fishermen and their experience-based knowledge (EBK) were accepted and considered equal to (and often greater than) scientists and their knowledge (RBK). Fishermen in these cases are considered to have "contributory expertise" (Collins and Evans 2000) related to gear and vessel operations and/or ecological knowledge related to the distribution of species and gear-environment-species interactions, and this knowledge was incorporated into the scientific research process. This is generally true for most gear-selectivity or bycatch research.

More specifically, fishermen contribute their vessel as research platforms, and their knowledge about handling and configuring gear, vessel operations, and time and areas of optimal fishing locations. Fishermen contribute their knowledge and skills to key logistical aspects of gear research – where and when to go fishing. Gear scientists also know a lot about gear technology and design, but in order to determine if a gear configuration meets its objectives, it must be fished in commercial mode and there must be fish around.

Powell et al. (2004) showed how failing to test a gear in commercial mode can lead to results that are atypical or do not achieve desired objectives. If a project aims to test a gear configuration designed to catch Species A and not Species B, the vessel must fish in an area where there are both Species A and Species B. For example, the GOM whiting fishery research used fishermen to find areas where cod existed to show that the gear could catch whiting while not cod. If a project aims to test a gear configuration designed to catch haddock and not cod, the vessel must fish in an area where there is both haddock and cod. This is where gear scientists really benefit from including fishermen. Another example, in the research that led to the Closed Area 2 Yellowtail flounder SAP, scientists utilized fishermen’s knowledge of where and when they could fish for yellowtail without catching cod. In addition, fishermen bring to these projects their knowledge of the problems that they see regarding their fishery, based on their experience. The FEBK that is used in gear studies is in many ways “technical” knowledge about gear design and deployment and vessel operations. Fishermen do also provide “ecological” knowledge related to how different gear interacts with different environments (e.g., bottom types, currents, depths). The other “ecological” knowledge is simply where and when to catch fish; i.e., the spatial and temporal distribution and abundance of fish and fish movement/behavior patterns. Although many gear scientists possess sufficient knowledge of gear design and fish behavior to do this kind of research without fishermen and FEBK, the outcome is less likely to be as widely (or easily) accepted by fishermen or relevant to current fishery problems. Fishermen also contribute their knowledge of "fishery conditions" – markets and management restrictions that many gear scientists outside the process are less familiar with. In addition, conducting the research without fishermen, particularly finding the fish would likely be more costly.

Including fishermen and their knowledge does not always guarantee success given the number of gear/bycatch reduction studies that for whatever reason failed to produce "usable" results. In some cases, fishermen are used basically as research platforms, such as the NMFS *Loligo*-scup selectivity research. However, the norm today is to see fishermen working with scientists from the beginning of the project design, to testing models in flume tanks, and then testing gear at sea, and then recommending modifications for future research. An "outsider" might have a difficult time differentiating the "scientist" from the "fishermen" in these projects.

Stock assessment related research

Studies that aim to improve the collection of fishery-dependent information, like the *Illex* squid real-time data collection (chapter 4) and the New England groundfish study fleet, often rely on fishermen to help design protocol for recording data that worked for commercial fishermen and was compatible with fishing operations. Yet, since fishermen are asked to simply fish as they normally do, no additional contribution by fishermen is made in the collection of data in these studies. In these studies, fishermen and their vessels can be viewed as "instruments" or data collectors.

There are several notable examples of cooperative efforts to improve the collection of fishery-independent data used in stock assessments (chapter 7 and 8). These aim to improve or enhance the spatial and temporal scale of fishery-independent data collected by the federal resource surveys. These "industry-based surveys" (IBSs) sometimes target species not surveyed well by the large-scale, multi-species federal survey (e.g., cod, yellowtail flounder, scallops, surfclams, monkfish, squid). Other IBSs focus on areas not sampled well by the federal resource survey (e.g., inshore waters or offshore, deeper water). These research efforts are conducted aboard industry vessels, operated by well-experienced fishing captains. Although they are by nature (i.e., methodological objective), fisher-independent, fishermen have contributed to these surveys their knowledge of gear/vessel operations and local knowledge about the ocean bottom (gear-environment interactions), as well as in some cases their knowledge of the timing and locations of fish populations (fish movement and behavior). Essentially, they contribute their knowledge regarding when, where, and how to fish.

For example, fishermen were heavily involved in the design of the net used in the Cod IBS, contributing their knowledge of gear and vessel operations. Some of the stations sampled in the Cod IBS were selected as fixed stations based on fishermen's knowledge of known areas of high concentrations of cod. Similarly, the locations of transects and fixed stations in the Mid-Atlantic Supplemental Finfish Survey were informed by fishermen's knowledge of areas of high abundance and local towability. These industry-based surveys can be considered "for-hire" cooperative research, where fishermen's vessels are chartered as research platforms, yet with a little more industry participation than traditional charters. With the exception of industry selected fixed stations, stations are selected randomly. Fishermen's knowledge and skill often become important when these random stations are areas of complex bottom making successful towing difficult without experience (i.e., nets get torn up or damaged due to boulders or other impediments to towing). In some cases, fishermen are consulted to find alternate towing locations as close as possible to the randomly selected station to avoid losing expensive fishing gear.

Tagging studies

There have been numerous industry-science cooperative tagging studies conducted in the Northeast, most notably the Northeast Regional Cod Tagging program (chapter 5). In tagging studies, fishermen provide their knowledge about fishing locations (both spatial and temporal knowledge), catching fish (using gear and vessels), and handling fish (recreational fisherman knowledge). Again, fishermen contribute their knowledge of where, when and how to fish. In some respects, tagging could be considered a for-hire type of cooperative research (chartering fishermen's boats) or using fishermen as field technicians rather than as an equal partnership, but in reality recent efforts go beyond this. Fishermen are critical to all stages of these programs. Fishermen not only find and capture fish to be tagged, but these programs also rely on fishermen's knowledge of catching the fish to get tag returns (reporting tag returns). In some cases, fishermen have been trained to do the tagging themselves in the absence of scientists on board. The contribution of fisher's knowledge of finding and catching the fish is knowledge that is not trivial. These programs would be extremely costly without the involvement of fishermen. In the past tagging programs more often than not used fishermen's vessels as research platforms, where scientists told the fishermen where to go and when to fish, or didn't use fishermen or their vessels at all, relying on more costly research vessels.

Because fishermen are generally skeptical of fishery scientists, they often do not return tags when caught. However recent efforts are showing seemingly greater success rates due to the outreach and involvement of the industry generating buy-into these programs. An example of this is the yellowtail flounder tagging program, where fishermen have proven critical by encouraging their fellow fishermen to return tags when captured (NEFSC pers. com). However, skepticism remains and there are stories of fishermen steaming the ocean with coffee cans full of tags that they refuse to report. It is also important to note that different tagging projects have different research objectives, and so fishermen and their knowledge fit in differently in these programs. For example, the Northeast Regional Cod Tagging program is looking at large-scale distributional questions regarding cod migration patterns. In this project, the methodology was such that fishermen were essentially allowed to tag cod whenever and wherever they wanted, limited only by a fairly large geographic area. The yellowtail flounder tagging study aimed to collect data for natural mortality, movement and growth, and is being conducted on a smaller scale.

Data Auditing, Sharing and Analysis

Boundary making or management occurs in relation to data quality control. This is discussed later when I consider the peer review process. At some point, either during the data collection process or immediately after, the data will usually undergo some audit to ensure quality. Human error associated with data recording can be significant. Some of these errors are readily detected by some basic analyses, such as graph of length and weight measurements. On the NOAA research vessel this is done while the data is being collected as part of its Fisheries Scientific Computer System. Some of the cooperative research projects have similar data entry programs. Only the scientists typically analyze data. Again, this is a fundamental aspect of most scientists' training, and not necessarily something that fishermen are as familiar with. Data analysis requires knowledge and skills of statistics that not all fishermen possess. Yet fishermen often feel they must be included in this phase of research, and when excluded question the legitimacy of cooperative research. Cooperative research is supposed to be an equal process, and fishermen are weary of being excluded from this most fundamental aspect to the research process. This was discussed in chapter 9 when I discussed the fate of the data and its use or non-use in fisheries management. When this happens, this can be considered boundary-making or maintenance.

Yet examples of fishermen contributions to data analysis are seen, although typically after an initial round of analysis done by the scientists. Fishermen can provide insight into how to interpret the results. An example of where this occurred was in the interpretation of the monkfish cooperative survey data. Another example is the Trawl Survey Advisory Panel, where fishermen helped interpret the results of the sea-trials of the proposed research gear. These are important examples of boundary spanning and capacity building seen in cooperative research.

Distribution of Results

Scientists most often write final reports just as they write proposals. Even though they probably in most cases have or can develop the skills, fishermen are not as comfortable writing research reports. However, unlike most scientific studies, fishermen sometimes participate in this process by reviewing and commenting on drafts written by the scientist before they are submitted. Through their participation in cooperative research, fishermen have learned what needs to be in final reports. They have built the capacity to participate in this crucial step.

Distribution of results is a critical step in the scientific research process. One way that this is done is through publication in peer-reviewed journals. Another is by oral and poster presentations at local, regional, or national conferences. In most cases, scientists alone publish and present results at conferences (sometimes with industry co-authors). In addition, in most academic forums where cooperative research findings are presented, scientists are the one presenting the findings. However, in many cases, typically when the venues are more stakeholder-based and/or management oriented (such as the Maine Fishermen's Forum, the RI Fish Expo, the Northeast Regional Bycatch Workshop, and two "Managing Our Nation's Fisheries" conferences), fishermen present findings from cooperative research. Fishermen have been panel members at academic-oriented meetings as well. At the American Fisheries Society annual meeting in 2005, a symposium featured numerous industry members talking about cooperative research and management (Reid and Hartley 2006). For example, a Maine fishermen spoke about the GOM grated whiting fishery (chapter 6) (Balzano 2006). This is another example of boundary spanning.

In most cases, the research was designed to answer a management problem or provide information that would contribute to fishery management process. As mentioned later, the fate of cooperative research in management has been limited. When it has succeeded, the project has involved someone active in the process that was able to shepherd the results through the process. The results of cooperative research need a voice in the management process in order to work. In some cases, fishermen have been that voice. In the case of getting the GOM grated whiting fishery approved as an exempted fishery (chapter 6), fishermen were right beside the lead scientist testifying at the council meetings. This is an important way fishermen contribute to the cooperative research process. Again, this is an example of boundary spanning and capacity building.

Participation

Another critical issue important when considering whether cooperative research is achieving its goal of integrating fishermen and their knowledge into science and management is participation, both its quality and quantity (McCay et al. 2006). In the various cooperative efforts discussed throughout this dissertation, we have seen different ways fishermen have participated and contributed their knowledge to science. In some projects, numbers of fishermen directly participating in a project were relatively high, such as the NE Regional Cod Tagging program, and in others only one or two boats participated, such as in the ME-NH Inshore Survey, *Loligo*-Scup selectivity studies, and the Mid-Atlantic Transect survey. This of course differs according to how you define "participation." The ME-NH inshore survey also included the "participation" by dozens of lobster fishermen who moved their traps to allow the survey to occur, and the Mid-Atlantic survey also included "participation" by those fishermen who purchased the research set-aside quota to fund the research. In addition, many of these projects received, even if only initially, advice from a planning/advisory board. The participation in these projects by fishermen who did not participate in the at-sea research should not be underestimated. For example, the “planning committee” of the Mid-Atlantic Transect Survey contributed significantly to the design, conduct, and outcome of the survey.

Regardless of the difficulties of quantifying participation in these cooperative research efforts, the perception of them as inclusive remains a fundamental issue. Indeed, many stakeholders interviewed feel that there is insufficient participation by enough different stakeholders in cooperative research. That is, many feel that the same boats and the same individuals are seen doing cooperative research. According to one industry spokesman, "There is a big perception among the fishing community as a whole that the same people keep getting the funding." Several industry members felt that the Northeast Consortium in particular only funded a small group of people and, as one industry group said, if you are not part of the “in crowd” then forget it. One industry group representative explained that they submitted funding for the NEC but were rejected but that this proposal was resubmitted exactly the same to the CRPP program, where it was funded. The reasons for non-funding by the NEC were such things as “poorly written” or “design flawed” – but then, they asked, why did the CRPP accept it? The industry member took this to indicate that the NEC did not fund their project because of political reasons (i.e., they were not part of the “in crowd”). Regardless, this indicates that different funding agencies have different views and/or expectations of what counts as “quality” science, indicating that the proposal review process may be somewhat subjective.

This research found that that most industry participants tend to be leaders in the fishing community. They are “insiders” in the management process, who know how to get involved and with whom. Those who do successfully become involved in cooperative research gain credentials that provide opportunities for future cooperative research, reducing options for newcomers. For example, in some cases research proposals or vessel bids (where industry members bid to participate in an already funded research effort) are often weighted for past experience doing cooperative research, thus giving those already involved a future advantage. Participation in cooperative research can be viewed as a competitive process, and unless a fisherman gets their “foot in the door” they will be excluded from the process. One scientist reflected on the challenges of broadening participation in cooperative research:

> “I think a lot of research vessels and fishermen have been sort of marginalized unintentionally. I mean there's very much in New England there's a group of boats and people that are involved in cooperative research that have gotten in from the beginning and are sort of in. And they do great work and they're great fishermen partners to have. I think there's a lot of other boats that are potentially great but they're either frustrated because they never got the vessel bid to do a research trip or they didn't quite put enough energy into it. We don't make it that easy. There's a lot of projects, it's very difficult to sort of find out for fishermen to find out when this project is you know how to get involved basically. It's like we don't send an announcement for every project we do to every fishing boat. So you have to kind of know the channels which I think some boats do and others don't so I think they're sort of continually been...so the more those group of fishermen that do know what they're doing they just kind of keep pursuing it so they keep getting research. So these guys keep getting further and further driven away.”

Learning how to participate in scientific research will not happen overnight. Fishermen, especially those “outside” the process, must be provided with opportunities to learn and participate. There have been numerous efforts to this end. For example, one research institute explained that it is important that some projects be put out to bid in order to provide industry members with opportunities to participate that were not involved in the original project development. This gets fishermen acquainted with the process and encourages them to participate again in the future. The NEC also asked fishermen to participate in the proposal review process as way to educate fishermen about what it takes to put a research proposal together, and many who were involved in the review process later went on to submit proposals. There are also outreach efforts like the MREP program and the Trawl Workshops funded by the NEC.

The issue of participation is difficult to reconcile. On one hand, the idea is to get as many people involved as possible, including introducing cooperative research to those unfamiliar with such activity. On the other hand, given the capacity building that takes place it is not a bad thing that once fishermen get involved, they continue to be involved. One project coordinator touched on these issues:

> "There are people who are semi-professional research fishermen now…They have 4,5,6 projects. But then again they are good fishermen and they were very good fishermen before too. I don't know. It would be good to involve people that would not otherwise be involved. Ninety-nine percent of the fishermen will never be involved. They don't know how. They don't feel that comfortable."

A gear scientist also appeared conflicted about wanting more fishermen to participate and on the other hand recognizing the challenges of working with inexperienced fishermen. Once a relationship has developed between a fishermen and scientist, they are more likely to want to work together in the future. This is not unlike what one sees in scientific communities:

> "The more you bring new vessels in, the more you have to go through the learning curve with people. There is a payoff there between getting lots of people who haven't been involved, getting them involved and perhaps not being as productive with them as you could have been had you worked with someone whose spent ten years working with you, and you know personalities."

And then there is the point raised by some participants, as seen in the quote from the project coordinator above, that regardless of the effort to get fishermen to participate some fishermen just do not want to be involved. Some feel that fishermen have to step forward on this. As one fisherman put it:

> "I'm sure that there are people that feel they are left out it. And I'm sure there are people that don't want anything to do with it. If you really want to do it, you find out about it, and you put the effort into planning it. We hear every once in a while that they need to get more people involved, people don't know how to get funded. We've been working on cooperative research for 5-6 years now and I don't believe there is an excuse for someone who wanted to get a project funded that they don't know how to do it. The outreach that the NEC has done, the staff - most of these places have…it's there if you want it. I don't mean to sound like that because I am someone who has been involved in this and did have success in getting funded. I mean that honestly. You've got to put some effort in…Projects are not going to come down and land themselves on your boat…Well, it's a lot easier to sit there and piss on the people who got funded than to go out and do it. I don't mean to sound like that, but…enough of the complaining."

Participation by a diverse group of stakeholders is critical to achieving the goals of cooperative research, especially the goal of integrating fishermen's knowledge into science and management. In addition, unless more different fishermen participate, the "buy-in" to fisheries science and management will not be achieved, and individuals will feel even more alienated from the process.

Considering the issue of participation raises the question again of "whose knowledge" should be used to improve fisheries management. Because fishermen's knowledge is heterogeneous (experience and locally-based), different fishermen are likely to have different knowledge to contribute. Fishermen utilizing different gear types, fishing in different locations and at different times of the year are likely to have different information to contribute. By not including a diverse group of fishermen, cooperative research will only integrate a portion of the available knowledge base of fishermen in the management process. Thus, if we increase the quality and diversity of participation by getting different people involved and in very meaningful ways, we can increase the diversity of knowledge available for fisheries science and management. Otherwise, we are not tapping into the scope and breadth of knowledge that exists in the fishing community.

Summary: Integration of Fishermen and FEBK in Cooperative Research

Based on the discussion above and the evidence seen in the case studies, fishermen and their FEBK are certainly being incorporated at important stages into scientific research through cooperative research. The cooperative research process itself appears no different than traditional scientific research, with the exception that it includes people not formally trained or employed as scientists. Most importantly, FEBK has proven useful in the development of research questions, research design, and in data collection. The level of integration differs according to the research needs and research program, where gear selectivity studies seem to be where fishermen's knowledge is most fully integrated. At the same time, there are important concerns regarding whether participation by enough different fishermen and the diversity of knowledge is sufficient (McCay et al. 2006).

Scientists play a more important role than fishermen do in the administrative aspects of cooperative research, such as permitting and report writing and submission of result, as well as data analysis. In this way, scientists act as "gatekeepers" to ensure that the project is done in a way that will generate legitimacy and authority in the policy making process. This is necessary if data from cooperative research are to influence the policy-making process. Interestingly, however, fishermen's contribution also is needed to ensure legitimacy and credibility among fishermen which also influences the policy-making process.

The boundaries between scientists and fishermen (and RBK and FEBK) indeed appear to be opening. Fishermen and their knowledge are making meaningful contributions to the scientific research process. They are both active participants and knowledge contributors. To be sure, fishermen's knowledge is incorporated through a process of translation or purification. That is, fishermen's knowledge is verified, aggregated, or otherwise made "scientific", but nonetheless makes an important contribution to the scientific project. Critics have noted that that process may change the nature of fishermen's knowledge and continues to privilege scientific knowledge over fishermen's knowledge. Yet, in the end, in many cases the outcome or knowledge produced does include fishermen's insights and knowledge.

The Fate of Cooperative Research in the Science Policy Process

To examine how cooperative research in incorporated into the cooperative research process (Figure 10-1, B), I observed the science policy process and interviewed stakeholders in the region to assess perceptions related to the fate of cooperative research. As discussed in the previous chapter, at least at this time the record is not great in terms of cooperative research influencing management. There is a perception, real or perceived, that not enough of cooperative research is making its way into the science policy process. Thus, spanning the knowledge/action or science/policy boundary has proven more difficult. To be sure, cooperative research is certainly not irrelevant in the process. It is widely discussed and referred to in both science and management processes.

This research found that in many cases the reason cooperative research has not fed into fisheries management has little to do with data quality (at least so far). Barriers to incorporating cooperative research into management appear no different than those that exist for the use of any knowledge in fisheries management, including traditional scientific knowledge produced by federal, state and academic scientists. There are legitimate and mundane reasons to account for the non-use of cooperative research in management. For example, some projects have not yet been completed (or perhaps never will be), did not produce data that was relevant for use in management (in some cases due to poor experimental design), or require a time series of data for use (i.e., they are long-term studies). In some cases, the data have "disappeared" or simply have not been shared (often because the results are not perceived as useful, data analysis has not yet been done, or the authors are waiting for publication). Many of these reasons for "non-use" are part of the learning curve of cooperative research. And most importantly, issues of data quality/peer review and transparency requirements make it difficult to incorporate new information into decision-making. Integrating cooperative research in management appears to be in part an institutional problem that arises from a political process requiring transparency and legal mandates. This is true for incorporating any knowledge into management, including traditional science.

Peer Review as a Boundary Management Process

One site of boundary management, and what some might argue of boundary making, is the peer review process. In cooperative research, the peer review process is complex and includes first a review of grant/project proposals and then the knowledge produced. The federal government scientists oversee both processes. These processes were discussed in chapter 3.

The peer review process distinguishes between what knowledge is valid for use in policy-making and what knowledge is deemed unsuitable, and therefore acts as a boundary making process. According to Jasanoff (1990) the institutionalization of peer review was facilitated by the emergence of a professional scientific community that wanted to ensure its self-interests, recognition, authority, and most importantly dependable knowledge. Peer review, she explains, was “a social compact created and sustained by the self-centered communal needs of science” (64). The process helps scientists maintain their “monopoly over scientific knowledge and over the allocation of funds for the generation of new knowledge.” Only scientists are viewed as being able to judge the validity of other scientists’ work. One problem, according to Chubin and Hackett (1990, 4) is that peer review “drives a wedge between nonscientists and the process of claims-making” because “scientists jealously guard their power to accept or reject the findings of their peers.”

In this research, a few stakeholders did question the credibility of the review process. For example, one industry representative felt that the Northeast Consortium was discriminating against members of her organization. She identified an “in crowd” that one had to be a part of to get funding, a claim that is probably not true, but perceived nevertheless. Interestingly, as evidence, she submitted a proposal that was rejected by the Northeast Consortium for having “serious flaws” but was later funded by the NMFS-CRPP program. Of course these are different funding agencies with different objectives, which may account for the difference, but nevertheless the differential treatment led the representative to question the legitimacy of the process. After all, the process is supposed to distinguish between acceptable and unacceptable science. Yet, in this case, the same science is considered acceptable one place and not in another.

Another stakeholder raised concerns about who was doing the reviews of the proposals and grants. Speaking about the MA-RSA program, he questioned whether it was appropriate to have external reviewers reject or accept proposals related to situations they knew nothing about. He was concerned that scientists outside the region would not understand the significance or practicality of specific research projects because they were not familiar with the context of the fisheries or marine system in this region. That is, they did not have the competence to make such decisions and so should not be given such authority and power. Moreover, he felt the peer review process did not function to ensure that the best scientific projects were funded, and hence questioned the legitimacy of the system.

Although the peer review process may seem a way for the government scientists to maintain their authority and power in the system, the story is more complicated than that. Not only is peer review necessary to ensure that the boundary between science and non-science is not made too porous, so as to ensure the legitimacy of the management process, but it is also a legal requirement. Legally, NMFS must ensure only the “best scientific information available” is used in fisheries management (as required by National Standard 2 and the Data Quality Act). NMFS is responsible for managing a public resource, and threats of litigation are significant, particularly by the environmental community. Providing a credible peer review of knowledge used in fisheries management is one way to ensure the public that they are not “letting the fox guard the henhouse.” If data are not reviewed for data quality, there is likely to be skepticism by fishermen and other members of the public.

Further, peer review of cooperative research is not dominated entirely by scientists, either government or non-government, and so the boundary is not as firm as one might expect. Rather it functions as an "extended peer review" process since fishermen and other stakeholders also contribute significantly to this process. For example, the Northeast Consortium review process and the NEFMC Research Steering and MAFMC Research Set-aside committees represent processes where non-scientists are included in review processes of research proposals and priority setting. In theory, the inclusion of these non-scientists make the peer review process more transparent and credible, since it taps into their expertise. In the NEFMC RSC, stakeholders and scientists review final reports to ensure their credibility and relevance for management. The question is whether including stakeholders in these review processes reduces or enhances legitimacy in the process.

The key to effective peer review is transparency and independence. As long as the peer review process remains transparent, potential legitimacy and credibility issues can be addressed. If the peer review process is not transparent, stakeholders are left to imagine where scientific advice used in management originated. They are also left to imagine why the results of a cooperative effort are not being used. Such questions can reduce the credibility and legitimacy of science, which is something that cooperative research aims to improve. Similarly, the process must be considered independent. In fact, fishermen involved in the science policy process often advocate the need for independent peer review by which they mean peer review by scientists outside the federal government. They do not trust the government scientists. There is heightened skepticism by fishermen as to the motives of government scientists, particularly in the post-Trawl gate era. Some fishermen feel scientists tried to cover up the trawl warp error, and some have gone as far as to say the federal scientists created a fisheries crisis that did not exist in order to secure funding for their research program. Many also do not feel it is credible for NMFS to judge its own scientists' work, and thus call for outside reviews. Transparency and independence are needed for fishermen and the public, particularly those not directly involved in cooperative research, to buy-in to the science.

As noted, in the Northeast there has been effort to make the cooperative research review process both independent and transparent. Several cases of transparent and independent peer review were noted in the case studies (e.g., Chouinard, Beutel, and Legault 2005; Chouinard, Weinbert, and McGovern 2006; Workshop Organizing Committee 2005). At these meetings, the reviewers were considered outside the projects that they were reviewing, and typically included at least one scientist from outside the region. These reviews were typically open to the public, although part of the review was held behind closed doors. Similarly, the NEFMC's RSC review of final reports is conducted transparently at public meetings. They are also announced at meetings of the entire regional council. If members are involved or otherwise connected to the participants in the project, RSC members recuse themselves from the review.

Involvement by fishermen and other stakeholders in these review processes is important to a main goal of cooperative research which is buy-in to the science, or increasing the legitimacy of science. Transparency is one of the aims of involving fishermen in research. The idea is that by being involved in cooperative research, fishermen will understand how science is done and consequently will have more confidence. This will allow them to "buy-in" to the science policy process, hopefully avoiding the dismissal of science that led to the groundfish crisis.

Cooperative Research as a Boundary Institution

Cooperative research can be considered a form of public participation that enables citizens with experience-based knowledge to contribute to the science policy process. They are able to share knowledge and expertise in the production of the science that forms the basis of policy-making. Cooperative research enables public participation by functioning as a "boundary institution" (Cash 2006; Guston 1996), one that negotiates the boundary between science and policy (and knowledge and action), while remaining responsible to both sides of the boundary. Cooperative research is expected to maintain scientific standards (i.e., through standard procedures and peer review) while being relevant to science policy. Cooperative research also allows for the integration of scientists and non-scientists (and their knowledge) while still demarcating between these different knowledge cultures. In cooperative research, fishermen and scientists are able to collaborate on important science policy issues and scientific questions while still maintaining their unique identities, specifically their knowledge shaped by their experience. Fishermen do not become scientists, nor do scientists become fishermen. Yet both fishermen and scientists are able to span the boundary between science and non-science.

Communication, translation, and mediation across the boundary are key functions of boundary institutions (Cash et al. 2004). These processes are linked closely. Many informants praise cooperative research for increasing communication between fishermen and scientists. As one fisherman explained:

> “Years ago we’d walk into a room and you’d go to a fishery management room or a PDT meeting, scientists would sit on one side and fishermen would sit on the other side and nobody would talk to each other. It was like nobody wanted to give up trade secrets. Now people are starting to have lunch together, talk to each other. The scientists are talking to fishermen to get the fishermen’s view. The fishermen are getting scientist’s view. So I think we’re on the right road, it’s getting better.”

The importance of communication in relation to conflict mediation was seen in the Trawl Survey Advisory Panel case study, where the conflict was between the NEFSC and the Panel (chapter 8). The lack of communication between the NEFSC and the Panel resulted in conflict that was mediated when communication improved. Also, the conflict between the different groups of fishermen resulted in part because the New England (GOM) fishermen did not communicate their concerns to the Panel when it was designing a net. The conflict between the groups may have been avoided had the fishermen brought their concerns to the Panel earlier in the process. By enabling communication across the boundary, disputes like these can be avoided.

Transparency is also necessary for communication. Cooperative research and the poor industry-science relationships (i.e., boundaries) emerged from distrust of science and management that occurred in the past. Many fishermen felt that scientists and government officials were conspiring against them, even going as far as to suggest that scientists were making up facts. Had the process been more transparent and open, and if communication between the groups had been the norm, perhaps this distrust could have been avoided. At the same time, the lack of communication left scientists thinking that fishermen were dismissing their advice simply because they did not like the consequences and accused them of being self-interested. Conflict between these groups emerged from this distrust. One of the most cited sources of conflict in cooperative research is the desire for fishermen to see the data and this, I believe, reflects the distrust that developed over the last several decades when fishermen and scientists were unable to communicate and understand each other.

Fishermen and scientists are able to communicate in part due to the translation that is possible. They are able to understand each other better due to a sharing of expertise or capacity building, or the movement of expertise moves from scientist to fishermen (and vice versa). Such capacity building was seen in the case studies. For example, several fishermen involved in the *Illex* squid real-time data collection effort were later able to contribute to the stock assessment process, in part because of the learning that occurred regarding the use of data in the assessment. In the NE regional cod tagging program, fishermen were exposed to and learned about the scientific research process. They not only learned how to tag and release fish, but also how to measure fish, take samples, and record data. They learned to appreciate the scientific need for standardization, as well as the importance of getting tag returns. These skills at data recording and a general understanding of standardization may be useful in other projects in the future. Similar learning has taken place with the fishermen involved in the industry-based surveys and gear studies. Fishermen also learn the language of science, including the meaning of scientific concepts like standardization and sampling. Thus, the capacity building seen (or new “interactional expertise” gained) related to assessments and science allows them to contribute their contributory expertise (i.e., experience-based knowledge) by being able to communicate and translate their knowledge to scientists, effectively allowing fishermen and their knowledge to span the boundary.

This ability to translate across the FEBK/RBK boundary facilitates conflict mediation in the policy process because it encourages buy-in to the science. This capacity building also creates a feeling of intellectual ownership and of greater access to fisheries information among fishermen. This access to information represents a resource for them to draw on in the science policy process. This new expertise gives them power in the process that they would not have otherwise since scientific knowledge is the currency in this arena. This shift in knowledge or expertise from scientists to fishermen is especially valuable in the long-term because it enables future exchanges across the boundary. This learning or capacity building may reduce conflicts between fishermen and scientists over the science used in fisheries management, and thus create “buy-in” to regulations based on that science. This can lead to management rules being viewed as more legitimate by stakeholders. Although cooperative research potentially can reduce conflict between fishermen and managers and scientists, it may create conflict between different groups of fishermen; those who participate and those who do not. While breaking down barriers between RBK and EBK, cooperative research also generates new boundaries, between those who are involved and those who remain outside the process. Those who participate in research gain expertise, often interactional rather than contributory expertise, related to science. This capacity building allows them to participate in the management process. They are able to communicate and translate their knowledge and interests. Those who do not participate may never gain these skills and expertise that can serve as a resource in the political process. This may affect the level of buy-in that is generated.

Another way cooperative research can mediate conflict is by reconciling the differential pictures of nature, which is due in part to the different scales at which their knowledge is produced. Ideally, by working together in cooperative research, fishermen and scientists (and managers) are more likely to agree on a single construction. In theory, it resolves conflict by merging or translating two perspectives into one shared view. Thus, they agree on the “facts” and policy-discussion can focus on what to do with those facts. The collaborations related to improving the NEFSC bottom trawl survey (i.e., IBSs and Trawl Survey Advisory Panel) are examples of fishermen trying to make the construction of Nature produced by the survey match their own experiences. Scientists similarly want to improve the accuracy and precision of their assessments, in part to increase the credibility of their work. We do not know yet if closer constructions will result from these collaborations, but that is certainly one intention.

Like other boundary institutions, cooperative research manages the expertise/policy and the FEBK/RBK boundaries by making use of “boundary objects” and “standardized packages.” Boundary objects serve as meeting grounds between actors on both sides of the boundary and can be used by individuals within each for specific purposes without losing their own identity (Star and Griesemer 1989). In this research, examples of boundary objects include proposed gear configurations that were being designed in collaboration by fishermen and scientists. Fishermen were able to bring to these efforts their expertise regarding gear and vessel operations and fishing, while scientists brought their expertise related to statistics and data collection. Other examples include the maps (mental or physical) that scientists and fishermen viewed when designing the industry-based surveys, electronic monitoring systems used to collect data, flume tank models and testing results, and preliminary data charts and tables.

Standardized packages define a conceptual and technical work space and are considered more robust than boundary objects, as they change practices on both sides of the boundary (Fujimura 1992). An example of this is the goals and norms of several cooperative research efforts. For example, the Trawl Survey Advisory Panel developed the characteristics of the trawl survey gear that they wanted to design, which balanced the scientific needs of standardization and consistency with the industry's desire to bring the gear into the twenty-first century. With these shared goals, written and accepted by consensus, both fishermen and scientists had to consider the needs of the other group, while still maintaining their own interests. Similar goals that balanced the interests of both groups formed the basis of other projects. Also, several norms of cooperative research, revealed in the previous chapter, guided these collaborations, such as treating fishermen as equal partners and cooperative research as more than chartering fishermen's vessels.

Most interestingly, we can expand the idea of "standardized package" and consider the shared meaning of science as enabling fishermen and scientists to negotiate the boundary between science and non-science. As discussed in chapter 9, fishermen and other stakeholders seem to accept the legitimacy of science, but question the credibility of the science currently produced. They also seem to accept the same definition of science as scientists and other members of the public. In fact, they are often heard advocating what could be considered Merton's norms of science: universalism, disinterestedness, organized skepticism, and communism. This is seen in calls for independent peer review and data sharing. An independent peer review process ideally supports universalism, interestedness, and organized skepticism, while data sharing supports communism. They want the basis of management to be science, but want to expand the definition of who is included in the process.

Boundary spanners are also critical to the effectiveness of cooperative research as a boundary institution. These come in many forms. In the case studies, key fishermen and scientists were seen as crucial to the success of these efforts. For example, in the *Illex* squid case study (chapter 4), the Rutgers University consultants and the captain who was also an appointed member of the MAFMC were seen as critical to increasing understanding between the industry and science. In the cod tagging case study (chapter 5), key boundary spanners included the tagging organization coordinators as well as the Gulf of Maine Research Institute. In the *Loligo*-scup gear selectivity studies (chapter 6), Rutgers University scientists and several experienced captains proved critical in these efforts, and especially the industry organization NFI-SMC. The Gulf of Maine grated raised footrope whiting fishery case study (chapter 6) illustrated the boundary spanning role played by state government scientists. The industry-based survey case studies also all included key fishermen and scientists who bridged the gap between fishermen and scientists. Again, those cases illustrated the critical role played by academic and state scientists. Finally, the members of the Trawl Survey Advisory Panel, both fishermen and scientists, functioned as key boundary spanners.

Another key to effective boundary management is the inclusion of diverse stakeholders. This has been noted already when I discussed participation, but deserves additional emphasis. Those who participate may have a greater understanding and capacity to span the boundary than those who do not. The *Illex* squid real-time data collection program collected data that was directly usable in the stock assessment process because the lead government assessment scientist was involved in the design and implementation of the program. On the other hand, it is not clear whether data from the NE Regional Cod Tagging Program will be used in the assessment process since the key cod assessment scientists were excluded from the project. Other examples similarly illustrate potential problems when those most likely to use the data are not consulted, such as the Cod IBS. Although the literature often simplifies the problem of incorporating fishermen's knowledge into science and management as being the result of a divide between two knowledge cultures, science and local knowledge, we are reminded that when thinking about cooperative research, we need to remember that there are several knowledge cultures. In the case of cooperative research, federal scientists often treated differently than state and academic scientists. These individuals also need to be understood in the context of the institutions in which they work. If not all participants, the process may fail as an effective boundary institution.

Conclusion: Integrating Fishermen and FEBK into the Science Policy Process

Cooperative research is a process that integrates citizens' experience-based knowledge with scientists' research-based knowledge to produce a new source of knowledge for decision-making. Specifically, it allows non-ordinary citizens — that is, expert and experienced fishermen — to share their experience-based knowledge with scientists' research-based knowledge. Fishermen's experience-based knowledge (FEBK) tends to be produced at a more local scale than fisheries scientists' research-based knowledge. Cooperative research makes local FEBK more relevant or usable in the science policy process either by making it fit the requirements of the scientific method or by aggregating it to a scale more compatible for science-based management. It also is able to do this by acting as a boundary institution, one that enables communication, translation, and mediation across the boundary between science and non-science.

While allowing boundary-spanning, cooperative research also both maintains and reaffirms the boundary between science and non-science and the hegemony of science. Scientific-based RBK remains privileged compared with FEBK, which continues to need refinement and translation before being utilized in the science policy process. This is necessary if it is to be utilized in the science policy process, as being “scientific” engenders credibility and legitimacy, while also meeting legal data quality requirements. Thus, interestingly, in order to span the boundary between science and non-science, citizens must at the same time maintain it.

Cooperative research is a better solution than relying solely on either scientists or fishermen to produce knowledge for policy. On one hand, overreliance on RBK may ignore crucial local processes and phenomenon, and may not engender buy-in or compliance to management. This was the condition of the process at the time cooperative research was initiated. The Canadian cod crisis illustrates a potential outcome of dismissing FEBK in favor of RBK (Finlayson 1994).

On the other hand, overreliance on FEBK should also be a concern. The New England groundfish crisis (Boreman et al. 1997) illustrates a potential outcome of dismissing scientific knowledge. Utilizing FEBK as the sole basis of management ultimately raises questions regarding whose local knowledge to utilize and how to fit it into the large-scale management paradigm? As noted previously, the heterogeneous nature of FEBK is an impediment to integrating it into science and management. Relying on FEBK may engender collective action problems. In the absence of agreement, stakeholders are unable to agree on conservation measures. Disputes are likely to emerge between different groups who aim to make their knowledge (and/or interests) the basis of management. The outcome may be the economic domination of the political process. In New England there is a cultural basis for avoiding such class conflicts, which explains the avoidance of ITQs. There is a tension here between having rule by experts (i.e., scientists) and rule by power/wealth. Cooperative research produces information that, although still a form of RBK/science, utilizes FEBK while making use of the benefits of science as a source of consensus. The key is that cooperative research maintains those standards accepted by all parties as producing legitimate and credible knowledge, including peer review.

Cooperative research, therefore, is both a mode of scientific knowledge production and a form of public participation. It can be thought of as "democratized science" (Guston 2004) and an extension of "joint fact-finding" (Andrews 2002) principles from the dispute resolution field, where diverse stakeholders seek out experts or information that are accepted as credible and relevant. It enables public participation in decision-making and is a form of citizen science, one that includes more than ordinary citizens, those with experience-based knowledge. As with any more participatory forms of policy-making, the collaborative process through which this knowledge is generated should produce more legitimate and effective management institutions by generating broader acceptance of both management decisions based on that science.

[1] In the past before, this “new wave” of cooperative research, fishermen were not as integrated in development aspects of research. There has always been management driven research, but fishermen rarely were involved in the process to the extent that they are now (i.e., at the table drafting research priorities and RFPs, and then reviewing research proposals as discussed later), although some contributed to identifying management priorities as members of the FMCs. One exception is that fishermen in the Northeast were members of what were called “development foundations” that did contribute to research priority setting for programs funded by the Saltonstall-Kennedy grant program.

[2] The Marine Resource Education Project (MREP) is a cooperative program initially funded by the Northeast Consortium to enhance stakeholder participation in fisheries policy and management decisions (Daigle 2003). Stakeholders, including fishermen, managers, and scientists, participate in two three-day workshops on fisheries science and fisheries management. The program was initiated in 2001 at the University of New Hampshire. Now the program is run by the Gulf of Maine Research Institute and has been expanded to include more fishermen. For example, the program was conducted in Newport, Rhode Island in January 2006 to accommodate Rhode Island fishermen. In my interviews, fishermen, scientists, and managers that had participated in the program praised it for helping to improve communication between fishermen and scientists.

[3] Like any scientific research proposal, the proposal will justify the relevance of the research (including possible references to existing literature), explain the design and why the methods chosen are adequate to address the given question, and state how the results will be analyzed. The proposal should also include a budget. In addition, a cooperative research proposal should discuss the roles of the various partners in the program – particularly emphasizing the contribution of the industry partner. The research funds for most of these cooperative efforts were created with the intention of increasing industry involvement in research. Thus, the proposals must specify the contribution of the industry partners. For the same reason, the budget must specify how much of the funds will go to the fishing industry partner. These proposals are submitted to various funding programs, often with strict deadlines to meet.

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Publications

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