

Assessing Vulnerabilities: Integrating Information about Driving Forces that Affect Risks and Resilience in Fishing Communities

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Abstract

Those engaging in fishing-related activities and the communities in which they live face many and varied pressures. Resource depletion and the associated regulatory responses impose constraints on fishing activities and can exacerbate economic and social pressures on fisheries stakeholders. Other factors, such as increasing coastal development and shifting demographics, have brought additional threats to the sustainability of fisheries and those dependent on them. Regional fisheries management councils and the National Marine Fisheries Service are required to consider the potential benefits and costs of proposed management measures, as well as vulnerabilities and risks to fishermen and fishing communities resulting from these measures. However, social and economic data related to fishery stakeholders are not always readily available.

Additionally, information on specific sub-groups that may have special needs and vulnerabilities in terms of the potential for disproportionate impacts resulting from proposed measures is even more illusive. A large number of factors—or driving forces—may contribute to individual and group vulnerability. In this paper we explore the utility of considering vulnerability in the assessment of potential impacts from fisheries management measures. We begin by reviewing a conceptual framework of vulnerability and the driving forces of vulnerability. We then discuss how a consideration of vulnerability can inform managers by presenting results from recent empirical work related to marine fisheries. Finally, we discuss the potential benefits of a specific focus on vulnerability to fisheries management measures.

Keywords: *vulnerability assessment, marine fisheries, social impact assessment, fishery management*

Introduction

Those engaging in fishing-related activities and the communities in which they live face many and varied pressures. Resource depletion and associated regulatory responses imposing constraints on fishing activities can exacerbate economic and social pressures on those involved in commercial fisheries (Heinz 2000). Other factors, such as increasing coastal development (NOAA 1997a; NOAA 1997b; Communities Panels Project 2003; Buchsbaum et al. 2005) and shifting demographics (Hall-Arber et al. 2001), have brought additional threats to the sustainability of fisheries and those dependent on them. Such economic, social, and regulatory pressures may also exacerbate the physical dangers fishermen face at sea (U.S. Coast Guard 1999; Murray and Dolomont 1994, 1995; Hall-Arber et al. 2001); these pressures may lead, either directly or indirectly, to loss of life, injury, and loss of property.

Regional fisheries management councils and the National Marine Fisheries Service (NMFS) are required to assess the social, cultural, and economic dimensions of impacts on fishery stakeholders. The Fishery Conservation and Management Act of 1976 (MSA), and its amendments (especially the Sustainable Fisheries Act (SFA) of 1996), require NMFS to assess potential benefits and costs and to consider vulnerabilities and risks to fishermen and fishing communities from regulations to protect fish stocks and habitats. The SFA also established National Standards for Fishery Management Plans that require them to assess the fairness and equity of management measures (National Standard 4) and their potential social impacts (National Standard 8). The need for fisheries' managers to consider the distributional and cumulative effects arising from regulations and rules is reinforced by Executive Order 12898 on environmental justice, signed by President Clinton in February 1994.

Rules, regulations, and environmental conditions may differentially impact some participants in commercial fishing activities because of myriad factors, including vessel size, species fished, gear requirements, and demographic factors. Information on potential social and economic impacts is not easily obtainable, with information on the special vulnerabilities and potential for disproportionate impacts to particular sub-groups even more illusive. In this paper we explore the utility of considering vulnerability in the assessment of potential impacts from proposed fisheries management measures. In particular, vulnerability is a concept that can guide collection of routine social, economic, and cultural data. Vulnerability refers to the way a human-environment system is likely to experience harm from exposure to specific threats, with specific attention given to differences among groups and regions (Kasperson et al. 2005; Turner et al. 2003a). Within

marine fisheries, vulnerability can arise at different scales within a human environment system, from individuals to local communities, economic sectors, regions, and nations. We begin by reviewing the relationship between risk and vulnerability, a conceptual framework of vulnerability, and driving forces of vulnerability. We then illustrate how consideration of vulnerability can inform fisheries management with a brief example from our recent empirical research. Finally, we discuss the potential benefits of a specific focus on vulnerability to fisheries management.

Definitions and Components of Vulnerability

Risk and vulnerability are intimately related concepts. Risks are the probability of hazards (including both stresses and events) that can cause undesirable outcomes. Vulnerabilities condition the magnitude/severity of those outcomes. Vulnerability is a function of the stresses people experience and their ability to cope with them. This basic relationship underlies many policy, regulatory, and research activities.

Typically, hazards are defined as threats to humans and things that they value (Burton et al. 1978; Hohenemser et al. 1985). Hazards can arise from natural, or biophysical, origins, such as hurricanes, floods, and droughts. However, environmental threats can also be a function of people, or human driving forces, such as resource depletion, emission of toxic chemicals into the environment, settlement in flood plains, and over-fishing. They are a result of interactions between people and the physical (or natural) environment, and the threats can be from singular, repeating, or chronic perturbations (e.g., disasters or events that cause impacts outside of the normal range of functioning of a system) or stresses (e.g., pressures on a system that result from processes within the "normal" range of functioning of a system). Consequences from hazards emerge through a causal chain, as shown in Figure 1, that links choices of activities or technologies (e.g., commercial off-shore fishing), events (e.g., new regulations, adverse weather) with outcomes (direct effects; e.g., reduced catches, damage to vessel) that result in various beneficial and adverse consequences (e.g., health, economic, social, ecological).

In general, concern with risk reflects a concern about the likelihood of harm occurring from some kind of hazard. For example, hazard managers and risk assessors have asked: How likely is a flood, and how many people might be harmed by the flood? In the arena of fisheries management, there is concern about the risk, for example, of:

- collapse and health of stocks,
- safety and health of fishermen,
- economic costs to fishermen,
- adverse impacts on fishery communities from changes in fish stocks and regulatory change.

However, degree of harmful impact is not just a function of the conditional probability of an event (i.e., stress or perturbation). It is also a function of the susceptibility of people, social systems, and natural environments to the stresses or perturbations. For example, differences in exposure to a hazard and to the sensitivity to the exposure can differentially affect individuals and groups and cause them to be more or less susceptible to adverse consequences. During a 100-year flood event, households unable to fill sandbags, move furniture to the upper floors, or evacuate are likely to suffer more. These differences are related to the vulnerability of individuals and groups.

At its most basic level, vulnerability can be defined as the “differential susceptibility to loss from a given insult” (Kasperson et al. 2001a, 24), although many definitions of vulnerability have been proposed in the literature². Dow (1992) notes that definitions of vulnerability are often expressed as a function of exposure to risk or as a measure of coping capabilities and that those definitions can vary according to the spatial and temporal scales that are considered.

In some cases vulnerability is conflated with risk or described as the opposite of resilience. Differences in definitions and conceptual frameworks arise as a result of different disciplinary roots, systems of interest (e.g., social vs. biophysical), and the efforts of some to analytically separate mechanisms that cause harm (e.g., exposure to stressor) from those that provide the capacity to respond (e.g., resilience, adaptive capacity). However, as Kasperson et al. (2001a, 25) point out, “although the specific terms, concepts, and criteria used to address vulnerability differ, basic concepts are consistent—the ability to continue to function within a normal range despite perturbation and the ability to recover from perturbations that substantially disrupt the normal functioning of the system.”

Increasingly, researchers of vulnerability have adopted a definition that is multi-dimensional, linking exposure to a hazard, the sensitivity of people to loss from the exposure, and the ability to resist or cope with the exposure or loss (Dow 1992; Kasperson et al. 2005; Turner et al. 2003a, 2003b; Smit and Wandel 2006). The dimensions of this definition are exposure, sensitivity, and resilience (Figure 1). Within a system these can be considered analytically as separate features, although the factors and processes that create and maintain them are often inter-related and inter-dependent.

Exposure refers to the presence of a threat (hazard), defined both temporally and spatially, to an individual or group. In the case of fisheries, exposure can refer to the implementation of new regulations, adverse weather, collapse of fish populations, and other kinds of events, stresses, and perturbations. Exposure can occur at multiple scales, including the

individual, household, community, regional, national, or global scales. Often those that are most exposed will be the most vulnerable to the effects of stresses and perturbations. However, exposure is not enough to define vulnerability. For instance, as the Hurricane Katrina disaster demonstrated, tremendous variability among groups condition how well they can weather a storm and rebuild.

Sensitivity refers to the degree to which an individual or group is likely to experience harm when exposed to a threat. The importance of this dimension is related to the frequency with which individuals and groups are differentially sensitive to a particular exposure; thus, sensitivity refers to the outcomes from “first order effects” or direct effects of exposure to a hazard. Sensitivity arises from features of human and environmental conditions. Many features of social/human systems can influence sensitivity. They include the characteristics of individuals (e.g., ethnicity, health, gender, age, wealth/poverty, education), including risk-seeking behaviors (see Pollnac and Poggie and Hall-Arber and Mrakovcich, both in this issue). Sensitivity may also be related to characteristics of communities and social relationships (e.g., differential entitlements and access to resources, absence of social support mechanisms) and institutions (e.g., differential enforcement of regulations affecting access to resources). Features of the biophysical environment may also affect sensitivities, such as location (e.g., proximity to danger, soil or marine productivity, climatic events). These are dynamic characteristics that vary with many factors such as the number of dependents in a household, health, and age. Again, those who are most sensitive to a particular exposure are likely to be the most vulnerable—but this is not always the case because people can temper their sensitivity by increasing their resilience.

Resilience refers to the ability of a system to withstand or to recover from a stress or perturbation and adapt to future stresses and perturbations³. A variety of terms, emphasizing different aspects of this trait, have been used to refer to the ability of social systems to recover from stresses or perturbations, including adaptation, coping, adaptive capacity, and adjustment. People do not necessarily passively accept danger—they move away from it, resist it, or attempt to limit impacts. Some actions may be anticipatory (e.g., avoid exposure to a future threat), occur as stresses and perturbations arise (i.e., short-term coping measures or adjustments), or change the human-environmental system in more fundamental ways (i.e., to reduce exposure to future stresses and perturbations, or adaptation). In other words, resilience arises from incidental or purposeful responses that occur after experience of an exposure or in expectation of a future exposure. People can enact measures to limit their exposure to a perturbation or stress, decrease sensitivity to the perturbation or stress, or the severity of the consequences of the stress or

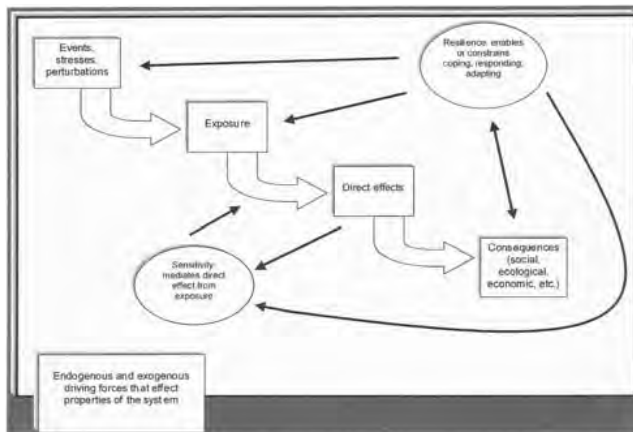


Figure 1. Exposure, sensitivity, and resilience mediate consequences from threats (i.e., events, etc.) in coupled human-environment systems.

perturbation. This is part of the reason that those who are most exposed may not be the most vulnerable in a particular situation. This also means that vulnerabilities can change over time as short and long term adaptive responses change: a) the character of threats, b) exposures to the threats, c) sensitivities, and d) efforts to recover from immediate outcomes and longer term consequences (see Figure 1; the shadows in Figure 1 are meant to illustrate that vulnerability and hazards change over time).

Resilience and sensitivity are closely related concepts—over time, the absence of resilience can lead to sensitivity and reductions in sensitivity can also increase resilience. For example, lack of financial assets can make a fisherman more sensitive to the impacts of new regulations that restrict fishing in certain areas (e.g., because of increased steaming times that increase fuel costs to get to fishing grounds). Access to financial assets can increase adaptive capacity by enabling the fisherman to buy new permits or manage increased costs.

It is important to differentiate these two dimensions for both analytical and practical reasons. First, sensitivity is a condition of the system that links exposures to direct outcomes resulting from the exposures. It is defined by variables that mediate people's direct experiences with a particular exposure defined in both time and space. For example, new restrictive regulations (the event) reduce the amount of fish caught (the direct effect). Fishermen with fewer days at sea or permits are more sensitive to new restrictive regulations (the event) than those fishermen who have permits to fish multiple sectors or have more days at sea that enable them to continue to catch enough fish to maintain financial viability. On the other hand, resilience refers to the capacity of individuals, groups, and systems to influence the human-environment system at a different point—"a process, action, or outcome in a system (household, community, group, sector, region, coun-

try) in order for the system to better cope with, manage, or adjust to some changing condition, stress, hazard, risk, or opportunity" (Smit and Wandel 2006, 282). In the case of new regulations that restrict days at sea, resilience refers to the ways that fishermen can respond to the regulation and its direct effect: they can purchase new permits, they can reduce crew size, they can sell their vessel and permit, they can change where they fish, their wives may start to work, etc. They change the human-environment system. This capacity to increase resilience by altering the system may be affected, positively or negatively, by sensitivities, but they are not equivalent. Moreover, repeated and cumulative exposure to stresses or perturbations may overwhelm adaptive capacities of individuals, groups, and institutions (e.g. use up "stocks" of reserves) leaving them more vulnerable to future threats because of increased sensitivity or reduced resilience (e.g., Kaspersen et al. 2005). These conditions may be actively constructed (i.e., differential access to economic assets) or not (e.g., physical strength due to age). But policy efforts to manage vulnerability may focus on providing new sources of resilience, such as low interest loans, for the most sensitive or to avoid strategies that place greater stress on sensitive populations.

Second, people may (intentionally) trade-off sensitivity and resilience against each other. For example, fishermen may decide to hedge their bets by obtaining licenses for different species and investing in additional vessels or different kinds of gear by taking out additional bank loans. By heightening their overall investment, these actions would have the effect of increasing their sensitivity to declining fish stocks and more severe regulatory responses, but also increasing their opportunities (and hence resilience) by allowing them to move between fisheries. The success of either strategy in reducing vulnerability is heavily dependent on the character of future events. Individuals and societies cannot be perfectly adapted to all threats.

Finally, by considering these interacting components within a larger human-environment system, a more nuanced understanding can be developed of how vulnerabilities vary across time, space, and groups. Moreover, "vulnerability to one stressor may entail multiple forms of harm, such as physical, economic, property, or psychological damage, with the implication that it is possible to design and prioritize adaptive strategies to reduce a particular form of harm or vulnerability" (Dow et al. 2007, 229). Analytically separating them can help to reveal aspects of the system that can inform management decisions and behaviors of those participating in fishing related activities. For example:

- Fishermen are exposed to varied threats in their work (See Hall-Arber and Mrakovcich in this issue). They may be exposed to adverse weather conditions while

out to sea. Working conditions can be dangerous, exposing them to injury or death, due to fast paced activities and limited space in which to work and move gear. They may also be exposed to economic threats because of limited fish stocks or regulations that prevent them from catching available stocks.

- Fishermen may be differentially sensitive to the exposures. The conditions that exist at the time fishermen experience these threats can affect the likelihood of them experiencing harm, and the magnitude of that harm. Some individuals may have more experience or training, work on newer, better equipped boats, or with captains that are more wary of placing crew in harm's way. Vessels may be of different sizes and structural strengths. Those who rely on income from a single person's fisheries-related employment may be more likely to experience harm from economic threats than dual-income households. Individuals with diverse skills or who are younger may be able to find part-time employment in other sectors (e.g., construction). While once fishermen may have been able to switch from one fishery to another with more ease, both regulatory constraints and the use of more advanced, but also more specific technologies, may now prevent such adaptation.
- At the same time, some individuals, households, communities, or sectors may be more resilient to such changes; that is, they may be more adept at anticipating emerging threats and taking action to avoid them once they are experienced. For example, fishermen may use available assets that allow them to absorb losses from slow times or damaged equipment. Skills and experience developed in a recent storm may be used to escape from dangerous conditions in the future. Or, fishermen may purchase additional licenses that allow them to fish more within a single sector or in different sectors.

Driving Forces of Vulnerability

Driving forces of vulnerability are factors that shape the three dimensions of vulnerability. A great number of driving forces of vulnerability have been studied in relation to environmental hazards, such as climate change, hurricanes, earthquakes, and drought. Driving forces related to vulnerability have been related to the degree of social capital in a community, exposure to environmental hazards and stresses, population and demographic changes, quality of monitoring and alerting systems, dependence and substitutability of natural resources, access to decision-making processes, and institutional learning and vigilance, regulatory systems, perceptions

of managers, and distribution, access, and depth of coping resources, assets and options.

Driving forces of vulnerability can be grouped in various ways. For example, they may be endogenous to the human-environment system (e.g., political forces that affect fisheries management councils) or exogenous to the system (e.g., election of a new president, global climate change, stock market crash). They can also be grouped with respect to the ways that they shape exposure, sensitivity, and resilience. Finally, they can be grouped according to their role as driving forces of vulnerability in coupled human-environment systems as shown in Table 1 (Dow 1992; Kaspersen et al. 2001a). Many important driving forces of vulnerability in fishery systems have been previously studied in each of these categories, although the language of vulnerability is rarely used; we briefly review examples of this work.

Table 1. Seven broad categories of factors and processes to characterize driving forces of vulnerability.

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- Demographic factors (e.g., age, illness, other physical limitations, class, gender, ethnicity, language)
 - Individual decision-making factors (e.g. human capital, capacity)
 - Institutional factors (e.g., regulatory and legal framework, access, scope of activities, accessibility of institutions, modes of participation)
 - Economic factors (e.g., economic assets, entitlements, safety nets, insurance)
 - Socio-cultural factors (e.g., social capital, social services, cultural norms)
 - Technological factors (e.g., availability, substitutability, failure rates)
 - Environmental factors (e.g., biophysical, ecosystem, natural resources)
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Demographic factors are related to vulnerability among fishermen and fishing communities. For example, in a series of studies Hamilton et al. (1998, 2000, 2001, 2003, 2004) found that the percent of older inhabitants in Newfoundland fishing communities increased as out-migration continued and the birth rate decreased. High percentages of older inhabitants can increase a community's sensitivity to additional exposures. On the other hand, they found a variety of responses aimed at coping. For example, female employment increased as male unemployment rose. In another context Allen and Gough (2006) describe the disproportionate effects on Hawaii-based Vietnamese-American longline fishermen from the 2001 NMFS ruling prohibiting targeting of swordfish due to interactions with threatened and endangered sea turtles. Additionally, Juravich (2005) illustrates how undocumented workers from Central America have little protection because of their undocumented status and the lack of unions within the fish processing sector. They also experience a lack of mobility because they are not able to get driver's licenses, thus, compounding their dependence on seafood processing

because the processing factories are among the only work places within walking distance. Many immigrants speak little English (or even Spanish) and there is a lack of employer support for English as a Second Language (ESL) courses.

Fishermen's decisions may affect their vulnerability. They may seek alternate employment or move their fishing activities to less regulated stocks (Hamilton 2003). Their actions may also put them at more risk. For example, the National Research Council (1991) and others (e.g., U.S. Coast Guard 1999; Murray and Dolomont 1994, 1995) have explored factors that contribute to accidents. They have also identified data gaps. Factors that were assessed included captain and crew decision-making, behaviors, and skills (as well as training), weather, fisheries management (e.g., regulations and incentives), weather services, and insurance.

Institutional factors, such as the regulatory and legal framework, access to fishing areas, accessibility of institutions, and modes of participation play a role in the characteristics of people's vulnerability. Acheson's (1988, 2003) work on the institutional and organizational context of the lobster fishery of Maine demonstrates the formal and informal rules and regulations that govern access to and harvests from this fishery. While historical experiences of fishermen have contributed to a strong conservation ethic, he also found that efforts to define and control distribution rights (territoriality) were particularly important in managing the fishery. Often, informal rules are enforced by "lobster gangs." In addition, decentralized management approaches have been important to the history of this fishery; "all of the more successful lobster management efforts have in common that they have embodied many of the elements of bottom-up or co-management" (Acheson 2003, 231). Others have also found that collaborative management can help to reduce exposure to threats (e.g., stock depletion) and sensitivities and increase resilience to negative trends in fish stocks (Pinto da Silva and Kitts 2006; Poitras et al. 2003; Hartley et al. (in this issue); Waage 2003). Although benefits of collaborative initiatives have been observed in many cases, not all are successful or uncontroversial (e.g., Wilson and McCay 1998; Poitras et al. 2003; Morin 2001).

Economic factors affect vulnerabilities in a variety of ways. For example, sensitivity to seasonal fluctuations in income among many Canadian fishermen was mitigated by reliance on unemployment insurance for at least part of the year (Hamilton 2003). Hall-Arber et al. (2001) shed light on the important issue of scale—how dependency and vulnerability are related to scales of individual fishermen, households, communities, and subregions. For example, at the community or regional scale vulnerability may appear to be small because the economic contribution of fisheries to local and regional economies is small relative to other sectors. Further-

more, larger vulnerabilities within one sector (e.g., ground-fishing) may be masked by smaller vulnerabilities in other sectors (e.g., inshore lobstering). Georgianna and Shrader (in this issue; see also Georgianna and Shrader 2005) studied employment, income, and working conditions in New Bedford's dragger and scalloper fleets over a ten year period (beginning in the early 1990s and ending in 2002). They found tensions between economic factors and safety (e.g., extended working hours off-shore with reduced crew sizes).

A study of fishing families provides insight into socio-cultural factors related to vulnerability—the dynamics of relationships within families and households (Zvonkovic et al. 1996; O'Dell et al. 1998; see also Smith 1995) and how families cope with the characteristics of fishing work, including long separations. They found that couples can cope with the demands of this cycle in different ways, and some are more successful than others. Strategies used include methods of maintaining and strengthening communication, increasing a sense of togetherness, and improving their abilities to be flexible to change (O'Dell et al. 1998).

Studies related to the importance of technological factors (e.g., availability, substitutability, failure rates) have highlighted the importance of infrastructure and services to fishermen. Hall-Arber worked with researchers and local coordinators to assemble "community panels" with knowledge about the local fisheries in New Bedford, MA, Gloucester, MA, Pt. Judith, RI, Portland, ME, and Beals Island and Jonesport, ME. Together these panels completed a series of reports (Community Panels Project 2003, 2004a, 2004b, 2004c, 2005) that documented the status of and changes to local fishery-related infrastructure. Such infrastructure includes mooring and dock space, vessel repair services and facilities, ice vendors, gear and supply vendors, and fueling facilities. Infrastructure was also defined as including the people necessary for a fully functioning fishery-based economy (such as experienced crew, skilled tradesmen (e.g., mechanics, welders, and attorneys), access to markets, availability of insurance and community-based and social support organizations (e.g., auction houses, cooperatives, fishermen's wives associations). Lack of important services in an area can increase sensitivities (e.g., by exacerbating the effects of stresses such as weather, reduced fish stocks, regulations) and reduce the capacity to cope (e.g., inability to get vessels repaired). Others have explored the ways vessel size and equipment are related to injuries to fishermen (U.S. Coast Guard 1999; National Research Council 1991).

Environmental factors (e.g., biophysical, ecosystem, natural resources) can exacerbate vulnerabilities. For example, coastal pollution and habitat loss can affect fish populations (Buchsbbaum et al. 2005). Less fish in areas traditionally fished can decrease fishermen's ability to adapt.

The advantages of considering vulnerability explicitly in assessments of fisheries can be illustrated by our recent empirical work. Specifically, we investigated the driving forces of vulnerability as factors in safety in New Bedford, MA and Pt. Judith, RI (Tuler et al. Forthcoming). These case studies explored how risk and safety in fishing are related to the vulnerabilities faced by fishermen. The interplay of policy, regulation, voluntary programs, and individuals' behaviors and attitudes in promoting safety is complex. Similarly, the conditions that give rise to risk in marine fishing are complex. The case studies revealed a number of factors—or driving forces—that may contribute to vulnerability among commercial fishermen.

Demographic Factors

In both cases our interviewees talked of how their age increases their individual vulnerability because their options are more limited. They also talked of how there are fewer young people joining the fisheries because of (perceived) limits in opportunities. For example, one interviewee in Pt. Judith stated that the fleet and the captains in Pt. Judith are both aging and that there is less incentive for youth to enter the industry. Moreover, he felt that the quality of mates and captains for vessels is decreasing; it has been reduced by perceived inability for these people to make a living and become boat owners.

An important factor in safety is the quality and quantity of crew. We heard numerous comments related to the ways that crew characteristics can affect safety. First, interviewees from both communities identified the availability of skilled crew as a major concern. In Pt. Judith we were told that there are many transients looking for fishing jobs. Transients may work full-time as crew, but they do not work for any single captain. Interviewees from New Bedford told us that “many men are willing to work but not all of them are experienced.” An interviewee from Pt. Judith told us that the biggest risks are training and experience levels—the caliber of people looking for work in the fishing industry is inferior to what it used to be. There is no training for them any more and no real future for them because there is no ability for them to get their own licenses. Interviewees from New Bedford stated that

if the net comes in all torn up I need someone to fix it. I just can't go out with four or five guys who haven't fished before. They have to have knowledge, at least two guys that know what to do. When steaming you need a mate that knows how to wheel watch . . . without experience he cannot do a watch by himself, need someone else with him.

Concerns were also expressed about alcoholism and drug use. An interviewee from Pt. Judith stated that there are more

drunks and alcoholics/drug users looking to be crew—people desperate for money and this is a quick way to get paid.

Second, captains are fishing with fewer crewmembers. Fewer crewmembers can affect safety. An interviewee from Pt. Judith reported that he used to go out five-handed, but now he goes out four-handed to get a better paycheck. This means less sleep for everyone, but the cost of fuel, insurance, gear, and bait have all gone up, while the price for fish has not. Similarly, a fisherman from New Bedford told us:

No one wants to go out fishing anymore. I have a hard time getting crew . . . right now we go out with four. We have a new guy that has never been fishing before. We need more, but we cannot get anyone to go out to fish . . . some boats are going out with three men, you don't sleep. It's a safety problem. They might fall asleep at the wheel.

Individual Decision-Making Factors

Safety—and vulnerability—can be affected by the ways that individuals and groups make decisions. They can decide to continue working in hazardous conditions (thus, increasing their exposure to a threat). Or, they may make decisions and take actions that mitigate their sensitivities or enhance their coping to threats. Their judgment and physical strength may be affected by long hours of work.

There is a very large body of research that underscores the ways that workload and fatigue contribute to accidents, including in the literature on fishing accidents and safety (Georgianna and Shrader 2005). For example, according to one interviewee, workload and fatigue “means that you are less sharp and may make less good decisions.” In combination with economic and institutional driving forces of vulnerability, captains may decide (and crews might demand or encourage) to do things that increase exposures to threats. They may decide to remain at sea during poor weather because they are reluctant to forgo the opportunity for income when operating at the margins, a form of economic vulnerability. As one fisherman put it: “another thing is safety. If I go out and bad weather comes, I am not going to go back in. Because if I go back in I'm gonna lose time, so I am gonna stay out there. That is how a lot of boats get lost.” A second stated that

It is easy to make those regulations [that constrain opportunities to make good catches], but the captain has to decide. If I don't make money by the time we get back to home, they are going to quit the boat and then I won't have any crew. So you have to make the catch, even if the weather is bad.

But, some did not, in spite of the same pressures: “He is a

good boss. He doesn't like to go in bad weather. He is safe. This is one of the reasons [I stay with him]."

Economic pressures (see below) can affect the kinds of decisions made; decisions are made under stress. Fishermen from Pt. Judith spoke of the ways they cope with economic pressures: the reaction to stress is to work harder and be more stubborn. These are factors that can also lead to poor judgments and errors that increase the risks of accidents and injuries.

Finally, from our interviews in New Bedford we also learned that language is an important driving force of vulnerability that can increase exposures and sensitivities, while at the same time improving coping. Within the predominately Portuguese-speaking groundfish fishing community, language was viewed as both a problem and an asset. Boats often have crew members that speak the same language, which is important for clear communication in a dangerous environment. However, in some cases we were told that there have been individuals speaking multiple languages on board. This can affect performance and safety; their exposure to hazards or their ability to respond (i.e., cope) may be affected by poor communication and misunderstandings brought about by different languages. This was also identified as an issue for vessels based in Pt. Judith, where language-related issues arise from the influx of immigrants from other countries into a community that is primarily American and the lack of enough local, skilled people who want to crew on fishing vessels. For example, one interviewee from Pt. Judith said that he has hired Guatemalans but that there were communication problems and they needed training.

Institutional Factors

A variety of institutional factors were associated with vulnerability among those we interviewed. Many of them were understood to affect safety and risk, and, in particular, the role of regulators and regulations as critical driving forces of vulnerability and safety. Regulatory regimes can affect vulnerability (and hence risk) and safety because incentives are created that exacerbate risk-taking among fishermen—the “race for fish”—and prices can be driven downward from market gluts of a particular species (e.g., Woodley 2000).

In particular, we were told frequently that regulations designed to protect fish stocks could end up exposing fishermen to greater risks. For example, one person we interviewed stated that the incentives for being unsafe are getting worse: “It takes 24 hours to steam to a fishing area, if the weather turns bad my incentive is not to waste 24 hours to go back and 24 hours to come back out again—DAS so few, the incentive is to stay.” Another person talked about the use of safe harbor options, and in particular Nantucket: “Now we cannot go to Nantucket, we must come back to New Bedford and

lose the rest of our trip.”

Interviewees from both communities discussed how, in their view, quota systems can increase unsafe decision-making and risk-taking. When a fishery is almost at its quota it is shut down by the authorities. This causes fishermen to race to get their fishing done before the quota is reached—even if it means going out in bad weather: “this drives unsafe decision-making.” Similarly, if a fisherman achieves his quota in a short time he must stay out for a full trip (e.g., 10 days) to get the accumulated daily quota for the fish he caught in the beginning—which can be dangerous if the weather turns: “if you catch too much, you need to either stay out more days or throw the dead fish overboard so you can come in.” Furthermore, he argued that ITQs would be safer, because it would lead away from pulse fishing; fishermen would not be forced to race for their part of the quota.

Finally, the role of regulations that constrain fishermen's flexibility to fish for different species was identified as a factor that can affect safety. For example, Pt. Judith, as a port, has many opportunities because it has access to many fisheries. It is very diverse. But these opportunities are slowly being constrained by regulations. Pt. Judith fishermen are affected in this regard differently than the fishermen we interviewed from New Bedford. Pt. Judith fishermen generally have smaller boats that allow them to access different fisheries, in a way that New Bedford groundfishermen can not.

Institutional factors can also help to improve safety through regulation of vessels and opportunities for training. Interviewees reported changing their behaviors by going to more safety classes and doing more drills aboard the boat than in past years, in large part because of a renewed emphasis on safety trainings in Massachusetts. Some fishermen have been hired to train people under the Fishing Vessel Safety Act. The law requires drills monthly, although an interviewee thought that “most vessels do not do them frequently enough. Maybe they do them four to five times per year, but not monthly.” He suggested that there may be inadequate vessel trainings and drills because it is hard to get the crew together on a non-fishing day and there is the complacency that they have been fishing for many years: there is a need to prioritize what is important. With money, it is easier to focus on safety, otherwise fishermen focus on paying the bills.

Economic Factors

Fishermen from both communities reported facing tremendous economic pressures. Many of them report working on the margins. Economic driving forces can interact with other types of factors, such as demographic characteristics (e.g., changes to the pool of potential crew). Economic pressures can affect safety because poor decisions may be made; one captain reported feeling a strong “incentive to stay out

when the crew is frustrated about a possible failed trip and lack of earnings. They might quit—but good crew needed, so I try to increase catch by staying out . . .”

In both communities, vessel and health insurance, cost of services and fuel, and maintenance were cited as important contributors to vulnerability. Costs associated with safety can be high, and they may be a disincentive to invest in risk-reduction measures when boat owners are operating at the margins.

Interviewees in both communities told us that vulnerabilities arise from increasing costs associated with insurance. Inadequate or absence of insurance can exacerbate the consequences of accidents and injuries. This point was elaborated in much more detail in our Pt. Judith interviews. In particular, these small vessel owners worried about owners and crew who fished without adequate insurance because they were unable to pay escalating premiums. Insurance costs can drive boats out of business or force owners to sell their boats. Or, owners may operate without insurance. After a few major claims an owner can get dropped. Poor vessel maintenance can lead to accidents and owners cannot get insurance until the underlying cause of the accident is fixed. Moreover, inadequate insurance can indirectly affect safety. For example, boats that do not have insurance or that do not insure crews may find it more difficult to attract quality and stable crew: “They are looking for the best boat, as soon as they see there is an opening on a boat that makes money, they are gone. They don’t care, they just look after their own interests. There used to be more guys, everyone was looking for jobs on draggers.”

As discussed above, in both communities we were told that the downward economics of fishing is leading owners to go out with fewer crew in an effort to “share up” better. One interviewee talked about how local boats in Pt. Judith used to go out with five individuals (captain and four crewmembers) but now only fish with four individuals so that they all get more income, as the cost of fuel, insurance, gear, and bait have all gone up, but the price for fish has not. Similar trends were told to us by interviewees from New Bedford. However, “this means less sleep for everyone,” as stated previously. This has implications for safety, as it can increase captain and crew fatigue, which can increase the risk of accidents.

Socio-Cultural Factors

Socio-cultural factors, such as social capital, social services, and cultural norms, were identified as having both positive and negative effects on the vulnerability of groundfishermen in New Bedford. The importance of local, community-based organizations was also identified as an important contributor to coping in Pt. Judith—this contributes to a reduction in vulnerability. In the context of this discussion on

safety we simply want to note that cultural norms are established and maintained among fishermen that can affect safety and risk. They can lead to risk-taking behaviors. They can also lead to a focus on safety (e.g., training, maintaining adequate gear). While our interviewees rarely explicitly raised cultural factors in the context of safety, its importance for safe fishing (e.g., Murray and Dolomont 1994, 1995) and other high-risk work is well-documented (Tuler et al. 1992).

One interviewee from Pt. Judith talked about the culture of safety within responsible management institutions. He argued that there are 10 standards under the Magnuson Act. Number 10 is health and safety, but “it is not a priority in the implementation of management until after a catastrophe like the Northern Edge last December.” Instead, he felt that economics seem to dictate over safety. But, of course, we found that viewpoints vary, and are not necessarily related to one’s occupation. For example, fishermen from both communities expressed a strong concern for the safety of their crews. A Pt. Judith vessel owner stated that his primary concern is that no one gets injured and everyone comes back alive. In New Bedford we heard from a crew member who stated that he likes to work for his captain, because he thinks the captain is safe and makes good decisions; he doesn’t push in iffy weather.

Technological Factors

Technologies were described as both helping to improve safety and increasing danger among those that participated in our research. For example, according to a fisherman from Pt. Judith, there have been many technological improvements for fishing to make it safer such as better autopilot, GPS, satellite phones, etc. And new safety inspection stickers are required on all boats—all boats must have a safety inspection before they can carry an observer and all boats must be able to carry an observer or else they can be grounded.

At the same time, aging boats may have more problems and they may not incorporate the latest safety technologies. Both Pt. Judith and New Bedford have aging fleets. Fishermen we interviewed stated that it is highly unlikely boats and equipment will be replaced because of the economic uncertainties of fishing. Moreover, because of economic pressures, aging boats may not be repaired or repairs may be delayed. One fisherman from New Bedford talked about how if he falls behind in payments then he may delay repairs, which can have safety implications. In addition, there is an increasing reliance on specialized or new gear to improve fishing and to meet regulatory requirements. On the one hand, this may reduce risk of, for example, injuries. But, specialization of gear can influence who is crewing on a vessel; the type of gear can affect recruitment and retention of crew. This can increase the workload of the captain. It can also increase risks of accidents among crewmembers with less skill.

In summary, driving forces of vulnerability may influence risk and safety in different ways. They may increase or decrease exposures, exacerbate or mitigate sensitivities, and promote or undermine adaptive capacities. Some factors increase exposure, which is expressed in fishing by the increased probability of one of many types of potential accidents. The differential risk faced by different fishermen, which gives rise to sensitivity, is in part a function of fatigue, communication systems, and the crews' experience. These case studies highlight the ways that vulnerability may arise from multiple stresses acting simultaneously (O'Brien and Leichenko 2001). The stresses may arise at different scales, such as individual decision-making and behavior, families, local economies, national regulations, and economic globalization. They are all related in creating pressure on individuals' vulnerabilities, but they are driven by separate forces and with complex sets of interactions among the consequences. For example, economic stresses on a family (e.g., lack of health insurance, sporadic income) can affect stress at work, which can potentially increase risky decision-making. Injuries that may result from taking additional risks can lead to additional stresses at home.

Fishermen have various means of coping with or adapting to exposures and sensitivities, such that their overall risk and safety can be reduced. The resilience of individuals may be increased by their participation in safety trainings because they will be better equipped to respond appropriately in emergencies (See Hall-Arber and Mrakovcich in this issue). Conversely, other characteristics may negatively affect the resilience of individuals, households, communities, or sectors. For example, while fishermen may have once been able to switch from one fishery to another, more recent regulatory constraints and the use of more advanced and specialized gear prevent such adaptation and flexibility. Thus, a vulnerability framework integrates the notion of coping (also, often referred to as 'adaptive capacity' and 'resilience') explicitly into safety management. The observation that events, stresses, and pressures differentially affect exposure, sensitivity, and adaptive capacities among commercial fishermen and, thus, differentially contribute to risk and safety, has not been widely documented in prior research.

Conclusion

Managers of marine fisheries systems in the United States are required to examine the potential social, economic, and cultural impacts resulting from regulatory changes. These mandates come from federal legislation, such as the Magnuson Stevens Fishery Conservation and Management Act and its amendments as well as from the National Environmental Policy Act. Additional requirements stem from

policy and strategic plans of relevant federal agencies, such as the Department of Commerce. Executive Order 12898 on environmental justice also has a bearing on this need.

One customary way for NMFS to collect routine social, economic, and cultural data about regulatory impacts and environmental justice considerations is through social impact assessments (SIAs). SIAs are required by the National Environmental Policy Act (NEPA), which stipulates that federal agencies must consider the impacts of major federal actions on the human environment. SIAs typically involve the collection of quantitative baseline data on social, economic, and cultural indicators from which the likely impacts of different policy scenarios are projected. Such information has often been supplemented with information gathered via other studies (e.g., Hall-Arber et al. 2001; Community Panels Project 2004a, 2004b, 2004c) or NMFS-based information gathering activities, such as the Sociocultural and Economic Survey Initiative and Community Profiles (e.g., Olson and Clay 2002).

While SIAs provide important information to inform management decision-making, they do have shortcomings. What is typically missing from such assessments and related studies is a nuanced representation of fishery systems' dynamics, including how impacts arise from multiple stresses and pressures. Another shortcoming is that impact assessments often reduce complex, interactive systems to discrete indicators that are readily measurable. Because economic variables are readily quantifiable, other equally important—if less readily quantifiable—social and cultural factors can inadvertently force the outcomes of concern to be too narrowly defined in economic terms only, or not fully represent the range of impacts about which fishermen and others may be concerned.⁴ Or, they may not be measurable with the kind of precision required by decision-makers. Often, there is little consideration of the ways that differential impacts arise or the cumulative and interactive effects of multiple stressors—if they are even considered at all.

Unlike impact assessments, vulnerability assessments help to focus attention on capacity factors, that is, factors that promote mitigation, coping, adaptation, and resilience as well as exposure to threats that can result in undesirable impacts. The empirical research reviewed here serves to illustrate how diverse marine fisheries are in terms of the exposure and sensitivity to risk of different communities as well as how driving forces of vulnerability are different between locations and within locations, and between sectors and within sectors. Understanding these groups, their differences, their sensitivities and exposure to threats is essential in understanding how they are differentially impacted by change, whether regulatory, environmental, social, or economic. It is the interactions of exposure to stresses or hazards, the susceptibility of peo-

ple to loss from the exposure, and the ability to resist or cope with the exposure or loss that can reveal vulnerabilities, their causes, and their consequences.

Furthermore, by considering these interacting components within a larger human-environment system, a more nuanced understanding of how vulnerabilities vary across time, space, and groups can be developed. Vulnerability can arise at different scales within a human-environment system, from individuals, to local communities, economic sectors, regions, and nations. A variety of frameworks have been applied to the assessment of vulnerability (Morrow 1999; MacKenedrick and Parkins 2004; Polsky et al. 2007; Turner et al. 2003b).

In short, the literature related to vulnerability provides important insights related to the dynamics of vulnerability, efforts to manage and reduce vulnerabilities, and a means for assessing vulnerabilities at different scales. Each of these insights has implications for understanding marine fisheries, including their management and prospects for sustainability. Explicit attention to vulnerability offers fishery managers and fishery stakeholders great potential for better understanding the effects of different management alternatives.

First, fisheries managers may gain better understandings of how both social and environmental causes may affect vulnerabilities among fishermen and within a fishery sector. Fisheries management has increasingly understood such relationships. For example, vulnerability of fishermen may be increased because of declining fish stocks. However, regulatory responses can also increase the vulnerability of particular fishermen or sectors because they expose them to additional threats (e.g., inability to catch fish) or constrain their ability to respond (e.g., by selecting different places to fish, use different gear, or switch what they are fishing for). As another example, while fishermen may be regularly exposed to adverse weather conditions, management decisions may create incentives for fishermen to expose themselves to even more dangerous conditions.

Second, attention is drawn to how factors that are both endogenous and exogenous to a system can affect vulnerability. Wisner et al. (2004) discuss “root causes” such as limited access to power and resources, political systems, and economic systems. Leichenko and O’Brien (2002) have studied how forces of economic globalization can influence the sensitivity of local populations to change. Natural resource dependent communities can be affected by socio-economic forces outside of the local community (Leichenko and O’Brien 2002; Turner et al. 2003b). Exogenous factors can be important to fisheries, and they have been the subject of research (Hamilton 2003; Hall-Arber et al. 2001). For example in the 1960s, ocean-going fish factories were able to harvest and process fish at sea and international fleets reaped the benefits of Georges Bank’s abundant waters. It was not until

1976 that the U.S. government, with the passing of the Magnuson-Stevens Act, established an Exclusive Economic Zone (EEZ) extending from the seaward boundary of each of the coastal states to 200 nautical miles from shore. Finally, studies also show how local decisions and activities can affect vulnerability. Local decisions and actions can both cause or exacerbate stresses/perturbations or help to avoid or reduce sensitivities and resilience (e.g., Acheson 2003); sometimes both occur within the same community. Individual perceptions of risk can influence people’s choices for risk reduction—a form of coping (Heijmans 2001; Murray and Dolomont 1994, 1995; see also Pollnac and Poggie this issue).

Third, structural characteristics of the economic, social, and political system can give rise to different vulnerabilities within marine fisheries. For example, lack of access to sources of power (e.g., marginalization), lack of access to resources, lack of social support networks, lack of substitutability of market goods, and formal and informal enforcement of property rights have been identified as important driving forces of vulnerability in research following the political economy tradition. Sen (1981, 1990) has provided an insightful discussion of how entitlements and access to resources can affect the vulnerability of individuals and groups. This is also true for marine fisheries. For example, fisheries management regimes include quotas, limits on days at sea, gear restrictions, area based management and other tools. Each of these approaches create differences in access to resources, substitution, and enforcement. Cultural factors, such as those that govern arrangements within lobster fisheries, carry specific implications for vulnerability. Finally, driving forces that are structural—including economic, institutional (regulatory), or cultural factors—can be difficult to change in the short term.

Fifth, fisheries managers can better understand the impacts of change and the potential for improving adaptation if they gain a deeper understanding of the active roles that individuals and groups play in determining their own vulnerability. A one-sided focus on structural causes of impacts or responses to change can suggest a passive or static understanding of vulnerability. This can have the effect of de-emphasizing human agency, which can play an important mediating role through mechanisms of response, including those that are anticipatory, occur during exposure to a stress/perturbation, or occur after the effects of the stress/perturbation are already being experienced (Kasperson et al. 2005). An example of this is the increase in fishermen’s organizations emerging in the Northeast U.S. in a context of rapid social, environmental and regulatory change (Pinto da Silva and Kitts 2006). Moreover, it is important to note that people’s responses—both within the community and outside of it—

can also increase their (current or future) vulnerability. For example, “lessons learned” from a crisis may not be the right ones and policy changes may further exacerbate vulnerabilities to future stresses or perturbations. Within the context of marine fisheries the lesson that vulnerability is dynamic has been observed repeatedly. Sensitivity to threats change over time—new opportunities for survival training may be provided for example. Regulations change on a regular basis, in some cases in response to particular events (U.S. Coast Guard 2005). The collaboration of fishermen and researchers in some cases illustrates efforts to actively anticipate and reduce vulnerabilities.

Sixth, fisheries managers’ efforts to understand change and its effects can be enhanced by consideration of diverse driving forces emanating from different scales and times. Studies that focus on specific scales can emphasize some causes, processes, and effects while deflecting attention from those that occur at other scales. Kasperson et al. (2005) make the further observation that “scale mismatches, such as the mismatch between the environmental system and the jurisdictional scope of the political authority, are a central issue in vulnerability analysis. Driving forces often emanate from macro-forces, institutions, or policies set at higher-level scales—land tenure regimes, technological change, international financing institutions, and government policy—and are articulated through a finer pattern of local scales with highly variable local resources and ecological settings.” Fisheries are a case in point. In addition to spatial and institutional scale, understandings of vulnerability are also affected by temporal scales: “vulnerability has its own history and its own trajectory” (Kasperson et al. 2005). For example, Bohle et al. (1994), in the context of food insecurity, show how over time sequences of events interact with dynamic social vulnerabilities to reduce adaptive capacities to make a human-environment system more susceptible to disaster. Again, there is a parallel to the effects of ecological, economic, regulatory, and social processes that have combined to reduce the coping capacities of fishery-dependent communities, thus increasing their vulnerabilities over time.

In summary, important insights about human-environment systems, including marine fisheries, and their management can be developed by explicit attention to vulnerabilities that arise from different policy options, scales, and contexts. Assessments of vulnerability, however, pose challenges, of which one of the most important is the ability to understand the relative contributions of multiple stresses (e.g., global economic change, local gentrification and markets, changing fish stocks). They can be both time consuming and expensive—just like SIAs—although, recently researchers have begun testing more rapid approaches to doing assessments that produce decision relevant information (see Polsky et al.

2007). Furthermore, choices must often be made about what scale or sectors on which to focus, the selection of indicators, and the validity and reliability of extant data for measuring them. The dynamics of fish populations, interactions with human activities (including non-fishing related activities), and interactions across scales and time make assessments within the marine fisheries context particularly challenging. At the same time, there are unique opportunities for conducting useful and high quality vulnerability assessments for fisheries management. Better information about vulnerability is important to fishery managers’ abilities to develop and implement effective interventions to reduce risk and promote sustainability of marine fishery systems.

Endnotes

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2. The literature on vulnerability has developed significantly over the last quarter century, although its roots have a much longer history (Dow 1992; Kasperson et al. 2005). Studies of vulnerability have highlighted how threats arise, how exposures and sensitivity to the threats can be differentially distributed both spatially and temporally, and how people adapt, mitigate or cope with the threats and their effects. Important insights about the causes and effects of vulnerability have emerged from research on common pool resources, political economy and political ecology, disasters, global environmental risk, environmental justice, sustainability, conservation ecology, natural resource management, resource dependent communities, adaptive management, food security, and international development among other topics. This literature is closely connected to work that has focused on other allied concepts, particularly resilience, community capacity, social capital, and adaptation. These are issues central to the creation and management of sustainable marine fisheries.
3. The concept of resilience has roots in ecology where it refers to the ability of a system to return to a reference state after a disturbance or maintain structure and function after a disturbance (Folke 2006; Gunderson and Holling 2002).
4. This concern has been addressed by researchers who promote qualitative SIAs (e.g. McCay and Cieri 2000). See also Pollnac and Poggie this issue.

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