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A rapid impact and vulnerability assessment approach for commercial fisheries management

Seth P. Tuler [a,*], Thomas Webler [a], Colin Polsky [b]

[a] Social and Environmental Research Institute, 278 Main Street, Suite 404, Greenfield, MA 01301, USA
[b] Graduate School of Geography, Clark University, 950 Main Street, Worcester, MA 01610, USA

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ABSTRACT

Fisheries managers are faced with a paucity of both data and tools to assess the socio-economic dimensions of fisheries management. However, Federal law requires fisheries managers to consider social and economic consequences of management plans (i.e., Magnuson–Stevens Fishery Conservation and Management Act of 1976 and its amendments). Assessing the potential consequences requires data and analytical tools that address not only multiple species but also multiple stakeholders and sectors of the economy. To help meet these mandates and overcome challenges to their implementation we developed an approach to rapidly and efficiently assemble decision-relevant information. We call this a *rapid impact and vulnerability assessment* (RIVA). RIVA builds on the concepts of risk and vulnerability to document causal linkages between management interventions (e.g., introduction of new rule) and downstream consequences, whether positive or negative. We illustrate its application and utility with an example from New Bedford, Massachusetts. It can help managers identify the ways individuals and groups within a given fishing community may be differentially impacted and able to respond to reduce harms. Such information can inform managers about how to intervene to mitigate consequences and promote positive forms of responding that do not create further undesirable ecological and social consequences. By being sensitive to agency resource constraints, the framework enables the rapid gathering of information in contrast to more traditional and large-scale social impact assessment or vulnerability assessment methods. A systematic application of this framework can facilitate learning and long-term policy making by guiding routine gathering of social, economic, and cultural data and identifying critical knowledge gaps and uncertainties. After illustrating the application of RIVA we discuss both its strengths and weaknesses.

1. Introduction

U.S. fisheries management is turning from a focus on single species management to ecosystem-based management (Brodziak and Link, 2002; Ecosystem Principles Advisory Panel, 1998; McLeod and Leslie, 2009; Pikitch et al., 2004). In the northeastern United States this is exemplified by the recent shift to a sector-based framework for the multispecies management plan (New England Fishery Management Council, 2011). The overarching goal of ecosystem-based management is to "sustain healthy marine ecosystems and the fisheries they support" (Pikitch et al., 2004). This goal must be accomplished in the context of existing legal requirements. Federal law requires fisheries managers to also consider social and economic consequences from management plans (i.e., Magnuson–Stevens Fishery Conservation and Management Act of 1976 and its amendments). Assessing the potential consequences of fisheries regulations therefore now requires data and analytical tools that address not only multiple species but also multiple stakeholders and sectors of the economy.

Fisheries managers are faced with a paucity of both data and tools to assess the socio-economic dimensions of fisheries management. While there is growing literature on how fisheries regulations affect health and safety (e.g., Georgianna and Shrader, 2008; International Labour Organization, 2000), economic well-being of fishery dependent communities (e.g., Hall-Arber et al., 2001), and infrastructure and waterfront land uses (e.g., Community Panels Project, 2004; Portman et al., 2009), the scholarship is limited and there is a noticeable lack of data about other important social, cultural, economic, and institutional components of the coupled human-

* Corresponding author. Tel.: +1 413 387 9320.
E-mail addresses: SPTuler@seri-us.org (S.P. Tuler), TWebler@seri-us.org (T. Webler), cpolsky@clarku.edu (C. Polsky).

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environment fisheries system. In addition, the socio-economic assessments needed to understand the far-reaching consequences of fisheries management decisions are methodologically challenging (National Marine Fisheries Service, 1997; Wilson and McCay, 1998). Social impact assessment (SIA) requires considerable data-gathering efforts from multiple segments of an affected population. To complicate matters, rules laid out in the Paperwork Reduction Act by the Office of Management and Budget (OMB) constrain the ability of agencies to collect data from the public. OMB approval for data gathering instruments is required if more than ten people will be asked the same question and gaining approval can be a time consuming process. And, in an age of tighter constraints on government funding, fisheries managers are challenged to hire the staff needed to fulfill their obligations under the Magnuson–Stevens Fishery Conservation and Management Act (and Amendments). In sum, fisheries management is growing in scope and complexity at a time when resources for implementing these mandates are declining.

To help meet these mandates and associated challenges, we developed an approach to rapidly assemble decision-relevant information in a timely manner with limited staff and financial resources. We call this a *rapid impact and vulnerability assessment* (RIVA). We illustrate its application and utility with an example from New Bedford, Massachusetts, which is one of three case studies we completed in the northeastern United States. The case study illustrates how new regulations can impact local economies, fishermen, shore side businesses, and local infrastructure. It builds on the concepts of risk and vulnerability (Clark et al., 1998; Polsky et al., 2007; Ratick et al., 2004; Tuler et al., 2008; Turner et al., 2003) by highlighting ways regulations and rules may produce a broad range of impacts, whether positive or negative. Importantly, this approach explicitly values the very social data alluded to above that are often missing from social impact assessments. This framework can help managers highlight the ways individuals and groups within a given fishing community may be differentially impacted and able to respond to reduce harms. Such information can inform managers about how to intervene to mitigate consequences and promote positive forms of responding that do not create further undesirable ecological and social consequences. While the details may be more limited than a full-scale social impact assessment of vulnerability assessment, RIVA is less resource intensive and can provide baseline and screening goals. A systematic application of this framework can facilitate learning and long-term policy making by guiding routine gathering of social, economic, and cultural data and identifying critical knowledge gaps and uncertainties. It complements social impact assessments and extends the toolkit of methods available to fisheries managers for characterizing the impacts of management plans.

2. Conceptual background (causal model of hazards and vulnerability)

Our approach to understanding the social, economic, cultural, and institutional consequences of fisheries management regulations is to document causal linkages between management interventions (e.g., introduction of new rule) and downstream consequences. We do this by using concepts and understandings of the causal pathways that link stressors, consequences, and vulnerability in coupled human-environment systems. The idea of vulnerability is used to reveal the dynamic ways that individuals and groups may experience consequences differently (Kasperson et al., 2005; Polsky et al., 2007). The key vulnerability concepts are exposure, sensitivity, adaptive response actions, and adaptive capacity.

A causal model – or framework – of environmental risks and hazards depicts threats and consequences as a causal sequence resulting from a stream of choices and activities, as illustrated in Fig. 1 and Table 1. This particular framework has been applied to a variety of human-environment challenges, such as nuclear waste disposal, coastal flooding, water pollution, and visitor safety in national parks (Clark et al., 1998; Kates et al., 1985; Tuler and Golding, 2002; Webler et al., 1995). The framework begins with an initiating event, or *stressor*, which creates an exposure with the potential to create benefits or harms. Many different kinds of things can be *exposed* to the stressor(s)—people, communities, institutions, markets, species, populations, ecosystems, economic sectors, belief systems, institutions, and so on. In this context the stressor is a fisheries management plan and we are concerned about impacts to: owners and captains of fishing vessels; crew; families of fishermen; fishermen cooperatives; owners and employees of fishing-related businesses (auctions, processors, ice suppliers, repair shops); fishing sectors[1]; small businesses in the tourism sector (e.g., hotels, restaurants, art galleries); social service providers; and local, state, and federal government agencies.

In the causal model, *exposure* to a stressor produces a series of first-order *outcomes*. For example, regulations affect who goes fishing, when they go fishing, how they fish, and where they fish. Outcomes are processes or events that occur in social or ecological systems as a result of the stressor. *Consequences* are positive or negative implications of the outcomes that affect those exposed. Negative consequences reflect losses or costs – whether realized or anticipated – to people or things that people care about. These include such things as death or injury, property damage, lost income, and loss of spawning habitat. Positive consequences can include, for example, income from servicing boats and providing supplies for fishermen that come to New Bedford from other locations, improvements in ecosystem health, and improved hazard mitigation (e.g., safety training requirements). Consequences can cascade into secondary, tertiary, or nth-order consequences. Some consequences are immediate while others are delayed. Thus, consequences are a special kind of outcome. Distinguishing first-order outcomes and processes from consequences has two important implications. First, it helps to clarify how a stressor changes the state of a coupled human-environmental system. Second, it helps to distinguish different kinds of management interventions that can be used at different points in the causal chain to prevent or mitigate consequences.

Consequences are mediated by *sensitivities*. These are contextual factors that mediate the way stressors act on the system. Sensitivities appear in Fig. 1 as variables that act upon a link between two nodes and are shown beneath the causal chain. In the context of commercial fishing examples of sensitivities include: crew experience or training; a captain's experience; a captain's willingness to take risks; vessel size; gear configurations; whether fishermen own their vessels outright or have large mortgage payments; and alternative sources for income. Consequently, two fishermen exposed to the same stressor may experience different outcomes and consequences because of differing sensitivities. Thus, when considering the vulnerability of individuals, households, communities, or sectors to regulatory changes it is important to understand sensitivities.

Response actions are taken to mitigate or avoid entirely unwanted outcomes or consequences, whether in anticipatory or

[1] A sector is defined as "a group of persons holding limited access vessel permits under the fishery management plan through which the sector is being formed, who have voluntarily entered into a contract and agree to certain fishing restrictions for a specified period of time, and which has been granted a total allowable catch (TAC) in order to achieve objectives consistent with the applicable FMP goals and objectives" (New England Fishery Management Council, 2011).

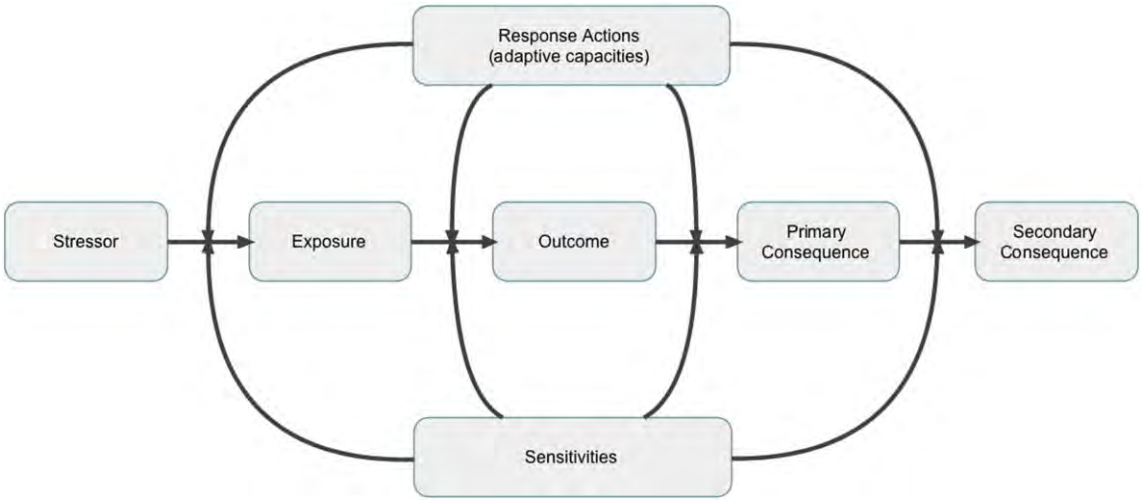

Fig. 1. A causal model of hazards integrated with vulnerability Adapted from Kates et al., 1985.

reactive modes. These actions appear in Fig. 1 as variables that modify or break causal links. Response actions may be taken by public or private entities. For example, fishermen may change their exposure to consequences of a new regulation by selling or leasing days. They may attempt to mitigate financial losses by taking a second job or fishing in poorer weather. Fisheries managers may disperse disaster assistance funding, enable public input in crafting new plans, or adopt new management strategies (e.g., sectors). Some actions will succeed, but others can unintentionally aggravate the situation. Response actions can have consequences too. For example, choosing to fish in poorer weather in response to a regulation that limits the season may increase a fisherman's opportunity for income, but it does so at the expense of safety (e.g., leading to derby fishing).

Response actions, as described in the causal model, require resources or "adaptive capacities" to be implemented. *Adaptive capacity* refers to the ability of an exposed individual or group to mitigate or avoid consequences that result from a specific exposure and associated sensitivity. This idea is closely associated with resilience (Smit and Wandel, 2006). Much of the current fishing industry has low adaptive capacity to switch from one fishery to another because of expensive and specialized gear (Clark et al., 1979, 2005).

Adaptive capacity is an important component of vulnerability. In this conceptualization, a coupled human-environment system that is exposed to a stressor and has high sensitivities are only vulnerable if they possess low adaptive capacity. To help understand adaptive capacity, a number of taxonomies or classifications of adaptive capacities have been suggested (Dow, 1992; Norris et al., 2008), which typically include social, human, institutional/legal, information, technological, financial, political, and community resources.

Table 1
Elements of a causal model diagram.

- **Stressor**: An event or process that may influence the dynamics of a fishery. Regulations and fisheries management rules are stressors.
- **Exposure:** The presence of a stressor (hazard), defined both temporally and spatially, to an individual or group.
- **Outcome**: Additional process(es) or event(s) that occurs as a result of exposure to the stressor.
- **Consequences**: Implications of the outcome(s) that affect individuals, communities or ecosystems, and which are valued by individuals and communities. Primary consequences can lead to secondary, tertiary, etc. consequences.
- **Sensitivities**: Characteristics of the social or biophysical environment that affect the magnitude and likelihood of the outcomes and consequences, often described as factors that mediate exposure–response relationships.
- **Response actions**: Proactive or reactive actions of managers and private parties (e.g., vessel owners, crew) that are intended to prevent or mitigate exposure to stressors, or associated outcomes and consequences.

3. The process and technique of rapid impact and vulnerability assessments

In this section we describe how we applied the concepts of hazards and vulnerability to create a process for rapid impact and vulnerability assessments. There are six steps to this approach, described in the following subsections, which derive from Schröter et al. (2005). We used it in three fishing-dependent communities in the northeastern US during 2007–2008. Chatham, MA, New Bedford, MA, and coastal New Hampshire were selected because they are considered important groundfishing communities and they represent a range of different types of fishing communities in the northeast, varying in: degrees and rates of gentrification, employment dependence on fishing, size of fishing-related infrastructure, complexity of management regimes, size of population, presence of important subgroups (e.g., Portuguese community in New Bedford), and research fatigue. Thus, taken as a group these communities presented an opportunity to explore various causal pathways and vulnerabilities and to study this approach in different contexts. Here we illustrate the approach by focusing on the New Bedford case study (additional details are available in the individual case reports, Tuler et al., 2009a, 2009b, 2009c).

3.1. Step 1: define the primary stressor

Our assessment began by defining a regulatory change that could produce significant consequences for the community. We were interested in characterizing social, economic, cultural, and institutional consequences that may arise from the introduction of a new fisheries management plan. For example, in our study of New Bedford, we considered two stressors created by a proposed 2010 rule by the New England Fishery Management Council to a) reduce days at sea limits, b) establish total allowable catch limits, and c) implement a sectors approach to management (NOAA, 2010).

3.2. Step 2: gather background information on the relevant community

We gathered data from existing reports and data sets for two purposes. First, we sought a better understanding of the community. We specifically wanted to know about the different groups involved in the fishing sector, their history and current status, concerns, and adaptive actions that have been taken. We learned, for example, that lower incomes have led fishermen to fish longer hours, sometimes in increasingly dangerous conditions. Second, we sought to identify and evaluate the available data that might help fisheries managers and stakeholders understand and track stressors, vulnerabilities, and the effectiveness of management actions. For the New Bedford based fishery we found studies about safety-related issues, economic well-being, and infrastructure and waterfront land uses, but a noticeable lack of data about other important social, cultural, economic, and institutional components of this coupled human-environment fisheries system. Examples of reports include those describing the demographic and economic character of New Bedford (Hall-Arber et al., 2001), issues facing immigrant (and undocumented) laborers in the fishing sector (Juravich, 2005), the interactions between fishing regulations and health and safety (Georgianna and Shrader, 2005, 2008), and the city's infrastructure that supports commercial fishing (Community Panels Project, 2004; Portman et al., 2009).

3.3. Step 3: conduct interviews with key informants

Through interviews with key informants we learned about the regulatory changes the fishing dependent communities have faced or could potentially face in the future. We spoke with them about the way these changes have affected livelihoods of fishermen, supporting shore side industry, and others in the community. We interviewed diverse individuals in the community familiar with community history and dynamics. During these interviews we explored how regulatory change creates intermediate outcomes and consequences, how local sensitivities come into play, the adaptive capacities of individuals and institutions, and actions taken to avoid or mitigate undesirable consequences (e.g., adaptive response actions).

In New Bedford we selected 15 individuals who had good understandings of how fishing activity is linked to other aspects of the community. While 15 individuals is a relatively small number, it is reasonable for a rapid assessment that is used to highlight key issues. We make no attempt, for example, to quantify the costs of consequences based on the number of people impacted. Rather, we were interested in breadth such that we would identify the most important causal pathways, consequences, and response actions in a particular community. Thus, our intent was to gather data from individuals who represented as broad a range of relevant local perspectives as possible, given resource constraints for the research. Indeed, one of the principal motivations behind producing the RIVA in the first place was to develop a protocol that could be implemented with limited human and financial resources. Having limited resources is a fact of life for coastal zone researchers. This constraint is only amplified when considered alongside the additional hope for fisheries vulnerability assessments: that these assessments be conducted on a sustained, regular basis, for monitoring purposes.

Individuals were selected using a snowball sampling technique in combination with the advice of leading individuals within the fishing community and regional fisheries managers who knew the various viewpoints well. The pool of key informants was relatively small and well known and people knew each other well. Of course, while we cannot be sure that individuals representing every possible viewpoint about causal pathways, vulnerabilities, consequences, and response actions were included, we believe this approach was successful in sampling across the range of viewpoints within the New Bedford fishing community. Interviewees included owners and captains of groundfishing vessels, staff of social service organizations, the harbor development organization, owners of companies providing shore side services (e.g., ice, auction), researchers, local officials, and fish wholesalers. In addition, five interviews with Portuguese speaking groundfishermen conducted in an earlier project were reanalyzed. We included these additional interviews because this sub-community is distinct socially and culturally. Furthermore, they experience different kinds of threats and opportunities for response based on social, cultural, and linguistic factors. We offered each interviewee a $30 honorarium as an incentive to participate. Confidentiality was preserved throughout the study.

3.4. Step 4: analyze data and describe causal pathways linking stressors, consequences, and the factors that contribute to vulnerability

For each case we constructed causal pathways showing how new regulations could create both negative and positive consequences in the community. We built the diagrams after analyzing interviews and secondary sources to elaborate causal pathways that produced consequences. Our interviewees tended to focus on negative consequences, as these were most salient. We also identified sensitivities, adaptive capacities, and response actions that mediated vulnerabilities. Reliability was promoted by having two researchers independently read the transcripts and identify key concepts. Scientific rigor was brought to the process by requiring that explicit evidence from the interviews be used to inform elaboration of the causal pathways. For example, evidence included quotations taken directly from interview transcripts.

There are many complex ways of deducing causality. We adopted the most simple form of *if… then…* statements using information provided by key informants and secondary sources. We also identified the context-specific factors that interviewees and our review of prior studies suggested were important for amplifying or attenuating the effect. In the language of vulnerability, these are the sensitivities of the system. Things such as price of fuel, demand for fish, and coastal development can amplify effects and affect adaptive capacity. Finally, we also added information about response actions for preventing or mitigating outcomes and consequences at different stages.

An important task at this point was to identify themes relating different causal pathways and to construct diagrams of the causal pathways that are elaborated versions of Fig. 1. It is impossibly complex to build a single diagram that illustrates all the causal pathways within a community, and we suspected that any effort to do so would hamper understandings of the system. For this reason, we grouped the causal pathways into general themes. In New Bedford we focused on three themes: impacts on shore side services, impacts on fishermens' finances, and impacts to health and safety. Fig. 2 illustrates how various outcomes from the introduction of new fishing regulations leads to various kinds of consequences. Sensitivities identified via the interviews included: age and heath of captains and crew, the mix of permits owned, the ability to tolerate an inconsistent income, crew size, language barriers among crew, size and type of vessel, skill and experience of the captain and crew, willingness to take risks, whether or not a spouse is working, access to markets, cost of services, cost of supplies, price of fish, price of fuel, and insurance costs. Response actions included: switching to the charter sector, switching to scalloping (younger crew only), fishing out of different locations,

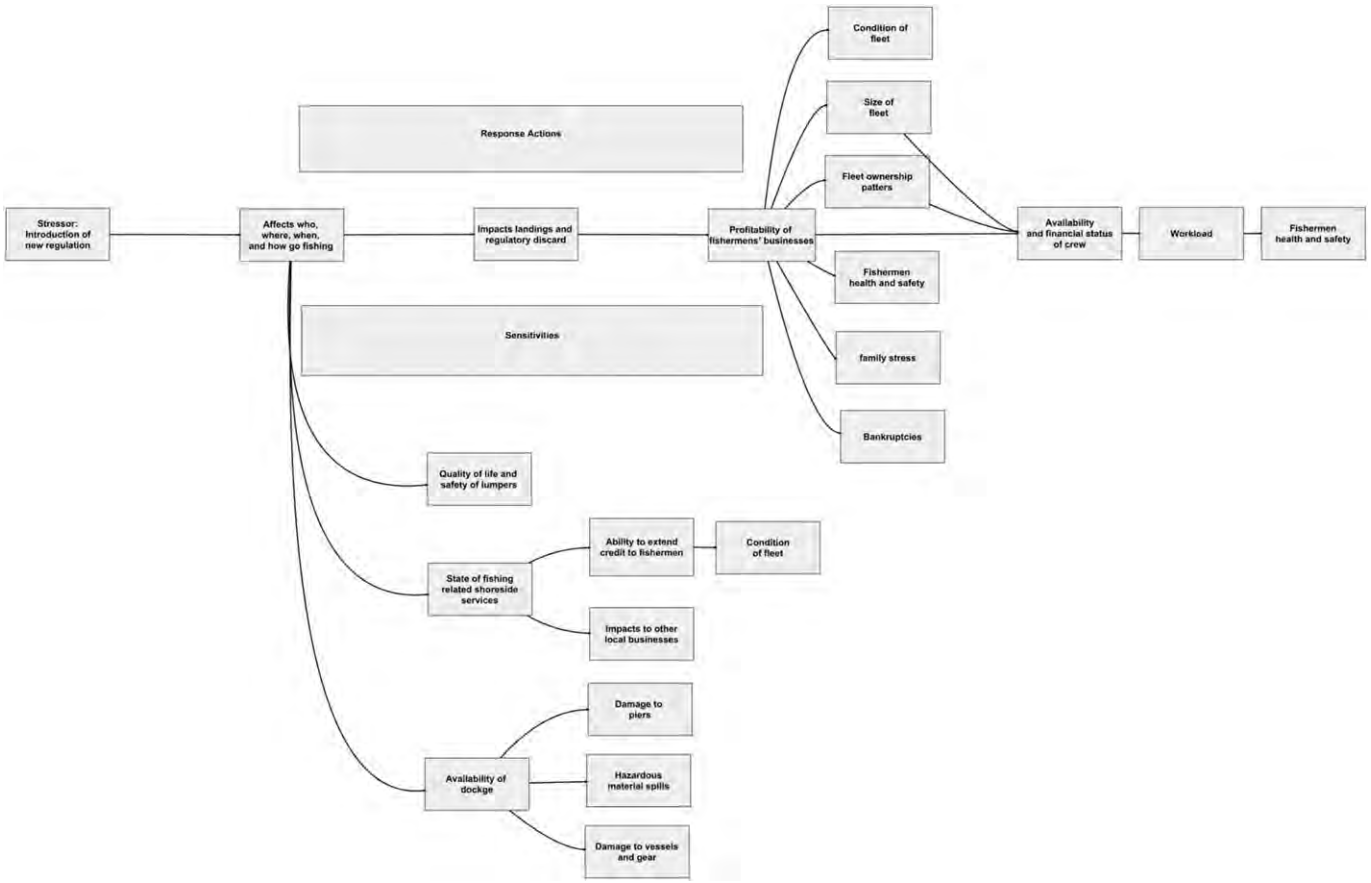

Fig. 2. Illustrative causal pathways linking the stressor of new fisheries regulations to impacts to fishermen, shore side services, and health and safety.

going out with fewer crew, buying more boats, getting loans, selling boats, selling or leasing days or permits, working part-time in non-fishing jobs, diversifying the catch, staying out longer, fishing in poor weather, going further to fish, delaying repairs or do own repairs, applying for disaster relief funds, and taking insurance off the boat. Due to space limitations we are unable to show a diagram with all pathways, sensitivities, and response actions.

The first theme related to impacts on shore side services, including infrastructure (e.g., docks) and fisheries related services and suppliers. When the fishing activities of groundfishermen change in response to new regulations there can be an immediate effect on fishing-related shore side services. Fewer trips means fewer supplies and services will be needed. There are impacts to specific types of workers onshore, such as lumpers (people who unload fish from boats). The hours that lumpers work has shifted dramatically in response to fishermen's ways of coping with the current regulatory framework. Availability of dockage, an important shore side service, has shrunk because more local vessels remain in port longer and the port of New Bedford is used more by vessels from other locations. Additional downstream impacts are mediated by changes to profitability of fishermen's businesses. As profits decline, impacts have occurred to fleet condition, size, ownership patterns, and hiring of crew, which further impact the use of shore-side services including suppliers and infrastructure.

The second theme was impacts related to fishermens' finances. The downstream impacts of financial stress are felt by captains, owners, and crew members. When landings decrease, the financial well-being of fishermen is negatively affected. Impacts on financial well-being are mediated by people's sensitivities to other factors, such as fuel costs and availability of fish (stock size). From these individuals, effects spread to households, families, networks, and communities. Financial impacts also have consequences for the boats and for the fleet, as well as to the physical and emotional health of fishermen and their families.

The third theme was health and safety. Fishing is inherently dangerous work (International Labour Organization, 2000; US Coast Guard, 1999). Injuries and fatalities are always possible, but regulatory change can increase these risks. For example, new regulations can cause fishermen to work longer hours. Workload and fatigue of captains and crew can increase. Increased workload and fatigue are associated with increased risk of injuries and fatalities in many labor contexts. Regulations affect emotional and mental health as well physical health. For example, regulations that require fishermen discard excess fish contributes to mental depression and sense of loss, according to our interviewees. Physical and psychological health effects have downstream impacts on fishermen and their families.

Of course, even though the themes are presented independently, they are interlinked. For example, injuries and fatalities may lead to changes in insurance costs, putting an extra stress on the profitability of a fisherman's business. Similarly, lower profitability can increase family stress. It can also decrease profits to shore side service businesses.

3.5. Step 5: prepare narrative descriptions and summary diagrams of the causal pathways

In step 5 we organized data into additional forms to assist with dissemination. First, we used narratives to tell the story summarized in the causal model diagrams. These narratives are important

elements of the RIVA approach because they explain the dynamics of the system. They provide an accessible way for interested people to learn about consequences and vulnerabilities. They also interpret the relative importance of different sensitivities or adaptive actions.

Second, we supplemented narratives and causal diagrams with vulnerability scoping diagrams (see Polsky et al., 2007). The Vulnerability Scoping Diagram (VSD) summarizes information from a case study theme in one place (Fig. 3). The VSD organizes information according to the three major dimensions of vulnerability: exposure, sensitivity, and adaptive response actions. The benefit of the VSD is that it allows all this material to be viewed at one time. One of the strengths of the VSD is that it illustrates response actions, that is, how fishermen claim they might attempt to respond to mitigate the impacts of the exposures and reduce the likelihood of future exposures. For example, fishermen may lease days, work with different captains, and take safety courses. A typical SIA would not examine this breadth of response actions by entities other than governments. Furthermore, The RIVA methodology pushes the VCAPS participants to identify adaptive response actions that may be desired but not implemented, for a variety of reasons. By contrast, SIAs tend to privilege observed interactions, which precludes identifying opportunities to improve current and future conditions.

The outer ring of the VSD highlights measures in the causal pathways that can be used to track the constituents of vulnerability. This information is not included in the causal diagrams. The measures are typically generated by the research team, and not the research participants. To identify these measures, the research

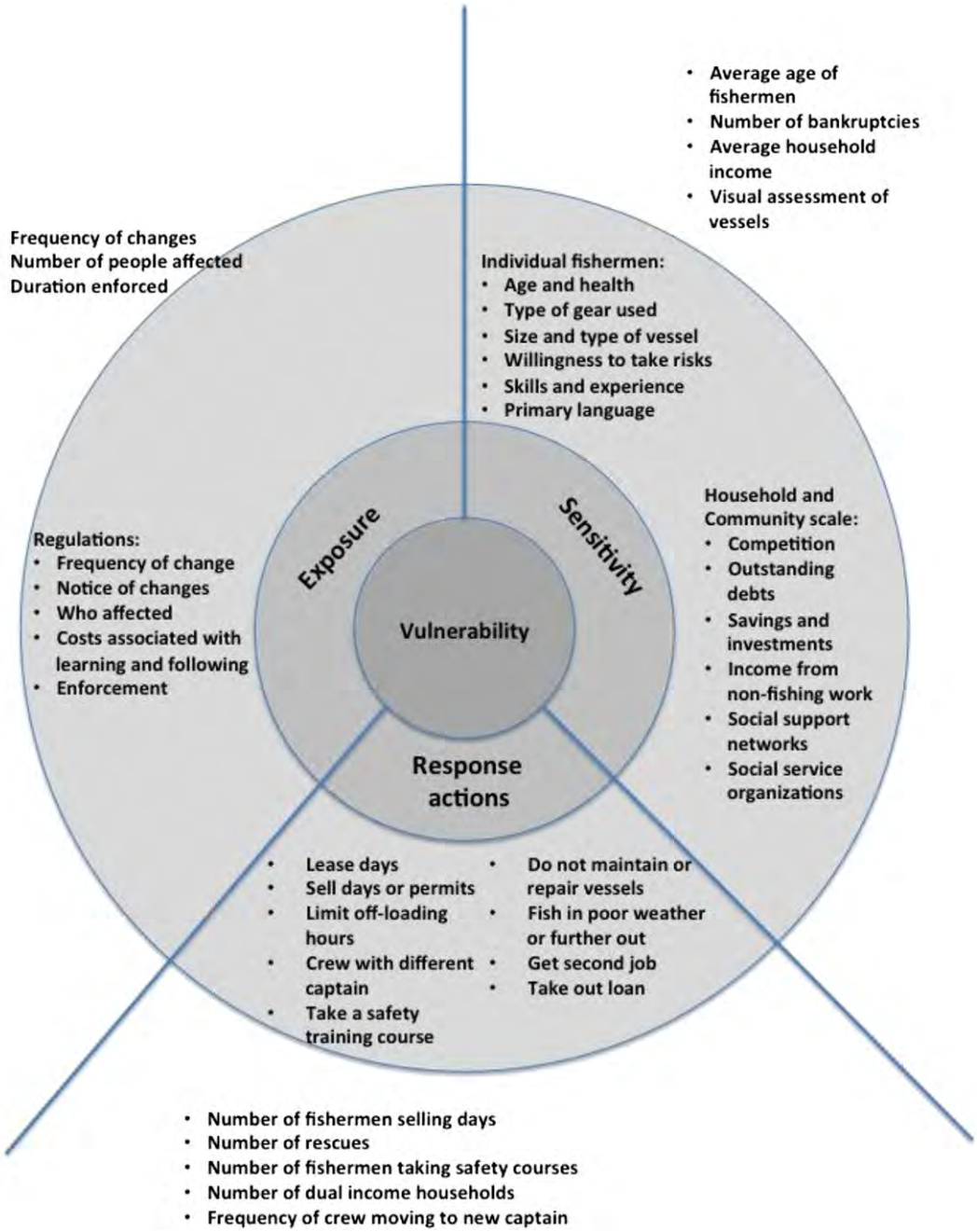

Fig. 3. Example vulnerability scoping diagram for health and safety in the New Bedford groundfishing sector.

team draws on expert knowledge and on input gained in interviews with community members. The measures presented in the outer ring of Fig. 3 illustrate ways to track exposure, sensitivity, and response actions.

3.6. Step 6: validate findings with key members of the communities

In the sixth step, we shared the information contained in the narratives, causal pathway diagrams, and vulnerability scoping diagrams with key stakeholders and interviewees for review and comment. Six key individuals provided feedback about the accuracy and completeness of the information and we revised the diagrams, narratives, and VSDs accordingly.

4. Strengths and weaknesses of the rapid impact and vulnerability assessment (RIVA) approach

The RIVA framework enables investigators to identify social, economic, cultural, and institutional consequences of fisheries management in a timely manner with limited staff and financial resources. This kind of information can support better ecosystem-based management for commercial marine fisheries. Sensitivity to resource constraints may increase the likelihood that assessments leading to useable knowledge are completed. However, performing assessments more rapidly and with limited data comes with a cost, and the weaknesses of this approach must be considered prior to any application. In this section we discuss both strengths and weaknesses of RIVA.

4.1. Strengths of RIVA

We identified three strengths of the RIVA process: (1) it produces decision-relevant information, (2) it promotes learning, and (3) it is economic in its demands on resources and time.

4.1.1. RIVA produces decision relevant information

Fisheries managers and fisheries-dependent community members need information that will inform their decisions. Gathering the right information is necessary to promote effective and legitimate policies. High quality and relevant information is the product of two activities: (1) fact-finding and (2) data analysis. RIVA organizes and coordinates fact-finding and facilitates analysis of these data through concept mapping.

4.1.1.1. Fact-finding activities. RIVA coordinates fact-finding by engaging fishermen and others in a community as knowledge experts and eliciting their knowledge in an organized fashion. The main advantage that RIVA has over conventional social impact analysis is that fact-finding is organized according to the conceptual frameworks for characterizing hazards, vulnerabilities, and their effects. Hazardous events unfold in a causal sequence, or in a step-wise manner. RIVA identifies conceptual categories in this causal sequence and organizes fact-finding to fully flesh out each step until the knowledge for a complete causal diagram is available. The spatial organization of the diagram makes it easy to see where additional information is needed. It also focuses attention on critical pathways.

For example, in New Bedford a consequence of more restrictive rules is that the size of the active fleet is shrinking (as illustrated in Fig. 2). Fishing is just not profitable enough to maintain the same number of boats. A smaller fleet means, for example, less fuel, ice, and repair services are required. More restrictive rules also impact the character of work in these support services, which is less documented in the literature. From our interviews we learned that lumpers, who unload fish at the dock, are finding that they need to be available 24/7 because the regulations place so many restrictions on when a boat leaves or returns from a journey. Because the jobs are few and far between, they are accepting work whenever it is available, even if it is back-to-back boats, because they do not know when the next job will be. Another example is illustrated by the way that restrictions have been leading to boats being tied up for long periods of time in the New Bedford port. This has resulted in crowding on the dock. Crowded docks make it more difficult for fishermen to conduct repairs, affecting the condition of vessels and gear. It also leads to more damage being done to the docks and has reportedly increased spills of hazardous materials into the harbor.

4.1.1.2. Data analysis activities. Analysis of data refers to the act of finding the relevant meaning or drawing conclusions from the data. Local knowledge is rich and valuable, but it is sometimes anecdotal. RIVA provides a mechanism for validating data to produce competent knowledge that will support sound decision-making. This happens in two main ways with RIVA.

First, the organization of local knowledge into a causal sequence is itself an analytical act. This is augmented by adding the categories of *sensitivities* and *response actions* to the causal sequence. Analysis here refers to reviewing whether or not the sensitivities or response actions identified are actually relevant to the hazard. For example, RIVA insists that each response action be evaluated for its ability to effect change on the hazard sequence. It also insists that each sensitivity be evaluated for its relevance to the hazard sequence. In New Bedford we found that safety was a function of the length of trips, the number of crew, captains' decisions when the weather turns poor, the timing of storms relevant to the trip, participation in safety training courses, and perceptions of economic duress. Similarly, we found that increased health risks to lumpers are related to restrictions on fishing that influence when loaded vessels return to port. During RIVA, these factors are reviewed for relevance by examining the literature (e.g., Georgianna and Shrader, 2008; International Labour Organization, 2000; US Coast Guard, 1999).

The second way that RIVA promotes analysis is through peer testing of conclusions with community members and prioritizing strategies to prevent or mitigate consequences. In our development of RIVA, we met with people one on one to do fact-finding and joint analysis. We tried to meet with everyone twice: once to build the diagram and once to review the completed diagram. During these meetings, the diagram and data were scrutinized by individuals with unique viewpoints, knowledge and experience. Our focused questions drew their analytical attention to specific elements in the diagram where we felt revision was needed, but they were also free to comment on anything they felt was relevant. For example, through our interviews in New Bedford a solution to the new working conditions of lumpers (described above) was proposed: have a regulation stipulating that off-loading could only happen between certain hours. Of course, the full impact of such a requirement would need to be explored in greater detail – our intent here is only to show how analysis contributes to the identification of options for managing hazards and their consequences.

In some cases observed consequences and response actions may be associated with non-fishing stressors, such as increasing fuel costs and nationwide economic recession. Information gained through RIVA assessments can help fisheries managers and stakeholders think about what can be mitigated by fisheries managers and what cannot. They are constrained by law, resources, knowledge, willingness to take risks or to change and a variety of other adaptive capacities (Norris et al., 2008; Smit and Wandel, 2006). For example, fisheries managers have no control over fluctuations in fuel prices, gentrification of fishing communities, banks' abilities and preferences to issue loans, and market demand for fresh fish.

On the other hand, federal and state fisheries managers and regulators can create requirements for safety trainings and minimum crew numbers, enforce compliance with safety regulations, perform inspections more regularly, establish loan guarantees, and support and maintain access to local infrastructure (e.g., dock repairs, fee structures, access roads). They can also create incentives that can help mitigate the risks taken by fishermen. Recent advances in technology can allow tracking and monitoring that will allow fishermen to return to safe harbors during storms without losing days or catch.

4.1.2. Learning over time is promoted

In addition to decision relevant information by organized fact-finding and thorough data analysis, RIVA can help promote learning among fisheries managers and other stakeholders. The step-by-step approach supports development of a consistent set of variables, so that managers can compare across different communities, create systematic data gathering efforts by focusing attention on key variables and their interactions, and learn from multiple experiences. Ecosystem-based management that is adaptive requires learning that is intentional and systematic (McLeod and Leslie, 2009; Scholz and Stiftel, 2005).

Fisheries managers can start with variables they know to be important (e.g., Hall-Arber et al., 2001; Norman et al., 2007; Sepez et al., 2006) and use RIVA to identify new variables, particularly those that are locally-relevant. For example, to monitor the economic well-being and stability of commercial fishermen, managers can count the number of bankruptcies, active vessels, and fleet size. They can also measure variables related to the processes that lead to bankruptcies, owners keeping vessels in port, and changes in fleet size. Relevant response-related variables could include: number of fishermen who prematurely retire, number of permits bought and sold, number of fishermen (and family members) seeking social support services, number of crew hired, frequency and magnitude of loans sought from banks, number of fishermen spouses who recently started working, if owners are doing their own repairs, and if owners change the profiting sharing/cost contract with crew. With repeated application of RIVA fisheries managers can monitor how such variables relate in time to the introduction of new regulations and plans. Over time unexpected or under-appreciated connections between fisheries management actions and consequences may be identified.

RIVA can help managers better understand the nuances that differentiate particular groups and communities. For example, information about sensitivities is developed as part of rapid impact and vulnerability assessments. Sensitivities mediate cause–effect relationships. They act as driving forces that allow a stressor to have a larger or smaller effect. They include individual characteristics, social conditions, economic conditions, institutional characteristics, cultural aspects, technological systems and components, and ecological systems and components (Dow, 1992; Smit and Wandel, 2006). A benefit of the assessment approach is that sensitivities of different individuals, groups, and communities are linked to specific outcomes and consequences. Knowledge of sensitivities is important in designing effective interventions or policy actions that prevent, reduce or compensate harmful consequences.

Similarly, repeated application of rapid impact and vulnerability assessments in multiple communities could lead to a more nuanced understanding of linkages by more systematically documenting similarities and differences. For example, in our studies of Chatham and coastal New Hampshire other themes included impacts and vulnerabilities related to the charter sector and to community structure and relationships, but these were not salient issues in New Bedford. Another illustration of how repeated application offers the potential for learning is illustrated by our three case studies: we found that the types of shore side services impacted varied in our three cases in part because of the alternative opportunities available to these businesses. Ice suppliers in New Bedford are able to establish new markets for their product. This was not true for those who unload fish (lumpers). Grocery stores and suppliers saw business with commercial fishermen decline, while purchases from recreational charters increased. However, bait suppliers and vessel mechanics may not have other ready options in places like Chatham. In New Bedford the availability of dockage, an important shore side service, may shrink because more local vessels remain in port longer. Because of shrinking fleets and support services in other regions fishermen are coming to larger ports like New Bedford for maintenance and upgrades, thus helping to ensure the continued profitability of those shore side businesses.

4.1.3. RIVA is inexpensive and places reasonable demands on staff

RIVA can complete a community assessment in one to two weeks, a far cry from the months required for a “full blown” vulnerability assessment (Schröter et al., 2005). RIVA also avoids problems that arise from other rapid assessment approaches because of the underlying conceptual models of risk and vulnerability that guide data gathering and explicitly point to management options. For example, Community Profiles (Norman et al., 2007) provide a “snapshot” of a community, but little information about the dynamics within the coupled human-environment system that can inform the design of fisheries management.

Finally, RIVA can also side-step another potential challenge to conducting research in a timely manner. The Paperwork Reduction Act of 1995 requires that federal agencies get approval from the Office of Management and Budget (OMB) before gathering information from ten or more people using the same set of questions in surveys or interviews. While there are expedited reviews in some cases (e.g., customer satisfaction surveys), they do not apply to social impact assessments and obtaining approval can be a lengthy and burdensome process (Wood et al., 2010, pg. 9, 42). Because RIVA is oriented toward gathering a broad range of input from a small number of stakeholders, it does not require using the same questions, therefore OMB approval would not be required. Our qualitative interviews were guided by a set of topics that we wished to discuss, not a set of pre-determined questions. Moreover, in some communities ten individuals may be sufficient for gathering the requisite information.

4.2. Weaknesses of RIVA

Drawing reliable conclusions about what are essentially complex coupled human-environmental systems requires quality data and sound analysis. RIVA focuses on collecting data quickly and this can raise questions about the validity of those data. Here we address two shortcomings: the number of people consulted and the human tendency to over-emphasize negative consequences.

4.2.1. The sample of stakeholders interviewed is small

Every study must make a decision about how many people and which people to include and then face the question: What it enough? The problem of generalizability and completeness is not unique to RIVA. Social impact assessments can suffer from the same problems, depending on the ways that data are gathered. For example, public meetings to gather input from the public may lead to biases because certain people attend and others do not (McComas et al., 2006). RIVA is similar to Rapid Rural Appraisal (RRA) or Rapid Impact Assessment (RIA) in that it is an expedient way to gather evidence from the field in order to make a judgment about what impacts are worthy of greater attention. Validating

these requires further investigation. RIVA gathers evidence from the existing literature and from interviews with a small number of individuals. Individuals are selected purposively, because they have broad experience in the fishing sector and in the community. The results are premised on the assumption that we sufficiently identified the bulk of diverse perspectives about the consequences and vulnerabilities associated with new rules. Of course, we cannot be certain that an important perspective is missing; the method sacrifices precision for speed. However, RIVA strives to gather data with high validity by drawing on a wide diversity of viewpoints and by validating all the data with informed community and value leaders. RIVA does not use a representative sample, but a representative sample would not be preferable to a purposive sample in this context.

4.2.2. Stakeholders tended to focus on negative consequences

Causal pathways developed as part of RIVA can represent both negative and positive consequences. What is included, however, depends on what information is available from existing studies and provided by interviewees. While we asked about both positive and negative consequences, we found that interviewees tended to focus on the negative. Negative consequences appeared to be more salient. We may also have inadvertently oriented them toward the negative consequences as well when we asked about vulnerabilities, adaptive capacities, and adaptive responses.

With a focus on the negative consequences we gathered limited information about the trade-offs raised by different adaptive responses. For example, while we learned that fisheries regulations can have immediate impacts on the financial health of fishermen, we heard little about short-term versus long-term effects and trade-offs. We also obtained little specifics about the ways that market prices for fish respond to limits on catches, either in volume or by season. On the other hand, we did learn about the ways that fishermen compensate for more limited days at sea or catch limits by increasing their workloads or fishing in poorer weather. Similarly, shore side businesses looked for additional markets and New Bedford is becoming a destination for repairs for fishermen based elsewhere. Further interviews may have filled some of these gaps.

In summary, the weaknesses of RIVA reflect limitations in the data gathered for the assessment. The importance of these weaknesses for decision makers is in part a function of how the results are to be used. RIVA is not intended to provide the same analytic power as, for example, hypothesis-driven scientific studies. Econometric studies of catch limits on shore side businesses, human factors studies about workload and accidents and other studies are needed to elaborate the dynamics within fishing communities and the effects of new rules. However, by its attention to breadth and highlighting key causal relationships, RIVA can provide benefits to fisheries managers seeking to develop qualitative understandings of the human-environment system and to identify key variables and interactions that warrant more detailed investigations.

5. Conclusion

RIVA offers practical, relevant, and credible knowledge for fisheries managers to promote management for sustainable marine fisheries and healthy fisheries communities. The core feature of RIVA is the systematic organization of information about social, economic, cultural, and institutional consequences of new regulations into a hazard event sequence. This information empowers fisheries managers to craft regulations and rules that achieve ecosystem management goals without bringing undesirable consequences to the human component of the fisheries system, thus satisfying the full intent of the Magnuson–Stevens Fishery Conservation and Management Act and its Amendments. While our focus has been on fisheries management, RIVA can be applied in a variety of natural resource and hazard management contexts, including forest management, watershed management, climate change adaptation planning, and hazard mitigation planning.

RIVA complements full-scale social impact assessment (SIA) or vulnerability assessment methods. First, it is much faster and much less expensive than those methods, and it can be used as an initial assessment or screening tool. RIVA is very flexible and can be quickly adjusted to shift its focus if that is deemed necessary. In fact, since the analysis of the data is happening at the same time that data are being collected, fact-finding can be oriented to fill gaps that are necessary for a robust analysis. Much of the reduced expense of RIVA has to do with lower demands on staff time. A few people can conduct a RIVA in as little time as one week.

Second, RIVA provides local knowledge that has been peer-tested and has high decision relevance. It draws on input from a diverse range of stakeholders and integrates this information to reveal opportunities for management interventions. Its open-ended, qualitative approach ensures that subjective yet important matters of social and cultural concerns/conflicts and psychological perceptions are incorporated into the final analysis. Our experience and feedback suggests that a carefully selected, but small group, of interviewees can ensure that relevant data are obtained and that an approach that links causal modeling with vulnerability assessment provides relevant knowledge for fisheries managers. Key informants are often in a better position to understand detailed dynamics of the social, economic, and cultural system in which they are embedded that fisheries managers who work and reside elsewhere. This information can be used to "ground truth" studies using analytic techniques from the social sciences, including economics, sociology, and anthropology.

RIVA enables managers to obtain an inexpensive and quick first-cut at understanding the impacts of introducing new rules and plans. They can use this knowledge to focus further detailed assessments that test the validity and completeness of results. Although it was beyond the scope of our project to systematically compare the results that would be obtained from application of the different methods in a particular context – and such a test would be very difficult to conduct – our study suggests that repeated application of rapid impact and vulnerability assessments within specific communities and in multiple communities could lead to a more nuanced understanding of linkages by more systematically documenting similarities and differences. By involving fishermen as informants and acknowledging and addressing concerns about social, economic, cultural, and institutional consequences, fisheries managers can begin to repair mistrust engendered by perceptions that such issues are not accounted for in management plans (Kaplan and McCay, 2004).

We encourage managers not to think of RIVA as a permanent replacement to SIA, vulnerability assessments, or community profiling. All these techniques have important contributions. For example, much of the objective data that stakeholders use to develop locally based understandings of their fishing industry and community are gathered through these other kinds of methods. Data are often expensive, but also invaluable. RIVA should be seen as one tool, among many, that policy makers have to understand how their actions can have unintended impacts. It is important to continue to fund activities to gather objective data about fishing communities.

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References

Brodziak, J., Link, J., 2002. Ecosystem-based fishery management: what is it and how can we do it? Bulletin of Marine Science 70 (2), 589–611.

Clark, G.E., Moser, S.C., Ratick, S.J., Dow, K., Meyer, W.B., Emani, S., Jin, W., Kasperson, J.X., Kasperson, R.E., Schwarz, H.E., 1998. Assessing the vulnerability of coastal communities to extreme storms: the case of Revere, MA, USA. Mitigation and Adaptation Strategies for Global Change 3, 59–82.

Clark, C., Clarke, F., Munro, G., 1979. The optimal exploitation of renewable resource stocks: problems of irreversible investment. Econometrica 47 (1), 25–47.

Clark, C., Munro, G., Sumaila, U., 2005. Subsidies, buybacks, and sustainable fisheries. Journal of Environmental Economics and Management 50 (1), 47–58.

Community Panels Project, 2004. New Bedford's Fishing Infrastructure Report – Draft 9/23/04. MIT Sea Grant, Cambridge, MA.

Dow, K., 1992. Exploring differences in our common future(s): the meaning of vulnerability to global environmental change. Geoforum 23 (3), 417–436.

Ecosystem Principles Advisory Panel, 1998. Ecosystem-based Fisheries Management. A report to Congress. US Congress, Washington, DC.

Georgianna, Daniel, Debra, Shrader, 2005. Employment, Income and Working Conditions in New Bedford's Offshore Fisheries. Final report for Saltonstall-Kennedy NA03-NMF-4270265, NMFS/NOAA, U. S. Department of Commerce.

Georgianna, D., Shrader, D., 2008. Employment, income, working conditions and vessel safety in New Bedford after Amendment 13 to the Multispecies Management Plan. Final report for contract No. NA05NMF4721057/UNH PZ06083 with the Northeast Consortium.

Hall-Arber, M., Dyer, C., Poggie, J., McNally, J., Gagne, R., 2001. Fishing Communities and Fishing Dependency in the Northeast Region of the United States (No. Final Report. NMFS Grant No. NA87FF0547). MIT Sea Grant Program, Cambridge, MA.

International Labour Organization (ILO), 2000. Safety and Health in the Fishing Industry. International Labour Office, Geneva. Report for discussion at the Tripartite Meeting on Safety and Health in the Fishing Industry. Geneva, 13–17 December 1999. Available at: www.ilo.org/public/english/dialogue/sector/techmeet/tmfi99/tmfir2.htm.

Juravich, T., 2005. Exploited: Cutting Fish in New Bedford. University of Massachusetts Labor Relations Research Center, Amherst, MA, Unpublished manuscript.

Kaplan, I., McCay, B., 2004. Cooperative research, co-management and the social dimension of fisheries science and management. Marine Policy 28 (3), 257–258.

Kasperson, J.X., Kasperson, R.E., Turner, B.L., Hseih, W., Schiller, A., 2005. Vulnerability to global environmental change. In: The Social Contours of Risk. Risk Analysis, Corporations & the Globalization of Risk, vol. II. Earthscan, London, pp. 245–285.

Kates, R.W., Hohenemser, C., Kasperson, J.X. (Eds.), 1985. Perilous Progress. Westview Press, Boulder, CO.

McComas, K., Besley, J., Trumbo, C., 2006. Why citizens do and do not attend public meetings about cancer cluster investigations. Policy Studies Journal 34 (4), 671–698.

McLeod, K., Leslie, H., 2009. Ecosystem-based Management for the Oceans. Island Press, Washington, DC.

NMFS, 1997. Guidelines for Assessment of the Social Impact of Fishery Management Actions. Downloaded from: http://www.nmfs.noaa.gov/sfa/reg_svcs/social_impact_assess.htm.

New England Fishery Management Council, 2011. Fishery Management Plans Northeast Multispecies – Sector Management. Available on the web at: http://www.nefmc.org/nemulti/index.html.

NOAA, 2010. NOAA Announces New Northeast Groundfish Management Measures. 31 March 2010. Available at: www.noaanews.noaa.gov/stories2010/20100331_groundfish.html.

Norman, K., Sepez, Jennifer, Lazrus, Heather, Milne, Nicole, Package, Christina, Russell, Suzanne, Grant, Kevin, Petersen, Robin, Primo, John, Styles, Megan, Tilt, Bryan, Vaccaro, Ismael, 2007. Community Profiles for West Coast and North Pacific Fisheries – Washington, Oregon, California, and Other U.S. States. Northwest Fisheries Science Center and the Economics and Social Sciences Research Program, Alaska Fisheries Science Center. Report prepared by the Socioeconomics Program. Available at: www.nwfsc.noaa.gov/research/divisions/sd/communityprofiles/Supplemental_Community_Profiling_Document_DRAFT.pdf.

Norris, F., et al., 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. American Journal of Community Psychology 41, 127–150.

Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E.D., Link, J., Livingston, P.A., Mangel, M., McAllister, M.K., Pope, J., Sainsbury, K.J., 2004. Ecosystem-based fisheries management. Science 305, 346–347.

Polsky, C., Neff, R., Yarnal, B., 2007. Building comparable global change vulnerability assessments: the vulnerability scoping diagram. Global Environmental Change 17, 472–485.

Portman, M., Jin, D., Thunberg, E., 2009. Waterfront land use change and marine resource conditions: the case of New Bedford and Fairhaven, Massachusetts. Ecological Economics 68 (8–9), 2354–2362.

Ratick, S., Capoccia, S., Dichter, A., Goble, R., Golding, D., Hattis, D., Tantuay, J., 2004. Determining the Vulnerability of Populations to Mercury. Prepared for the US EPA, contract no. XA – 83067901-0. February 9, 2004. Clark University, Worcester, MA.

Scholz, J.T., Stiftel, B. (Eds.), 2005. Adaptive Governance and Water Conflict: New Institutions for Collaborative Planning. Resources for the Future, Washington.

Schröter, D., Polsky, C., Patt, A., 2005. Assessing vulnerabilities to the effects of global change: an eight step approach. Mitigation and Adaptation Strategies for Global Change 10 (4), 573–595.

Sepez, J., Norman, K., Poole, A., Tilt, B., 2006. Fish scales: scale and method in social science research for North Pacific and West Coast fishing communities. Human Organization 65 (3), 280–293.

Smit, B., Wandel, J., 2006. Adaptation, adaptive capacity, and vulnerability. Global Environmental Change 16, 282–292.

Tuler, S., Agyeman, J., Pinto da Silva, P., LoRusso, K., Kay, R., 2008. Assessing vulnerabilities: integrating information about driving forces that affect risks and resilience in fishing communities. Human Ecology Review 15 (2), 171–184.

Tuler, S., Golding, D., 2002. A Review of the Literature for a Comprehensive Study of Visitor Safety in the National Park System. Prepared for the National Park Service Under Subcontract (# GNK756) to the University of Idaho. Cooperative Park Studies Unit, Moscow, ID.

Tuler, S., Webler, T., Polsky, C., 2009a. A Risk-based Approach to Rapid Vulnerability Assessment in New England Fishery Communities. Case Study of the Groundfishing Sector Chatham, Massachusetts. Social and Environmental Research Institute, Inc, Greenfield, MA. SERI Report 09-002. PDF available from: http://www.seri-us.org/content/rapid-vulnerability-assessment-of-fishery-communities.

Tuler, S., Webler, T., Polsky, C., 2009b. A Risk-based Approach to Rapid Vulnerability Assessment in New England Fishery Communities. Case Study of the Groundfishing Sector in Coastal New Hampshire. Social and Environmental Research Institute, Inc, Greenfield, MA. SERI Report 09-003. PDF available from: http://www.seri-us.org/content/rapid-vulnerability-assessment-of-fishery-communities.

Tuler, S., Webler, T., Polsky, C., 2009c. A Risk-based Approach to Rapid Vulnerability Assessment in New England Fishery Communities. Case Study of the Groundfishing Sector in New Bedford, Massachusetts. Social and Environmental Research Institute, Inc, Greenfield, MA. SERI Report 09-004. PDF available from: http://www.seri-us.org/content/rapid-vulnerability-assessment-of-fishery-communities.

Turner, B.I., Kasperson, R., Matson, P., McCarthy, J.J., Corell, R., Christensen, L., et al., 2003. Science and Technology for Sustainable Development Special Feature: A Framework for Vulnerability Analysis in Sustainability Science 100 (14), 8074–8079.

US Coast Guard, 1999. Dying to Fish. Report of the Fishing Vessel Casualty Task Force. US Coast Guard Office of Investigations and Analysis, Washington, DC.

Webler, T., Rakel, H., Renn, O., Johnson, B., 1995. A comparative analysis of concerns about land application of municipal sewage sludge. Risk Analysis 15 (3), 421–436.

Wilson, D., McCay, B., 1998. Social and Cultural Impact Assessment of the Highly Migratory Species Management Plan and the Amendment to the Atlantic Billfish Management Plan. Prepared for the Highly Migratory Species Office, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, July 1998. The Ecopolicy Center, New Brunswick, NJ. Available on-line at: www.st.nmfs.gov/st1/econ/cia/hms.pdf.

Wood, S.F., Long, R., Borkowski, L., Michaels, D., 2010. Strengthening Science in Government: Advancing Science in the Public's Interest. George Washington University School of Public Health and Health Services, Washington, DC. Report of the Scientists in Government Project. Available on the web at: http://defendingscience.org/newsroom/Scientists-in-Government-full-report.cfm.