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Taxonomy of USA east coast fishing communities in terms of social vulnerability and resilience

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ABSTRACT

Increased concern with the impacts that changing coastal environments can have on coastal fishing communities led to a recent effort by NOAA Fisheries social scientists to develop a set of indicators of social vulnerability and resilience for the U.S. Southeast and Northeast coastal communities. A goal of the NOAA Fisheries social vulnerability and resilience indicator program is to support time and cost effective use of readily available data in furtherance of both social impact assessments of proposed changes to fishery management regulations and climate change adaptation planning. The use of the indicators to predict the response to change in coastal communities would be enhanced if community level analyses could be grouped effectively. This study examines the usefulness of combining 1130 communities into 35 relevant subgroups by comparing results of a numerical taxonomy with data collected by interview methods, a process herein referred to as "ground-truthing." The validation of the taxonomic method by the method of ground-truthing indicates that the clusters are adequate to be used to select communities for in-depth research.

1. Introduction

Changing coastal environments can have varying impacts on coastal fishing communities. Much interest today is being directed at potential changes due to projected global climate change as well as variations in availability of the natural resources upon which the communities depend. These variations can be directly related to climate change, but also to factors such as increasing human use or harvesting of the resources, pollution, and/or other natural or anthropogenic influences, including restricted access due to management efforts. Independent of the sources of variation, it is assumed that different coastal communities will manifest varying degrees of vulnerability and resilience to the changes.

Vulnerability and *resilience* to change constitute one commonly understood framework for assessing community response to change. While these terms resonate with the public (e.g., resilience plans have largely replaced sustainability plans for coastal communities, see CNRWG, 2014), there have been a wide range of conceptual definitions proposed depending on the context, disciplinary focus or personal preference. Increased concern with the impacts that changing coastal environments can have on coastal fishing communities, led to a recent effort by NOAA Fisheries social scientists to develop a set of indicators of social vulnerability and resilience for the U.S. Southeast and Northeast coastal communities (see Jepson and Colburn, 2013; Jacob et al., 2010; Jacob et al., 2013).

The NOAA Fisheries indicators define vulnerability as the pre-existing characteristics of a community that create or negate the potential for harm, including conditions such as powerlessness and marginality of physical, natural, and social systems (re. Cutter et al., 2008; Adger, 2006). Resilience, meanwhile, is a social system's ability to cope well prior to a disturbance and its ability to respond to, and recover from, a disturbance (Cutter et al., 2008). This includes returning to a *desirable* state (see Cinner et al., 2012; McClanahan and Cinner, 2012; Cutter et al., 2009; Pollnac et al., 2008; Abesamis et al., 2006) rather than simply returning to the same pre-disturbance state (see Gibbs, 2009; Folke, 2006; Walker et al., 2004; Carpenter et al., 2001).

The use of indicators to measure vulnerability and resilience at the community level facilitates policy decisions aimed to address changing conditions in coastal communities. Quantitative measurements based on secondary data are cost effective and more easily incorporated into policy frameworks than traditional ethnographic methods. Recent focus on holistic approaches, such as ecosystem-based management, has increased interest in the development and use of indicators for efficiently incorporating socioeconomic aspects into fishery regulatory efforts (Gibbs, 2009; Jacob et al., 2013). In the United States (US), Social Impact Assessment (SIA) for proposed changes to fishery management regulations is a required component under the National Environmental Protection Act of 1969 (NEPA; 42 U.S.C. § 4321 et seq.) for all

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Table 1
The 12 vulnerability/resilience indices developed by NOAA Fisheries social scientists and indicators comprising each index.

Personal disruption index	Population composition vulnerability index
Percent unemployed	Percent white alone
Percent in poverty	Percent female single headed households
Crime index	Population age 0–5
Percent females separated	Percent that speak English less than well
Percent with no diploma	
Labor force structure index	**Poverty index**
Percent females employed	Percent receiving assistance
Percent population in the labor force	Percent of families below poverty level
Percent self employed	Percentage over 65 in poverty
Percent people receiving social security	Percentage under 18 in poverty
Housing characteristics index	**Urban sprawl index**
Median rent in dollars	Population density
Median mortgage in dollars	Nearest city w/50 k population in miles
Median number of rooms	Cost of living index
Percent mobile homes	Median home value
Retiree migration index	**Natural amenities index**
Households with one or more over 65	Rental vacancy rate
Percent receiving social security	Percent homes vacant
Percent receiving retirement income	Boat launches by population
Percent in labor force	Percentage water cover
Recreational fishing reliance index	**Recreational fishing engagement index**
Recreational fishing mode charter by population	Recreational charter fishing pressure
Recreational fishing mode private by population	Recreational private fishing pressure
Recreational fishing mode shore by population	Recreational shore fishing pressure
Commercial fishing reliance index	**Commercial fishing engagement index**
Value of landings by population	Value of landings
Number of commercial fishing permits by population	Number of commercial fishing permits
Dealers with landings by population	Number of dealers with landings
Percent in forestry, farming and fishing occupation	Pounds of landings

Environmental Impact Statements (EISs). Further, National Standard 8 of the Magnuson–Stevens Fishery Conservation and Management Act of 1976 (MSA; 16 U.S.C. § 1801 et seq.) mandates social and economic analysis that takes into account the importance of fishery resources to fishing communities (16 U.S.C. §1851(2)(8)). Until the advent of the NOAA Fisheries indicators, there had been limited quantitative data with which to effectively conduct comparative SIA analysis on a large scale.

Previous analyses show that the vulnerability/resilience indicators developed by NOAA Fisheries manifest a great deal of variability across geographical regions (see Jepson and Colburn, 2013; Jacob et al., 2013). Accounting for this variability could potentially result in more effective efforts to manage resources and improve coastal communities' response to changes. For this reason, it is important to determine if any patterns exist to the observed variations. Recognition of patterns may enable managers to more efficiently obtain data for management decision making (cf. Smith et al., 2011) and to develop policy plans appropriate for groups of communities that exhibit similar levels of resilience/vulnerability based on comparable indicators.

In this paper, methods of numerical taxonomy based on cluster analysis are used to combine fishing communities into relevant subgroups, i.e., clusters based on the communities' scores on the vulnerability/resilience indices developed by NOAA Fisheries (Jepson and Colburn, 2013).

Table 2
Results of a principal component analysis of transformed (T) vulnerability/resilience indices (varimax rotation).

Transformed indices	Social problems	Gentrification	Recreational fishing	Commercial fishing
Poverty T	0.848	−0.054	−0.041	0.153
Personal disruption T	0.817	−0.207	0.058	−0.001
Housing T	−0.661	−0.200	0.246	−0.475
Population dulnerability T	0.617	−0.547	0.031	−0.107
Labor force T	0.004	0.919	0.020	0.029
Retiree migration T	−0.100	0.899	0.076	−0.089
Natural amenities T	−0.124	0.611	0.222	0.336
Recreational fishing engagement T	−0.072	0.100	0.941	0.015
Recreational fishing reliance T	0.010	0.135	0.930	0.032
Commercial fishing reliance T	0.031	0.108	−0.116	0.895
Commercial fishing engagement T	0.150	−0.082	0.283	0.775
Urban sprawl T	−0.469	−0.221	0.389	−0.502
Percent variance	20.652	20.873	17.645	16.973

However, as Smith et al. (2011) point out, numerical taxonomy techniques can sometimes provide unreliable results. There are two primary reasons for this: first, unless all attributes of the element to be classified are used (which is impractical), human decision making is involved in the process; second, there are many techniques used in numerical taxonomy, and the method selected can influence the results (e.g., Brusco and Köhn, 2008; Frey and Duek, 2007). For this reason, it was considered essential to establish the external validity of the cluster analysis obtained in the present study against several independent data sets, a process herein referred to as "ground-truthing."

The main purpose of this paper is to demonstrate the utility and validity of using a set of previously developed vulnerability and resilience indicators derived from secondary data to classify a very large sample of commercial and/or recreational fishing communities into subgroups composed of communities manifesting similar profiles with regard to the vulnerability and resilience indicators. Our purpose is not to discuss the details and implications of the profiles, but to determine the validity of the subgroupings by ground-truthing a sub-set of clusters that were characterized by varying social vulnerability/resilience profiles and dependence on commercial and/or recreational fishing activity. The assumption is that if the subgroupings are composed of communities manifesting very similar social vulnerability/resilience profiles then the clusters could be used to stratify sampling to efficiently select a sub-set of communities representing social vulnerability/resilience profiles of interest for in-depth analysis. This is an important consideration given the frequently limited time frame within which SIAs are conducted.

The processes for development of the initial data set using the vulnerability/resilience indicators, as well as the cluster analysis and ground-truthing methods are described in the following section. Results of the cluster analysis and ground-truthing processes are presented separately. Finally, findings derived from the two processes are compared and discussed, emphasizing the applicability of the numerical taxonomic methodology to policy making in coastal fishing communities.

2. Methods

2.1. The initial data set

The initial data set for the cluster analysis was developed by NOAA Fisheries social scientists by taking a set of social, demographic, and fishery variables (listed in Table 1) and transforming them via a factor analysis (see Jepson and Colburn, 2013). The grouped indicators comprise 12 vulnerability/resilience indices (see Table 1) for 1130 fishing communities along the U.S. coast from Maine to Texas reporting commercial and/or recreational fishery landings in 2010. Factor analyses were then conducted on all 12 variable sets (indices), each resulting in a single factor. Because the factor analyses are of previously constructed indices, the scales are not necessarily unrelated unlike what would be expected