Creating Space for Community in Marine Conservation and Management: Mapping "Communities at Sea"*

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Abstract

We explore, through the practice of mapping communities at sea, the challenges and opportunities to fishing communities and social sciences from the turn to ecosystem based management. From our previous work in mapping how communities are linked to and use spaces and places on and off the ocean, to new efforts to utilize maps of communities at sea, we argue for the importance of linking social scientific notions like communities to the databases and data analyses that support interdisciplinary efforts and policy innovations. Through visualizing communities and linking them to other efforts, we hope to foreground inter-relationalities, multi-scalar processes, assemblages and aggregations of species, mutual dependencies, and a shared ecosystem well-being as a foundation for sustainability.

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Introduction:

The challenge of the Anthropocene to marine resource management, the challenge of a marine environment thoroughly modified by human practices, will require more than a technology for maximizing the harvest of single species, which itself is appearing not only less possible than once thought but also less desirable as a path toward human and environmental wellbeing (Fogarty 2014). As elsewhere (Steffen et al., 2011), the challenge of the Anthropocene within the marine context will require a more holistic approach and a foregrounding of biophysical interactions and relations over space; indeed, it will require an ecosystem approach cognizant of not only the role of humans in modifying past ecosystems but also our responsibility to create felicitous conditions for future ecosystems (Pitcher 2001).

As social scientists we are heartened and emboldened by the “turn toward ecosystems” (USCOP 2004) insofar as it foregrounds process, interrelationality, context, and diversity, long held key concepts, starting points, and indeed hallmarks of critical social science (Hicks et al., 2016). Furthermore, we are pleased to find that what exactly constitutes an ecosystem approach remains open, even contested, because, for us this suggests there remains room for experimentation, new integrations, and possibility. Indeed, “ecosystem” provides a site where scientists, managers, and members of human communities can imagine alternative and inventive scientific methods, solutions to degradation, and forms of production or engagement beyond those provided by the narrow confines of single species management (Sievanen et al., 2011). In this sense, the shift in marine and fisheries science and management toward an ecosystems approach is a hopeful move that makes visible and analytically incorporates inter-relationalities, multi-scalar processes, assemblages and aggregations of species, mutual dependencies, and a shared ecosystem health or well-being as a foundation for sustainability.

Such ecosystem-based work is emerging in a number of sites relevant to marine science and management and is increasingly prioritized in policy development and planning practices, despite the many challenges of deeply institutionalized modes of knowledge production and management focused on single species (Pitcher et al., 2009). In practice, an ecosystem approach will require, and we clearly see many signs of, new streams of data, new synergistic metrics, and spatial methods and technologies that not only reveal but allow for the assessment and modeling of ecosystem relationships, dynamics, and trajectories across space from particular estuaries to continental scale ecosystems (Berkes 2012; Koehn et al., 2013).

A parallel shift in marine social science will also be needed, one that shifts beyond analyses that presume and privilege a singularly driven individual human actor, the fisherman, harvesting from a single stock, to an understanding of human dimensions that, like ecosystem-based approaches, foregrounds interactions and relations, multi-scalar processes, assemblages and aggregations, mutual dependencies, and a shared health or well-being as the basis for sustainability. The concept from social science that best captures these sensibilities is that of “community.” Community is the site, whether physical or epistemological (Creed 2006), where such characteristics and processes exist (Jentoft 2000). Furthermore, not unlike “ecosystem” or “ecosystem-based approach,” “community” is notoriously ill-defined yet wonderfully productive as a site of progressive imaginaries, a wellspring for shared action and innovation

(Cameron and Gibson 2005), and the locus of adaptation and sustainable futures (Gibson-Graham and Roelvink 2010).

In this chapter we propose a novel method to engage with “community” as a measurable and mappable unit of analysis. Our goal is to create an approach that defines actual spaces at-sea where we can document the presence of community as it relates to fisheries (e.g. shared ecological knowledge, history and culture, common fishing grounds and practices, and co-produced adaptations and innovations). We call this approach “communities-at-sea” to contrast it with social science approaches that have until now focused on community as a shore-side phenomenon largely divorced from the actions and practices of fishing offshore and, importantly, from the ecological systems within which such actions and practices occur. On the contrary, communities-at-sea represent the clustering at-sea of practices and processes that necessarily link onshore and offshore precisely because of the way that shared experiences and mutual dependence are, at the same time, a collective impact on particular habitats, ecosystem elements, and environments.

In what follows we further specify the concept of communities-at-sea and its technical manifestation. We then demonstrate how it might productively be used to document change over time as it relates to the fate of fishing communities, to integrate knowledge of community processes and practices into fisheries and ecosystem analyses and modeling, and to expand community beyond its association with only local concerns to a region-wide foundation for analysis and action. We are hopeful that communities-at-sea might contribute to the interdisciplinary and creative work by scientists, managers, and communities themselves that will be needed to effectively address the challenges of the Anthropocene.

Locating Community in Fisheries Science and Management

Community as both a concept in the social sciences, and as a participant in policy processes, long predates making the maps of communities-at-sea proposed here, a history that underscores why community maps matter in the advent of the more contemporary move to ecosystem based management (EBM). Certainly the notion of community itself has long been seen as a “warmly persuasive” (Williams 1976) but vague idea beset by multiple meanings (Hillery 1955). The concept found an ally among scholars working in common property theory (e.g. Ostrom 1990, McCay and Acheson 1987), as a space between an inevitable tragedy of the commons and restrictive government intervention, but was also quickly critiqued within those same circles for a lack of attention of power and heterogeneity (e.g. Agrawal and Gibson 1999). Indeed, the generic call to conceive of ecosystems as including humans leads to similar questions: but which humans? Which humans are linked to ecosystems, engaging with them, altering them, affecting them, and living with them?

Within US fisheries management more specifically, laws such as National Standard 8 (NS8) to the Magnuson–Stevens Act (MSA) require the assessment of impacts to fishing communities from regulatory measures. NOAA Guidelines for NS8 define such communities as “a social or economic group whose members reside in a specific location and share a common dependency” and further note that regulatory measures “may economically benefit some communities while adversely affecting others” (50 C.F.R. § 600.34). Here, communities are "simply the places that get impacted" (Olson 2005: 249), potential players in a zero-sum game, on-land rather than linked to territories at sea. As a result, while the many processes and practices that constitute community, which constrain the behaviors of its members or activate their potentials, may be relevant to how communities will react to management measures derived from ecosystem analyses, they do not figure in the ecosystem analyses or management measures themselves despite their overlap and integration with marine environments, habitats, species, and so on. Indeed, if humans are part of ecosystems (Berkes 2004), then where and how communities utilize and inhabit the marine environment must be considered essential information by which we can address the many challenges of the Anthropocene.

Therefore, to move beyond community as shore-side container, we, like many social scientists, start from an understanding of community as a site of processes and practices that include knowledge exchange, reciprocal relation, mutual support, and shared well-being. [1] In this case, community draws attention to how fishers engage in similar fishing practices on shared fishing grounds, maintain and share local ecological knowledge of marine species and habitats, develop a common understanding and topology of marine space, are bound by mutual dependencies at-sea and on shore, and experience a shared social, economic, and cultural well-being. The boundary of these groups with shared concerns is necessarily fuzzy and fluid even as the shared processes which link fishers into communities have concrete effects that range from livelihood maintenance to ecosystem health.

Community has to date been activated primarily by anthropologists and geographers via ethnographic methods and other forms of qualitative analysis such as histories and biographies (St. Martin 2006). This work is mostly port based and while participants might refer to at-sea experiences, such experiences and detailed knowledge of place, habitat, and territory are rarely mapped or specified. As a result, the many processes of society, culture, and local economy, despite being well-documented by social scientists in ports, are rarely integrated into a fisheries science and management concerned with fish populations, habitats, and the predicted behaviors of fishers at-sea. Furthermore, the knowledge of fishers' lives and livelihoods produced by social scientists is most often in narrative form rather than represented in metrics or measures, making its integration into science or policy development (as opposed to impact analysis) challenging at best. As a result, community is made real and known in-depth across a range of experience and difference but it remains distant and vague as a measured phenomenon affecting fishing practices in particular locations or areas at-sea. Stakeholder engagement might bring voices from communities into impact analyses or decision-making but it does not put community-level processes and practices into the maps and metrics that inform science and policy formation itself.

[1] For further discussion of community as process and relation rather than timelessness and boundaries, see arguments in, for example, Massey (2005) and Cameron & Gibson (2005). Clay and Olson (2008) provide a review of the literature on fishing communities specifically.

A Method for Mapping Communities At Sea

Mapping those areas upon which fishers and fishing communities rely grew out of research that sought to document and make usable to management the local ecological knowledge (LEK) of experienced fishers (e.g. Murray et al., 2008). Acknowledging the spatial contingency of LEK as well as the limits of LEK given mobility and territorial constraints of fishers made it clear that mapping (of habitats and other ecological phenomena, season harvesting rounds, fisher biographies, and fisher topographies) was an essential mode of documentation as well as an effective form of communication with fishers.

Such research is often interview-based and engages fishers using standard nautical charts upon which fishers can indicate where and how they fish, detailed environmental histories, social topographies, and the locations of particular incidents or phenomena. Interviews might also solicit fishers' long-term experiences and knowledge of change over time: change in fishing locations, species compositions, environmental parameters, and human community use and social-economic context. Such extraordinarily rich and detailed information offers a distinctly geographic addition to fisher oral histories and community ethnographies.

Our work shares the goal of mapping human use, dependence, and experiences at sea but, unlike map biographies, it starts with vessel logbook data collected by the National Marine Fisheries Service. Vessel Trip Report (VTR) data is collected for all trips taken by commercially licensed fishing vessels fishing in federal waters (from 3 to 200 miles from the coast). VTRs have been collected since 1994 and contain information on date of sail and date of landing, catch and bycatch, number of crew, and, importantly, trip location. This self-reported data is often questioned for its accuracy, yet studies have shown location reporting approximates that estimated from observer records, especially for less mobile gear on shorter duration trips (DePiper 2014). Moreover, when groups of vessels taking many trips over many years are used as the basis for mapping rather than any individual vessel, auto-correlated patterns and clusters at sea become evident. Spatial outliers and misreported locations become minor concerns to analysis (visual or statistical) when the data is used only in aggregate. The question then is how to aggregate: how to group vessels in ways meaningful to social and scientific analysis, management, and fishers themselves.

Although the use of secondary data, such as VTR, is subject to various limitations including the "silences" about phenomena of interest to critical social science as well as interpretational difficulties (St. Martin and Pavlovskaya 2010), it can be productively re-read using understandings gained in ethnographic fieldwork and, importantly, in cross-referenced readings with fishermen themselves. Our ethnographic and community-based fieldwork in the Northeast (St. Martin 2001; Olson 2011) made clear that fishing practices and locations are largely a function of community-level processes of communication, knowledge exchange, and mimicry. Fishers working from the same port, using similar gear, and sailing on vessels of similar length and design, tend to fish for the same species, on the same fishing grounds, and at the same time of year. While these tendencies vary from fishery to fishery and/or port to port, they suggest a unit of analysis vital to understanding the role of shared socio-economic and cultural processes relative to fishing practices and locations at sea. Furthermore they suggest a unit of analysis that our work confirms resonates with fishers themselves. Peer groups of vessels with shared characteristics and originating from a shared socio-economic and cultural milieu are our communities-at-sea, whose various spatial ranges turn fishing vessels into a vehicle to link the divided concerns, and disciplinary objects, of ecosystems and communities. Like ecosystems, communities-at-sea should be understood as starting points for analysis and not as definitive bound entities; they are an ontological statement about the existence of processes and practices of community in places (e.g. sharing of environmental information) rather than a definition of membership or denotation of division.

To activate communities-at-sea we developed an algorithm by which we can aggregate vessels and vessel trips to best fit the peer groups of fishers. In our work such a “community” is a function of gear type and port. VTRs specify gear but knowing the port with which a vessel is associated is less straightforward. VTRs specify the port of landing ([PORTLAND]) while permit data specifies two other port variables suggesting port association and which are declared by the vessel owner: home port ([HPORT]) and principal port ([PPORT]). Our interviews with fishers in the Northeast suggest that home port is most often understood as where a vessel is registered whereas principal port is most often understood as where a vessel is most active. In addition to the port declared by the vessel owner (what we call [DECPORT]), a vessel could be seen to be associated with a port if it lands there often. We specify a port association based on a 50 percent or greater frequency ([PERPORT]). In all cases, the port of community association ([COMMUNITYPORT]) must also be an actual fishing port ([OFFICIALPORT]), rather than inland or other municipality (e.g. based on a fisher’s home address).

Therefore, after joining home port and principal port (found in permit data) to the VTR records, we use the following rules to associate vessels and trips with particular port locations:

If [PPORT] = [OFFICIALPORT] then [DECPORT] = [PPORT]
Else If [HPORT] = [OFFICIALPORT] then [DECPORT] = [HPORT]
Else [DECPORT] = [PORTLAND].

Calculate [PERPORT] as port with 50% or greater landings by a vessel.

If [PORTLAND] for a given trip = ([DECPORT] or [PERPORT])
then [COMMUNITYPORT] = [PORTLAND].

This algorithm allows us to group trips into particular peer groups of vessels that are most likely to be sites of a host of community processes. Furthermore, the fishing locations of these communities can be mapped such that the pattern and practice of different communities-at-sea becomes available to visual as well as spatial statistical analysis. Mapping peer groups of vessels based on trip locations usefully delimits the range of a community; weighting locations by labor time, however, allows us to map degree of community presence and, therefore, dependency upon particular locations. We refer this key variable as [FISHERDAYS].

[FISHERDAYS] for a given trip = number of crew [CREW] x trip length [TRIPDAYS]

Fisherdays offers a measure of invested time on the part of a community in particular trips and trip locations at-sea. It is distinct from other common variables indicating fishing effort (e.g. catch or value of catch) insofar as it foregrounds labor inputs, rather than harvest outputs or profit, as a measure of community engagement and dependence upon particular fishing grounds. While effort in terms of labor often correlates with effort in terms of harvest, there are fisheries and locations where they diverge. Divergence could, for example, help us to identify those fisheries or fishing grounds where fishers consistently make a living yet catch relatively fewer fish than other large-volume fisheries or overfished fishing grounds; the implication is that some communities may already be fishing "sustainably." Fisherdays allows us to explore both the socio-economic and spatial-ecological implications of different community fishing practices and traditions, ecological knowledge, and harvesting priorities; it creates an opening for analyses that begin to measure sustainability in terms of the continued existence and health of both fish populations and local livelihoods.

Using the techniques defined above we can develop various communities-at-sea databases (depending upon project and scope) where individual fishing trips are assigned to particular communities and fisherdays are calculated for each trip. Once developed, such data can then be used to characterize communities and entire regions in terms of community characteristics and change over time. Furthermore, using the geographic locations of trips (weighted by fisherdays) we can examine the spatial patterns of communities-at-sea by deriving density surfaces ("heat maps") and percent volume contours that we interpret as depicting community presence at-sea. As we describe in the following sections, communities-at-sea data (in a variety of forms: tabular, graphic, and map-based) can then be integrated into social, economic, and ecological analyses.

Utilizing Communities-at-Sea: Data and Tools for Analysis

As with any research or policy development project, data development can be one of the most challenging for a variety of reasons that include, as in this case, questions of confidentiality. VTR data is managed by the National Marine Fisheries Service (NMFS), a federal agency, yet access to the data is strictly limited due to its confidential nature (i.e. individual vessel level data). While communities-at-sea data is derived from VTRs, it is designed precisely to avoid any compromise of confidentiality. That is, communities-at-sea data is necessarily aggregated information made up of trips from all vessels in a given peer group (see above). When a "community" has fewer than the number of vessels needed to mask individual practices (currently three as mandated by NMFS) then such peer groups of vessels are simply not recorded as a community and hence not reported, summarized, or mapped as a community-at-sea. Such data might be pooled into a new category (e.g. trips by independent vessels) but they are not analyzed or utilized unless also appropriately aggregated. The result is a database of only community-level information accessible to analysis and policy development. Furthermore, our experience also suggests that this data is easily understood and trusted by fishers themselves.[2] Indeed, insofar as communities-at-sea data can be used to depict the relationship

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[2] Communities-at-sea maps and other summarizations of community activity were presented in several workshops as part of the Atlas project (see Final Report, Northeast Consortium subcontract 06-028, *An Atlas-based Audit of Fishing Territories, Local Knowledge, and Potential for Community Participation in Fisheries Science and Management*, available at www.northeastconsortium.org) as well as the MARCO data portal project (see www.portal.midatlanticocean.org). Fishing community members responded positively to the map products from these projects. They were not concerned about confidentiality once it was clear that the maps did not directly display VTR data but only data aggregated into communities-at-sea.

between community well-being and access to particular fishing grounds, fishers see the maps produced by communities-at-sea data as a way to legitimate their claims relative to an access threatened by, for example, conservation closures, energy development lease blocks, and other spatial management measures (St. Martin and Hall-Arber 2008b).

Representing communities in terms of metrics, descriptive statistics, and maps allows us to visualize and integrate communities into forms of bioeconomic and ecological analysis previously closed to community concerns due to the requirements of quantification and the need to identify discrete units of analysis. To be clear, we do not wish to undermine ethnographic and narrative forms; quite the opposite, we wish to use communities-at-sea as a metrological space where ethnographies, histories, and biographies might be located and associated with other quantified and mapped processes, be they regional economic or ecosystem dynamics, habitat transformations, conservation initiatives, energy development, or climate change. In its most literal form, such a community-based database would allow GIS-based querying of locations at sea that would be populated with community-specific information and result in community-level metrics.

Understanding community dynamics as they relate to fishing practices, dependencies upon particular resources, and histories (both social and environmental) in particular locations at-sea would seem to be fundamental to both policy development and impact analyses yet this is rarely the case. While communities-at-sea do not reveal all aspects of community, they nevertheless create a foundation for investigation, corroboration with other data sources (qualitative and quantitative), and community engagement; they present a geography and social sea-scape (see Figure 1) that we can query and quantify to ask the following:

Given a communities-at-sea database we might query by location to ask:

- *Which community or communities utilize this area?*
- *To what degree is community employment dependent upon this area?*
- *What species do they catch in this area?*
- *What is the history of community use of this area?*

Alternatively we might query by attribute to ask:

- *Do vessels from this community fish in the same locations and when?*
- *What are the primary, secondary, or tertiary fishing grounds that support this community in terms of employment, catch, or value?*
- *What is this community's spatial pattern of fishing (e.g. tightly clustered, distributed, or random) and has it changed over time?*
- *How does this community's fishing overlap with morphologic features, habitats, or water depth?*

These basic queries can be linked to other qualitative (e.g. interview) information to ask:

- *Why does your community fish in these locations and how did you come to know them?*
- *In what ways and when does your community depend upon these locations?*
- *What is the social and environmental history of these locations?*
- *What environmental changes have seen here and how are they linked to socio-economic processes and change?*

These questions and many others suggest a usefulness of communities-at-sea not just to impact analysis but policy development. For example, a region-wide analysis might use a communities-at-sea database in conjunction with other spatial decision making methods that incorporate a wide range of environmental information to ask: Which areas can we close to fishing to meet our conservation goals and minimize negative impacts on employment in vulnerable communities (cf. St. Martin and Hall-Arber 2008a)?

Communities at Sea as Analytical Practice

Querying communities-at-sea using the basic tools outlined above allows us to map community use of particular locations at-sea, thereby creating a space where we might examine community-level processes and practices relevant to a range of not only socio-economic but also ecological outcomes. From the impacts of wind energy siting on local economy to the links between changing fish distributions and fishing practices, it is vital that we know in each case and in each location who maintains key local ecological knowledge, which fishing practices and harvesting techniques are dominant, and whose livelihood and well-being is most directly relevant. Communities-at-sea gives us the means to link systems previously disconnected and supplement analyses in ways previously devoid of community concerns, such that the uneven impacts of area management initiatives and, alternatively, the spatial effects of non-spatial regulations (e.g. constraining fishing of a particular species) become clear and available to decision makers and communities alike.

Communities-at-sea makes available the concerns of communities to a wide range of analyses. For example, social scientists interested in the effects of a global transformation of marine space driven by neoliberal policies promoting quota systems in fisheries and rights-based distributions of resources generally might use communities-at-sea data to examine socio-economic outcomes at the level of community rather than economy as a whole (cf. St. Martin 2007). A clear antecedent of our work is Olson's use of VTR data to group peer groups of vessels and thereby foreground the heterogeneity and social spaces of fishing in the Northeast and the potential for subsequent uneven (and unjust) distributional outcomes from neoliberal policy development (Olson 2010, 2011).

Using a community-level sensibility, Olson reveals fishers' dependencies on particular locations at-sea also using a spatialized metric of labor time rather than catch or value as a measure of effort (ibid.). The latter are more common ways of mapping human use of the marine environment that obscure social relations, processes, and practices. For example, a map of fishing effort based on catch or value may show "hot spots" of activity, but these hot spots cannot always be equated to the areas that are important to many fishermen. Indeed, it does not tell you how many vessels were involved or how many people were fishing in the hot spot, among other things. A hot spot could represent the effort of one vessel or a thousand, so without further information its social and economic importance is unclear. Furthermore, the relation between specific fishing practices and ecological outcome in terms other than quantity caught is left unexamined.

The idea of resource dependency, on the other hand, was used by Olson to ascertain what percentage of a vessel's annual catch is landed in what areas, giving rise to a way of visualizing relative spatial dependence that showed the waters along the Northeastern coast were the most important for most fishing communities, despite not having the highest effort overall. Density maps comparing the spatial practices of those fishermen most dependent on a single statistical area with those more mobile fishermen clearly suggested distinct areas of importance and a sea-scape differentiated by a range of socio-spatial practices (see Figure 2).

Olson's work reminds us that there are many different reasons that underlie fishers' choice of where to fish. Some may be economic, such as lower fuel costs, but there are also sociocultural motivations, such as wishing to return home daily. These decisions of where to fish are socially embedded, and they provide insight into different socio-economic processes and practices depending on what scale and unit of analysis is used for analysis, map-based or otherwise.

While a heterogeneous sea-scape of human communities and territories allows us to better address questions related to the uneven distribution of the costs of marine policies (e.g. conservation and energy development), it also makes accessible a space of intertwined human and environmental processes. As a result, research projects investigating complex coupled systems, but challenged by the call for interdisciplinarity, now have a common ground where both socio-economic and ecological processes are not only manifest but also interrelated. In such cases, communities-at-sea acts as an ontological foundation linking discipline specific modes of investigation, understandings of process, and recommendations for action.

For example, we are engaged in an interdisciplinary project focused on climate-induced shifts in the distribution of commercial fish species (on the latter see Pinsky and Fogarty 2012, Pershing et al. 2015).[3] The project seeks to understand both the ecological and socio-economic dimensions of species' shifts, and it hopes to inform both policy development and community-level adaptation strategies. Beginning from the overlap of communities-at-sea with shifting biomass, we are performing a variety of analyses that range from spatial statistics to in-depth interviews with fishers from those communities most dependent upon apparently shifting species. Our goal is to assess both quantitatively and qualitatively the relationship between fishing practices and ecological change; in particular, we seek to better understand the effects of fishing on range shift as well as the nature of adaptation to range shift at the level of community.

The above examples demonstrate concerns and forms of analysis that communities-at-sea can facilitate and routinize by making "communities" available as tangible processes and practices in place. As such, communities-at-sea can serve as data vital to scientific understanding, policy development, and community-level strategies and innovations. "Community" need not remain onshore embedded only in retrospective analyses; it can be integrated into modes of analysis seeking to understand key processes and dynamics which are transforming marine space.

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[3] *Adaptations of Fish and Fisheries to Rapid Climate Velocities* (National Science Foundation #1426891). See also Fenichel, Eli P., et al. (2016).

From Local Concerns to Regional Analysis and Action

Community experiences, knowledge, and concerns are often solicited, welcomed, and enthusiastically expressed at regional fisheries council meetings or similar marine decision-making fora. Yet, they are also as often dismissed as anecdotal or as unobservable in data streams collected and analyzed at the level of the region – the level of marine management itself (St. Martin 2001). To consider them more effectively relative to region-wide science and management initiatives, a unit of analysis closely corresponding to the experiences of fishers, yet expressed in a standardized and scalable form, is required. While our work has used a communities-at-sea approach to facilitate the exploration of fishers' experiences, knowledge, and concerns in situ (for example, via participatory mapping practices, it has done so cognizant of the need to "scale up" in order to make such information accessible and, indeed, vital to region-wide assessments.

Communities-at-sea foregrounds a host of scalable variables that we might understand as expressions of community processes and practices corresponding to fishers' lived experiences. These include metrics and measures that let us examine where and how communities fish (e.g. how far they travel, where and which species they target, what gear they use, and how much labor is expended). It also lets us examine fishing pattern (e.g. which communities consistently fish together on the same fishing grounds, which are distributed widely, and which overlap with other communities and to what degree). And, importantly, with a time series of spatial data, we can characterize not only practice and pattern but change over time (e.g. which communities have changed fishing grounds, species, or gear, to what degree and when). These variables can be mapped, explored in graphs, or used as input into statistical procedures demonstrating trends across a region or by type of community.

In practice we can begin from the most general of fishers' concerns, the survival of communities themselves. For example, at the scale of the region, it is clear that the dramatic declines in catch over the last decade due to overfishing and subsequent cut-backs in fishing effort, at least in the Northeast, have negatively impacted many livelihoods and fishing communities across the region. As social scientists we can begin to document this decline, for example, in terms of the number of active vessels (see Figure 3a), which might then be examined more closely by sector or in terms of trips taken. Here (see Figure 3b) we have divided data on groundfishing by vessel size and can clearly see that the cost of reductions in fishing expressed in numbers of trips (e.g. due to regulations, consolidation of access, and so on) is born primarily by the small vessel sector.

Understood as indicators of employment opportunity, production capacity, or relative distribution of wealth, these summary statistics usefully document and corroborate fishers' concerns for their own livelihoods as well as the survival of their communities. Yet, how change is distributed and how it is experienced by fishers within particular communities remains unexamined in these common statistics. Using a communities-at-sea approach we can see that change not only affects some sectors more than others, it apparently affects some communities more than others with implications for not only fishing effort but also for localized cultural, historical, and socio-economic transformations (see Figures 4 and 5).

Communities-at-sea are, however, more than just port-based experiences, they also represent a shared at-sea experience thereby linking cultural and socio-economic lives onshore to offshore processes and practices of fishing (the raison d'etre for communities-at-sea). Using the entire series of data we can do analyses at the region-level concerning changes in fishing effort and location and then examine what might be experienced locally relative to those broader changes. For example, we might perform a Median Trend analysis using rasterized data developed from communities-at-sea data and representing labor time (i.e. fisherdays) by location to show hotspots (and coldspots) of those locations where most change has occurred. Looking at small-trawler groundfish vessels, whose patterns of fishing relative to larger vessels are often contentious and who have also long advocated for more science and management directed at near-shore fisheries, clearly shows the locations that have changed most in terms of either increase or decrease in fisherdays expended (Figure 6). Fisherdays, as community investment in place, can also be mapped by community to better understand the relationship between regional trends and the experiences of particular communities. Indeed, over the time period examined many small vessel communities have not changed their fishing locations while others have moved to new fishing grounds, perhaps following fish responding to changes in water temperature, expanding harvest in new areas due to new technologies, or retracting from areas of conflict or overfishing.

To better understand how change is experienced by communities themselves we can query the locations of most change by community to see who fishes in these locations and to what degree over time (Figure 7). Analyzing community-at-sea variables lets us integrate the practices of individual communities (and the experiences and concerns of individual fishers) into typologies of communities across a region, which can then be seen in relation to region-wide phenomena (e.g. distributions of species, environmental and climate variability, or regulations effecting fishing locations, species, and quantities). Our intention in this "scaling up" is not to overwrite the diversity of experience across space but to be attentive to diverse practices, responses, adaptations, and innovations as we engage in region-wide analyses and management decision-making.

Conclusion

The metrological space of communities-at-sea is accessible and potentially informative to both ethnographic and modeling (economic and ecological) forms of analysis, and it can work to link such analyses via a common ground, common space, and common community-level unit of analysis. Furthermore, it avoids many of the problems of spatial or otherwise local information solicited directly from fishers which, despite its richness and analytical purchase, is challenging to use as input into current forms of analyses and policy development that demand standardization, quantification, and an ability to scale regionally. Shifting from intensive and time-consuming interviews to such forms of data as federally mandated VTR data as a means of accessing fishing practices and locations effectively addresses such issues, while the problem of confidentiality is avoided as communities-at-sea data is *by definition* aggregated and representative of only community-level patterns and spatial practice. The result is a novel form of data designed to foreground community attributes and spatial practice thereby making them available to a range of statistical and spatial analyses and depictions.

Furthermore, a communities-at-sea approach addresses the conceptual and in-practice gap that exists between onshore communities and offshore ecosystems, between the livelihoods of fishers and the management of fish, and between ethnographic and ecosystem knowledge production. Our goal is to make the processes and practices that constitute communities (i.e. shared ecological knowledge, history and culture, common fishing grounds and practices, and co-produced adaptations and innovations) present within the space of fisheries science and management, to create the ontological ground for visualizing, modeling, engaging, and activating community as a site of shared well-being and potential relative to sustainable futures. We do not wish to reduce community to a cartographic and statistical object, but to insert community as a measurable and scalable set of concerns and practices within forms of analysis and management where it has been long absent.

Communities-at-sea is gaining momentum in interdisciplinary projects attempting to address the challenges of climate change, environmental degradation, industrial decline, and community crisis. Furthermore, it is proven to resonate strongly with communities themselves as a mode of self-reflection and as a device engendering innovation (Snyder and St. Martin 2015). As scientists and environmental managers, we must be attentive to the trajectories of human communities because they most directly bear the burdens of an ongoing environmental degradation, economic decline, and social-cultural transformation which are likely to be compounded by climate change. Yet, the Anthropocene also makes clear that our actions and practices may also lead to forms of well-being shared within and between human communities and the ecosystems upon which they depend. In this case, it is vital that we understand the processes and practices of communities insofar as it is from these sites that key adaptations and innovations will emerge.

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Figures

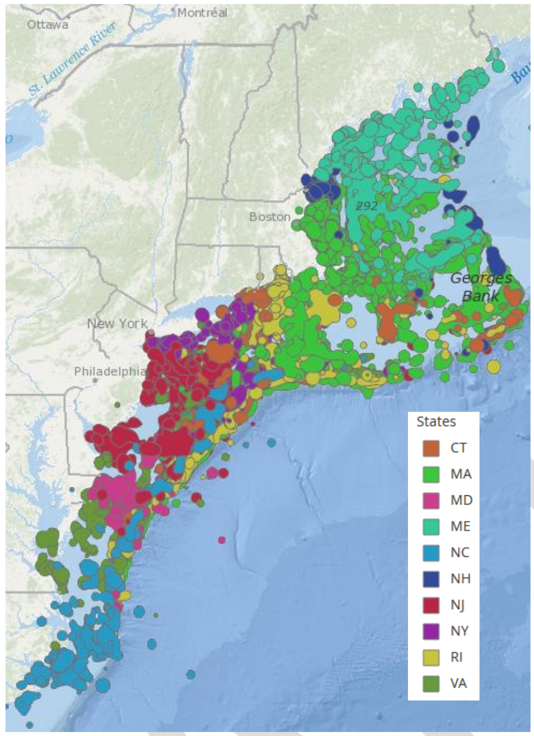


Figure 1: Select communities-at-sea. Outlines based on percent volume contours (75% of fisherdays). Colors indicate state of port association.

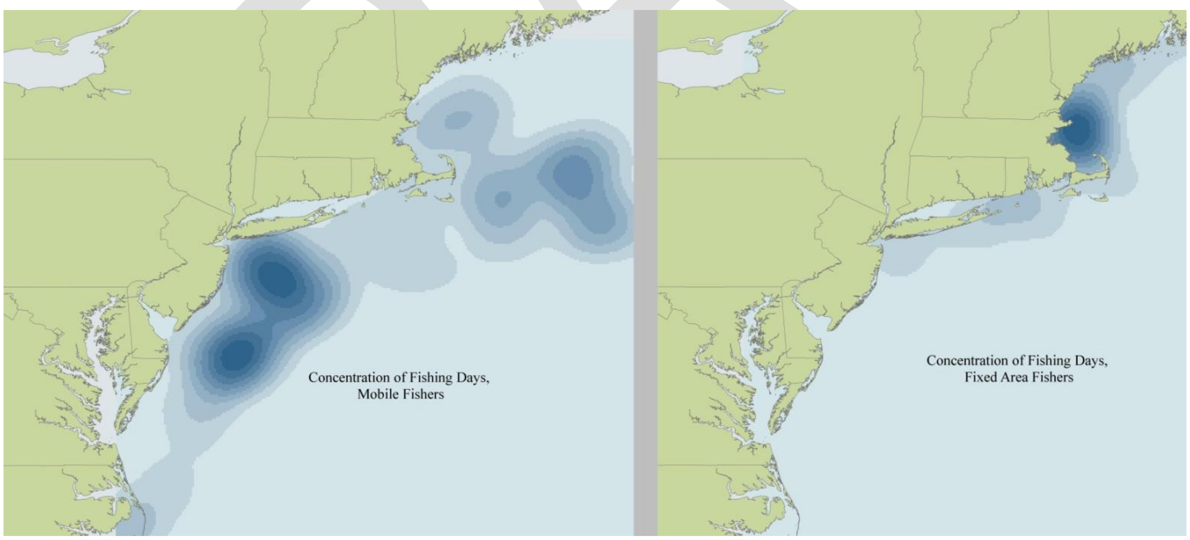
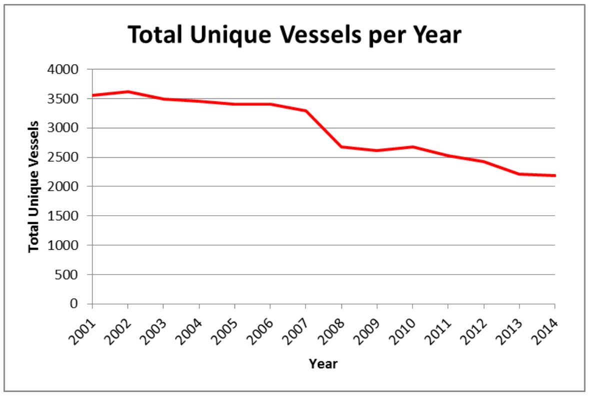


Figure 2. Kernel density maps comparing fishing grounds of mobile and non- mobile fishermen. Data is based on NMFS 2008 Vessel Trip Report data.



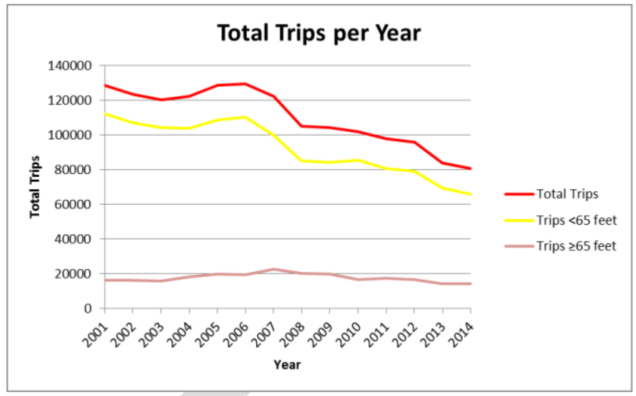


Figure 3a: Total unique vessels active in commercial fishing. Figure 3b: Trips taken by commercial vessels using geartypes primarily associated with groundfishing.

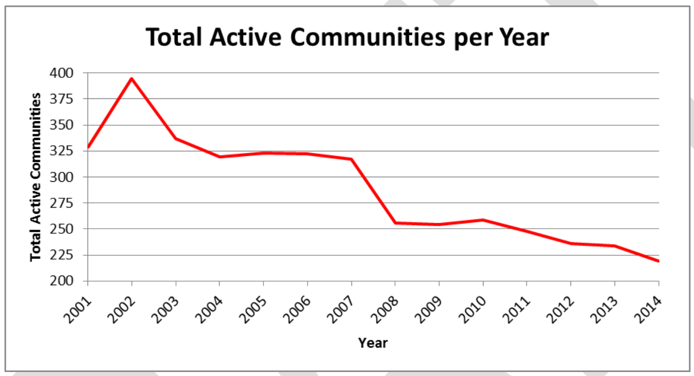


Figure 4: Active communities based on communities-at-sea data.

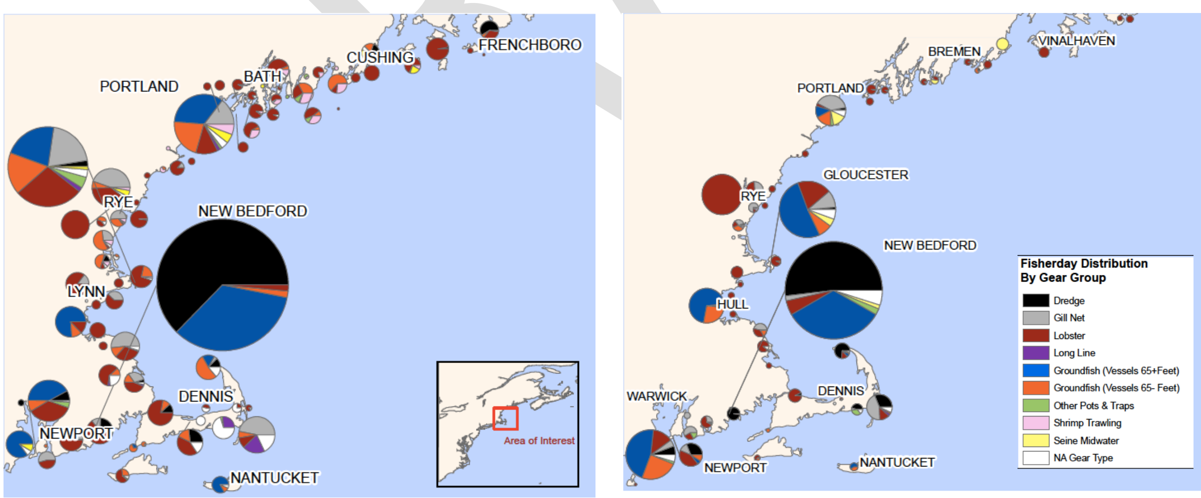


Figure 5: Port-based fishing activity in 2000 and 2013. Circle size is total fisherdays by port. Pie slices are major gear groups.

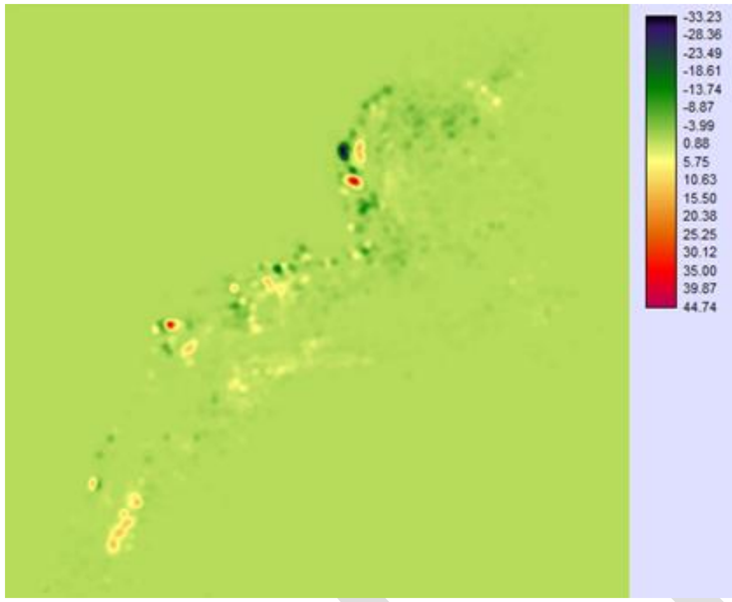


Figure 6: Median Trend analysis for Northeast region developed from annual density surfaces representing small-vessel trawling activity (i.e. fisherdays). Hot spots (red) represent areas of significant increase in fisherdays. Cold spots (deep green) represent areas of significant decrease in fisherdays.

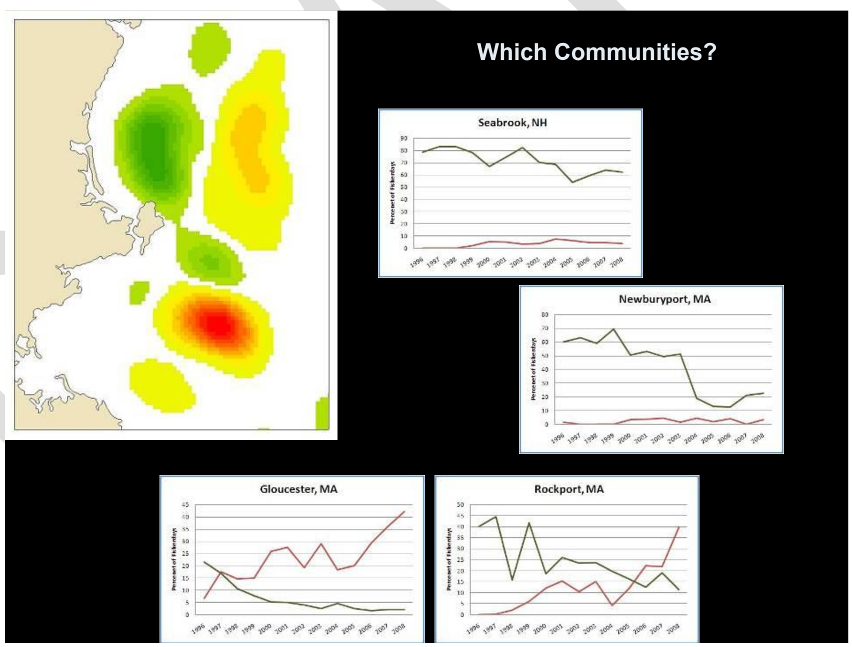


Figure 7: Hot (red) and cold (green) spots near Cape Ann, MA. Graphs show the degree to which particular communities expended effort (i.e. fisherdays) in these spots over time. Not all communities participated equally in the movement from the green to red spot despite their close proximity and use of these fishing grounds.