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Helping Communities Adapt and Plan for Coastal Hazards: Coastal Zone Management Program Recommendations for National Tool Developers

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ABSTRACT

Adapting to changing coastlines is an unprecedented planning challenge as coastal hazards, including those associated with climate change, influence all areas of resource management. Tools have been developed to aid in understanding coastal hazards and to facilitate the planning and implementation of adaptation strategies. Through interviews with members of eight geographically distributed state Coastal Zone Management (CZM) Programs and several federal and nonprofit partners, we explored the utility of current tools for on-the-ground adaptation planning and implementation needs. State CZM Programs operate as trusted information brokers at the nexus between national resources and local needs. Here we provide seven recommendations for how to overcome the challenges identified with tool discovery, lack of trust, and the coarse spatial resolution of national tools. Our findings suggest local community needs are better addressed when end-users play a role in the tool development process. We also recommend leveraging CZM Program connections because they have the knowledge and expertise to identify solutions and disseminate information. While the recommendations presented here were taken from the perspective of state CZM Programs regarding coastal tools, the lessons learned may provide valuable insight into the tool development process for other resource management fields.

KEYWORDS

adaptation; case study; coastal; coastal management; resilience; tool(kit)

Introduction

Coastal hazards are complex issues, as are the efforts needed to adapt and build resilient communities (Curtice et al. 2012; Dyckman, St. John, and London 2014; Few, Brown, and Tompkins 2007; Spaulding et al. 2016). Key challenges in planning for coastal hazards include understanding and predicting the probability of the timing and severity of future events and evaluating risk tolerance (Spaulding et al. 2016). All coastal communities must engage in adaptation planning¹ and implementation to continue to thrive on our nation's dynamic and changing coastlines. We define coastal communities as all stakeholders living and working in the coastal zone of the ocean and Great Lakes states

and territories, including local governments, businesses, and other organizations. To plan for the future, these communities must have access to risk information and knowledge at appropriate scales and levels of reliability.

Ensuring community access to reliable and usable information is a function of the Coastal Zone Management Program (CZM Program). The Coastal Zone Management Act (CZMA 1972) is a voluntary state-federal partnership that provides assistance to states with federally-approved CZM plans. Currently, 34 of the 35 eligible states and territories participate in the program. Each state plan is designed to implement CZMA in accordance with specific state needs, in partnership with NOAA's Office for Coastal Management (OCM). State and territory CZM Programs work with federal agencies and collaborate with regional and local partners such as universities, regional planning commissions, and local businesses. Through these partnerships, state CZM Programs provide planning, financial, and technical assistance to local communities and take the lead in managing coastal resources using their expertise and on-the-ground knowledge of issues. Between 2012 and 2017, state and territory CZM Programs worked with 1,165 coastal communities nationwide to undertake coastal hazard mitigation efforts (Coastal States Organization 2018). Recent CZM Program-led efforts included implementation of the Coast Smart program in Maryland that helps communities prepare for short and long-term coastal hazards, the Coastal Hazards Planning Guidance developed for Indiana's local governments, and the Texas Coastal Resiliency Master Plan that significantly helped the state recover after Hurricane Harvey (Coastal States Organization 2018).

State and territory CZM Programs characterize and prioritize the different coastal hazards impacting their coastlines that include discrete, single events such as hurricanes and tsunamis and chronic issues such as flooding, lake level changes, and shoreline erosion all of which are exacerbated by the impacts associated with climate change. In 2017, the hurricane season alone included three of the five most expensive natural disasters in U.S. history, and the impacts of these storm events were compounded by climate-driven sea level rise (NOAA National Centers for Environmental Information 2018). Ultimately, the complexity of the issue has resulted in the proliferation of tools² intended to support local decision-making. The U.S. Climate Resilience Toolkit alone hosts approximately 500 tools from a variety of organizations and agencies (U.S. Federal Government 2015). Many of these resources are national in scope and developed by federal agencies and national non-governmental organizations (NGOs). Online resources have been developed to curate these resources and to help users determine which tools are appropriate for a given purpose. The Climate Adaptation Knowledge Exchange (CAKE) helps users manage their time and navigate the unwieldy number of resources by identifying and explaining relevant data tools and other information (EcoAdapt 2017).

As the coastal zone combines dense development and critical infrastructure in areas prone to flooding and severe weather, many adaptation tools focus on the coast. The link between large-scale efforts and local communities is important because climate adaptation is a national priority (Lysák and Bugge-Henriksen 2016) yet adaptation and mitigation planning often occur at the local level (Fu et al. 2017; Measham et al. 2011). National resources include the Sea Level Rise and Coastal Flood Web Tools

Comparison Matrix that compares the functions and methods of sea level rise and coastal flood web tools (The Nature Conservancy, NOAA's Office for Coastal Management, Climate Central 2017), and NatureServe's guide for adaptation planners to assist in ecosystem-based climate planning (Rozum and Carr 2013). Coastal communities may lack the capacity to gather information and develop tailored solutions to meet the needs of their local economic, political, social, and environmental conditions, therefore these national tools may be the only resources available to them.

The role of local governments, local NGOs, and the private sector in adaptation and mitigation planning is critical (IFRC 2009) and national support must be directly linked to, and aligned with, the local communities building resilience against coastal threats. However, we have little understanding of how useful national tools are for their intended audiences. In this manuscript we explore the utility of available tools for on-the-ground adaptation planning and implementation and generate a distilled set of principles that can be used by any national agency or organization involved in the tool development process to improve the usability of future tools. As described previously, state CZM Programs partner with a wide range of state, federal, and NGO tool developers and serves as a bridge between national programs and coastal communities. We focused on understanding community needs from the perspective of state CZM Programs, as they are trusted brokers of information for these end-users. CZM Staff work with communities throughout their coastal zone, therefore we also gained a comprehensive perspective for a broad range of community types by using this approach.

Methodology

Interviews

To understand the relationship between national-level tools and the needs of local communities, 22 state agency employees representing CZM Programs, along with a local planner, and three federal agency partners were interviewed in 2016³. In an effort to create a national picture of the issue, interviewees were selected from four regions: the East Coast (New Hampshire, Rhode Island, and Maine), Gulf Coast (Florida), the Great Lakes (Illinois, Indiana), and the West Coast (California, Washington). We specifically sought out state CZM Program staff that work directly with local communities on coastal adaptation and implementation efforts. In addition, three interviews were conducted with federal employees whose agencies are responsible for tool and/or toolkit development⁴. To ensure consistency, a set of defining terms was provided at the beginning of each interview⁵. We use the terms "externally-developed" or "national tools" to distinguish tools created by federal agencies or NGOs that are national in scope and not developed with a single state or community in mind. This terminology is continued throughout the report, and definitions for these and other common terms can be found in the Glossary (found at the end of the text).

Internal reviewer input

Using the information collected during our interviews, a manual, qualitative content analysis (Bengtsson 2016) was used to generate the findings and recommendations

presented in the following sections. In order to create a cohesive narrative that reflects the common views expressed by CZM Programs, this manuscript was reviewed by all interviewees, Coastal States Organization (CSO) Staff, additional state CZM Program staff not involved in the initial interviews, and NOAA-OCM Staff working on the Digital Coast. CSO is a nonpartisan nonprofit organization whose Staff works to support the work of the CZM community and to help unify these national programs on coastal topics. The Digital Coast is a web-based collection of resources and a partnership designed to support coastal management practitioners; these NOAA Staff are considered experts in national tool development and resource curation for coastal users. Therefore, to the best of our knowledge and ability the findings reported here represent consensus views from coastal management practitioners and expert partners knowledgeable on the needs of coastal communities. Unless otherwise stated, the recommendations provided below are intended for representatives from national agencies, NGOs, academic institutions or other groups involved in developing and implementing tools that are intended to assist coastal communities with planning for and adapting to the impacts associated with climate change.

Findings

Despite the abundance of national coastal tools, state CZM Program representatives stated that communities rarely use them and reported three key challenges to using existing tools:

1. Finding tools that suit the needs of the user to address a specific problem.
2. Intended users lack trust in tools and toolkits.
3. Tools are rarely available at sufficiently high resolution for decision-making.

Overall, we contend that tools developed to help communities in the future could be more impactful if they were more informed by the local needs and constraints of the intended end-users. The recommendations provided below are a first-step in improving and informing this process with respect to three main challenges: Discovery, Trust, and Resolution. We understand that these are overlapping categories and recommendations can address multiple issues.

Discovery

CZM Program Staff expressed feeling overwhelmed by the quantity of tools available and noted challenges with the search process due to limited program capacity and the non-specificity of the term “tool.” The challenges described here were also identified by a California Energy Commission 2007 study, which found that the ability of local coastal managers to prepare for current and future threats is inhibited by monetary constraints and limited staff resources (Moser and Tribbia 2007). The broad use of the term “tool” complicates the search process as it can be used to describe products ranging from phone applications, to story maps, or technical reports on best practices. Additionally, the language used to describe tools does not necessarily match the language used by local communities. For example, the word “conservative” can be read to

imply “more robust” by municipal engineers while a “conservative” sea level rise viewer is inferred to produce low estimates. Both monetary constraints and limited staff resources limit program capacity and, as described by CZM Program Staff, the reality is that most local planners work across a range of projects and are not focused on coastal hazards planning alone. These are fundamental challenges given the multidisciplinary field of coastal management and below we provide several suggestions for navigating these language and information barriers.

Existing tool portals are also time-consuming to navigate and it remains difficult for end-users to readily ascertain which tools can be tailored for a community’s need. In response, some state agencies have developed state-specific portals that compile resources relevant to their communities’ geographic region and needs. For example, both Maine (Maine Adaptation Toolkit) and California (University of California Berkeley and The California Energy Commission 2017) have developed sites where state-specific information on climate change is shared, including data and tools relevant to the coastal zone. Given the many actors involved in adaptation planning, tool developers would benefit from identifying these key hubs within the network to facilitate communication and tool distribution.

Recommendation 1. *Tools, toolkits, and search portals acknowledge and accommodate the diverse vocabulary used by local communities to describe the issue.* There are many kinds of tools available and scaled at different levels for diverse uses. The Glossary provided at the end of this manuscript demonstrates the diverse definitions of the term “tool.” This confusion can complicate tool accessibility as in reality, these resources may be accessed by individuals with disparate levels of experience and expertise, unknown to the developer. At present, there is no consistent set of categorical “buckets” used across national resources. In a perfect world, a consistent vocabulary would be adopted by all coastal tool developers to help communities readily find tools relevant to their needs. However, this is unrealistic given the large number of existing tools and established sites that each define, describe, and categorize tools differently. Instead, we suggest that national tool developers acknowledge the diverse vocabulary by end-users and create a glossary for how major terms are used for the given tool/toolkit. Additionally, the service provider can design sites with broader keyword search functions.

Tools can also be better sorted by need as communities dealing with similar challenges can often be roughly sorted based on locality. We found search portals that include the functionality for sorting categories by locality (state, region) and for characteristics of localities (inland, coastal, riverine, urban, rural) are most useful (e.g., CAKE, Gulf TREE 2017). When time and other resources allow, state agency staff can be used as “human filters” to aid in curating the search process. Additionally, each state CZM Program could create their own portal(s) that categorizes relevant tools using vocabulary and “buckets” tailored to the needs of their coastal communities. These sites could also be tailored for specific industries involved in adaptation that share a common language and basic level of ability (e.g., engineers, city planners) to streamline the search process. We acknowledge that while useful, the creation of a one-stop-shop developed by each state CZM Program would require sustained coordination between state and federal agencies and NGOs, as well as dedicated financial resources to develop and maintain these sites (see Recommendation 7 for more discussion on funding).

Recommendation 2. Tools explicitly state their assumptions, limitations, and requirements. In addition to the opinions expressed by our interviewees, a national report by Rozum and Carr (2013) found there can be a mismatch between existing tools and the specific needs of the project qualifications of the staff at hand. We recommend that every national tool include a list of necessary resources (both external and in-house), skill sets required, and/or specific personnel needed to fully implement a tool. For example, local planners need to know what additional departments or individuals (e.g., GIS specialists) will be needed to supplement or verify the results of a tool and the specific adaptation process it supports. Ultimately, there should be enough information for a user to determine whether it is more cost effective to use an “off the shelf” resource or to design a more customized tool in-house.

Acknowledging the tradeoffs that local communities must consider, we encourage national tool developers to also indicate the amount of time required to successfully apply the tool to a given problem. This will hopefully prevent users from becoming discouraged by how long it takes to implement and thus quitting before the task is complete, as time is an often a limiting staff resource. We found the Gulf TREE (Tools for Resilience Exploration Engine, 2017) decision-support search engine does allow users to filter based on both cost and the level of effort required which should address the main concerns posed above. With adequate training and education on the limitations, assumptions, and constraints of national resources we believe tools will be better used and adapted for the specific purposes of the end-user.

Recommendation 3. Tool developers identify and utilize trusted information hubs within the network of affected communities to collect feedback and share their tools. State and territory CZM Programs are excellent examples of “hubs” within the coastal users’ network. In addition to publishing new tools and sharing resources via existing distribution channels, tool developers should share their tools directly with the network of CZM Programs. Sharing tools with state CZM Programs will reduce the effort communities need to discover new tools and ensure that tools reach the appropriate end-users via established and trusted national and local networks. A primary role of state CZM Programs is to critically evaluate and relay information from a variety of sources and provide technical support to local communities. Not only would the communication channel help community end-users discover relevant tools, it would serve to increase tool use by engaging via a trusted party (National Research Council 2012). A Government Accountability Office (GAO) report on climate information exchange, found nonfederal institutions have a significant formal role in serving as providers of technical assistance and direct work with trusted information brokers are key to successful adaptation (GAO 2015). The CSO network of CZM Programs provides a national platform where agencies and NGOs can share their tools directly with coastal management practitioners. CSO currently operates a webpage with resources on tools, in-person trainings, and webinars, and communicates this information in a bi-monthly newsletter received by more than 1,200 coastal management practitioners.

CZM Program Staff reiterated an important qualifier to this recommendation – not all tools should be promoted at the local level. Trust is a limited resource that needs to be carefully guarded and if a tool is irrelevant then nothing will be gained by having a CZM Program share it with the local community, and they might even risk credibility

when doing so. Therefore, tool developers should consider consulting with information brokers and end-users from the beginning of the tool development process to help ensure that resources are both needed and relevant. The Digital Coast Partnership is an example of a federal agency (NOAA) working closely with eight NGO partners on behalf of national coastal management practitioners to help ensure that tools developed and shared are relevant to the intended end-user. We build on this idea of establishing trust in the next section.

Trust

Nationally, trust is an important factor in how adaptation occurs at the community level and trust is needed to overcome the uncertainty prevalent in adaptation planning (National Research Council 2012). We found that state CZM Programs have an understanding of the decision-making challenges associated with uncertainty because they build relationships with their local communities. CZM Programs attribute the limited use of externally-developed tools to a lack of confidence exhibited by local communities that stems from not knowing the developer and/or the process used to create a national resource. Often externally-developed tools do not incorporate the local data that state CZM Programs utilize, so that the assessment of the problem may not align with locally known and trusted methodologies.

A study by Reed et al. (2014) found that trusting environments are required for learning to occur and that communities of practice⁶ (CoP) can facilitate social learning and action. The close relationships CZM Programs build with their local communities establishes a CoP and consequently, local communities often seek help and recommendations directly from CZM Programs. For example, coastal communities in Maine look to the state for guidance when they need a trusted expert to walk them through analysis and application of data for a given problem. The Maine Coastal Program fosters this relationship by giving multiple presentations each year to the public and local decision-makers on coastal hazards and municipal adaptation strategies. Lindeman et al. (2015) found that participants of science-based adaptation planning workshops, emphasize the need for local champions to relay adaptation issues to local audiences. These examples highlight the significance of a trusted information broker in the field of adaptation. National tool developers could benefit from leveraging the established relationships that local communities have with CZM Programs in order to give their tools a trusted “face.”

Recommendation 4. *Those seeking to develop new coastal tools or toolkits consult with end-users from the beginning of the project.* This recommendation is corroborated by the General Services Administration (GSA) that described the need to develop tools through a user-focused, iterative approach (GSA 2016). CZM Program Staff agreed that this process should include close consultation with end-users and information brokers before the tool is fully developed. States have detailed understanding of the challenges at the local level and if/how new ideas might fit those needs. Some local challenges do not necessarily require more tools, so it is important to seek feedback during the conceptual phase. When creating new resources, we recommend that tool developers consider four key questions:

1. Who is the intended audience?
2. What decision is the tool trying to inform?
3. Is this the right question to be asking given the problem at hand?
4. Does an existing program or tool already answer the question?

Federal agency staff supported this recommendation and stated that a bottom-up approach helps to justify the need of a given tool or toolkit. State agencies are also able to identify factors that an outsider would not know to include (e.g., agency consensus documents, existing models, property rights issues). This consultation does occur, as our federal representatives indicated, and in certain cases agencies convene focus groups with members of state CZM Programs to present ideas for new tools. Based on the feedback received, the agency decided to forgo the development of a new tool in at least one case. In the age of tool proliferation, this type of collaboration can save both time and agency financial resources and should be the norm.

We acknowledge that providing and receiving input on a new tool is time intensive for all parties and it can be difficult for locals to allocate the time when the benefit of the tool to the end-user is unclear. Therefore, developing tools that are requested or initially vetted by end-users may help ensure that state or local feedback is later volunteered. On our panel of interviewees alone, several examples for new tools needed in California were identified, including estimating sedimentation rates for San Francisco Bay, and models that account for the changing frequency in coastal storms and extreme rain events in the region. We contend that communities are more likely to use a tool if they are created with stakeholder input from the beginning (i.e., the idea phase) and this also results in superior tools. We would encourage that more formal engagement mechanisms are incorporated into the tool development process so that strategic needs are addressed, and the usefulness of tools clearly discerned prior to creation. Building closer relationships among tool developers, information brokers, and end-users through a CoP will also instill greater faith in the products ultimately developed.

Recommendation 5. *Tool developers regularly offer end-user training and tutorials, in conjunction with community-trusted programs.* As time was frequently cited as a limiting factor in a CZM Program's ability to find and use new tools, we recommend that holding targeted trainings can build capacity and trust in local communities and ultimately reduce the time needed to learn how to use a new tool for decision-making. If national tool developers face similar resource limitations as their end-users, tools could be incorporated into existing trainings hosted by community-trusted programs. For example, state CZM Programs hold regular trainings with local planning bodies and, when appropriate, they partner with NOAA to include trainings on materials and resources found on Digital Coast. These state-federal partnerships are beneficial because NOAA is given the opportunity to showcase national tools while state CZM Programs share their local resources, which results in the education of both the end-user and national tool developer. The federal representatives on our interview panel reinforced this view and shared that agencies do conduct "road shows" by visiting state CZM Programs and their affiliates to promote and provide training on new tools. CSO hosts an online calendar featuring state and regional CZM Program meetings that could be used to identify and coordinate these opportunities.

Additionally, promoting case studies of how tools have been utilized by communities help demonstrate the benefit to local decision makers. CZM Programs benefit from learning about successful adaptation projects at a national level, especially learning about the maintenance required, environmental outcomes achieved, and whether local communities felt it was a good use of public dollars. This information could be included in case study reports to help CZM Programs identify appropriate projects and encourage, or require, long-term monitoring of outcomes. Digital Coast, CAKE, and the Adaptation Clearinghouse (Georgetown Climate Center 2018) do help promote tools by messaging through “stories from the field” and “case studies.” These examples are drawn from local communities and help demonstrate the value of a given tool. In the future, this demonstration of value could occur through consultation with end-users during tool development phase, as described above in Recommendation 4. Communities willing to pilot a given resource by conducting iterative trials and in-situ testing could be identified.

Resolution

When CZM Programs identify resources that address a relevant issue for their communities, they find the tool is often not developed at a fine enough spatial scale to be used in decision-making. Many nationwide tools use data that is interpolated across broad areas and based on the availability of national data. Additional challenges are presented when tools are older and do not reflect the latest science or current land-uses. This is especially a concern in coastal areas, as NOAA data demonstrates that coastal land cover changes twice as fast along the coast as in the rest of the nation (Coastal States Organization 2018). CZM Programs understand the difficulty federal agencies face with developing national tools at a fine resolution and also see the needs of local users that must consider the unique physical, social, and political circumstances of their communities. For instance, to update coastal plans, planning for sea level rise, or addressing other coastal hazards at the local level, individual property-level data (parcel) is often needed for tools to be useful. Federal tools are often limited to a minimum of 50 m grid resolution while locally-developed tools can meet 5 m or 1 m grid data requirements. Therefore, rather than adapt national tools, some CZM Programs fill the need by providing technical and financial resources that empower local planning agencies to create their own tailored resources.

While developing tools tailored for a specific community or audience is ideal, the budgets and time constraints on CZM Programs do not allow for individualized tools to be developed for all issues associated with the suite of coastal hazards impacting our nation’s coasts. Though the coarse granularity of national tools often prevents them from being used to assess site suitability, states and local communities can still benefit from the resources developed by federal agencies and NGOs if the user understands that most national tools are intended for general planning. CZM Program Staff report that they often use external tools to access certain GIS layers or other geospatial data that can be incorporated into state or community-specific viewers. Some programs use federal tools for screening purposes, or a first-level analysis to identify whether there is a potential problem in an area. After an initial assessment, they can then pursue a more in-depth analysis. However, using these tools may require expertise by the end-user to

understand the data requirements of the tool and/or the ability to code. This ties into our earlier recommendation that addressed the need to build trust and facilitate trainings that educate end-users on the feasibility of using national tools to address local needs.

Recommendation 6. *When possible, tools are designed to be customizable at different spatial scales and relevant for community needs.* There are mechanisms to bring coarser national models down to the property scale and tool developers could accommodate certain modifications by providing instructions and assistance that can help communities working to customize tools. For example, for software tools, the underlying code can be shared which will allow end-users to tailor the tool to suit their needs. This could mean requiring standards for metadata such as the inclusion of explicit instructions on how to incorporate new data sets and to add/adjust parameters. Many tools available on Digital Coast, for example, are screening-level tools that can be customized by local communities to incorporate local and/or higher resolution data and often the code to develop the tool and access to underlying data services is provided. This sort of modularity could be incorporated into other tool's design such as building GIS tools with a user-friendly "data import" functionality or including an application programming interface (API) with the software. For example, the U.S. Department of Transportation's [climate] Vulnerability Assessment Scoring Tool designed for the Gulf Coast, allows users to input data and select or de-select what data is included in a given analysis (ICF International 2015).

Future tools could benefit from incorporating known and trusted datasets, including those hosted on Digital Coast. The basic tool could report national averages to accommodate new tool users and those looking for first-level uses, while the ability to import customized data sets could accommodate more advanced users. We understand that this would increase the costs of national tool development but argue that making customizable tools would increase tool utilization rates. This recommendation is supported by the GSA study that found private sector planners and municipal analysts often seek raw data because these can be tailored to individual needs and situations (GSA 2016). Some federal agency partners reported that they increasingly see their role as developing basic platforms that provide a starting point for data and mapping and empower end-users to customize the tool. Some NGOs and federal partners, including The Nature Conservancy, Association of State Floodplain Managers, and NOAA-OCM reach out to local communities to stay informed of local needs in order to best use the funding to ensure national coverage of locally-scalable and necessary data.

Recommendation 7. *End-users are appropriated funding and/or given in-kind support to create tools specific to the needs of on-the-ground adaptation projects.* Monetary constraints and limited staff resources are some of the greatest challenges facing local coastal managers, and financial resources are required to both build custom tools and maintain them. While helping all states create in-house tools is likely not feasible, prioritizing funding for these uses could help areas that do not have in-house resources, such as rural, underserved, or inequitably represented communities. Because state CZM Programs know their end-users well, they have the knowledge and expertise to create tools but often lack funding for tool development. This emphasis on funding is supported by Curtice et al. (2012) who explained that because tool development is time and resource intensive, end-users need sustained, reliable funding streams to hire

the appropriate staff with skill-sets that ensure a quality product. We know that funding for adaptation-specific needs helps catalyze change; and communities are more likely to pursue adaptation strategies if they know they can find resources to support their actions. Currently, many state CZM Programs fund local projects through federal investments that are passed through the state to local communities and coupled with technical assistance provided by the state agency. In the future, federal grant funding to states and their NGO partners could explicitly set funds for broader impacts and specify that trainings and/or tools developed to help ensure that results of the project, and any relevant data, are made available to local communities and decision-makers.

Another benefit to increased communications would be to help reduce tool redundancies. The GAO report on geospatial information found that the federal government invests billions of dollars on geospatial data, but duplication of effort is common (GAO 2013b). In the CZM community there is the perception that more financial resources are available for creating new tools than are committed to maintaining, monitoring, and adapting existing tools. Improving existing tools relies on the availability of quality data as a tool is only as good as the data that supports it. CZM Programs recommended national entities focus on updating and improving data quality which could improve usage of current resources and reduce the need to develop new, but similar tools. This process could also be better informed if tool developers understand which tools are being regularly accessed and used by the intended end-users and for which states or communities' finer resolution tools have been developed. Online tracking of downloads or user surveys could be conducted to achieve these results.

Experts are needed throughout the decision-making process, as supported by the GAO report (GAO 2013a), because local decision-makers require assistance in translating climate data into locally relevant information. Trusted information brokers such as state CZM Programs, can provide technical expertise for communities to help them make location-specific decisions. Allowing in-kind support could also benefit end-user development efforts. National tool developers could also support CZM Programs in their development of new tools by acting as consultants for the creation of location-specific resources. In many cases, the highest-utility application of national tool developers' expertise is in assisting local end-users to help themselves through the tenants of cooperative federalism. The Great Lakes Restoration Initiative, a partnership of federal agencies with input from states, tribes, universities, and private sector partners collaborate to strategically spend federal funds to support locally-relevant and strategic restoration projects including an intensive wetland monitoring program (Uzarski et al. 2017). From this effort, the Great Lakes Coastal Wetland Decision Support Tool was created that allows local decision-makers to set coastal wetland conservation and restoration priorities, including defining actions that will help communities mitigate impacts of coastal hazards. This initiative is a successful example of federal, state and local agencies partnering with on-the-ground NGOs and universities to create a tool that is regionally significant. The Adaptation Clearinghouse is another example of a multi-level partnership that helps local users search adaptation plans by state and even community.

Finally, we acknowledge that issues could arise if a federal agency acting in a consulting role identifies problems in community plans but lacks the ability to assist in the appropriate actions required to address the problem. This could have negative consequences for both outcomes on- the-ground and for building and maintaining trusting

relationships. Therefore, any issues identified by a federal partner in a product or tool should be discussed with the state or local manager before the information reaches the broader community and time should be allowed for fixes to be employed. Working with local managers to develop effective communication and outreach strategies is very important to building trust and promoting appropriate actions. While CZM Programs may be the appropriate mechanism for generating certain tools, we want to be sure to communicate that end-users should be included in the process directly and provided resources to develop their own tools at the local level. CZM Programs should not necessarily be the sole tool developers in the coastal area because this raises questions about feasibility, transferability, and parity in access to resources. We believe that establishing a CoP and increased communication between end-users, national agencies, and national NGOs will help clarify the necessary scale of a given tool and the appropriate producer.

Concluding remarks

CZM Programs cite a variety of factors that spur the need for adaptation in their local communities, such as severe storm events that serve as a call to action, availability of new funding streams, and the influence of trusted individuals that advocate for communities to prioritize adaptation needs. National tools developed by federal agencies and NGOs can be part of the solution for communities addressing these challenges. Interviews conducted with a selection of CZM Program Staff across the nation helped us identify existing challenges that end-users face, given the broad number of national resources currently available. We hope that this manuscript helps outline opportunities for national tool developers to shape effective products that address coastal adaptation planning and implementation. Strategies can include developing nationally-applicable tools in consultation with end-users or providing financial assistance that enables communities to develop locally-relevant tools. Threading throughout our paper is the important role of state and territory CZM Programs operating as trusted information brokers at the nexus between national resources and local needs. Our overarching recommendation for national coastal tool developers is to leverage CZM Program resources, expertise, and relationships to build a Community of Practice that helps local decision-makers address current and future resource needs. While the recommendations presented here rely on the perspectives of state CZM Programs and their partners, we believe that the lessons learned may apply to national-level tool development for other resource management fields.

Glossary

- **Tool:** a device or implement used to carry out a particular function.
^ See tool categorizations below.
- **Toolkit:** a collection of tools and resources addressing a specific challenge.
^ For example, Georgetown Climate Center's Adaptation Clearinghouse- a collection of resources addressing the policy challenges associated with adaptation.
- **Portal site:** a website containing many tools and toolkits all relating to a central theme. Portals are often intended for broad audiences and contain many sub-themes.
^ For example, toolkit.climate.gov or CAKE.

Tool categorizations

- **Planning document:** a written document that provides guidance and support on a given topic. Scale and scope of applicability varies. Non-interactive, static.
- **Information sharing tools/portals:** used to disseminate best practices. Can include case studies.
- **Data portals:** used to disseminate data.
- **Analysis tools:** GIS or other platforms that allow you to collect data and characterize/visualize problems and conduct analysis.
- **Process tools:** help support a process to evaluate and prioritize actions.
- **Policy and Regulatory Tools:** help support the implementation of strategies.

Notes

1. Adaptation planning can be defined as visioning for long-range planning horizons that incorporate uncertain scenarios that guide smart development practices and investments to achieve a community's vision for the future.
2. The term "tool" encompasses resources ranging from decision support documents to GIS analyses.
3. The coastal program interview questions used can be found in [Appendix 1](#).
4. The "developer" interview questions used can be found in [Appendix 2](#).
5. The terms are provided in the glossary.
6. Communities of practice are "social groups bound by a common concern or passion and a desire to learn how to improve their practice" (Reed et al. 2014, 231).

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References

- Bengtsson, M. 2016. How to plan and perform a qualitative study using content analysis. *NursingPlus Open* 2:8–14. doi: [10.1016/j.npls.2016.01.001](https://doi.org/10.1016/j.npls.2016.01.001).
- Coastal States Organization. 2018. Coastal zone management programs and the blue economy. <http://www.coastalstates.org/wp-content/uploads/2018/10/Coastal-Zone-Management-Programs-and-the-Blue-Economy.pdf> (accessed November 28, 2018).
- Coastal Zone Management Act. 1972. 16 C.F.R. § 315.
- Curtice, C., D. Dunn, J. Roberts, S. Carr, and P. Halpin. 2012. Why ecosystem-based management may fail without changes to tool development and financing. *BioScience* 62 (5):508–15. doi: [10.1525/bio.2012.62.5.13](https://doi.org/10.1525/bio.2012.62.5.13).
- Dyckman, C. S., C. St. John, and J. B. London. 2014. Realizing managed retreat and innovation in state-level coastal management planning. *Ocean & Coastal Management* 102:212–23. doi: [10.1016/j.ocecoaman.2014.09.010](https://doi.org/10.1016/j.ocecoaman.2014.09.010).
- EcoAdapt. 2017. Climate adaptation knowledge exchange (CAKE). <https://www.cakex.org> (accessed July 26, 2017).

- Few, R., K. Brown, and E. L. Tompkins. 2007. Climate change and coastal management decisions: Insights from Christchurch Bay, UK. *Coastal Management* 35 (2-3):255–70. doi: [10.1080/08920750601042328](https://doi.org/10.1080/08920750601042328).
- Fu, X., M. Gomaa, Y. Deng, and Z.-R. Peng. 2017. Adaptation planning for sea level rise: A study of US coastal cities. *Journal of Environmental Planning and Management* 60 (2):249–65. doi: [10.1080/09640568.2016.1151771](https://doi.org/10.1080/09640568.2016.1151771).
- General Services Administration (18F). 2016. Climate data user study/results. Commissioned by NASA, NOAA, and OSTP. <https://climate-data-user-study.18f.gov/download/final-report-and-results.pdf> (accessed November 5, 2018).
- Georgetown Climate Center. 2018. Adaptation Clearinghouse. <https://www.adaptationclearinghouse.org/about.html> (accessed November 24, 2018).
- Government Accountability Office (GAO). 2013a. Climate change: Future federal adaptation efforts could better support local infrastructure decision makers. GAO-13-242.
- Government Accountability Office (GAO). 2013b. Geospatial information: OMB and agencies can reduce duplication by making coordination a priority. GAO-14-226T.
- Government Accountability Office (GAO). 2015. Climate information: A national system could help federal, state, local, and private sector decision makers use climate information. GAO-16-37.
- Gulf Tools for Resilience Exploration Engine (Gulf TREE). 2017. <http://www.gulftree.org/> (accessed November 28, 2018). Northern Gulf of Mexico Sentinel Site Cooperative, Gulf of Mexico Alliance, and Gulf of Mexico Climate Outreach and Resilience Community of Practice.
- ICF International. 2015. U.S. DOT vulnerability assessment scoring tool: User's guide. https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/scoring_tools_guide/index.cfm.
- IFRC. 2009. Climate change adaptation strategies for local impact: Key messages for UNFCCC negotiators. International Federation of Red Cross and Red Crescent Societies, Red Cross/Red Crescent Climate Center, and ProVention Consortium. <https://www.unfccc.int/resource/docs/2009/smsn/igo/054.pdf> (accessed July 26, 2017).
- Lindeman, K. C., L. E. Dame, C. B. Avenarius, B. P. Horton, J. P. Donnelly, D. R. Corbett, A. C. Kemp, P. Lane, M. E. Mann, and W. R. Peltier. 2015. Science needs for sea-level adaptation planning: Comparisons among three U.S. Atlantic coastal regions. *Coastal Management* 43 (5): 555–74. doi: [10.1080/08920753.2015.1075282](https://doi.org/10.1080/08920753.2015.1075282).
- Lysák, M., and C. Bugge-Henriksen. 2016. Current status of climate change adaptation plans across the United States. *Mitigation and Adaptation Strategies for Global Change* 21 (3):323–42. doi: [10.1007/s11027-014-9601-4](https://doi.org/10.1007/s11027-014-9601-4).
- Measham, T. G., B. L. Preston, T. F. Smith, C. Brooke, R. Gorddard, G. Withycombe, and C. Morrison. 2011. Adapting to climate change through local municipal planning: Barriers and challenges. *Mitigation and Adaptation Strategies for Global Change* 16 (8):889–909. doi: [10.1007/s11027-011-9301-2](https://doi.org/10.1007/s11027-011-9301-2).
- Moser, S. C., and J. Tribbia. 2007. Vulnerability to coastal impacts of climate change: Coastal managers' attitudes, knowledge, perceptions, and actions. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2007-082.
- National Research Council. 2012. *A national strategy for advancing climate modeling*. Washington, DC: The National Academies Press. <https://www.nap.edu/catalog/13430/a-national-strategy-for-advancing-climate-modeling>. doi: [10.17226/13430](https://doi.org/10.17226/13430) (accessed July 26, 2017).
- NOAA National Centers for Environmental Information (NCEI). 2018. U.S. billion-dollar weather and climate disasters. <https://www.ncdc.noaa.gov/billions/>.
- Reed, M. G., H. Godmaire, P. Abernethy, and M.-A. Guertin. 2014. Building a community of practice for sustainability: Strengthening learning and collective action of Canadian biosphere reserves through a national partnership. *Journal of Environmental Management* 145:230–9. doi: [10.1016/j.jenvman.2014.06.030](https://doi.org/10.1016/j.jenvman.2014.06.030).
- Rozum, J. S., and S. D. Carr. 2013. Tools for coastal climate adaptation planning: A guide for selecting tools to assist with ecosystem-based climate planning. NatureServe. <https://www.natureserve.org/biodiversity-science/publications/tools-coastal-climate-adaptation-planning-guide-selecting-tools> (accessed July 26, 2017).

- Spaulding, M. L., A. Grilli, C. Damon, T. Crean, G. Fugate, B. A. Oakley, and P. Stempel. 2016. STORMTOOLS: Coastal environmental risk index (CERI). *Journal of Marine Science and Engineering* 4 (3):54. doi: [10.3390/jmse4030054](https://doi.org/10.3390/jmse4030054).
- The Nature Conservancy, NOAA's Office for Coastal Management, Climate Central. 2017. The sea level rise and coastal flood web tools comparison matrix. <https://www.sealevel.climatecentral.org/matrix/> (accessed July 26, 2017).
- University of California Berkeley and The California Energy Commission. 2017. Cal-adapt: Exploring California's climate change research. [Cal-adapt.org](http://cal-adapt.org) (accessed December 27, 2017).
- U.S. Federal Government. 2015. U.S. climate resilience toolkit. <https://www.toolkit.climate.gov> (accessed July 26, 2017).
- Uzarski, D. G., V. J. Brady, M. J. Cooper, D. A. Wilcox, D. A. Albert, R. P. Axler, P. Bostwick, T. N. Brown, J. J. H. Ciborowski, N. P. Danz, et al. 2017. Standardized measures of coastal wetland condition: Implementation at a Laurentian Great Lakes basin-wide scale. *Wetlands* 37(1):15–32. doi: [10.1007/s13157-016-0835-7](https://doi.org/10.1007/s13157-016-0835-7).

Appendix 1: Coastal Program Interview Questions

INTERVIEW QUESTIONS:

1. Please give me a brief description of your role within, or relationship to, the Coastal Program.
2. What do you think of when we use the word “tools” or “toolkits”?
 - a. Does it match with the definitions we have listed above?
3. Broadly, what types of tools do you use?
 - a. How do you use them?
 - b. What is your primary mechanism for finding or learning about new (or existing tools)?
4. Have you, or someone else on your team, been to CAKE, toolkit.climate.gov, Georgetown Climate Center, Digital Coast or other summary/portal sites?
 - a. Why or why not? If so, what was your impression?
 - b. Were you able to find what you were looking for?
5. Which specific tools are you actively using?
 - a. How are the tools being used?
 - b. How often and in what capacity?
6. Which tools, or categories of tools, have been tried in the past but are no longer being used?
 - a. Why are they no longer being used? What were the limitations you found? Did you develop something better?
 - b. Is there a specific tool that does not currently exist but you wish did?
7. Has your program developed any of its own tools?
 - a. How and why were these tools developed?
 - b. Were any existing tools used in the development of the personal tool?
8. In your experience, what is driving adaptation response?
 - a. Do you have any specific examples?
 - b. Is there a specific tool that does not currently exist but you wish did?
9. How do coastal programs match community needs with available resources?
 - a. Are any of these resources tools or toolkits?
 - b. Can you describe the relationship of the coastal program with the local communities?
10. What drives adaptation response at the state or state government level?
 - a. Are actions taken on a state level opposed to the community level?
11. Have you ever been contacted to consult in the development of a tool or toolkit?
 - a. If so, could you please describe the process?
 - b. Did you find it helpful and was your feedback incorporated?
 - c. Do you know anyone else who has been consulted?

12. How would you like to be included in toolkit development?
 - a. Is there a particular mechanism you think would work best?
13. Are there any other topics relating to tools that you'd like to address?

Appendix 2: Developer Interview Questions

INTERVIEW QUESTIONS:

1. Please provide a brief description of your role within your agency.
2. What do you think of when we use the word “tools” or “toolkits”?
 - a. Does it match with the definitions we have listed above?
3. Broadly, what types of tools do you personally use?
 - a. How do you use them?
 - b. What is your primary mechanism for finding or learning about new tools?
 - c. Are these tools generally from within your agency?
4. Have you, or someone else on your team, been to CAKE, toolkit.climate.gov, Georgetown Climate Center, Digital Coast or other portal sites?
 - a. Why or why not? If so, what was your impression?
 - b. Were you able to find what you were looking for?
5. Broadly, what kinds of tools are developed in your agency?
 - a. Could you provide some specific examples of tools or toolkits?
6. Specifically, which tools have you, or are you, involved in developing? Please describe them.
 - a. What is the target audience or end user for each tool?
7. Could you describe the overall development process? From idea to product release?
 - a. Could you describe where the idea to create a new tool generally comes from?
 - b. Was there research done into existing tools to check for overlap?
 - c. How did you engage with stakeholders?
 - i. How frequent was the consultation?
 - ii. How did you incorporate feedback?
 - iii. Can you describe the relationship you have with this stakeholder group?
8. How do you measure how many people are using each tool?
 - a. And what they are using it for?
9. Do you ever add to or update existing tools?
 - a. If yes, what was the motivating factor to do so?
10. In your opinion, what drives an adaptation response?
 - a. At the local, state, regional, and national levels?
 - b. What role do you see your tool(s) playing in adaptation planning?
 - c. How do you determine if it will have the intended impact?
11. Many states express a need for data at a property scale, is this something you can provide?
 - a. What are the challenges/limitations with providing data at such a fine scale?
12. Have you ever assisted state-level or local organizations in the development of a property-scale tool?
 - a. If so, how did it go?
 - b. If not, is this something you/your agency would be open to?
 - c. Ideally, what role would you like to play?
13. If you found it beneficial, how would you ideally like to engage the coastal programs in tool/toolkit development?
 - a. Is there a mechanism you think would work best?
 - b. What level of involvement would you seek?
14. If asked, what role would you like to, or be willing to, play in a coastal programs development of a tool?
15. Are there any other topics relating to tools that you'd like to address?