

NIDIS Carolinas Drought Early Warning System: Supporting Coastal Ecosystem Management

Scoping Workshop Report

Wilmington, North Carolina

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Introduction

The NIDIS Carolinas Drought Early Warning System Scoping Workshop was held on July 31 – August 1, 2012, in Wilmington, North Carolina. Participants represented a diverse group of organizations and interests (see Appendix B for the participant list). The objectives of this workshop were to identify important issues of concern for the coastal region and to establish and refine priorities for a pilot project. The agenda included background presentations about NIDIS and drought-related concerns for coastal ecosystems in the Carolinas, World Café –style sessions to facilitate small group discussions of regional needs and pilot project ideas, and full-group sessions on the second day to elaborate on ideas and select specific projects to pursue (see Appendix A).

Workshop Motivation & Background

The National Integrated Drought Information System (NIDIS) Act, signed into law in 2006, calls for an interagency, multi-partner approach to drought monitoring, forecasting, and early warning, led by the National Oceanic and Atmospheric Administration (NOAA). NIDIS draws on the personnel, experience, and networks of the National Drought Mitigation Center, the Regional Climate Centers, and the Regional Integrated Sciences and Assessments (RISAs), among others.

NIDIS regional early warning system pilots or prototype systems are being developed to coordinate and strengthen capacity among states, counties, agencies and tribal communities for developing, managing and using drought early warning information. These systems support the following functions at regional, watershed and local scales:

- (1) Communication and education,
- (2) Integrating monitoring and forecasting products,
- (3) Impacts assessments and decision support tool development,
- (4) Drought portal development at regional and watershed levels,
- (5) Engaging preparedness communities, i.e., embedding information from items (1) through (4) into planning and adaptation.

To date, NIDIS has developed pilot projects in four regions of the United States: (1) The Upper Colorado River Basin, (2) the Four Corners Region, (3) the Apalachicola-Chattahoochee-Flint (ACF) River Basin, and (4) critical areas in California. In 2012, NIDIS staff began work with the Carolinas Integrated Sciences and Assessments (CISA) to develop a Carolinas pilot project. The intended focus of the pilot is coastal ecosystems.

CISA has conducted previous work to identify needs and gaps in the understanding of drought impacts on coastal ecosystems. The CISA team conducted a workshop in March 2010 with researchers, resource managers, and education and outreach specialists engaged in coastal resource issues in South Carolina. The primary objectives of the workshop were to identify drought impacts and vulnerabilities related to coastal ecosystems and to identify ways in which drought planning and preparedness activities could better address coastal ecosystem needs and vulnerabilities.¹ Attendees identified a need for greater

¹ Lackstrom et al., 2011. [Understanding Needs for a Drought Early Warning System: Drought Impacts and Stresses on Coastal Ecosystems](#). Columbia, SC: Carolinas Integrated Sciences and Assessments

availability of appropriate drought data and information to manage coastal resources during drought. The current state of knowledge on this topic was seen as poor and minimal. Participants recommended that a “State of Knowledge Report” would be an essential first step to improving understanding and developing an effective means to monitor and forecast drought.

*The Impact of Drought on Coastal Ecosystems in the Carolinas*² was completed in response to this recommendation and provides a synthesis and analysis of the peer-reviewed literature examining drought impacts on coastal ecosystems. The research reviewed for this report indicates that drought is discussed primarily in terms of the hydrology-related impacts that affect coastal ecosystems, such as changes to river discharge, freshwater inflows, water level, and water table depth. The severity of these effects depends upon the longevity and recurrence interval of drought event(s) and may be compounded by other anthropogenic stressors on the system. In addition, some drought-related research considers how sea level interacts with freshwater precipitation and runoff to influence the salinity levels experienced by these systems. The review indicated that some ecoregions and locations have been better studied and researched than others.

The report also identified key literature gaps and research needs, including: examining drought impacts in ecosystems not studied by existing research, implementing long term studies to identify and examine causal relationships, and developing a set of indicators with which to monitor ecological change and impacts. More research and information is needed regarding drought impacts on groundwater resources, the significance of drought during different seasons, the longevity of droughts in relation to long-term impacts and/or length of recovery, and responses to potential future changes in salinity regimes.

As a next step in working towards the NIDIS Carolinas Drought Early Warning System, a steering committee was formed in April 2012 and tasked with developing the scoping workshop agenda and identifying interested workshop and pilot project participants. An initial meeting was held on May 1, 2012, in Ft. Johnson, South Carolina. The group discussed regional needs and brainstormed possible pilot project ideas to be proposed and developed further at the scoping workshop. While many potential drought early warning projects were identified at this meeting, two broad areas of interest emerged: public health and public land management. Potential stakeholders identified by the group included federal agencies, state agencies, scientific and technical experts, resource managers, non-profits, and others who are affected by drought or interested in improving the management of coastal resources during drought events. The steering committee continued to meet by conference call until the scoping workshop.

The following report includes information shared during speaker presentations about the goals and objectives of NIDIS for the early warning system pilot projects; background information regarding CISAs work on drought in the Carolinas; current work conducted in North and South Carolina by their respective drought advisory committees; and specific drought-related concerns for coastal ecosystems in the Carolinas including land management, salinity intrusion, and public health concerns. The report

² Gilbert, S., K. Lackstrom, and D. Tufford. 2012. [The Impact of Drought on Coastal Ecosystems in the Carolinas. Research Report: CISA-2012-01](#). Columbia, SC: Carolinas Integrated Sciences and Assessments.

describes the process through which pilot project ideas were generated and chosen for further development, including specific priorities for selecting the pilot projects and metrics for success. The final sections outline the four pilot projects selected by participants and next steps for implementation. The meeting agenda is provided in Appendix A.

Speaker Presentations

The first morning of the workshop was used to provide participants with background information regarding drought in the Carolinas and to lay the groundwork for developing priority needs and gaps and potential pilot project ideas. The following are brief descriptions of information presented by workshop speakers. The PowerPoint presentations used by these speakers can be viewed on the [NIDIS drought portal](#)³.

Background on the National Integrated Drought Information System: “What is a Drought Early Warning System”

Lisa Darby (NIDIS) provided the context within which the group would be working to develop pilot project ideas. Her presentation provided information on the legislation under which NIDIS was established, the components, goals and objectives of the NIDIS program, and the elements of a drought early warning system. These include monitoring, forecasting, establishing management triggers for a drought plan, anticipating impacts, and effectively communicating with stakeholders. She also explained the components of pilot projects developed by other NIDIS working groups in the Upper Colorado River basin, the Apalachicola-Chattahoochee-Flint River basin, and throughout critical areas in California.

Drought and coastal ecosystems – previous work by CISA

Kirsten Lackstrom (CISA) presented background information on the CISA research group, which is one of eleven NOAA Regional Integrated Sciences & Assessments (RISA) projects. Drought is one of the core focus areas of research for CISA, along with coastal management, public health, adaptation, and climate and watershed modeling. This combination presents a unique opportunity for involvement in a drought early warning system project as these various research foci intersect. Specific drought-related projects which CISA principal investigators oversee include the Dynamic Drought Index Tool, assessment of drought indicators and triggers used in the Carolinas, stakeholder communication strategies in relation to uncertainty and drought, and assessment of the impact of saltwater intrusion in the Carolinas. CISA also sponsored a workshop in March 2010 to engage stakeholders in order to better understand needs for a drought early warning system and prepared the peer-reviewed, state of knowledge report *The Impact of Drought on Coastal Ecosystems in the Carolinas*⁴ which helped to inform the development of the scoping workshop.

Public lands and drought

Ed Christopher (Pocosin Lakes National Wildlife Refuge) presented information on the challenges drought poses for public land management. He cited specific fire events on the refuge in the recent past

³http://www.drought.gov/portal/server.pt/community/carolinas/Carolinas_Drought_Early_Warning_Scoping_Workshop_Presentations

⁴ Gilbert, S., K. Lackstrom, and D. Tufford. 2012. [The Impact of Drought on Coastal Ecosystems in the Carolinas. Research Report: CISA-2012-01](#). Columbia, SC: Carolinas Integrated Sciences and Assessments.

which were intensified by drought, to include the impact of drought on peat soils, air quality and invasive species. Christopher discussed challenges and risks posed by changes to the landscape caused by climate change and exacerbated by drought. Specific examples included sea level rise, salinity intrusion, topography change due to burned peat soils, invasive plant and animal species, and increased occurrences of disease. In addition to these ecological changes, conflicting stakeholder interests (i.e. public land managers and private land owners) and funding shortages present additional challenges to overcome. The presentation concluded with a discussion of opportunities for development of a drought early warning system such as utilizing weather and drought forecasts to determine resource needs, partnership development, information exchange, and grant partnering opportunities to address interconnected needs.

Salinity Intrusion: Integrating Riverine and Coastal Forces

Paul Conrads (USGS) explained the dynamics of the saltwater/fresh water interface and the movement of this interface dependent on flow scenarios. Comparison of specific conductance readings and drought index historical data between January 2000 and August 2009 shows a correlation between higher specific conductance, which is a measure of salinity, and more intense drought categories. Conrads highlighted current work by the USGS South Carolina Water Science Center on conceptual modeling of salinity intrusion using a 3D response curve with variables of flow, tidal range and salinity. The 3D response curve is very specific to the estuarine system and is useful in determining scenarios under which salinity intrusion is most likely to occur, a phenomenon that requires fairly specific conditions. He outlined the benefits of a salinity coastal drought index and provided information on real-time data networks which are available to support this tool.

Ecological and human health threats related to drought in coastal systems

Geoff Scott (Center for Coastal Environmental Health and Biomolecular Research) provided workshop participants with background on the ecological and public health implications of drought in coastal ecosystems. Scott presented health impacts of drought published by the Center for Disease Control in 2010 which include compromised water quality and quantity, compromised food and nutrition, impaired air quality, diminished living conditions due to temperature extremes, increased recreational risks, and increased incidence of infectious, chronic, and vector-borne diseases. These impacts will intensify under changing climatic conditions due to altered ecosystems. Specifics of correlations between ecosystem and human health impacts were presented, such as reduced shellfish production caused by increased salinity levels. Research on *Vibrio* species was highlighted. Scott concluded by reiterating the role climate change will play in the intensity of drought and its impacts in the future.

Drought in the Carolinas

The final presentations of the morning were given by the North and South Carolina state climatologists. Both state climatologists explained that their programs and state drought management efforts would benefit from better understanding and reporting of drought impacts in coastal areas and explained how state drought management systems currently operate. Hope Mizzell (South Carolina) explained the structure of the SC Drought Response Plan including the legislation which gives regulative authority to the state and local drought committees and the process of issuing drought declarations. Mizzell also reviewed available drought management plans and response ordinance inventories, water conservation actions, and the dynamic drought index, all of which can be used to address the impacts of drought in

the state. Ryan Boyles (North Carolina) also provided information on legislation passed in his state to address drought. The Drought Management Advisory Council was established in 2003 and expanded in 2008 for broader representation. A key aspect of North Carolina’s effort is a weekly technical webinar with experts in the field to provide the current status of drought in counties across the state and the impacts any drought situations may have on fire activity, agriculture, and water quality and supply. In addition, collaboration with the federal agencies that develop the US Drought Monitor ensures that the national data are consistent with data for the state which is available on the [Drought Management Advisory Council’s](#) homepage⁵. Boyles ended with key needs to address in the development of a NIDIS pilot project for the Carolinas to include building on existing efforts, enhancing outreach and education, enhancing monitoring, connecting drought indicators to impacts, and developing a sustainable service which integrates sciences into decision support.

World Café Sessions

Introduction

The World Café Process⁶ is a method used to facilitate dialogue and engagement around a question or issue. This method was used to provide workshop participants with an opportunity to share information, learn about other interests present in the group, and collaboratively develop ideas for a Carolinas Drought Early Warning System pilot.

Format

A total of five World Café sessions of 25 minutes each were scheduled for the afternoon of Day 1. For the first four sessions, participants could chose four (of eight) tables to attend. Table topics (Table 1) were based on ideas that emerged from a brainstorming session at the NIDIS Carolinas Pilot Project Steering Committee on May 1, 2012. These seed ideas and topics were used to initiate and focus discussions during the World Café sessions.

Table 1: World Café Table Themes

Topic	Discussion Focus
<i>Improving Understanding of Ecosystem & Species Impacts</i>	<ul style="list-style-type: none"> • The physical, chemical, biological effects of drought on ecosystem processes, habitats, and individual species • Identifying the most vulnerable/sensitive coastal areas and species
<i>Public Health Risks</i>	<ul style="list-style-type: none"> • Identifying public health impacts and potential strategies to address risks
<i>Impacts & Management Strategies for Coastal Lands</i>	<ul style="list-style-type: none"> • Impacts and management strategies for public and private lands (including state and federal refuges, impoundments, plantations, land trusts, conservation easements) during drought
<i>Water & Drought Management</i>	<ul style="list-style-type: none"> • Impacts of existing water and drought management strategies and plans on coastal ecosystems during drought
<i>Economic Impacts of Drought</i>	<ul style="list-style-type: none"> • Impacts of drought on ecosystem services and how they

⁵ <http://www.ncdrought.org/>

⁶ <http://www.theworldcafe.com>

	contribute to economic impacts to businesses, industries, resource users in coastal areas
<i>Drought Early Warning Metrics & Tools</i>	<ul style="list-style-type: none"> Identifying already existing tools, how tools can be adapted or made more useful, users and user needs
<i>Ties to Climate Change Adaptation</i>	<ul style="list-style-type: none"> Identifying potentially useful connections between drought response/early warning pilot projects and climate change adaptation planning
<i>Communication and Education</i>	<ul style="list-style-type: none"> Identifying strategies and practices to improve the dissemination of drought information

A moderator and notetaker were assigned to each table in order to guide and record the discussions. Participants addressed a series of tasks at each table: 1) identify priority needs or gaps for a regional drought early warning system – possible categories included monitoring, management, communication, collaboration, science, and research, 2) identify the types of activities that would support or build a drought early warning system – participants were asked to focus on projects that would meet selection criteria and priorities, 3) identify existing resources and possible synergies with other projects and programs, and 4) identify next steps involved in advancing project ideas. With each round, a different group of participants considered contributions from the previous group(s) and added further ideas and information.

The fifth and final session was the same for all tables and focused on furthering small-group discussions of pilot project selection criteria and identifying metrics for success.

Pilot Project Selection Criteria and Metrics for Success

Prior to the world café sessions, Lisa Darby asked participants to focus on identifying projects that would meet selection criteria and address key regional priorities. General guidelines for possible selection criteria presented to participants included:

- Feasibility: Doable within a 2-year period, availability of existing resources and capacity
- Participation: Builds partnerships, includes or engages multiple partners
- Regional focus
- Potential to be self-sustaining
- Replicable/Transferable
- Uses and benefits from existing resources
- Produces measurable results, tangible products
- Produces long-term benefits, minimizes potential losses
- Contributes to an existing decision-making tool or process
- Sufficient energy and time to support activity

Workshop organizers considered this discussion important to the overall success of choosing pilot projects because these priorities help to establish the scale and scope of work for a drought early warning system in the Carolinas.

In addition, Darby asked the group to begin considering how the pilot could include an evaluation component. Establishing metrics for success would assist NIDIS in their efforts to evaluate Carolinas

drought early warning pilot activities. Such metrics might include specific criteria to determine if a particular project or the pilot as a whole adequately addressed stakeholder needs and improved drought early warning in Carolinas coastal ecosystems. While the final metrics for success are likely to be project-specific and developed for individual projects as they are planned, NIDIS wanted to start the discussion of potential metrics for success at the Wilmington meeting. Darby presented metrics for success developed by the California scoping workshop as an additional resource for the Carolinas workshop participants. These included:

- Drought impacts and costs have been reduced
- Institutional capacity has been improved
- Decision-making capacity has been improved by the provider or drought knowledge
- There is a demand for expansion of the pilot
- There has been a quantifiably measureable increased use of data, products, and/or resources
- The pilot project has influenced content on the national drought portal, in the drought monitor, or the drought outlook

By establishing the groundwork for these metrics for success during the workshop, participants were encouraged to consider the end result of chosen pilot projects and how they might continue to support drought early warning beyond the two-year pilot period.

Day 1 Wrap-Up

Having developed a variety of ideas, the plenary at the end of Day 1 was designed to set the stage for the Day 2 goal of identifying the top priorities. Moderators shared the highlights of the table discussions of project selection criteria and metrics for success. Participants were encouraged to think about all they had discussed and the relative strengths of all ideas in preparation for Day 2 discussions.

In addition to the project selection criteria presented earlier in the day, workshops participants added the following during the final round of the World Café sessions.

- Geographic focus on coastal ecosystems, differentiated from work further inland
- Applicable to both North and South Carolina
- Builds on existing partnerships
- No-regrets strategies
- Political acceptability, decision-maker acceptability
- Transferability from research to useable information
- Not necessarily “one-size-fits-all” but should be transferable to other regions and/or users
- Broad stakeholder interest and support
- Highest economic impact/positive benefits/loss reduction
- Public support
- Technically feasible
- Informs broader NIDIS efforts as other pilots move forward

Wilmington attendees also added the following suggestions for metrics for success:

- The project has been extended to decision makers or users and it is perceived as effective

- Evaluation of the project is not tied to having a drought during the time of the pilot
- At the end of the pilot project period, we are more knowledgeable about drought in coastal ecosystems and this knowledge can easily be applied to drought early warning

Day 2 – Introductory Session

The first session of Day 2 focused on further clarifying priorities for the pilot project. The group reviewed the list of priorities developed at the end of Day 1 and participants were asked to select those priorities which they considered the most important in development of a pilot project. ‘Transferability from research to useable information’ was selected by the most participants, followed by ‘building on existing partnerships,’ ‘highest economic impact/positive benefits/loss reduction,’ and ‘technical feasibility.’ Participants were asked to keep these priorities in the forefront of their minds when choosing from potential pilot projects presented during moderator reports from each World Café table.

World Café Table Reports

The moderator-notetaker teams consolidated key needs and pilot project ideas into PowerPoint slides. These slides were used to present information about the table discussions and recommended pilot project activities on Day 2 of the workshop.

During the morning of Day 2, moderators from each of the World Café tables presented the pilot project ideas generated by participants on Day 1. The following are brief descriptions of each of these presentations to include needs and gaps identified by participants, potential pilot project ideas and significant discussion points generated by participants. Please note that this list is not completely exhaustive, rather it includes those project ideas which were developed enough during the World Café sessions to merit further consideration as options for the final choices in pilot projects. Ideas for less developed project ideas, as well as table discussion notes, were kept on record following the workshop for possible incorporation into the chosen pilot ideas or as stand-alone projects as opportunities become available.

Communication and Education

Jerry McMahon, (SE Climate Science Center) moderated the Communication and Education table. McMahon presented the table’s discussion as the first World Café report because of the topic’s relevance to project ideas generated by the other tables. The table’s discussion focused on identifying strategies and practices to improve the development, communication and use of drought information. Participants indicated that these strategies and practices should be based on the determined priority audiences, the decisions, interests and concerns which motivate the audience to want drought information, and specific, measurable endpoints that provide information of consequence in terms of these decisions, interests and concerns. The determination of the priority audience will be dictated by the individual pilot project, which will in turn determine the proceeding attributes of decisions, interests and concerns and measurable endpoints or indicators. Participants stressed the need to utilize existing outreach expertise and resources of extension. Additionally, participants suggested the usefulness of technological tools such as smart phone apps and social media to both gather and disseminate

information. Data-mining and network analysis were also included as possible tools to gather information about important issues and/or decisions for priority audiences.

Improving Understanding of Ecosystem and Species Impacts

The discussion foci for this table were the physical, chemical and biological effects of drought on ecosystem process, habitats and individual species. Identified priority needs were the development of a list of stakeholder-relevant indicators and indices, determination of the extent to which anthropogenic stress is a cofactor or cumulative cause of ecosystem response to drought, models to assist with drought impact forecasting and an environmental sensitivity index. Daniel Tufford (CISA) moderated this table and reported on the pilot project ideas generated by participants based on these four identified needs.

1) Evaluation of Drought Indicators / Indices

- Currently there are indices and indicators of drought for agriculture, reservoir management, and water supply, among others, but there is no similar set for coastal ecosystems. This project would aim to fill that gap. (This pilot idea was selected as one of the top four and is introduced in greater detail later in the report).

2) Evaluation of Ecosystem Resilience to Human Impacts in the Presence of Drought

- As coastal development increases drought stress to ecosystems may also increase, which may in turn lead to a negative economic impact in coastal areas. Research would include determining whether the proximity to a developed area influences the impact of drought on coastal ecosystems, especially near densely populated areas.

3) Development of Models of Drought Effects

- Simulation and empirical models can be used to help understand complex drought effects, which could then possibly be used as forecast tools. Ecosystem responses are often the result of complex interactions; therefore, models would also help to identify gaps in data or knowledge.

4) Drought Sensitivity Index

- This project called for development of a map indicating levels of drought sensitivity across a geographical area and would be a conceptual analogue to an environmental sensitivity index. The project would address the need for understanding of the geographic extent of drought impacts. There are long-term data for water quality and salt marshes available which could be incorporated into the map as well as recent research on estuarine plumes.

Public Health Risks Associated with Drought Impacts on Coastal Ecosystems

This World Café table was charged with identifying the public health component of drought impacts and possible strategies to address risks. Lauren Thie (NC Department of Health and Human Services) moderated this table, which generated specific project ideas that incorporated drought impacts associated with water quality, seafood safety, and air quality. In addition, information sharing between North and South Carolina was noted as a need to the extent that a pilot project idea was generated from the discussion.

1) Effect of Water Quality Degradation on Vulnerable Coastal Communities

- This project idea was generated based on a specific example in Robeson County, NC where there are back flooding problems with the available septic system. Due to high unemployment rates and low wage earnings, residents are unable to afford to purchase treated drinking water from the local municipality and are suffering the consequences of a degraded water supply. A need to better understand the effects of salt water intrusion to drinking water was identified.
- 2) Seafood Safety Forecast
 - The purpose of this pilot project would be the creation of an early warning system for fishermen who harvest drought-sensitive seafood, in both fresh and salt waters in the coastal regions of the Carolinas. To begin the process reaching out to subsistence fishing groups and developing a tool that communicates risk to fishing communities was suggested. (This pilot idea was selected as one of the top four and is introduced in greater detail later in the report).
 - 3) Drought and Air Quality Program
 - Understanding the correlation between drought, air quality and public health would be the goal of this project idea. Public service announcements and distribution of literature to affected populations would be incorporated as activities for the pilot.
 - 4) North and South Carolina Drought Surveillance Network
 - Participants noted the lack of a formal information sharing mechanism between the two Carolinas as the motivation for developing this project idea. North and South Carolina drought groups were listed as an existing resource. Development of state reports was noted as an important part of this project.

Impacts and Management Strategies for Coastal Lands

This table included discussion of impact and management strategies during drought for both public and private lands, including state and federal refuges, impoundments, plantations, land trusts, and conservation easements. Specific needs identified by participants were better connections between land managers and adjacent land owners, better data management to coordinate data and entities, and a forecast tool for planning. Jess Whitehead (SC Sea Grant Consortium) moderated this table and reported the following pilot project ideas.

- 1) Development of Best Management Practices to Address Drought Management Issues
 - This pilot idea would entail a demonstration project where coastal land managers address a place/issue-driven local problem, such as using fire as a management tool. The project would address needs for forecast products for planning for fire management and understanding limits to how fire can be used as a management tool during drought.
- 2) Research on Habitat Change Influenced by Drought
 - This project calls for a multi-agency collaboration to document habitat classifications and find existing baseline data, to create a single database for information gathering and sharing, and to conduct a vulnerability assessment. Concerns about changing habitats and land cover were raised by participants. In addition, the project would address a need for better data management to coordinate data and entities.
- 3) Salt Wedge Early Warning System

- The scope of this project would include research to better understand the salt wedge and its impacts as well as to improve understanding of the impact of drought length and severity on soils.
- 4) Inventory of Technological Resources
- A stakeholder meeting to inventory technological/biological resources for mitigating drought impacts on lands would address the low understanding of technologies that help manage lands during drought. Discussion of which technologies are acceptable for use by most stakeholders would also be a goal of the meeting.

Water and Drought Management

Kirsten Lackstrom (CISA) moderated the Water and Drought Management table which focused discussion on the impacts of existing water and drought management strategies and plans on coastal ecosystems during drought. Primary needs addressed by the project ideas generated at this table centered on improved understanding and awareness of downstream impacts of upstream water use and management as well as improved information and data to examine research questions such as salinity intrusion and impacts to the water supply, surface water-ground water interactions including groundwater recharge, and impacts on wetlands and coastal flows.

1) Research on Low Flow

- The objective of this pilot project idea was to build a comprehensive, regional understanding of how low inflows impact coastal resources. Specific components of this plan included:
 - Identification of operating rules and policies for different river basins – identify differences between in stream [and downstream] needs and operating rules [upstream]
 - Identification of existing “water budgets” for water availability and water use
 - Identification of thresholds, i.e. at what low flows should actions be taken, what are the projected impacts at a given threshold or action level
 - Data mining: Exploring previous research/existing datasets to avoid duplicating efforts

2) Groundwater Monitoring and Management

- Monitoring and research to improve understanding of drought impacts to groundwater was presented as a pilot idea in order to improve available information and data to examine research questions such as: salinity intrusion impacts on water supply; surface water – groundwater interactions including groundwater recharge; drought impacts on wetlands and coastal flows. In addition, more effective monitoring of groundwater could also be used to understand connection to ENSO to be used for drought early warning.

3) Drought Communication Strategies

- The Water and Drought Management table participants also reiterated the need for improving communication and awareness, with the focus of this discussion on providing information about hydrological systems. In particular, the need to communicate the importance of considering groundwater and surface water as a combined system to water users was noted. In addition, improving communication with sectors that are not

reached effectively, and with small scale water suppliers in order to assist in efficient water pricing were cited.

Economic Impacts of Drought on Coastal Lands

Guided by Rick DeVoe (SC Sea Grant Consortium) participants at the economic impacts World Café table discussed the impacts of drought on ecosystem services and how they contribute to economic impacts to businesses, industries, and resource users in coastal areas.

- 1) Documenting Health Costs Related to Drought Impacts
 - Specifically, this pilot project would focus on drought impacts to such things as air and water quality, which could in turn lead to public health issues. This discussion reiterated the importance of a greater understanding of these potential threats as Geoff Scott described during his presentation on the first day of the workshop. The ability to aid decision makers in developing planned response to these threats would be a key benefit of this research.
- 2) Drought Influence on Economic Viability of Energy Generation
 - The potential for drought to affect energy generation in the Carolinas is influenced by the use of water resources for hydroelectric and nuclear power in the region. Identifying which specific drought impacts would have potential to affect energy generation and using this information to develop and implement a statewide/regional energy plan were the objectives of this pilot idea. Participants noted that future energy development will be a significant driver for water consumption and a plan is key for sustainability.
- 3) Putting a Dollar Value on Drought Impacts
 - A multi-sector economic assessment of drought impacts on coastal resources would include components such as a cost-benefit analysis of impact vs. response, review of the economic ‘chain’ of drought effects, and linking various existing datasets for a more comprehensive understanding of this issue. This could be conducted as multiple basin-scale projects. Specific sectors to assess include coastal recreation and tourism, commercial and recreational fisheries, and water supply (e.g. local communities, groundwater, surface water, salinity intrusion, agriculture, and public health issues).

Drought Early Warning Metrics & Tools

Identifying tools that already exist, tools that can be adapted or made more useful, and users and user needs were the foci of discussion at the metrics and tools World Café table led by Mike Hayes (National Drought Mitigation Center).

- 1) Bio-Hydro-Climo Database
 - Participants identified a need for a database in order to provide a central source for integrated drought data and information. In addition, the database would help to identify gaps in both data and our understanding of drought in coastal ecosystems which would lead to more focused research. This would also provide linkages between drought indicators and impacts in coastal ecosystems.
- 2) Stakeholder Needs Assessment

- Before creating new products or tools, participants identified a need to better understand exactly what tools would be most useful to the end-user. First priority for this project would be determination of different audiences who have a need for drought information and then developing an understanding of those drought information needs through either a survey or more in-depth personal interviews. This process could also be used to inform appropriate indicators, triggers and tipping points of drought.
- 3) Coastal Ecosystems Drought Monitor
 - Specifics of the drought monitor pilot project include finer spatial resolution, such as sub-climate divisions or a county scale, which would build off of earlier project ideas developed by the metrics and tools table participants (e.g. bio-hydro-climo database and stakeholder needs assessment). The emphasis during the presentation of this pilot idea was development of a sustainable process for the drought monitor rather than the final product. This process should include committed partners and regular, timely, iterative input. Participants noted a need to monitor drought that is specific to coastal ecosystems which could also be used to inform the US Drought Monitor.
 - 4) Drought Forecasting for Coastal Ecosystems
 - This pilot would be used to inform decision making in the event of drought by forecasting drought conditions or a specific drought index, dealing with the representation of forecast uncertainty, and providing an opportunity for enhancing drought representations using GIS. (This pilot idea was selected as one of the top four and is introduced in greater detail later in the report).
 - 5) Drought Impact Reporting
 - This project idea focused on contributions of the public and stakeholders to report and archive drought impacts through citizen science platforms such as CoCoRaHS, the Community Collaborative Rain, Hail, and Snow Network. Added benefits here would be improvement of monitoring, building stakeholder awareness and engagement, and building linkages between drought indicators and impacts. Current understanding about impacts and economic benefits of preparedness activities related to the NIDIS pilot, drought mitigation and planning strategies were noted as needs and gaps which would be addressed by the project. (This pilot idea was selected as one of the top four and is introduced in greater detail later in the report).

Ties to Climate Change Adaptation

Linda Rimer (EPA Region 4) led this World Café table which worked to identify potentially useful connections between drought response/early warning pilot projects and climate change adaptation planning. Overarching needs and gaps identified by table participants included incorporation of the ‘climate question’ in future planning (i.e. planning which includes possible future climate scenarios), development of information for models that have designated end-users, translation of science into actionable items, and identification of existing resources for collaboration.

- 1) Incorporating Future Climate Scenarios in Planning
 - Suggested specific projects for this pilot idea were inclusion of future climate scenarios in local government hazard mitigation planning and fisheries management. This pilot addressed the larger need to ask the ‘climate question,’ meaning that such plans should

include not just planning based on historical data and information, but projections for the future as well. Translation of climate science into information which is useful for decision makers when developing these types of plans was noted as a key component to any project undertaken here.

2) Updating Tools used for Future Planning

- This project idea was suggested as a result of the first project idea above to include future projects in planning. Specifically, the option to update 7Q10, which is the lowest 7-day average flow that occurs on average once every 10 years and is used to inform NPDES permitting and water management planning, was identified as a possible tool to update.

3) Inventory of Monitoring Projects

- Similar to other projects suggested at multiple other World Café tables, this pilot idea addressed the need for a clearinghouse of data and information relevant to drought indicators and impacts which would be useful to decision makers and planners. The importance of user-friendly search engine was highlighted by table participants in order to make the tool as useful as possible.

Pilot Project Selection Process

Initial Selections for Pilot Projects by Table Topic

After each World Café table topic presentation, voting was held to determine the highest level of interest among the pilot project ideas for that topic. Voting was conducted using the Turning Technologies Audience Response System. Using a combination of clickers for participants, a wireless receiver, and custom software, participant responses are integrated in real time into an active PowerPoint presentation. Initially, it was anticipated that the top two project choices for each topic would move forward for consideration in final voting rounds. However, several tables developed project ideas which ranked relatively closely among participants. In these instances, the top three choices were brought forward for consideration. Below are the 17 pilot projects which received the highest level of interest after each moderator presented his/her table’s ideas (Table 2).

Table 2. Initial Shortened List of Pilot Project Priorities

World Café Table Topic	Pilot Project Idea – Participant Top Choices
<i>Improving Understanding of Ecosystem & Species Impacts</i>	<ul style="list-style-type: none"> • Evaluation of Drought Indicators/Indices • Ecosystem resilience to human impacts in the presence of drought • Drought Sensitivity Index
<i>Public Health Risks</i>	<ul style="list-style-type: none"> • Effect of Water Quality Degradation on Vulnerable Coastal Communities • Seafood Safety Forecast
<i>Impacts & Management Strategies for Coastal Lands</i>	<ul style="list-style-type: none"> • Development of Best Management Practices to Address Drought Management Issues • Research on Habitat Change Influenced by Drought • Salt Wedge Early Warning System
<i>Water & Drought Management</i>	<ul style="list-style-type: none"> • Research on Low Flow

	<ul style="list-style-type: none"> • Groundwater Monitoring & Management
<i>Economic Impacts of Drought</i>	<ul style="list-style-type: none"> • Drought Influence on Economic Viability of Energy Generation • Putting a Dollar Value on Drought Impacts
<i>Drought Early Warning Metrics & Tools</i>	<ul style="list-style-type: none"> • Stakeholder Needs Assessment • Drought Forecasting for Coastal Ecosystems • Drought Impact Reporting
<i>Ties to Climate Change Adaptation</i>	<ul style="list-style-type: none"> • Incorporating Future Climate Scenarios in Planning • Updating Tools used for Future Planning

Participant Voting and Selection of Pilot Project Ideas

In order to narrow the field to the top three or four pilot project ideas during the afternoon of Day 2, participants were asked to vote for their top 3 choices out of the 17 chosen during the morning moderator presentations. Several rounds of voting were conducting during this session.

Ultimately, *Evaluation of Drought Indicators/Indices*, *Seafood Safety Forecast*, *Drought Forecast Communication*, *Drought Impact Reporting* project ideas received the highest levels of support. Lisa Darby indicated that a top four was acceptable for NIDIS and moved to develop next steps and nominations for steering committee members for these project ideas. Pilot project ideas which were not selected during this voting process will be considered for incorporation into the final iteration of each project. The individual pilot steering committees and stakeholders of each individual pilot will be working to refine these projects. Lisa Darby will coordinate efforts for initial steering committee calls and determination of viable stakeholders for each pilot project. The following sections describe each of the selected pilot projects in more detail.

Selected Projects

Evaluation of Drought Indicators and Indices

Many of the commonly used drought indices were not developed with the unique characteristics of coastal ecosystems in mind. There are drought indices and indicators for agriculture, reservoir management, and water supply, among others, but there is no similar set for coastal ecosystems. Predicting the onset, intensification and demise of a drought could be improved with more knowledge of drought indicators and indices in coastal ecosystems. The goals developed by workshop participants for this particular pilot project include determining which current drought indicators and indices are appropriate for assessing drought in coastal ecosystems, and investigating the benefits and feasibility of creating a drought index based on real-time salinity data.

This pilot offers potential synergies with all three of the other pilot projects. Collaboration with the *Drought Impact Reporting* pilot provides opportunities to relate indicators and indices to drought impacts in coastal ecosystems. Collaboration with the *Drought Forecast Communications* group may allow for communication of findings on best practices for using drought indicators and indices. In addition, this pilot may be positioned to determine appropriate drought indicators and indices to use for a seafood safety forecast.

Next steps in the development of this pilot as suggested by workshop participants include determining the scope of the project, which might include a specific geography or ecosystem type or may be based on data availability, among other parameters. In addition participants suggested a review of existing research and available data to build upon.

Seafood Safety Forecast

During drought, freshwater flows are reduced and water temperatures rise. Impacts of these changes include: increases in concentrations of pollutants; increases in salinity; changes in pH; increases in harmful algal blooms (HABs); increases in shellfish predator populations; increases in *Vibrio* bacteria and Cyanobacteria. All of these changes, among others not listed here, can have harmful effects on seafood. The *Seafood Safety Forecast* pilot project would aim to provide an early warning system for commercial, recreational and subsistence fishermen who harvest drought-sensitive seafood in both fresh and salt waters in the coastal regions of the Carolinas.

As mentioned previously, the *Evaluation of Drought Indicators and Indices* pilot project may provide a very useful synergy with this project in determining those most useful for a seafood safety forecast. Next steps for this project may include communication with fishing groups to determine specific needs, which may be coordinated through a stakeholder workshop, and development of a monitoring system, or determination of an appropriate existing system, to monitor and analyze conditions that affect seafood safety.

Drought Forecasting for Coastal Ecosystems

Numerous drought, hydrometeorological and climate products are available to stakeholders in the Carolinas. However, stakeholders may not be aware of all products which are available, may not have the products they need to make decisions (i.e. the regional or temporal scale may not be adequate), or may not know the best way to tailor the products to their region or situation. This pilot project idea was designed by workshop participants to focus on introducing stakeholders to current products used for drought forecasting and ascertaining what additional drought forecasting products stakeholders need and what time scales are of most interest to them. One specific recommendation from participants during the World Café session which developed this pilot idea was the need to determine the best way to deal with uncertainty resulting from forecast data, including how uncertainty is conveyed to stakeholders.

Next steps identified at the workshop include an initial assessment of stakeholder needs in a drought forecast. This would include a better understanding of what forecast and outlook products are currently being used, what forecasting gaps need to be filled, time scales of information needs (e.g. daily, weekly, monthly, seasonally) and any sector-specific information needs.

Participants also noted the significant outreach component which would be necessary for this project. Determining the best methods to relay information about drought forecasting tools was noted as a key next step in project development as well.

Drought Impact Reporting

Participants identified many possible benefits of improving drought impact reporting to include improved drought monitoring, building stakeholder awareness and engagement, and building linkages between drought indicators and impacts. The current understanding of drought impacts and economic

benefits of preparedness activities related to the NIDIS pilot, and mitigation and planning strategies were noted by workshop participants as needs which should be addressed. The overarching goal suggested by participants for this project will be to assess ways in which drought impacts might be monitored through stakeholders and citizen science and to investigate ways to improve the communication of coastal ecosystem drought impacts. Current examples of impact reporting tools include: the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS⁷), which already includes drought impact reporting; the National Drought Impact Reporter⁸; the National Phenology Network⁹; and the state of Arizona's drought impact reporter¹⁰.

Next steps for this project suggested during the workshop include understanding what information is needed by the North Carolina Drought Management Advisory Council and the South Carolina Drought Response Committee in order to improve their drought assessments. Additionally, identification of other groups/stakeholders which might benefit from drought impact reporting was suggested. This will guide the choice of specific groups of stakeholders with whom the steering committee might engage to participate in impact reporting or development of baseline observations in the absence of drought conditions. A key point made at the workshop was the necessity to provide a benefit to stakeholders who contribute to the drought impacts reporting system. Suggestions for developing understanding of specific stakeholder drought information needs included a workshop or webinar, or informal interviews.

It was mentioned several times at the workshop that there needs to be a way to relate drought indicators and indices to drought impacts. The work from this project may also become a key component in the *Drought Indicators and Indices* project. Increased reporting of drought impacts could also enhance the work of the *Seafood Safety Forecast* project.

Next Steps

Many attendees at the Wilmington Workshop volunteered to be on the planning committees for the pilot projects. Committee members will also identify additional experts to recruit for each pilot to ensure adequate expertise to carry out project goals.

Initial steering committee conference calls to brainstorm ways in which each project may develop will be the first step in moving these pilot projects forward. Objectives for these calls include setting potential goals and deliverables, identifying stakeholder groups who may be interested in participating in the projects and identifying who will lead project activities.

Once the committees have decided on the details of the project, they will each develop an action plan that states the goals, workshop needs, deliverables, estimated deadlines, project leaders, project budget, and metrics for success.

The Drought Early Warning System Scoping Workshop was successful in making substantial progress in identifying key needs and pilot projects to address them. Collaboration among participants as well as

⁷ <http://www.cocorahs.org/>

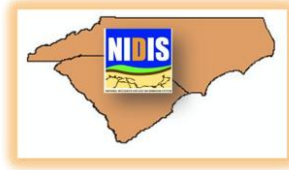
⁸ <http://droughtreporter.unl.edu/>

⁹ <http://www.usanpn.org/>

¹⁰ <http://azdroughtwatch.org/>

other stakeholders will continue in order to ensure pilot projects advance the regional ability to cope with drought in Carolina coastal ecosystems.

Appendix A: Workshop Agenda



Carolinas Drought Early Warning Scoping Workshop

*Tuesday, July 31-Wednesday, August 1, 2012
Hilton Wilmington Riverside Hotel, Wilmington, NC*

Tuesday, July 31

- 8:30 a.m. Check-in and continental breakfast
- 9:00 Welcome and Introductions
*Lisa Darby, National Integrated Drought Information System
Kirstin Dow, Carolinas Integrated Sciences & Assessments*
- 9:15 Background on the National Integrated Drought Information System: “What is a Drought Early Warning System”
Lisa Darby, National Integrated Drought Information System
- 9:45 Drought and coastal ecosystems – previous work by CISA
*Kirsten Lackstrom, Carolinas Integrated Sciences & Assessments
Dan Tufford, Carolinas Integrated Sciences & Assessments*
- 10:00 Public lands and drought
Ed Christopher, Pocosin Lakes National Wildlife Refuge
- 10:20 – 10:40 Break**
- 10:40 Salinity intrusion
Paul Conrads, USGS South Carolina Water Science Center
- 11:00 Ecological and human health threats related to drought in coastal systems
Geoff Scott, NOAA Center for Coastal Environmental Health and Biomolecular Research
- 11:20 Drought in the Carolinas
*Ryan Boyles, State Climate Office of North Carolina
Hope Mizzell, South Carolina State Climatology Office*
- 11:45 Discussion, Questions and follow-up to presentations
Introduction to afternoon sessions: World Café process
Small-group sessions designed to identify priority needs and possible pilot project activities:

Ecosystem Impacts	Water Management
Ecosystems & Public Health	Economic Impacts
Drought Early Warning Metrics & Tools	Education & Communication
Impacts and Strategies for Coastal Lands	Ties to Climate Change Adaptation

12:30 – 1:30

Lunch

1:30 World Café Session 1

2:00 World Café Session 2

2:30 World Café Session 3

3:00 – 3:15

Break

3:15 World Café Session 4

3:45 World Café Session 5

All tables to discuss pilot project selection criteria and metrics for success

4:15 Pilot selection criteria and metrics for success: Report back and discussion

5:15-5:30

Break

5:30 – 6:30 Happy Hour and hors d'oeuvres

Wednesday, August 1

8:30 a.m. Continental breakfast

9:00 Review selection criteria and metrics for success; goals for the day

9:15 World Café reports

10:35 – 10:50

Break

10:50 World Café reports

12:15 – 1:00

Lunch

1:00 Develop list of pilot project priorities

2:30 Next steps and wrap-up

3:00

Adjourn

Appendix B: List of Participants

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