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Preparing for a Changing Climate: The State of Adaptation Planning in Maine's Coastal Communities

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Abstract

Climate change is having a range of impacts on Maine's coastal communities, impacts that will be further exacerbated by increased coastal flooding, storm events, and a warming Gulf of Maine. To better understand the status of adaptation planning by Maine coastal communities, we conducted a survey and in-depth interviews with decision makers from coastal communities. We found that communities are addressing the effects of climate change and have moved towards specific implementation strategies. Adaptation planning to date includes incorporation of climate change impacts in comprehensive planning and addressing impacts on roads, culverts, and waterfront infrastructure. Respondents indicated the need for more specific data on the direct impacts of climate change in their communities over the next two years. They identified a preference for spatial data and interactive websites, followed by support from technical experts. Although the majority of respondents had an understanding of the physical vulnerabilities their communities face, they identified a need for increased resources to assess social vulnerability impacts. Additionally, communities face challenges in identifying appropriate funding sources that match identified needs. Adaptation planning processes are often stymied by the lack of dedicated funding that enables coastal communities to be proactive in addressing the physical and social impacts of climate change.

INTRODUCTION

With one of the longest coastlines in the continental United States and with predicted increases in extreme storm events, Maine faces particular challenges in addressing the impacts of climate change (Camill et al. 2012; Johnson 2015; Johnson et al. 2018; Johnston, Slovinsky, and Yates 2014; White et al. 2010). Maine's coastal communities face impacts from two climate-related threats, one punctuated and one longer duration: (1) extreme rainfall and storm-surge events that can lead to failures of stormwater infrastructure and localized coastal flooding and (2) sea-level rise that can threaten coastal resources with flooding, inundation, and protracted loss of habitat and infrastructure (Dahl Fitzpatrick, and Spanger-Siegfried 2017; Tang et al. 2013; Tebaldi, Strauss, and Zervas 2012).

Adaptation requires a systems approach (across communities, departments, and disciplines) that integrates global patterns with an understanding of local impacts (Bennett et al. 2015; Murphy et al. 2014; Wilby and Keenan 2012; Young 2010). When addressing climate change impacts, rural coastal communities face challenges that are distinctly different from large urban areas (Cutter, Ash, and Emrich 2016; Dahl, Fitzpatrick, and Spanger-Siegfried 2017). These challenges are associated with the nature of Maine's peninsular and island communities, reliance on limited road infrastructure, limited capacity for assessing and responding to climate impacts, and less-formal governance structures (Camill et al. 2012; Hamin and Gurran 2015; Hamin, Gurran, and Emlinger 2014; Johnson 2015; Johnson et al. 2018; Johnston, Slovinsky, and Yates 2014; White et al. 2010).

To develop more-effective climate-change-adaptation strategies at a state level, it is crucial to understand the barriers faced by coastal municipalities in accessing information and resources and developing institutional capacity to address a wide range of challenges, both climate related and nonclimate related. We need a range of approaches to best understand the perceptions of impacts, barriers, and effective mechanisms for addressing climate change impacts (Eisenack et al. 2014; Nordgren, Stults, and Meerow 2016).

The livelihoods of many residents of Maine's coastal region are closely linked with coastal resource use and extraction. The region also has a strong history of local control and highly devolved governance frameworks,

placing small-town municipal officials in decision-making roles related to climate change adaptation. To be effective in such settings, decision-support tools and guidance should be codeveloped by and with input from end users (Cash et al. 2006; Jasanoff 2006). Furthermore, for climate-change-adaptation initiatives, the data and information needs of municipal decision-makers must be highly locally specific (Cash et al. 2006; Ostrom 1990; Wilbanks and Kates 2010).

This study builds upon prior scholarship and studies (Cone et al. 2013; Jain, Stancioff, and Gray 2012; Johnson 2015; MMA 2017). Maine Sea Grant surveyed 71 municipal officials in coastal Maine communities in 2010 regarding their concerns and needs related to climate change adaptation (Gray 2012). Results indicated a widespread concern about the effects of climate change, though few communities reported taking any adaptation actions. Respondents indicated that they needed reliable information about the potential impacts of a changing climate, but the vast majority got their information from nonscientific and nontechnical sources, most commonly newspapers and television news. Many also used technical information from the National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA), but had little or no access to localized technical information on climate impacts or projections.

Johnson (2015) surveyed municipal officials in Washington County, Maine, regarding their beliefs about climate change. Beliefs, defined as thoughts or orientations toward an issue or object (Vaske 2008), regardless of factual validity, are commonly measured by social scientists because they are known to be precursors to values, attitudes, and behaviors (Ajzen et al. 2011; Vaske and Donnelly 1999). The study used six standard questions to measure beliefs about climate change by researchers including the Pew Research Center (2014), Leiserowitz et al. (2014), Raymond and Spoehr (2013), and Hamilton and Keim (2009). The questions employed a five-point Likert scale ranging from "strongly disagree" to "strongly agree," and responses were averaged to produce a composite belief score on a scale. From a panel of 708, 204 respondents answered the questions pertaining to climate change beliefs. Of these respondents, 65 percent of composite belief scores were in the "agree" or "strongly agree" range, meaning that they agree that climate change is happening and that humans are a primary cause (Johnson 2015: 118). This result was similar to the

findings of Yale Climate Opinion surveys in 2016 (68 percent) and 2018 (67 percent) for Washington County (Marlon et al. 2016, 2018).

A survey conducted by the Maine Municipal Association (MMA) in 2017 at the behest of the Maine Legislature indicated increased concern about climate change and more adaptation activities among coastal communities compared to previous surveys. This finding prompted our study to fully investigate these changes and characterize evolving needs. Our goal was to survey municipal officials to understand shifts since the prior surveys in their perceptions of their community's vulnerability to climate change and the need to take action. Additionally, the study sought to investigate how communities are adapting and how their needs for information and technical support might be shifting.

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METHODS

To assess the state of adaptation planning in Maine's coastal communities, we conducted a survey of municipal officials in coastal communities, based upon and expanded from surveys conducted in 2010 (Gray), 2015 (Johnson), and 2017 (MMA) to provide a longitudinal study comparison (Babbie 2010). The survey was designed to help us better understand the risks and vulnerabilities that coastal communities face as climatic conditions change, activities they are undertaking to respond to climatic changes, and the barriers that make adapting difficult. The survey was reviewed by a staff member of a regional planning agency, the Maine Department of Environmental Protection (DEP), and the MMA. Coastal municipal officials were invited to participate as part of our research and outreach project, Adaptation Strategies in a Changing Climate: Maine's Coastal Communities, in 2018. Participation was voluntary and confidential, and data were deleted from the online system on March 15, 2019.

The survey was emailed by the MMA to 143 municipal officials (town managers, city administrators,

and members of select boards) representing a total of 122 coastal towns and cities in 2018. Reminders were sent to potential participants over a three-month period. Twenty-nine survey questions inquired about adaptation and planning activities in respondents' communities, knowledge about climate impacts, information sources, and beliefs and observations related to climate change. We analyzed the survey responses using descriptive statistics.

We conducted eight semistructured interviews and one focus group with decision makers representing a range of roles that included volunteer and professional staff at the municipal and regional level. All participants selected were involved with identifying and analyzing hazards and proposing or enacting policy solutions. To ensure geographic distribution, we selected at least one participant from each of Maine's coastal counties (with the exception of Waldo County) and included one island community. We transcribed the interviews and analyzed the data with Nvivo software using a codebook developed by researchers. The interview data was used to triangulate our survey data and identify additional themes associated with climate adaptation planning, including the role of leadership, collaboration, funding, and public perception.

RESULTS

We received a total of 56 responses from 143 emailed surveys, a 39 percent response rate. Sixteen respondents provided answers to most questions but did not complete the survey. Our survey respondents represented 52 of 122 coastal communities, resulting in 43 percent of coastal communities represented in survey results. Each coastal county was represented by at least one survey response (Cumberland [6], Hancock [12], Knox [3], Lincoln [3], Penobscot [2], Sagadahoc [2], Washington [4], Unidentified [17]). The majority of respondents (78 percent) were staff members of a municipal department (manager, clerk, planner or economic development, code enforcement, law enforcement, public works, emergency management/ fire department, sustainability department), served as elected officials (selectboard, road commissioner, legislator, shellfish commission), or were in an appointed or volunteer capacity (comprehensive planning committee, economic development committee, budget committee). Over 33 percent of respondents held multiple roles in their community, providing a range of perspectives

on the status of climate adaptation planning taking place in coastal communities. Seventy-three percent of respondents were 50 years or older, and 57 percent of respondents have served over 10 years in their current role, providing longer-term perspectives on community response to climate change. Fifty-four percent of respondents held college degrees or higher, and an additional 15 percent completed a vocational or associates degree or had completed some college education.

Impacts of Climate Change

The majority of respondents indicated that coastal flooding and high rain events have had a negative effect on their communities over the past five years. Only 16 percent of the respondents indicated that there had been no effect from coastal flooding, and 13 percent reported experiencing no effect from high rain events.

Sixty-five percent reported that tick-borne disease has had a major effect on their community, a departure from earlier surveys in which tick-borne illnesses were not mentioned by respondents. Other environmental challenges that are having major effects include forest pests and shifts in terrestrial and aquatic species due to climate impacts. These survey findings are supported by interviews with local officials. Reflecting our survey findings, interviewees referenced flooding impacts on their communities to the greatest degree, but also indicated challenges posed from tick-borne illnesses and other pests such as browntail moth caterpillars. These findings reflect a growing understanding of the range of impacts of climate change on coastal communities.

Status of Adaptation Planning

We found that coastal communities are increasingly taking steps to address climate change impacts. Since the prior survey was conducted, more communities have moved from early-stage or preliminary planning to the implementation stage for adaptation strategies with a wider range of responses. In 2008, 50 percent of the respondents indicated their community was planning to perform maintenance on existing infrastructure. In 2019, 75 percent reported that they were preparing for the effects of climate change for a range of specific adaptation projects including updating waterfront infrastructure (31 percent) and updating culverts and roads (38 percent). Many reported integrating adaptation planning into comprehensive planning processes (27 percent) and engaging in hazard-mitigation planning (29 percent). Interviewees articulated concerns about

direct impacts of climate change on local and regional economies, as well as how best to address safety of residents during storm and flood events.

Role of Policymakers

The status of adaptation planning is reflected by the beliefs and actions of respondents, who represent a wide range of local policymakers distributed geographically from southern coastal to Downeast communities. Respondents indicated an urgency to address climate change and were concerned that climate change will negatively affect their communities (87 percent). In addition, they reported believing that not only do municipalities need to prepare for climate change (89 percent), but also that immediate steps need to be taken to address these impacts (89 percent).

There is a high level of awareness and engagement about climate change impacts among respondents. Ninety-three percent reported having some degree of knowledge of the expected effects of climate change on Maine. They reported having compelling information

about the anticipated future impacts of climate change (73 percent) and stated a willingness to act on compelling information. Sixty-four percent reported devoting professional time and resources to addressing these impacts, but acknowledged there were ongoing barriers due to a lack of funding to implement specific adaptation projects; 65 percent, however, stated a willingness to take action if there were adequate funding (Figure 1). Interviewees echoed our survey findings and discussed challenges to identify and then secure funding for implementing adaptation plans. Specifically, interviewees stated that funders' requirements were at times too narrow or specific for communities to qualify.

Climate Beliefs

The number of respondents who believe climate change is real and caused by humans (89 percent, Figure 2a) is significantly higher than in previous surveys in Maine, which found belief rates between 55 percent and 74 percent (Hamilton et al. 2009; Johnson 2015; Marlon et al. 2016, 2018). For comparison, Figure 2b

FIGURE 1: **Level of Agreement Related to Work Responding or Adapting to Climate Change**
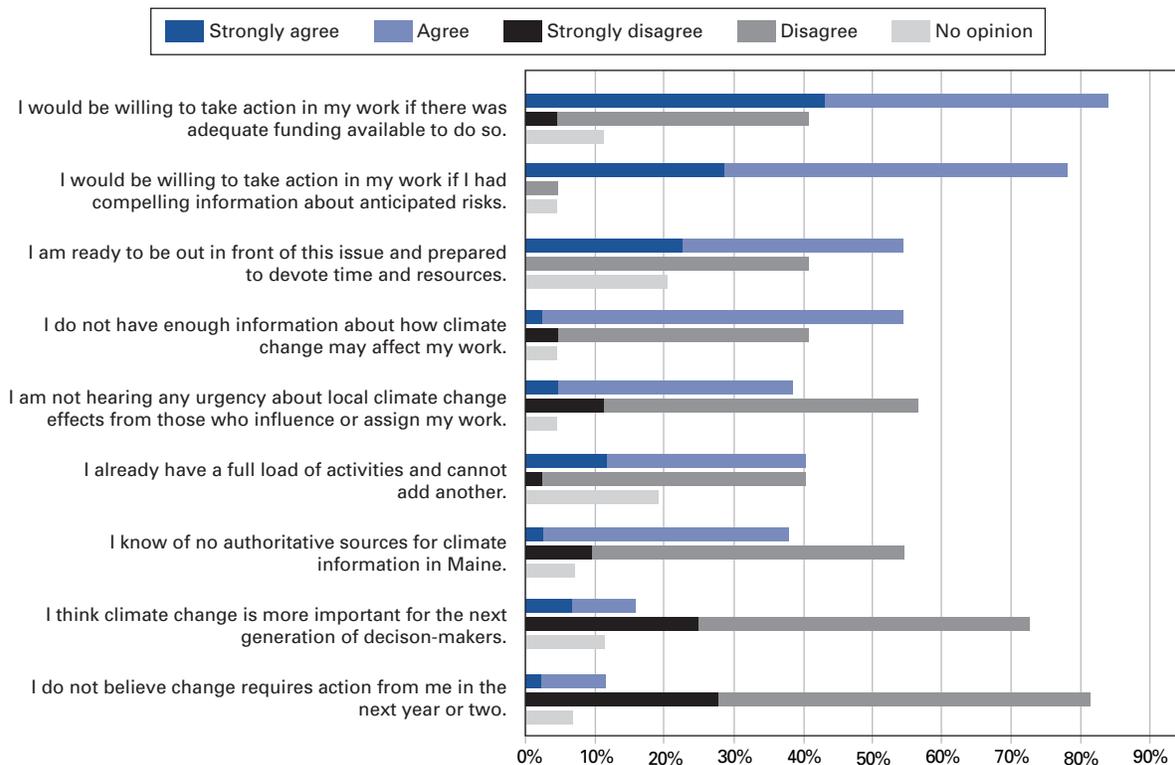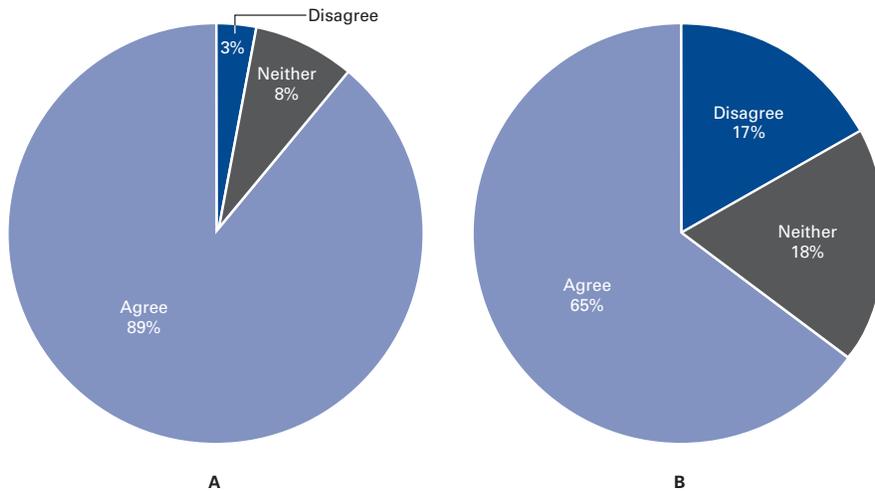
FIGURE 2:   **Mean of Global Warming Belief Items of Municipal Officials from (A) the Present Study in 2019, and (B) Washington County in 2015 (adapted from Johnson [2015])**

A

B

shows the results of identical questions from Johnson's survey of over 200 Washington County municipal officials in 2015 with results that were consistent with the other cited surveys in Maine. While statistical change analysis is not possible between the 2019 and 2015 Washington County surveys (only four Washington County officials responded to the most recent survey), the results suggest an increase in the number of local municipal officials who believe climate change is real and caused by human activity.

Interviewees described the importance of public outreach at all phases of adaptation planning. They articulated the realities of information overload around climate change and its impacts and noted the need for increasingly creative modes to engage the public and develop support for adaptation initiatives. Effective strategies include using targeted and localized information on climate impacts and engaging the public in documenting impacts such as nuisance flooding.

Interviews with policymakers indicated that adaptation planning is progressing despite a diversity of views among residents about climate change. Many interviewees stated the importance of avoiding broader discussions about the causes of climate change, which had the potential to derail progress on adaptation planning. They described the importance of framing discussions on adaptation planning around flooding (nuisance flooding, storm events) and other impacts that directly

affect residents, enabling discussions about addressing these impacts. However, interviewees did report an emerging ability to talk about climate change more explicitly as they noted shifts in public perspectives towards climate change. Interviewees noted that these shifts are key in enabling progress on adaptation planning.

Resources and Training Needs

Respondents rely on a more diverse set of resources for information now than in 2010 (Figure 3). As stated earlier, they appear to be more confident in their knowledge and information about climate vulnerabilities and adaptation options. By far, the most useful forms of information for adaptation are spatial in nature: GIS analyses or interactive maps. Other resources identified as very useful are technical assistance from experts and personal connections. These findings are reflected in our interviews with local policymakers. Interviewees indicated that visual data such as maps are key in building support for adaptation planning. National reports and academic journals were identified as less useful (Figure 3). This contrasts with results from the previous study, where respondents identified news media as the most common sources of information.

Respondents reported that they primarily use state-based data sets, such as those provided by the Maine Geological Service (MGS), Maine Sea Grant, University of Maine Cooperative Extension, and other colleges and universities versus using federal data and websites. Forty-four percent of respondents used the MGS's Sea Level Rise/Storm Surge scenarios map, which is one of the longer-term resources available for communities. Ninety percent of policymakers reported using state-level data and resources (MGS, Maine Flood Resilience Checklist, and the Maine Adaptation Toolkit within the Maine DEP Adaptation website) as compared to 73 percent who used federal data sets (NWS, NOAA, and the Environmental Protection Agency).[1] In the 2008

FIGURE 3: **Usefulness of Information for Understanding Climate Change Impacts**
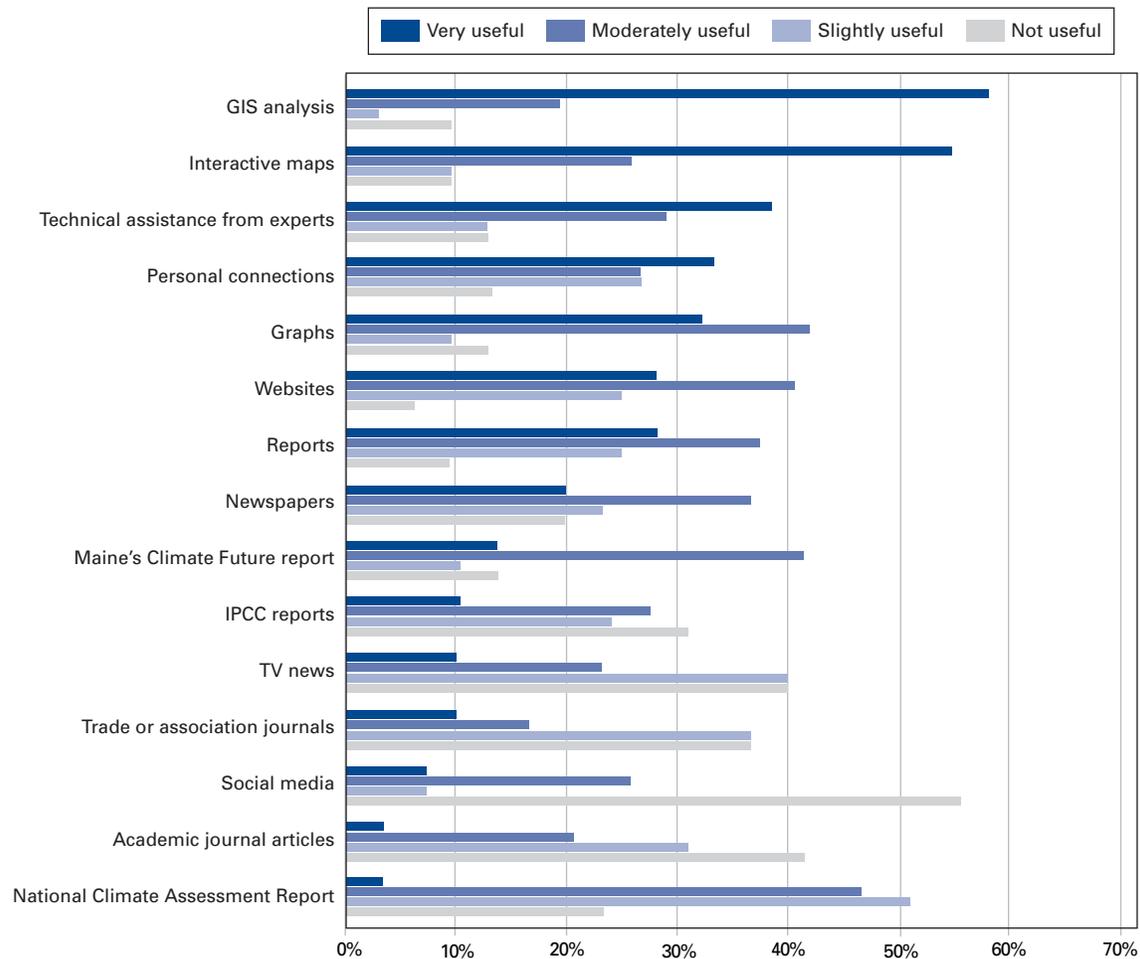

survey, respondents relied to a greater degree on federal data sets; NOAA user rates dropped from 72 percent to 33 percent. This change suggests that users are relying on an increasingly diverse set of sources now available, such as localized data sets and on other municipalities and the Maine DEP adaptation program, established after the 2008 survey. Interviews with local policymakers identified a key role for state agencies in providing expertise and legitimacy for municipalities.

Although respondents have greater knowledge and access to a wider range of resources, they identified the need for continued training, particularly on finding and acquiring funding (Figure 4). This response aligns with the identified need for funding and reflects a shift away

from more generalized knowledge on climate change impacts to an emphasis on taking direct action.

A significant gap associated with assessing the impacts of climate change on municipalities is understanding social vulnerability, the resilience of a community based on factors such as income, access to services, or other social factors. While respondents stated that physical vulnerabilities had been identified through updating waterfront (31 percent) and road and culvert infrastructure (38 percent), only 5 percent stated that a social vulnerability assessment had been conducted in their communities. Respondents also stated a need for training on conducting social vulnerability assessments (33 percent).

FIGURE 4: **Ranking of Need for Information and Training within the Next Two Years**
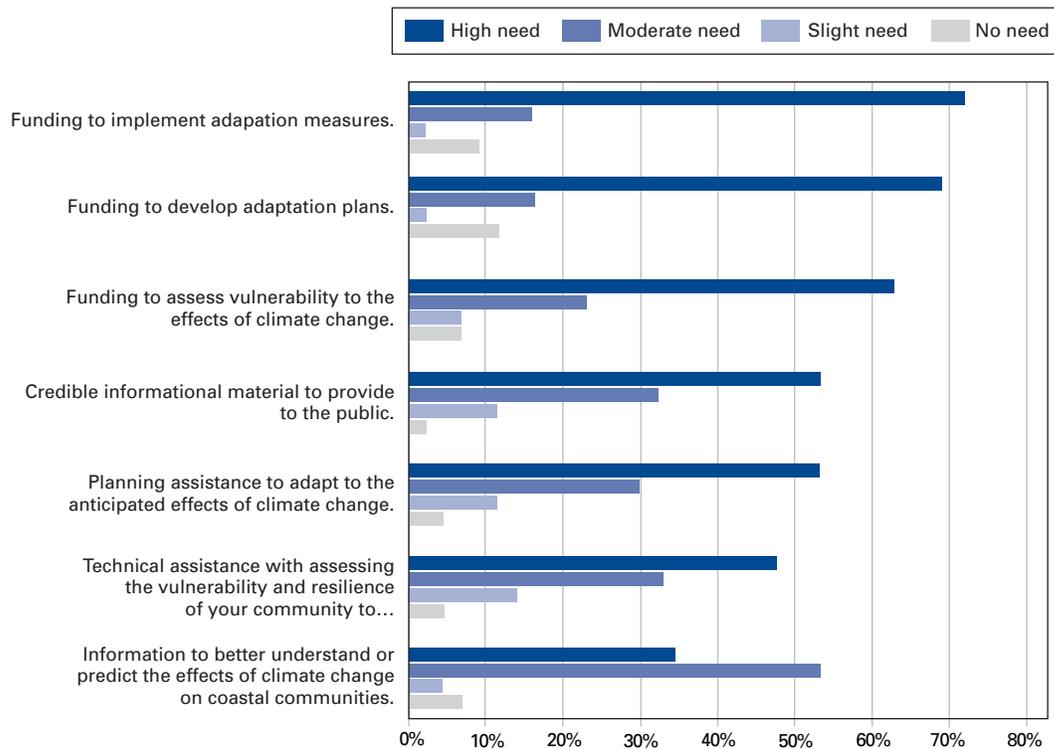
Interviewees described the importance of targeted information for the public and some of the challenges of having too many sources of information. Examples of useful data formats include photographs of storm events. Interviewees discussed the need for technical assistance on the use of online tools.

Opportunities

Communities reported collaborating with other communities and local, regional, and state agencies to achieve adaptation planning goals. Sixty-seven percent of respondents reported that they were currently collaborating with other entities (municipalities, regional planning councils, and state agencies) to advance adaptation planning. Interviews highlighted these collaborations as a key asset in creating pathways for knowledge sharing and developing expertise. Fifty-one percent of respondents identified other municipalities as sources of information. Policymakers viewed partnerships as a means of increasing the likelihood of receiving grants. Regional, state, and federal

agencies serve a key role in fostering networks among municipalities working together to identify and secure funding and implement adaptation projects. These findings were supported in interviews.

Many policymakers are well networked in the state. They stressed the importance of fostering networks to access and use resources and in addressing impacts that are more regional in nature, such as flood impacts on transportation systems.

Barriers

As mentioned earlier, an ongoing challenge is the lack of funding available for climate-change-adaptation projects. Funding continues to be a primary barrier, which aligns with findings in the earlier survey. In 2008, policymakers described a general need for adaptation planning. Yet in our study, respondents describe a need for funding for specific adaptation projects and less for adaptation planning in general, reflecting planning processes that have been taking place. Interviews with policymakers revealed a frustration with the challenges

of funding cycles and resources. Interviewees stated that in certain cases funding only became available after a storm event to address damage, rather than being able to access funding to mitigate potential storm impacts.

DISCUSSION

Our study identified significant changes in the ways in which coastal communities understand and are responding to climate change, yielding insights that can provide guidance for programs aimed at helping communities adapt. Far more than they were a decade ago, communities are taking steps to build local resilience, progressing from assessing vulnerabilities to understanding vulnerabilities, and many are now seeking funding to implement specific adaptation measures such as infrastructure projects.

Policymakers now view themselves as better informed and have a stronger belief in the causes of climate change. They are finding climate-related information from a much more diverse array of sources than in the past, drawing especially on resources produced by state agencies, and they express an increasingly nuanced set of information needs. Respondents pointed to GIS maps and analyses as especially useful. The online maps and data produced by the MGS are used by many communities; they are interactive and include data scaled specifically for local use. By contrast, in the 2010 study, many communities reported using NWS sources, which at the time included much coarser-scale data in forms that were less applicable to local needs. Maine DEP's Adaptation Toolkit is a valuable compilation of tools and data sources related to community resilience, and about one-third of our survey respondents report using it. These results point to the need for further investment in Maine in fine-scale, interactive, and locally applicable maps and analytical tools to support resilience planning, along with training for communities in the use of such mapping tools.

A useful model for providing localized information is the materials provided by the Maine Department of Agriculture, Conservation and Forestry's (DACF) Municipal Planning Assistance Program to local municipalities in support of the comprehensive planning process. Compiled for each town and designed to support decision-making, these packages include statistical information, static maps, links to interactive maps, documentation of important and protected

resources, and more. The Beginning with Habitat (BwH) Program under the Maine Department of Inland Fisheries and Wildlife (DIFW) provides another model, compiling best-available GIS data on natural resources and providing data and static maps for each community in Maine. The program has streamlined and improved conservation planning since its inception in 2000, according to many planners in the state. However, smaller communities typically lack the technical capacity to use the BwH data to create their own maps, and the program has now made some data sets available for use in online mapping to allow more communities to have greater access.

It is important to note that respondents not only identify a need for maps and data, but they also require the ability to analyze data to identify vulnerabilities and examine options for adaptation. Many respondents in the survey report using key resources that provide analytical support or scenario-based planning tools such as the MGS Sea Level Rise/Storm Surge mapping tool and data, the Adaptation Toolkit provided by the DEP, as well as more localized resources. Most communities require outside assistance and expertise from the state, local researchers, or contracted consultants to perform such analysis or to interpret and apply results; so it is important for such analyses to be updated and expanded to support adaptation planning.

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The increasing emphasis on implementing infrastructure projects brings a growing need for new types of funding. Funding agencies often require technical capacity to identify and qualify for support for such projects. They involve hydrological, economic, and geographic analysis; engineering for scoping and design; and writing of complex grant and loan proposals. Most Maine communities lack the resources to successfully pursue such funding on their own, and federal funding

programs are often geared specifically toward larger municipalities. Some focus group participants mentioned that emergency management funding often hinges on responding to storm impacts, rather than planning to avert them. State programs such as the Maine Coastal Program (MCP) and regional planning commissions and councils of governments provide crucial assistance to communities and can help them navigate such challenges. In downtown resilience projects in Machias and Damariscotta, for example, regional councils of governments have partnered with municipalities to provide technical assistance in moving infrastructure projects through engineering and funding milestones. The town of Machias, with much support from the Washington County Council of Governments, is now wending its way through a technical and complex

> …communities need to better understand social vulnerability factors and to incorporate social vulnerability assessments into adaptation planning.

Federal Emergency Management Agency (FEMA) proposal to support full engineering design of a proposed flood barrier to protect large swaths of the commercial district from significant flooding threats (WCCG 2019). In consultation with local municipalities, Lincoln County Regional Planning Commission has secured eight grants through the Coastal Community Grant Program to examine options around ordinance development, emergency preparedness, and infrastructure investments to address the impacts of sea level rise and storm events. Outputs included local level visualizations to inform municipal officials on the impact of storm events and engineering assessments towards infrastructure investments in two downtown areas (Maine Coastal Program 2019). It is clear that robust, ongoing support for regional planning commissions will be crucial as more Maine communities continue to pursue funding for an increasing number of similar coastal infrastructure projects. At a state level, the Climate Change Adaptation Providers Network (CCAP), comprised of state and federal agency staff, local and regional officials,

and representatives from the academic community, has collaborated to raise awareness for climate adaptation planning since 2010. By sharing expertise and providing support to local and regional coastal communities, CCAP contributes to a continued and growing understanding among local decision makers for the need to address climate adaptation planning. An ongoing state-wide network, such as the Maine Climate Council, is critical for continued knowledge sharing and expanded support provided to coastal and inland communities.

An identified gap is that communities need to better understand social vulnerability factors and to incorporate social vulnerability assessments into adaptation planning. Coastal communities will face impacts to both physical infrastructure and social systems. As summarized in the Coastal Maine Climate Futures report (Birkel and Mayewski 2018) and many other recent reports (Johnson et al. 2018), social impacts will be felt across a broad range of community functions, including reduced access to homeowners during coastal flood events and disruptions to agriculture and marine fisheries with associated regional economic impacts. Social vulnerability assessments would identify the community members most at risk to climate change impacts. Available tools such as the Nature Conservancy's Maine Coastal Risk Explorer (https://coastalresilience .org/project/maine/) and the Maine Flood Resilience Checklist provide important resources for identifying social impacts (Birkel and Mayewski 2018; Johnson et al. 2018). Funding and technical support may be needed to assist communities in identifying social vulnerabilities and identifying critical steps towards building social resilience.

Some of the needs identified in the survey are best addressed at the regional level, and many respondents said they are looking for opportunities to collaborate with communities facing similar challenges or to join regional efforts. Regional partnerships can allow for coordinated solutions and economies of scale, particularly for resources like transportation networks, waterways, and shellfish flats that cross municipal and county boundaries (Johnson et al. 2018). The Frenchman Bay Regional Shellfish Committee, for example, has a seven-town consortium that manages shellfisheries bay-wide by implementing local ordinances and conducting shared projects such as water quality initiatives and activities to address infestations of invasive green crabs. This committee, in existence for a decade, has accomplished a wide array of regional projects that would have

been beyond the capacity of any individual member town; it involves the support of researchers from the University of Maine and College of the Atlantic. Such regional partnerships addressing fisheries or infrastructure rely on support from relevant state agencies and researchers and extension agents from colleges and universities. Many are coordinated or supported by regional planning commissions. Again, Maine-based support systems are critical elements in ensuring the success of adaptation efforts.

There may be some sampling bias in the results showing that a larger-than-expected percentage of the officials of coastal communities believe in climate change: people who believe in climate change may be more likely to respond to a survey about climate change (Babbie 2010). However, based on our over 40 years of collective experience of working with Maine coastal communities and on discussions with other providers of climate-change-adaptation support, we have observed decreased skepticism about climate change in the communities we work with. Comments from the interviewees in this study offer similar observations. We suspect that sampling bias is insufficient to explain such a large difference in beliefs from past surveys. Some of this shift is due likely to a widening acceptance as people—particularly municipal officials—have experienced climate impacts and have participated in community activities aimed at assessing local vulnerability. Further investigation will reveal more about this trend.

We found that the state of adaptation planning varies along the coast and is advancing largely based upon the work of local champions who may have a variety of roles within their communities. With acceptance widening among municipal officials, the number of these champions may be growing. These local champions receive support and information from Maine-based regional planning commissions, state agencies, nonprofits, and universities. However, they are challenged by the myriad responsibilities associated with climate adaptation planning: educating themselves on the direct impacts on their community, identifying community vulnerabilities, seeking funding for adaptation planning processes and projects, and educating the public on impacts and the need to make investments. Although the public seems to be moving towards a broader acceptance of climate change impacts, perceptions range, and local champions must navigate a some-times-challenging path to educate the public; they must

increasingly rely on creative approaches to effectively engage the broader community.

Our study provides important evidence that local champions are intuitively employing best practices for community engagement, which are well documented in the academic literature. With less-formal governance frameworks, especially in the more rural areas of the coast (Johnson 2015), local champions are working with regional planning commissions and others to create opportunities for coproduction of knowledge (Cash et al. 2006; Jasanoff 2006). The information sources they favor are locally specific, produced in Maine, making them not only more useful but also more credible (Cash et al. 2006; Ostrom 1990). They are focusing specifically on local vulnerabilities and priorities, while avoiding arguments about the causes of climate change, which helps ensure traction for adaptation efforts (Wilbanks and Kates 2010).

CONCLUSION

Given the broadening scope of climate adaptation needs among Maine's coastal communities, we recommend the following measures for improving the system of supports required to ensure they succeed in improving resilience:

- develop more comprehensive, scalable, and localized data and map resources
- support and expand analytical and scenario-planning tools designed to support localized adaptation planning
- ensure that regional planning commissions and councils of governments have the expertise, funding, and resources they need to help communities plan and implement complex adaptation projects
- recognize and support the vital role of key Maine-based support providers such as the state's Municipal Planning Assistance Program, Maine Geological Survey, university and college researchers, nonprofit organizations, and state agencies
- support initiatives such as provision of technical service or funding mechanisms to identify and address social vulnerability impacts at the local, regional, and state level
- foster collaborative efforts to identify regional needs and implement adaptation on a regional scale wherever that is most advantageous

- support local champions in implementing best practices for engaging communities in climate adaptation

With the passage of Governor Mills' climate bill (LD 1679) and establishment of the Maine Climate Council, we hope that the findings can inform approaches for assisting communities with adaptation planning. Overall, this study provides reason for optimism, showing significant progress among Maine's coastal communities towards increasing their own resilience through local actions. The challenge for those who provide support for communities is keeping up with their increasingly sophisticated and localized needs. A thoughtful and coordinated investment in these supports will be key to continued progress. ❧

ACKNOWLEDGMENTS

ENDNOTES

1. Sea Level Rise/Storm Surge scenarios map: https://www.maine.gov/dacf/mgs/hazards/slr_ss/index.shtml; Flood Resilience Checklist: https://digitalmaine.com/mgs_publications/521/; Maine Adaptation Toolkit: https://www.maine.gov/dep/sustainability/climate/adaptation-toolkit.html

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