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The connection between fisheries resources and spatial land use change: The case of two New England fish ports

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ABSTRACT

This study examined interactions between targeted fish populations, aspects of the fishing industry and land use changes along two ports in New England. By tracking changes in land uses over a two-decade period using parcel level data and geographic information system (GIS) tools, we examined the relationship of changes in species biomass, landings and other fishing industry variables to community spatial change. Using logistic regression models we assessed the impacts on essential infrastructure for continued fishing industry activity. Our findings have implications for land use policy that should accompany efforts being made to rehabilitate fish stocks; it should ensure that current marine infrastructure will remain in place to support the fishing industry if and when species rebound. Our models show that in New Bedford Harbor, the larger of the two ports, increasing scallop biomass (considered a long-term factor) is associated with the increase of marine-related land uses. In Provincetown Harbor, short-term factors, such as value and volume of fish landings as well as stock sizes, influence land use change. These findings suggest that the smaller port (Provincetown) is more vulnerable to market conditions and therefore in need of greater land use controls to prevent the conversion of marine-related uses. We propose some directions for further research and present the methodology used as one that can be applied to research questions of a similar nature.

Introduction

Each year countries around the world dedicate significant effort and expense to rebuilding fishery resources in ocean areas where commercial fish populations have been severely depleted. The hope is that with various restrictive measures in place, such as the closure of certain areas to fishing, prohibitions on the use of certain types of gear, and strictly managed quotas, species will rebound. Off the coast of New England there are some positive signs of success from fisheries management measures (Brodziak et al., 2005; Worm et al., 2009), but in the near term it is expected that decreases in stocks will be reflected in the spatial character of communities dependent on commercial fishing (Hall-Arber et al., 2006).

Some impacts may be observed in the characteristics of cities and towns with major fishing ports, including in portside land use and physical infrastructure. If fishery resources do increase, the related land-based infrastructure that is lost when stocks are low will not be available if land use has switched in the meantime to non-marine related use (Bergeron et al., 2005). In some ports throughout New England and on the eastern seaboard, many waterfront businesses have diversified into non marine-related businesses in past decades (Hall-Arber et al., 2006). In others, marine-related activities have increased (Portman et al., 2009). Simultaneous examination of spatial changes within the context of fish stock increases or decreases in ports of different types and location will further our understanding of the multiple socio-spatial effects of fluctuations in marine resources and the related fisheries industry.

Certainly, we can better understand longitudinal changes by modeling the fisheries stock and land use change relationships in two ports and by making comparisons. This paper begins with a brief summary of theoretical background that highlights the importance of integrating environmental change with various aspects of human communities including spatial characteristics. The next section describes the two case study areas. The Methods section describes the modeling approach, both theoretical and applied. Results of the research follow. The penultimate section of the paper points out some limitations of the method and the study and pos-

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sibilities for further research efforts. The final section presents conclusions from research findings and provides a brief discussion in view of our findings.

Integrating the physical and the socio-economic

Until recently ecology and socio-economics addressed physical (non-human) or human systems, respectively, without making strong connections between the two; scientists and resource managers addressed either the biocentric physical aspects of the environment or socio-economic "anthropocentric" concerns (Norgaard, 2008). Consequently, approaches emerged such as integrated coastal management (ICM) and ecosystem-based management (EBM) that consider the various elements of ecosystems, including humans, and the myriad of activities they espouse that impact or are impacted by the physical environment. These two approaches emphasize the need to maintain coastal environments in a healthy, productive and resilient condition to provide the *services* humans want and need (Cicin-Sain and Knecht, 1998; COMPASS, 2005). But they do more than set the stage for integrating the physical with the social–economic. As it became clear how significantly ocean and coastal land uses and users can affect one another, practitioners and policy experts articulated the need for integration across varying landscape units especially across the land-sea divide. ICM refers to the integration of all relevant policy areas, sectors, and levels of administration. It supports integration of the terrestrial and marine components of the target territory that makes up the coastal zone in both time and space while balancing conservation with development.

Although the exact meaning of ICM may be debated, in broad terms it seeks to address the conflicts between economic demands and ecological needs in the coastal area (Olsen, 2003; Lau, 2005). Olsen et al. (2004) points out that ICM should be a "stepping-stone" toward making EBM for the marine environment an operative reality. With respect to integrating human concerns, EBM is akin to bioeconomics and ecological economics. The former studies the dynamics of living resources and relates these to economic models. It is related to the early development of theories in fisheries economics, initiated in the mid 1950s (Gordon, 1954; Scott, 1955). The latter – ecological economics – is a trans-disciplinary field of academic research that aims to address the interdependence of human economies and natural ecosystems. It focuses on how to operate an economy within the ecological constraints of earth's natural resources. Both these fields recognize the need to examine relationships between populations of culled species, associated human activities and their repercussions for coastal land use whether these activities occur on land, at sea or both. This interconnectedness is quite salient when one examines the fishing industry. Fishing and interaction with marine resources can be much more than an economic activity occurring solely in the sea (Kaplan, 1999; Hall-Arber et al., 2006; Olson, 2006; Le Heron et al., 2008).

Marine resource management authorities whether sectoral or integrated, recognize the consequences of fisheries management for ecosystem health and community well-being. On a global level, Agenda 21, revealed at the United Nations Conference on Environment and Development ("Earth Summit") held in Rio in 1992, devotes a chapter to ocean and coastal issues in which fisheries management problems play a predominant role.[1] In the US, fishery management problems were addressed by passage of the Sustainable Fisheries Act (SFA) of 1996. National Standard 8 of the SFA requires explicit consideration and minimization of community impacts resulting in a focus on social science aspects of fisheries management. As a consequence, the US National Marine Fisheries Service (NMFS) has committed itself to understanding the well-being of surrounding human populations that are dependent on fisheries (Pollnac et al., 2006).

Experience and extensive literature show that management actions will affect a wide range of social entities including individuals, firms, families and communities (Martin, 2006; Rosenberg, 2009). The US National Oceanic and Atmospheric Administration funded studies that have developed frameworks for the analysis of community responses to changes in fisheries and for the development of methods that can be used to assess social impacts. Social impact assessments examine socio-cultural impacts of regulation similar to how environmental impact assessments examine impacts of regulatory programs and projects on the physical environment. Social scientists have worked to improve social impact assessment for fisheries regulation since the 1960s; such assessments have become more institutionalized over time (Pollnac et al., 2006). However, they fall short of what some researchers would like to use for identifying fisheries–community interactions (Martin, 2006; Le Heron et al., 2008) and largely ignore physical impacts on communities as these are observable through land use change and related to market or regulatory forces.[2]

As an example, one theoretical framework developed to facilitate the study of effects on communities of changes in the fishing industry is the concept of vulnerability. It has been applied to fisheries management both in regards to fish populations and human communities. While "vulnerability" is used in different ways in various fields, it is generally accepted as referring to a state of pending loss (Füssel, 2007). For example, vulnerability is used in assessing the potential damage from sea-level rise caused by climate change to coastal properties (Bin et al., 2008). In regards to fisheries, Tuler et al. (2008) explores the utility of considering vulnerability in the assessment of potential impacts on communities from proposed fisheries management measures in the Northeastern US Webster (2009) uses a related framework centering on "vulnerability response" and applies it to highly migratory species of fish regulated in the international arena using the North Atlantic fisheries as a case study. For both these fisheries-related applications, vulnerability is related to risk. In the former, vulnerability defines the magnitude of the undesirable outcomes whose probability of occurring is expressed as risk. For the latter, vulnerability is gauged based on capacity for competitiveness and flexibility (availability of alternative revenue sources). Understanding the level of vulnerability is key for predicting community or institutional positions[3] on regulatory design and on access to and conservation of fishery resources.

While these and other approaches cover numerous aspects of communities (e.g., economic development, lost revenues or sources of employment, changes in social organization and political orientation) none of them explore spatial changes. Yet spatial change can be an indicator of well-being and physical infrastructure can be an important socio-economic support element (Hall-Arber et al., 2006). Surprisingly, little work examines the influence of ocean resource extraction on coastal land use, par-

[1] Problems discussed include local overfishing; unauthorized incursions by foreign fleets; ecosystem degradation; overcapitalization and excessive fleet size; undervaluation of catch; insufficiently selective gear; unreliable databases; and increasing competition between artisanal and large-scale commercial fishing and between fishing and other activities (Cicin-Sain and Knecht, 1998).

[2] Changes can also be the related indirectly to combinations of market and regulatory forces. For example, infrastructure investment required for public access or for consistency with harbor management plans may encourage gentrification within fishing ports or may lower profitability of private commercial fish docking facilities.

[3] At the nation state level in Webster's (2009) case study.