A Proposal to Scale from a Regional to a National Webcam COastal Observation System (WebCOOS)

Principal Investigator:
Debra Hernandez, Executive Director
SECOORA
PO Box 13856
Charleston, SC 29422
P: 843-906-8686
E: debra@secoora.org

Financial Representative:
Megan Lee, Chief Financial Officer
SECOORA
PO Box 13856
Charleston, SC 29422
P: 843-864-6755
E: mlee@secoora.org

PROJECT DURATION: Three years

FUNDING TYPE: Cooperative Agreement

APPLICANT TYPE: Non-profit

FUNDING REQUEST BY YEAR: Year 1: $398,532; Year 2: $397,463; Year 3: $399,351

TOTAL FUNDING REQUEST: $1,195,347

Table of Contents

Project Title: A Proposal to Scale from a Regional to a National Webcam Coastal Observation System

Primary Contact: Debra Hernandez, Executive Director, SECOORA, PO Box 13856, Charleston, SC 29422, P: 843-906-8686, E: debra@secoora.org

Primary Recipient Institution: Southeast Coastal Ocean Observing Regional Association (SECOORA)

Other Investigators: Scientific Principal Investigator Joseph Long, UNC Wilmington; Dwayne Porter, University of South Carolina; Alex Pang, University of California Santa Cruz; Kyle Wilcox, Axiom Data Science; Greg Dusek (collaborator), NOAA COOPS

Brief Project Summary: The ability to observe the coastal environment is growing increasingly critical as coastal hazards such as high tide flooding, rip currents, coastal storms and erosion continue to impact the growing populations living in our nation's coastal communities. These impacts affect community economies, safety, and public health. Communities need more coastal environmental observations, and webcams are being used to deliver them. As any web-search will reveal, webcams have become ubiquitous along our beaches, within our urban coastal communities and along waterways and transportation corridors. They are inexpensive, easy to install, and low maintenance. Though traditionally used to monitor surf conditions, to watch the weather at the pier or boardwalk or monitor traffic congestion, webcams have increasingly been utilized by the scientific community to collect a wide range of environmental observations (see: Dusek et al., 2019 and the references therein). Over the past five years, the Southeast Coastal Ocean Observing Regional Association (SECOORA) and partners have successfully piloted and transitioned to operations a coastal webcam network for the Southeast US. The network, known as WebCOOS, streamlined the collection, storage, and access to real-time and historic webcam imagery and enables image analysis and development of derived products that can be used for decision-making. These derived products, developed with open source artificial intelligence (AI) machine learning (ML) or pixel intensity thresholding algorithms, show rip current locations, dune overwash, shoreline erosion, beach usage, and flood monitoring - all critical information needs of ocean and coastal managers. This WebCOOS infrastructure can be leveraged

to scale up to a national webcam network and provide a transformational, cost-effective, multi-use observing network. In fact, the estimated resource requirements to initiate and maintain a national webcam network are miniscule compared to nearly any traditional observing network. For these reasons, we propose pursuing a national WebCOOS implementation. WebCOOS progressed the Southeast regional network by developing and implementing standard protocols for webcam sensor installation and operations, data management, algorithm development, and image and video processing. In the upcoming final months of the project, products will be available for users to aid in decision making. Engaging the network of IOOS Regional Associations (RAs), this project will transition WebCOOS from RL 6, (*Demonstration of a prototype system)* to RL 8 (*Finalized system shown to operate within user's environment; user training and documentation completed*). This transition will benefit partners (IOOS RAs; NOAA; USGS; USACE; academics, etc.) by expanding the number of webcams and spatial coverage of the WebCOOS infrastructure to locations with critical coastal observing gaps across the coastal US and Great Lakes. This will dramatically lower cost and effort required to collect webcam observations in other IOOS RAs, and better enable a sustained national webcam capability. This transition will benefit users such as coastal communities, emergency managers, beach safety personnel, public health officials, weather forecasters, and researchers by providing easy access to standardized coastal webcam observations that would be otherwise not available.

Name and affiliation of the Transition Manager: Megan Treml, Independent Contractor, SECOORA

Partners: AOOS Sheyna Wisdom, wisdom@aoos.org, CariCOOS Patricia Chardón-Maldonado, Ph.D. patricia.chardon@upr.edu; CeNCOOS Henry Ruhl, hruhl@mbari.org, GCOOS Jorge Brenner, jorge.brenner@gcoos.org; GLOS Ana Sirviente, ana@glos.org; MARACOOS Gerhard Kuska, kuska@maracoos.org; NANOOS Jan Newton, janewton@uw.edu and Roxanne Carini, rjcarini@uw.edu; NERACOOS Tom Shyka and Jake Kritzer, jake@neracoos.org; PacIOOS James T. Potemra, jimp@hawaii.edu; and SCCOOS Clarissa Anderson, cra002@ucsd.edu

Project Description

A. Goals and Objectives

The organizational structure of a national WebCOOS implementation would be like what has been implemented for other observing networks, i.e., gliders and high frequency radars implemented within the US IOOS framework. SECOORA will contract with an operations manager or company to serve as the primary logistics and operations coordinator for the national network. The webcam hardware and associated operations and maintenance would either be the responsibility of the funded private company, or of the RAs in which the webcams reside. The components housed within SECOORA would include: Data Assembly Center (DAC); website hosting, including operations and maintenance; technical support; and project coordination.

The RAs will be responsible for leveraging local partnerships to host the webcams, and coordination of webcam installs within their regions. This can include identifying and utilizing cameras of opportunity, which may require no additional funds. RAs will identify and engage with users and potentially partner with academic institutions to develop RA-specific webcam products beyond the standard WebCOOS suite. Newly developed webcam products could be incorporated as part of the national WebCOOS system if there is broad applicability and interest. The developer of any new webcam products would be responsible for quality assurance and quality control (QA/QC) for those products. RA responsibilities in detail are to:

- Conduct user engagement within the regions
- Identify and coordinate partner webcam opportunities
- Coordinate the installation of new webcams
- Participate in two technical meetings to refine standards and operating procedures, and discuss user needs for products

- Provide links/pointers to webcoos.org from their websites or portals
- And may host web pages or apps supporting specific user groups or communities

The goal for this project is to: Transition WebCOOS to a sustained, national network hosting multiple webcams from each RA integrated into the publicly accessible WebCOOS system providing long-term access to historical and real-time coastal webcam observations and products. The primary objectives are to 1) Identify locations for and install webcams, or integrate cameras of opportunity, in all IOOS RAs; 2) Apply open-source AI/ML and thresholding algorithms to newly installed webcams and convene to determine new applications of the data; and 3) Refine webcam installation and operation procedures, data management SOPs, and develop training materials to ensure transferability and continuity of operations.

B. Background

The idea for WebCOOS originated from the NOS-funded Webcam Coastal Application Testbed (WebCAT), which started in 2017 as a public-private partnership between NOAA, SECOORA, USGS, Surfline Inc. and the University of South Carolina (Dusek et al., 2019). The initial WebCAT project provided a proof-of-concept for deploying webcams and providing both real-time and historic video imagery for a wide-range of research use cases. The focus of this initial effort was to install and operate webcams for specific science use cases, and determine how to transmit, store, and disseminate video footage. The project team also completed a workshop in 2018 with partners and users to better understand requirements of a webcam network, should the project continue past the initial pilot stage.

In 2020, the project team was awarded $1.15m over three years as an Integrated Ocean Observing System (IOOS) Ocean Technology Transition (OTT) funded project to transition the initial WebCAT prototype into an operational network in the Southeast known as WebCOOS. Operational for our purposes is delivering live and historical webcam data and any derived products with a target uptime of 85%. The focus of this three-year project (WebCOOS Phase 1) was to develop an operational webcam

coastal observing network in the Southeast for scientific analysis, public safety and health, and resource management for coastal communities. See Figure 1. Objectives are focused on:

1. Engaging with partners and users on webcam installation and product generation
2. Operationalizing a regionally scalable data management network, with a 85% uptime goal
3. Automating processing of imagery to assess beach usage, rip currents, and shoreline change and dune erosion
4. Packaging imagery products into decision-support tools for coastal communities (in progress)

In addition to the project team's efforts to operationalize the WebCOOS network in the Southeast, several webcams from other RAs including Waikiki (PacIOOS), Point Reyes, CA (CenCOOS), and Holland Beach, MI (GLOS) have been incorporated. These webcams demonstrate how WebCOOS can be broadly applicable and how once the network infrastructure is developed, expansion is easily implemented. Also in process is deployment of a new application that differentiates between seals and sea lions using the feed from CeNCOOS as an example of how WebCOOS might be expanded with new types of algorithms and analysis to serve additional science and community needs.

Figure 1: Images captured of Hurricane Ian coastal impacts by WebCOOS.

C. Audience

We will engage two tiers of users: 1) project partners that are committed to long-term use of image-based products, and 2) user groups that include environmental resource managers whose operations benefit from derived webcam products. Tier 1 users include NOAA National Ocean Service and National Weather Service, U.S. Geological Survey, U.S. Army Corps of Engineers, who were engaged in the WebCAT and WebCOOS efforts and are established users of webcam imagery. Tier 2 users are groups such as coastal communities, beach safety personnel, emergency managers, public health officials, and environmental resource managers. These users have an interest in the imagery and products but may not be familiar with the technical aspects of the project and generally do not perform their own analysis work. Examples of current WebCOOS Tier 2 users include Currituck County, NC; Jennette's Pier, East Carolina University; Lowcountry Alliance for Model Communities, Charleston Citizen Research to Action Board, the Rosemont Neighborhood Council in Charleston, SC (See Figure 2); and The Marine Mammal Center in California.

Figure 2: Flooding in the Rosemount Community in Charleston, South Carolina during Hurricane Ian captured by a WebCOOS webcam. WebCOOS monitoring before, during, and after Hurricane Ian is providing critical data for Rosemont leaders and residents to strengthen the community for disaster risk reduction, response, and recovery.

D. Approach

Objective 1: Identify locations for and install webcams, or integrate cameras of opportunity, in all IOOS RAs.

The types of webcams utilized in the network will fall within two categories: WebCOOS supported webcams, which are installed by the team to meet a specific user need, and cameras of opportunity, which are pre-existing webcams integrated into the system. *WebCOOS supported webcams* can include webcams that are entirely funded and supported by WebCOOS, webcams that include partial WebCOOS support (e.g., hardware funded by WebCOOS and installation and operations and maintenance funded by a partner), or webcams that are entirely partner supported (e.g., an RA or partner completely funds webcam installation for the purpose of including it within WebCOOS). *Cameras of opportunity* are pre-existing webcams for which the webcam location and view is potentially beneficial to some coastal application, environmental management, or scientific question. These could be webcams with existing beach views, water views, frequently flooded infrastructure views, animal or coastal environment views, harbor, channel, or road traffic monitors. Project funding will support installation and/or streaming of an estimated of 20 additional webcams in Year 1, and continued operation of 17 existing webcams by SECOORA; 20 additional webcams in Year 2, and continued operation of 37 Year 1 webcams; and 20 additional webcams in Year 3 and continued operation of 57 Year 1 and 2 webcams. Webcam stations cost between $250 and $5000 each, and operation costs vary depending on availability of power and internet.

1.1 Determine user need (applications) for webcams: Determining where webcams are needed throughout a region is a critical first step in this project and requires engagement with both Tier 1 and 2 users. RAs will work with users to determine locations for new webcams, or for locations of existing cameras of opportunity to integrate. They will use existing outreach material which describes WebCOOS and the steps needed to

share video with the network. For each webcam, RAs will document user needs for products that support local decision making.

1.2 Train RA PIs or staff on site selection, installation, and operation techniques: In Year 1, we will hire an operations manager or private company who can support all RAs in the identification of appropriate webcam hardware and locations, guide webcam installation, and help integrate webcams into the WebCOOS data management system. As seen in other national level observing systems (high frequency radar, gliders) this type of technical resource is critical to expedite implementation. The operations manager will leverage lessons learned from the Southeast implementation to ensure efficiency in integration of new webcams. The operations manager, as well as WebCOOS PIs, will support a technical workshop in Year 1 focused on webcam installs, products, and standards. Attendees will include designated representatives from each RA, Tier 1 Users, and project PIs. This Year 1 workshop will build expertise in the regions to support future installations and streamline data ingestion.

Objective 2: Apply open-source AI/ML and processing algorithms to newly installed webcams and convene to determine new applications of the data.

2.1 Test existing algorithms on new webcam images and video: WebCOOS Science PIs (Long, Pang, and Porter) have spent the past 3 years developing AI/ML and pixel intensity thresholding algorithms for applications to: identify rip currents, track beach erosion and wave runup (Figure 3), and perform object counting (people, vehicles, and wildlife). The operation manager and data manager will help PIs develop automated validation tests to make sure PI algorithms are working as expected on new webcams. Axiom Data Science is the WebCOOS data manager, and is responsible for providing software engineering and cyberinfrastructure support, working with webcam providers to ingest webcam data feeds via direct communication with webcams or webcam provider systems, working with PIs to integrate processing algorithms and webcam products, and maintaining the WebCOOS-branded data portal to show real-time webcam data feeds and archives of raw or processed webcam products, indexed by location, time, and

variable. The PIs will test their algorithms on images and video, QA/QC the derived/analysis products, and adjust the code if necessary, based on the results of the QA/QC. The PIs may also be involved in initial evaluation of webcams to determine appropriateness for their specific application. At the end of Year 2, WebCOOS will add derived products from the new webcams into the webcoos.org product pages to expand its geographic scope.

2.2 Host a workshop to explore new webcam uses and applications: While the network has existing science applications as noted above, there are numerous other coastal and ocean management decisions and applications that can be supported with the imagery and data from webcams. Partners in the Great Lakes are interested in ice flow monitoring. On the West Coast, there is interest in marine mammal identification and counting. In the mid-Atlantic, there is interest in additional flooding products. To sustain the network in the long term, investigating these additional applications is critical. The project manager, working with the team, will host an all-RA workshop focused on current products from webcam data (e.g., rip current identification, object identification, shoreline erosion) and potential new applications (e.g., marine mammal monitoring, ice monitoring, HAB detection) in Year 2 to strategize development of new products, and identify regional and national priorities.

Figure 3: Example of overwash detected using brightest pixel image product during Hurricane Ian.

Objective 3: Refine webcam installation and operation procedures, data management SOPs, and develop training materials to ensure transferability and continuity of operations*:* After learning from the experiences of installation in Year 1, the operations manager and data manager will develop community-reviewed technical documentation for webcam installation procedures, data pipeline and

management protocols, FAQs, and Getting Started guides. These standard operation procedure (SOP) documents will assist with the installation and maintenance of additional webcams in all regions in Years 2 and 3, and support the transferability and long-term sustainability of the system.

While webcam installs, maintenance, and product delivery will continue, Year 3 will largely focus on the shift to RL8. A transition plan developed throughout the first two years in collaboration with the IOOS program office will be reviewed and finalized. The focus of the transition will be on integrating webcam data from RAs throughout the nation into a WebCOOS Data Assembly Center (DAC).The operations manager will travel to individual RAs to finalize technical documentation, document example uses, and train RAs on the entire process - from location identification through product delivery. The goal of this outreach in Year 3 will be to ensure each RA can continue to add webcams as funding allows without the support of an operations manager.

Throughout the project, in addition to the activities of the operations manager, a project manager will organize and facilitate team meetings, develop website content, support outreach efforts around, assist with workshop agenda development and facilitation, develop progress reports, and facilitate the development of a transition plan. The WebCOOS data manager will also be engaged in each step of the project, with a focus on webcam integration, data ingestion, display, standards development, testing environments, documentation, and ensuring reliability.

E. Benefits

WebCOOS Phase 1 has successfully demonstrated webcams as a source of critical environmental observations, and is transitioning the technology from research to operations within the SECOORA region. WebCOOS Phase 1 has already developed infrastructure scalable to a national webcam network. Some of the key benefits of implementing a national webcam network include:

- Meeting user requirements for critical public safety, coastal hazard and climate observations
- Monitoring a variety of coastal hazards and other activities and phenomena with a single webcam installation
- Versatility and cost effectiveness ($250 - $5000/installation) compared to traditional scientific observing sensors
- Ability to incorporate potentially hundreds cameras of opportunity that already exist in key locations throughout the country - with no new funding
- Standardization of webcam imagery data, metadata and access will promote research, broaden the use cases and ease development of downstream imagery products

"The livestream footage from the webcam at Point Reyes National Seashore is not only a valuable real-time tool for The Marine Mammal Center to help monitor our patient releases and current elephant seal rookery numbers," said Justin Hodges, Northern Range Operations Manager at The Marine Mammal Center. "The stored historic video footage gathered through the partnership with WebCOOS will also provide key data for elephant seal population counts and the timing of annual pupping season as well as aiding in reducing wildlife harassment violations during these crucial birthing and nursing times."

These benefits suggest the potential for a transformational, cost-effective, multi-use observing network.

A critical component of the WebCOOS network is ensuring that user products are delivered effectively and benefit intended users. We will use the NOAA model of service delivery developed for the NOAA Water Initiative (NOAA, 2020), which provides guidance on the critical steps needed to guide the delivery of decision support products and services.

Service delivery roles and responsibilities

Service delivery of the imagery and products will be led by WebCOOS PIs, the operations manager and the project manager. RAs will support service delivery by building relationships with regional partners and users and gathering needs to help define WebCOOS technical requirements.

Defining the cycle for service delivery

The cycle for service delivery will loosely follow the cycle defined in the NOAA Service Delivery Framework (Figure 4) and consist of the following steps:

Figure 4. A reproduction of Figure 1 in NOAA (2020), which visualizes the components of service delivery that WebCOOS will employ to ensure effective product and service delivery.

Building WebCOOS user relationships (Build): The project team and RA's will be responsible for continuing existing and building new user relationships. This is critical for finding and incorporating cameras of opportunity as well as for the installation, operations and maintenance of new webcams. These relationships will also enable the gathering of user needs for video imagery and resultant products.

Gather user needs (Gather): User needs will be collected on a regular basis and documented, including needs for specific webcam installations, needs for how to access and deliver imagery, and needs for development and delivery of products.

Defining technical requirements (Translate, Assess): A key element of the project will be translating user needs into technical requirements and then assessing these requirements to prioritize ongoing WebCOOS product development.

User outreach and training (Deliver): The operations manager will develop outreach and training materials, and will train and then rely on RAs to help deliver this information to partners and users within their regions.

Product evaluation (Evaluate): New products or improvements of existing products on the WebCOOS website will be regularly evaluated for accuracy, functionality, and whether they are meeting user needs.

F. Milestones

Year/Quarter	Milestone
Continuous	Install and/or integrate webcams from RAs, stream live and historic webcam data and products
Y1 Q1	Hire an operations manager
Y1 Q4	Host a technical workshop focused on webcam installs, products, and standards
Y1 Q4	Develop draft transition plan for review by partners and IOOS Program Office
Y2 Q1	Develop community-reviewed technical documentation for webcam installation procedures, data pipeline and management protocols, FAQs, and Getting Started guides
Y2 Q2	Establish QA/QC protocols for application of products to new webcams
Y2 Q3	Coordinate team / IOOS Program Office review of draft Transition Plan
Y2 Q4	Host workshop focused on current products from webcam data (e.g., rip current identification, flooding, shoreline erosion) and potential new applications (e.g., ice monitoring, HAB detection), and provide summary report of regional and national priorities
Y2 Q4	Integrate derived products from new webcams into the webcoos.org product pages
Y3 Q3	Meet with RAs to finalize technical documentation, document example users, and train RAs on the process from location identification through product delivery
Y3 Q4	Finalize Transition Plan and a technical report will that includes a cost and benefit analysis

G. Project Budget

Funding is requested to 1) install and operate webcams in all 11 IOOS RAs, 2) host technical and science workshops, and train regional partners, 3) operate and maintain a webcam DAC, and 4) establish and implement QA/QC on new webcam data streams for application of analysis, AL/ML and pixel intensity thresholding products. Details are provided below and in Appendix 4.

WebCOOS Budget

		Year 1	Year 2	Year 3
SALARY & FRINGE		$ 2,666	$ 2,799	$ 2,939
TRAVEL		$ 24,520	$ 24,520	$ 9,000
SUPPLIES: Webcam Installation		$ 60,000	$ 60,000	$ 60,000
CONTRACTS:	Ops Manager	$ 80,000	$ 80,000	$ 80,000
	Project Manager	$ 21,420	$ 22,491	$ 23,616
	Data Manager (Axiom)	$ 80,000	$ 80,000	$ 80,000
OTHER:	Workshop expenses	$ 7,800	$ 7,800	$ -
	Webcam O&M	$ 15,000	$ 28,000	$ 51,000
	Subaward: UCSC	$ 25,562	$ 26,645	$ 27,794
	Subaward: USC	$ 25,790	$ 25,956	$ 26,127
	Subaward: UNCW	$ 26,834	$ 26,582	$ 26,582
	Admin fee	$ 3,000		
IDC		$ 25,941	$ 12,670	$ 12,294
TOTAL		$ 398,532	$ 397,463	$ 399,351
GRAND TOTAL				**$ 1,195,347**

H. Literature Cited

Dusek, G., D. Hernandez, M. Willis, T.C. Vance, J. A. Brown, J.W. Long and D.E. Porter, (2019). WebCAT: Piloting the development of a web camera coastal observing network for diverse applications. Frontiers in Marine Science. doi: 10.3389/fmars.2019.00353

National Oceanic and Atmospheric Administration (NOAA), Water Initiative, (2020). A Model of Service Delivery for the NOAA Water Initiative: A Proven Method for Integrating Decision Support and Service Delivery. Authored by the NOAA Water Team.