MID-ATLANTIC BLUE OCEAN ECONOMY 2030

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Marine Fisheries in the Mid-Atlantic Region: Challenges from Changes in the Ocean Environment

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DISCUSSION PAPER

Dr. Jonathan Hare has studied fisheries oceanography for the past 25 years. He oversees multi-objective oceanographic monitoring programs for the NOAA Northeast Fisheries Science Center and contributes oceanographic data to stock and ecosystem assessments. His research interests include: the effects of climate variability and change on living marine resources; incorporation of climate and oceanographic factors into assessments and management; understanding the structure and function of the northeast U.S. continental shelf Large Marine Ecosystem; and the biological and physical processes that drive the dynamics of marine fishes. He has been lead author on more than 20 peer-reviewed publications and junior author on more than 80. Recently he has been involved in the development of NOAA Fisheries Climate Vulnerability Assessment and lead the implementation of the assessment methodology in the Northeast.

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Marine fisheries are an important component of the blue economy of the Mid-Atlantic region. Commercial landings totaled $512 million in 2015 (NMFS 2017). Sea scallop ($151 million) and blue crab ($100 million) were the most valuable. Eastern oyster and hard clam, which are aquaculture species, also contributed significantly to commercial landings ($57 million and $40 million respectively). In total, commercial fisheries in the region, not including imports, contributed $820 million value added and employed more than 26,000 people. In particular, the aquaculture sector has been growing rapidly in recent years; the value of cultured clams, mussels, and oysters increased nationally by more that 60% from 2009 to 2014 (NMFS 2015). Recreational fisheries also are important in the region and contributed $2.6 billion value added to the regional economy and employed 37,000 people. Key recreational species include: summer flounder (10.9 million fish), Atlantic croaker (8 million fish), and striped bass (6.4 million fish). 2 million recreational anglers fished in the Mid-Atlantic Region in 2015 contributing to tourism in the region (Ditton et al. 2002).

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) is the primary law governing marine fisheries management in U.S. federal waters (>3 miles from shore). Key objectives of the Magnuson-Stevens Act are to: prevent overfishing, rebuild overfished stocks, increase long-term economic and social benefits, and ensure a safe and sustainable supply of seafood[1]. Magnuson-Stevens created Regional Fisheries Management Councils and fishery species in the Mid-Atlantic are managed by the Mid-Atlantic Fishery Management Council[2] (e.g., summer flounder) and the New England Fishery Management Council[3] (e.g., sea scallop). States manage marine fisheries in state waters (<3 miles from shore) and the formation of Atlantic States Marine Fisheries Commission[4], which is an interstate compact, acknowledges the necessity of cooperation to promote and protect marine fisheries resources. The Atlantic States Marine Fisheries Commission and the Regional Fishery Management Councils work together to achieve sustainability of the region's marine fisheries resources that occur both in federal waters and state waters.

[1] https://www.fisheries.noaa.gov/resource/document/magnuson-stevens-fishery-conservation-and-management-act
[2] http://www.mafmc.org/
[3] https://www.nefmc.org/
[4] http://www.asmfc.org/

The marine environment of the Mid-Atlantic region is changing relatively rapidly as a result of climate change and multi-decadal climate variability (Figure 1). Climate change is a long-term change in components of the land-atmosphere-ocean system. The ocean and estuaries have been warming, the Gulf Stream path has been shifting further north, sea-level has been rising, and precipitation has been increasing (NEFSC 2017). All of these changes are partially or wholly attributable to climate change. Climate variability are natural variations in the land-atmosphere-ocean system. Two dominant signals of multiannual variability in the region are the North Atlantic Oscillation and the Atlantic Multidecadal Oscillation. The North Atlantic Oscillation is a pattern of cold-dry winters (negative-NAO) and warm-wet (positive-NAO) winters (Hurrell et al. 2003). We are in a period of positive NAO; in 18 of the last 27 years, the NAO has been positive (NEFSC 2017). The Atlantic Multidecadal Oscillation is a pattern of warm and cool sea surface temperatures across the North Atlantic with a period of ~50-70 years (Schlesinger and Ramankutty 1994). The AMO has been positive (warm) since approximately 2000.

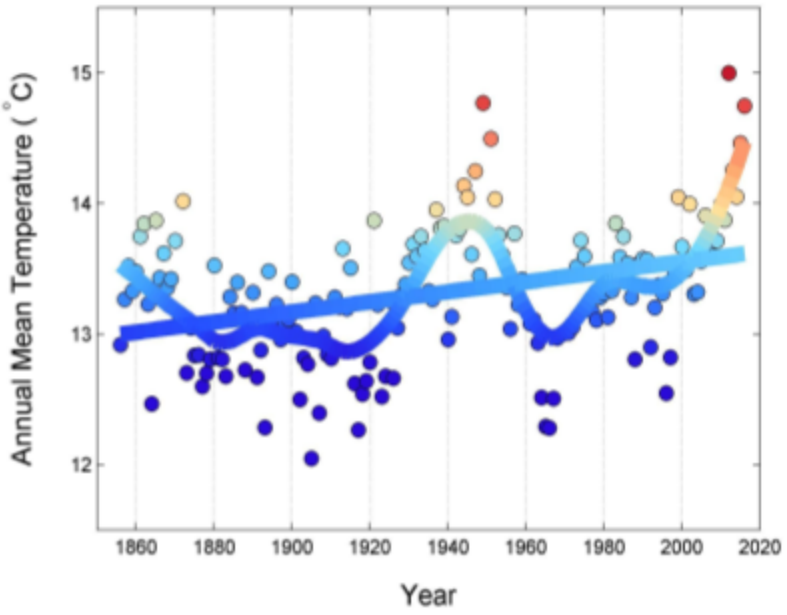

Figure 1. Annual sea-surface temperature on the Northeast U.S. Shelf from the ERSSTv3b dataset. Colors represent annual temperatures. The straight lines shows the long-term change in sea surface temperature (i.e., climate change signal). The wavy line is a LOWESS smoother of sea surface temperature. The multi-decadal variability (peaks in the 1850s, 1950s, and 2010s) is closely related to the Atlantic Multidecadal Oscillation (i.e, climate variability signal).

The changes in the environment are causing changes in fish and shellfish populations. In the Mid-Atlantic region, the abundance of some species are increasing (e.g., scup, black sea bass), whereas the abundance of other species are decreasing (e.g., winter flounder, Atlantic cod).The productivity of some species have been linked to

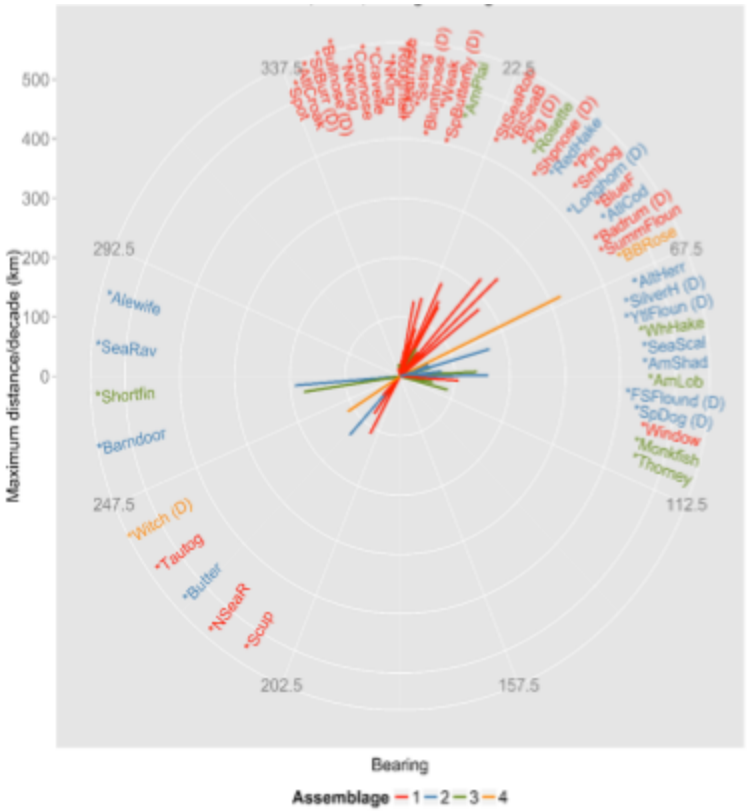

Figure 2. Bearing (0–360 degrees) and distance (km) between the centers of biomass in 1968–1978 and 2001–2012 for species in Mid-Atlantic Bight. The presence of a '(D)' after an abbreviation refers to a species that has a significant deepening trend over the entire time series determined by linear regression (from Kleisner et al. 2016).

temperature: productivity increases with increasing temperature for Atlantic croaker (Hare et al 2010) and decreased with increasing temperature for winter flounder (Bell et al. 2014a) and Atlantic cod (Fogarty et al. 2008). Distribution of a number of species is changing as well (Figure 2); one study found more than two-thirds of species shifted northeastward and offshore (Nye et al. 2009). Some species shifts have been linked to changes in the environment, whereas other species shifts have been linked to changes in abundance resulting from decreases or increases in fishing effort (Bell et al. 2014b). These studies indicate that in a given region, some species will be positively affected by climate change and multidecadal variability, whereas other species will be negatively affected. In the Mid-Atlantic region, a recent study concluded that about half of the federally managed species will be positively affected by climate change and a quarter will be negatively affected; the remaining quarter will likely not be affected by climate change in the region (Hare et al. 2016).

The changes in fish and shellfish populations are causing changes in fisheries. Landings have shifted northward along with fish populations (Pinsky and Fogarty 2012). Fishing effort has also shifted northeastward; for example in the Atlantic surfclam fishery (NEFSC 2017). The vulnerability of coastal communities to climate impacts on fisheries is varied through the region (Figure 3, Colburn et al. 2017). In general vulnerability to

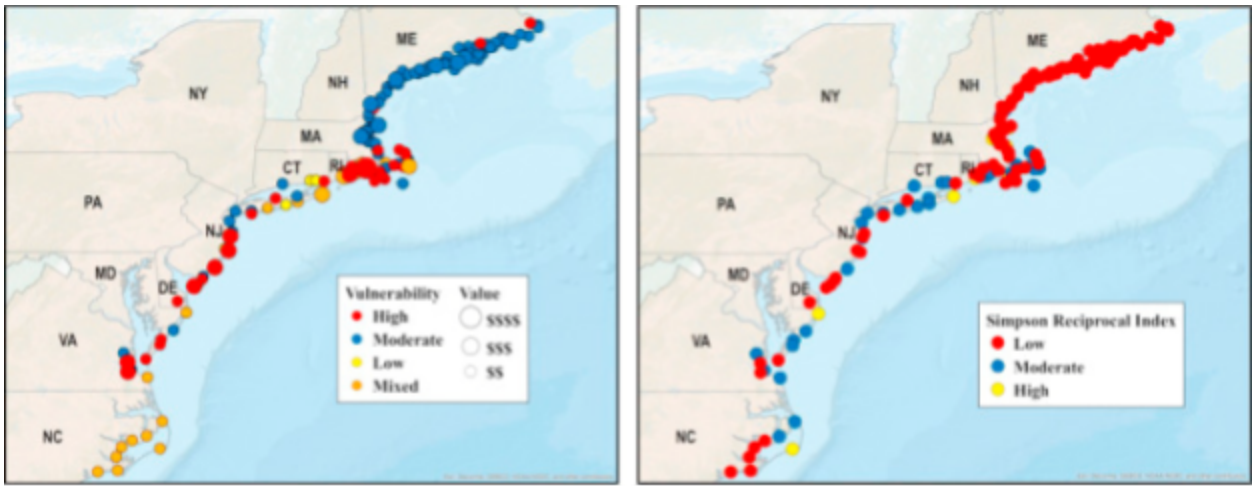

Figure 3. New England and Mid-Atlantic Fishing communities' climate vulnerability classification based on categories of dependence on vulnerable species (left), and catch diversity scores (Simpson's Reciprocal Index (right)). Only communities with total landings value of 100 thousand dollars or more were mapped (from Colburn et al. 2017)

climate change is high because of the region's reliance on shellfish fisheries, which are likely to be negatively impacted by warming and ocean acidification (Cooley et al. 2015). Fishing businesses also are vulnerable to sea-level rise (Colburn et al. 2017) and the Mid-Atlantic is an area of greater than average sea-level rise (Sallenger et al. 2012). Fishing communities with a low diversity of catch are also more economical vulnerable to change (Sethi et al. 2014; Cline et al. 2017); landings diversity is variable throughout the region but ports with low diversity are more vulnerable to change (Colburn et al. 2017).

Climate change and variability are but one facet of a broader recognition that multiple factors affect fisheries. The primary factor is fishing, but climate, habitat, species interactions, and human dimensions all affect fisheries. This multifaceted view is termed Ecosystem Based Fisheries Management: building and maintaining a sustainable fishery over the long-term means taking into account more than just fishing on that one species. Long-term sustainability requires a holistic, science-based approach that looks at the entire ecosystem (NMFS 2016). To this end, NOAA Fisheries has released an Ecosystem-Based Fisheries Management Roadmap (NMFS 2016) and a National Climate Science Strategy (Link et al. 2015). A Climate Regional Action Plan has been prepared for the Northeast region (Hare et al. 2016); a regional ecosystem-based fisheries management action plan is underdevelopment. These documents identify regional science needs. In addition, the Mid-Atlantic Fisheries Management Council has developed an Ecosystem Approach to Fisheries Management

Guidance Document[5]. An East Coast Climate Change and Fisheries Governance Workshop brought together all the organizations responsible for marine fisheries management on the east coast[6]. Potential approaches for managing fisheries in a changing climate have been identified (Morrison and Termini 2016).

The broader question relates to managing fisheries in the context of other ocean uses. This concept is term Ecosystem Based Management, which recognizes that the ocean provides a number of products and services, a subset of which are related to fishing. Ecosystem Based Management allows for consideration of resource tradeoffs that help protect and sustain diverse and productive ecosystems and the services they provide[7]. Trade-offs already exist in the ecosystem. Wind energy is being developed that excludes fisheries. Shipping poises a direct threat to protected species recovery. Coastal development can result in the modification or destruction of habitat (Leslie and MacLeod, 2007). The Mid-Atlantic Regional Council on the Ocean[8] provides one venue to identify and discuss trade-offs in ocean use.

To mitigate and adapt to climate effects on fisheries, action is needed at the single species level, at the sector level (i.e., Ecosystem Based Fisheries Management) and at the ecosystem level (i.e., Ecosystem Based Management). The science needed to support species and sector level actions has largely been identified. However stronger connections between physical, natural, and social sciences are needed. Actions at the ecosystem level are being defined, but in a sector-to-sector context. More effort is needed at the science, governance, and public level on developing multi-sector Ecosystem Based Management. The issues related to ecosystem management have been likened to 'wicked problems' (DeFries and Nagendra 2017): problems that are difficult to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize[9]. Approaches for addressing such problems include *"multisector decision-making, institutions that enable management to span across administrative boundaries, adaptive management, markets that incorporate natural capital, and collaborative processes to engage diverse stakeholders and address inequalities"* (DeFries and Nagendra 2017). The Mid-Atlantic Blue Economy 2030 Forum can serve to identify opportunities to promote, protect and prosper from the

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[5] https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/589a2b61d2b8575c64fe05ff/1486498674225/EAFM_Guidance+Doc_2017-02-07.pdf

[6] https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5432a188e4b09dc5c385d079/1412604296736/Climate+and+Governance+Workshop+Report.pdf

[7] http://ecosystems.noaa.gov/

[8] Mid-Atlantic Regional Council on the Ocean

[9] https://en.wikipedia.org/wiki/Wicked_problem

ocean ecosystem; to do so sustainably will require aspects of Ecosystem Based Management.

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