Launching WebCOOS: Webcams for Coastal Observations and Operational Support

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Project Title: Launching WebCOOS: Webcams for Coastal Observations and Operational Support

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Brief Project Summary: Significant gaps exist in the nation's ability to monitor and accurately forecast various weather, ocean, ecological and public health hazards that have the potential to impact people, places, economies and environments. Gaps are especially apparent in the coastal environment and include both the availability of observations and the skill in modeling complex weather, ocean and ecological phenomena. One promising observing approach to address these gaps is the use of web cameras (webcams). They are ubiquitous, low cost and underutilized coastal observing platforms (Dusek, et. al. 2019). The operation and maintenance of webcams is substantially lower than in situ instrumentation and a single stream of webcam imagery can be used to provide a variety of data types. For instance, webcam imagery enables the identification of specific coastal processes or features (e.g. rip currents, wave runup) and quantification of beach use statistics through the use of Artificial Intelligence (AI) and Machine Learning (ML). This proposal builds on the success of the NOAA funded Web Camera Application Testbed (WebCAT) to transition to a sustained network of Webcams for Coastal Observations and Operational Support (WebCOOS).

The objectives of the project will progress the network and its products to near RL 9 by establishing standards for webcam sensor installation and operations, data management, AI/ML applications to image and video processing, and delivery of training and products to end users for

decision making. The results will have immediate benefits to both partners (e.g. NOAA, USGS, USACE) and end users (e.g. environmental resource managers, public safety officials, tourism officials and public health officials), as there will be critical coastal observations where presently very limited or no observations exist. Other benefits include supporting the validation and improvement of the NOAA rip current forecast model; joint USGS-NOAA forecasts of total water level and coastal change; and the development of tools to assess beach usage, beach and surf zone conditions and water quality for swimmer safety and shellfish harvesting.

Transition Manager: Debra Hernandez, SECOORA

Partners: Our team includes partners with key roles in project implementation. Details of roles and leveraging activities are described in the Letters of Support collected in the Appendix and briefly described here. Katherine Brodie and Brittany Bruder, U.S Army Engineer Research and Development Center, will provide guidance on quantitative image processing and leverage ongoing work on a quantitative coastal imaging data portal. Jenna Brown, USGS St. Petersburg Coastal and Marine Science Center, will provide image processing expertise and camera calibration surveys. Gregory Dusek, NOAA NOS COOPS, will serve as primary NOAA collaborator leading the technical components of the rip current detection and inundation observations. Michael Churma, NOAA NWS Meteorological Development Laboratory (MDL) will leverage MDL's existing rip current reporting efforts to compare webcam imagery to rip reports. Geoff Scott and Paul Sandifer, co-Directors of the Center for Oceans and Human Health and Climate Change Interactions (OHHC$_2$I) will coordinate engagement with community partners to ensure products and training meet community needs. Melissa Ide, Deputy Director of National Estuarine Research Reserve Central Data Management Office, will provide input on requirements of NERRs managers and stakeholders for products and training.

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Project Description:

A. Goals and Objectives: The NOAA funded Web Camera Applications Testbed (WebCAT) was launched in 2017 as a public private partnership with SECOORA and Surfline, Inc. to facilitate and promote standardization of the collection of coastal webcam imagery, maximize access to data, and demonstrate the benefits of webcams for diverse end user applications (Dusek et al., 2019). We seek to build on the successes of WebCAT and progress the network and its products to near Readiness Level (RL) 9 by establishing standards for webcam sensor installation and operations, data management, AI/ML applications to image and video processing, and delivery of products to end users to aid in decision making. Our primary focus will be on addressing the bottleneck in creating actionable information from webcam videos. The development and testing of AI/ML methods will be critical in reducing the demands of existing image and video processing methods on personnel time. In addition to providing image products, the project will also establish opt-in processes for end users to access, utilize and analyze standardized webcam data streams from cameras of opportunity.

Our primary goals for this project are to 1) Engage demonstrated webcam operators and other end users; 2) Operationalize the WebCAT system to a national webcam data management network; 3) Automate and validate downstream processing of webcam data; and 4) Package image products into geographically and thematically transferable decision-support tools.

B. Background: Over the past several decades coastal imagery has become a proven and invaluable tool for remote sensing of the coastal environment. Uses for imagery data range from coastal morphological change to surf zone hydrodynamics, beach attendance and safety, and even detecting marine debris (Dusek et al., 2019). Fixed position cameras for scientific coastal monitoring have been in use since the 1980's with the Argus systems the most well-known and utilized (Holman and Stanley, 2007), along with several other systems and approaches (Pearre and Puleo, 2009; Nieto et al., 2010; Brignone et al., 2012; Taborda and Silva, 2012). These systems typically consist of one or more stationary cameras at well-elevated positions with a wide field-of-view, onsite computer for image processing and file transfer, and a set of algorithms that use individual pixels or groups of pixels for monitoring coastal features and processes.

Although use of camera systems for coastal observations has expanded with reductions in size, complexity and cost, there are challenges preventing widespread camera installation and operational use of video data. The WebCAT project helped to address this coastal ocean observing need by installing and operating several webcams capable of meeting the short-term needs of diverse users including NOAA, USGS, state health agencies, academia and others.

The WebCAT project determined methods for operational imagery collection, storage, processing, access and archival requirements to foster collaboration across research and operational user communities. As part of the pilot, seven webcams were installed at six locations along the US southeast Atlantic and Gulf coasts for a period of over 18 months. This project progressed the webcam network through RL 6 and enabled successful demonstration of imagery application for several use cases including: counting animals on the beach and migrating right whales, identifying rip currents, validating wave runup models, and understanding human use of natural resources (Dusek et al., 2019).

We propose to build upon the accomplishments of the WebCAT project to address the following specific areas of interest: 1) sensors for physical parameters, 2) potential use of cloud-based technologies and platforms, and 3) novel data management, analytics and integration to improve service delivery to customers.

C. Audience: As demonstrated by the WebCAT project, webcams are transforming how environmental monitoring is conducted with potential applications related to transportation and commerce, preparedness and risk reduction, public health, resource allocation, and stewardship of coastal resources (Figure 1). Standardization of image collection, data management, image processing, and access to situational awareness tools that coalesce these data will support a broad range of stakeholders. In this proposal, we will engage two tiers of users 1) project partners that are committed to long-term use of products, i.e. demonstrated operators, and 2) end user groups that include environmental resource managers (e.g. SC Department of Health and Environmental Control), public safety officials (e.g. City of Folly Beach), tourism officials (e.g. Town of Surfside Beach), public health officials (e.g. SC Department of Health and Environmental Control), local weather forecast offices (Wilmington, NC and Morehead City, NC) and representatives of potentially vulnerable populations (e.g. Lowcountry Alliance for Model Communities). Some of these tier 2 users are expected to become demonstrated operators.

Figure 1. One of the initial WebCAT webcams installed by Surfline Inc. in Miami, FL

Tier 1 users are project partners such as NOAA NOS and NWS, USGS, USACE, were engaged in the WebCAT effort and are established users of webcam imagery. They will be assisting with the development and operationalization of the webcam network and utilizing output from the products as detailed in the approach. The operational webcam network will provide critical coastal observations for these users including rip current occurrence, wave runup and erosion, and estimation of beach use and attendance.

Tier 2 end users are expected to use products to help inform actionable decisions related to flooding, beach usage, beach and surf zone conditions (e.g., rip currents and coastal inundation), and water quality for swimmer safety and shellfish harvesting. Tier 2 users will include users not familiar with other aspects of webcam data, and thus appropriate training will be required to ensure utilization of products correctly and effectively.

D. Approach: *Goal 1: Engage demonstrated operators (Tier 1) and other end users (Tier 2)*
Beginning in Year 1 and throughout the project, both Tier 1 and 2 users will provide guidance, input and review in support of product development, and outreach to and education of other user groups. The steps of this engagement include 1) define requirements of Tier 1 and 2 users, 2) evaluate costs of requirements, 3) develop transition plans, and 4) assess market potential and stakeholder satisfaction.

In Years 2 and 3 the Center of Excellence for Oceans and Human Health and Climate Change Interactions ($OHHC_2I$, see letter of support) will develop, assess and disseminate stakeholder-appropriate outreach and education materials (Ellis et al., 2014; Neet et al., In press; Henderson et al, In press; Friedman et al., 2015). Potential venues for distribution of materials and demonstrations of social media approaches include marinas, fishing piers, community events, faith-based institution events, and hotels/motels. In recognition of the growing Latino-speaking populations, materials will be produced in both English and Spanish.

We will identify testers within our networks which include the 11 IOOS Regional Associations, the Coastal Imaging Research Network, National Estuarine Research Reserves, local government users from Surfside and Folly Beach, SC, NOAA Weather Forecast Office (WFO) staff, and others identified during the project. A survey will be conducted to assess ease-of-use, utility of various analyses and informational products, as well as willingness to pay for webcam imagery or downstream product access or customization.

Goal 2: Operationalize the WebCAT system to a national webcam data management network

To meet the needs for improved data access and processing capabilities, this project will operationalize the functional prototype WebCAT system to provide an interactive web portal to access live webcam feeds, historical archive footage, and webcam products. This effort will leverage and expand upon the investments made by NOAA in the WebCAT prototype, including continuing to operate existing WebCAT camera installations and videos as baseline data and build on the established capabilities for data acquisition, processing, storage, metadata documentation and delivery.

Standardizing webcam imagery and metadata documentation and delivery is critical to maximize the benefit of the observing network, meet operational monitoring and modeling requirements, and to enable innovation beyond traditional research applications. As such, an end-to-end data management workflow will be applied following community-developed standards to ensure continuous integration and standardization of webcam data to provide reliable access for users of both real-time and historical data imagery and derived image products.

This project will use the SECOORA data management infrastructure to manage and share the webcam data, and will use standards and best practices defined by the NOAA U.S. IOOS Data Management and Communications committee (IOOS, 2010). The infrastructure is an operational stack of open source software components developed by Axiom Data Science, with support from IOOS and SECOORA, that manage large numbers of continuous data feeds and a data catalog framework to integrate and disseminate a variety of data products. Webcam feeds will be ingested and consolidated through a continuous data system following standards and exposed via a web portal for data exploration, analyses and distribution. Data will be standardized and stored with metadata to ensure they are available for re-use.

Web-based, server-side scripting is a functional requirement for automating and validating the processing of webcam data. The operational WebCOOS environment will utilize a Jupyter Notebooks cloud-based system that will allow partners to produce derived analytical products using Python or R scripts and execute that code on the Axiom High Performance Computing (HPC) server infrastructure. The secure Jupyter Notebook server instance, integrated within the SECOORA data system, has access to the real-time and historical webcam feeds and will be configured by project partners to conduct the downstream processing of webcam data to include standard image products and automated feature extraction, and imagery georectification in select instances. The data system will create an ingestion process to enable adding external camera imagery (e.g. cameras of opportunity) and downstream products. The operational platform will automate product creation to analyze and gain insight on coastal processes thereby reducing the current bottleneck in creating actionable information from video.

A dedicated WebCOOS portal (expanded from the WebCAT prototype) will provide an easily navigable and searchable source of real-time and historical webcam feeds and camera products, indexed by parameter, over space and time. The data will be exposed through interoperable systems and user-interface tools to enable discoverability and exploration. The portal will offer capabilities to meet end user needs including browsing raw and processed products for each site over time, displaying informational and general overview narratives about each product, providing static metadata about each camera installation, and allowing for downloads of user-specified products and time ranges for each site. Input from the project team and user audiences will be gathered to further inform the development of the final, operational portal.

Quality assurance and quality control (QA/QC) mechanisms are integrated into the

SECOORA data system workflow to ensure the best functioning tools and systems are made available. The WebCOOS system, built on the SECOORA infrastructure, will take advantage of this existing functionality. The SECOORA data center and services, operated by Axiom Data Science, are monitored 24/7 and utilize Nagios alerts when components fail. This platform has the ability to readily diagnose data interruptions and is a critical component to ensure a high-level of uptime and trust in the system.[1] Video files streaming into the SECOORA data system will have to pass gross QA checks before being disseminated to make sure the files are complete, consistent, and standardized for application in derived data products and by end users. As an additional data quality step, the availability of data streams will be visualized in the WebCOOS and SECOORA data portals to show users when data was available or when webcam feeds were down or problematic. Performance testing of the portal will also be routinely conducted to measure system load, timing of specific transactions relative to load variation, and average response times, which acts to ensure data integrity.

GOAL 3. Automate and validate downstream processing of webcam data. Though the raw I magery data have value as an end product (e.g. for weather/surf observations), the true usefulness of coastal imagery lies in its derived products. On the most basic level of processing, all 10-minute video clips will be automatically processed into snap-shots (a single frame), time-average (averaging a subsample of the clip), time-variance (variance of the subsample of the clip), and brightest and darkest pixel (highest and lowest intensity pixels of a subsample of the clip) images. Following this basic level of processing, a series of more complex analyses will be applied to the imagery to provide additional products as described below. The output from these approaches will be made available as described in Goal 2. These approaches have synergy and

[1] Since August 2018, Axiom has maintained a 99.92% uptime of the SECOORA data system.

shared development. For instance, the flow-based rip current detection approach will rely on the shoreline detection automation, and the beach usage can be combined with rip detection to assess people's exposure to hazards. Also noteworthy is that these additional analyses have the potential for significant savings of staff time e.g. via automatic classification of whether a 10-minute segment contains a rip current or not.

3.1 Automated Beach Usage Detection. Artificial Intelligence (AI) / Machine Learning (ML) software (using openly available 'tensorflow') will be utilized to perform feature extraction on camera feeds. Such feature extraction or object detection include people and objects associated with beach utilization, i.e. beachgoers, swimmers, chairs, umbrellas (Figure 2). These automated processes can continually in near real-time provide timestamped counts and movement tracking within the processed camera feed images and derive trends from those collections. These derived data will be collected and stored in a database for further utilization for tracking, notification, reporting and download purposes.

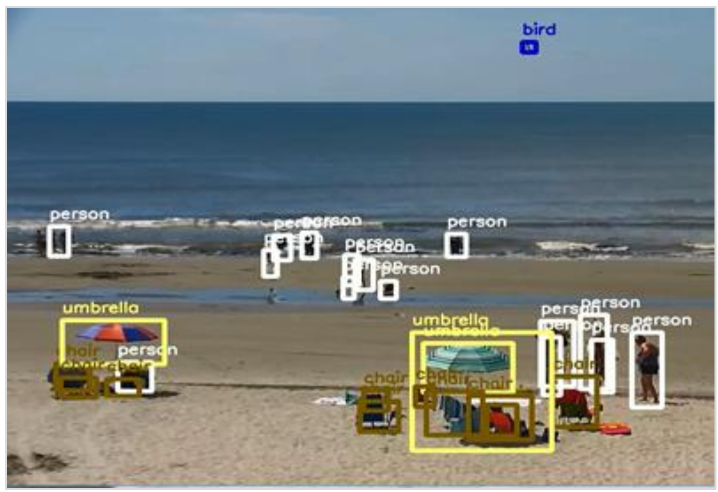

Figure 2. Example of automated feature extraction of people, animals and other beach objects.

Similar to how businesses currently or in the future could use webcam data to automatically monitor customer flows and habits to optimize their sales and transportation needs, webcams can be automatically processed to better understand crowd flow and safety for events related to beach access control and swimming advisories.

3.2 Rip Current Detection. Rip current detection will be advanced using two different approaches: (1) machine learning, and (2) flow-based analysis (Figure 3). The work will focus on the continued development of the ML approach but will incorporate as much of the flow-based approach as possible. The application of rip current detection to webcam imagery will be operationalized as a component of the WebCOOS output.

Machine Learning Identification of Rip Currents: This approach is based on training an ML model to recognize rip currents. Thus far, we have used faster Regions with Convolutional Neural Network (RCNN, Shaoqing et al., 2015) features trained on hand-labeled still images and tested on expert classified videos including those from two of the WebCAT webcams (Buxton and Miami). Initial results are very promising for rips that are characterized by flanking breaking waves. We plan to improve rip detection capabilities by: (a) investigating bounding box alternatives such as oriented bounding boxes and region based labelling that can provide a tighter fit and hence more accurate rip identification; (b) investigating variations of the rip detection metric that take persistency of features across frames into account; (c) adding more training still images to recognize other types of rips, (e.g. characterized by water discoloration, foam, etc.), and investigating training with video clips to enable the model to learn about *behavior* instead of just *appearance*.

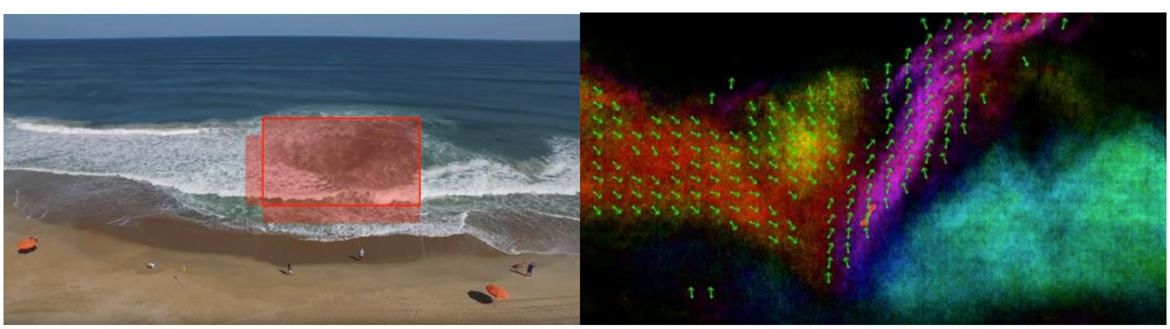

Figure 3. Examples of rip detection using both Machine Learning-based (left) and flow-based (right) approaches to detection. Drone video was used and the rip can be seen in the central region of the both images.

Flow-based Analysis: The optical flow map is the underlying basis for flow-based analysis and is generated by analyzing consecutive frames of a video to infer the velocities of surface currents. Our strategy is to apply flow visualization techniques to analyze the optical flow map from the webcam videos. In particular, we explore different methods for analyzing time-varying velocity fields notably *timelines, pathlines* and *streaklines*. *Timelines* are analogous to a chain of virtual buoys and when placed along the shoreline allow visualization of rip channels as seaward protrusions of the timeline. *Pathlines* trace the trajectory of a virtual untethered buoy over time, while *streaklines* are effectively virtual dye, and trace the trajectory of a series of particles that are continually injected into the flow from a fixed source.

3.3 Shoreline Water Levels Impacting Beach Accessibility and Dune Erosion. The location of maximum total water levels (MTWL) are influenced by the combination of tides, surge, and wave runup. The extent of MTWL can both limit the availability of beach accommodation space (e.g., for beach users or ecosystems) and, if extreme enough, cause erosion of the primary dunes. Elevated levels of wave runup occur during large storm events when beach visitation may be low or dune erosion expected, but also occur frequently when large waves approach the coast from distant offshore storms or when moderate waves coincide with abnormally high tides. In these instances, in particular, water levels are required to inform emergency management professionals, forecasters, and local municipalities who may have infrastructure at risk. Videos collected using the webcam network will be used to develop automated algorithms that detect MTWL using the contrast between the pixel intensity of foam and sand (Figure 4) (e.g., Aarninkhof et al., 2003; Plant et al., 2007; Pianca et al., 2015). In addition to beach access and dune erosion, these detected MTWL will also inform the rip current detection algorithms by providing a bounded region between the MTWL and the surf zone edge to identify rip currents.

At each site, the beach width (in units of pixels) during calm conditions will be determined using existing webcam archives. The location of the dune base will also be identified. In the operational framework, MTWL will be identified from the videos in real-time and compared to these predefined metrics. For instance, the location of MTWL will be used to determine the time and duration of events that limit the beach width by 25%, 50%, or 75%. Similarly, the MTWL will be compared to the location of the dune base to detect the timing and duration of hazardous dune erosion events. While important for real-time situational awareness and validation of coastal hazard models, these metrics can be archived and used to assess trends in both beach availability and occurrences of dune erosion.

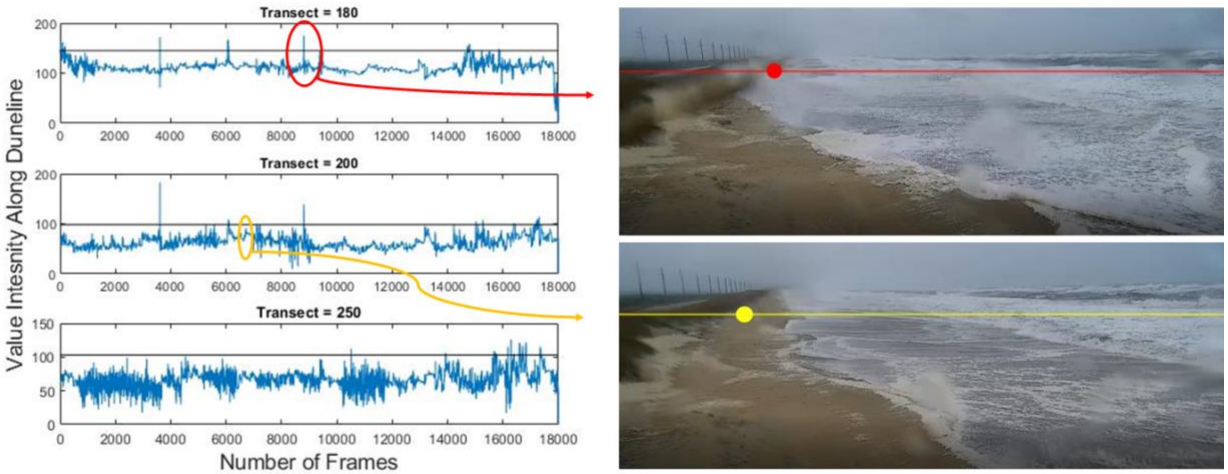

Figure 4. Time series of pixel intensity at the dune position for each transect (left panels) on September 13, 2018 from 10:10-10:20am using the WebCAT Buxton, NC webcam. Threshold for dune collision events is three standard deviations above the average duneline pixel intensity (horizontal black line on each panel). Time-varying analysis identifies instances where water levels impact the base of the dune (top right) or remain on the beachface (bottom right).

3.4 Transition to Operations. Though the three analysis approaches described in detail above have all been demonstrated in a research environment, some additional R&D and customization for the particular locale of a webcam is needed along with steps to transition the three approaches to the operational WebCOOS environment. For each approach:

1. Further R&D: Additional development and enhancement of the approaches are needed and planned for Year 1 of the proposal and will be documented in journal articles and project reports.

2. Development of prototype: Operational prototypes must be developed for each of the

approaches and will include automated analyses and the display and storage of resultant output. These will rely on the WebCOOS camera data and demonstrated in Year 2.

3. Validation of prototype: The resultant output of the operational prototypes will be validated through manual and expert review. This will occur in Years 2 and 3.

4. Operationalization of approach and resultant output: The prototype approaches will be fully operationalized as part of WebCOOS in Year 3, which includes automated operation in near real-time on WebCOOS imagery and the dissemination of resultant output as described in Goal 2 above. These outputs will also be integrated into the decision support tools described in Goal 4.

Goal 4: Package image products into geographically and thematically transferable decision-support tools. With SECOORA and OHHC$_2$I support of an operational decision-support system that nowcasts water quality conditions of swimming beaches and shellfish harvesting waters and provides daily updates to end users via automated reports and a mobile app (HowsTheBeach.org; Neet, et al. In press; Buskey, et al. 2015; Neet, et al. 2015; Porter, et al 2015.), we have initiated a partnership with the Folly Beach, SC to deliver site-specific water quality data and condition nowcasts for both the swimming beaches on the Atlantic Ocean side and the shellfish harvesting waters of the Folly River. Building upon the success of our WebCAT project to integrate video feeds from the Folly Beach Pier with automated feature extraction algorithms to identify and summarize beach utilization during times of weather, currents and water quality warnings, we will develop, validate and operationalize a 'situational monitoring and reporting' tool.

Automated image extraction algorithms (Goal 3) will be used to identify, summarize and report on human beach usage during times of beach-oriented community events (e.g. 4th of July celebrations) and beach swimming advisories for water quality and rip currents. This tool will assess beach usage during events and advisories and send automated reports to end users. In addition, the existing HowsTheBeach app will be enhanced to include notices of rip current forecast products as developed by Dusek and Seim. (2013).

This goal clearly addresses a major need for critical decision-support tools that are predictive and protective of human and ecosystem health in response to climate variability and other hazards, and provides an adaptive approach to better protect the public (Sandifer, et al. 2017; Scott, et al. 2016). Upon completion, our results will demonstrate the utility of incorporating current water quality and conditions from coastal and ocean monitoring programs and predictive models to better protect human health and economic vitality via an operational situational monitoring and reporting decision-support system. Moreover, this approach supports both geographical and thematic expansion from SC and the Southeast to other coastal areas highlighting the decision support tool's transportability to a broader spatial expanse.

E. Benefits: As described in section C. Audience, the users of this effort include project partners (demonstrated operators) and end users. Project partners include federal agencies such as NOAA, USGS and USACE who will utilize the webcam data and the downstream products as part of their day-to-day research and operations. This project will result in immediate benefits to partners by filling a gap in critical coastal observations. NOAA will rely heavily on camera observations of rip currents to validate and improve their new rip current forecast model, and USGS will rely on camera observations of wave runup to support research on beach erosion, overwash and inundation. In both of these cases and others, there are extremely limited coastal observations available to address these needs. The users of webcam observations have been included on the project team to ensure their requirements are central to the progression of the WebCOOS network. Partner requirements and the delivery mechanisms for webcam observations have been established and refined as part of the pilot WebCAT effort (SECOORA, 2018), however they will be further codified as central components of Goal 1 of this proposal.

Strong, existing relationships with end user organizations such as the Lowcountry Alliance for Model Communities’ Charleston Community Research to Action Board, the Interstate Shellfish Sanitation Conference, in addition to newer connections with coastal municipalities such as Folly Beach, SC and Surfside Beach, SC, will ensure that the informational products and tools developed are both meeting the needs as expressed by the users (see Goal 1), and that these groups are trained in the use of the tools. Building on current collaborations, these groups are expected to use the developed products to assess beach usage, beach and surf zone conditions, and water quality for swimmer safety and shellfish harvesting, and to provide notifications to the public and public health and safety officials.

F. Milestones. Table 1 includes major project milestones and estimated completion times, in yearly quarters.

Table 1. Milestone schedule

Goals and Objectives	**Year 1**				**Year 2**				**Year 3**			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Engage users												
a. Define requirements	x	x	x									
b. Evaluate costs		x	x									
c. Develop/update transition plans				x	x			x				x
d. Host project & user meetings	x	x	x	x	x	x	x	x	x	x	x	x
2. Operationalize webcam data network												
a. Select camera provider and maintain webcams	x	x	x	x	x	x	x	x	x	x	x	x
b. Create webcam data ingestion process				x								
c. Leverage/ implement standard metadata profile					x	x	x	x	x	x		
d. Operationalize data, analysis and product integration and access				x	x	x	x	x	x	x	x	x
3. Automate and validate processing of webcam data for beach usage, rip current, water level and dune erosion.												
a. Further develop detection algorithms	x	x	x	x	x	x	x					
b. Develop prototype products	x	x	x	x	x	x	x	x				
c. Validate and conduct beta tests of							x	x	x	x	x	

products												
d. Operationalization approach and outputs									x	x	x	x
4. Package image products into decision support tools												
a. Design and develop decision-support tools	x	x	x	x	x	x	x	x	x	x		
b. Develop informational products					x	x	x	x	x	x		
c. Evaluate and provide training on decision-support tools								x	x	x	x	x

G. Project budget: Total project budget for this 3-year effort is $1,151,994. Major funding components include project coordination, webcam operation and Transition Plan development by SECOORA, development and operationalization of a national webcam data management network by Axiom Data Science, and development of image products and decision support tools by UNC Wilmington, USC, and UCSC. The majority of the budget is therefore devoted to transitioning an operational webcam infrastructure to RL 9 and further development of analysis and decision-support tools to enable broad application by users. Annual and summary budget information for funded institutions is included in Table 2. Detailed budget information is in the Appendix.

Table 2. Annual and total budgets for funded institutions

	SECOORA	Axiom	USC	UNC-W	UCSC	Total
Year 1	$ 81,843	$ 75,864	$ 85,145	$ 64,939	$ 74,852	$ 382,643
Year 2	$ 73,293	$ 70,006	$ 84,719	$ 66,290	$ 86,354	$ 380,662
Year 3	$ 81,553	$ 69,876	$ 87,501	$ 56,825	$ 90,037	$ 385,791
Total	$ 236,689	$ 215,746	$ 257,365	$ 188,054	$ 251,243	$1,149,096

Appendix A: Literature Cited

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Appendix B: Letters of Support

December 6, 2019

Ocean Technology Transition (OTT) Program
US IOOS Program
SSMC 3 Room 2703
1315 East West Highway
Silver Spring, MD 20910

To whom it may concern:

We (Drs. Katherine Brodie and Brittany Bruder) are writing to express our strong support for the proposal, *Launching WebCOOS, Webcams for Coastal Observations and Operational Support* as well as acknowledge our current and future in-kind participation in the project. The proposal aims to develop a sustained operational webcam coastal observing network for quantitative scientific analysis, public safety, and resource management for coastal municipalities. To accomplish this, standardized data processing and management methodology will be established to provide stakeholders actionable information from web cam video.

Quantitative coastal imaging research has been ongoing at ERDC's Field Research Facility (FRF), in collaboration with Oregon State University for over 30 years, and now the Coastal Imaging Research Network (CIRN). The FRF is a world-renowned coastal oceanographic research facility that makes continuous in-situ and remote observations of nearshore waves and morphology, providing open access data in near-realtime. Thus, we acknowledge we will provide guidance and support on data management practices and quantitative image processing to the proposed project.

In addition to ongoing coastal imaging research, ERDC is developing its own quantitative coastal imaging data portal for its mini-Argus cameras, an imaging tool designed for our U.S. Army Corps of Engineers districts. The public data portal is currently being designed by Axiom Data Sciences, the developers of the WebCat data portal. We support leveraging this effort with the proposed effort, by sharing resultant algorithms, frameworks, and lessons learned. Both efforts support ERDC's interests in facilitating access to actionable information from coastal imaging to improve U.S. Army Corps of Engineers' management of coastal sand resources within the United States.

Sincerely,

Katherine L. Brodie, Ph.D.
Research Oceanographer

Brittany L. Bruder, Ph.D.
Research Coastal Engineer

Field Research Facility
U.S. Army Engineer Research and Development Center
1261 Duck Rd, Duck, NC 27949

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
St. Petersburg Coastal and Marine Science Center
600 4th Street South
St Petersburg, FL 33701
(727) 502-8000
(727) 502-8001 Fax

December 20, 2019

To Whom It May Concern,

The USGS St. Petersburg Coastal and Marine Science Center (SPCMSC) would like to give their strong support for the proposed project, "Launching WebCOOS, Webcams for Coastal Observations and Operational Support". The USGS Coastal Change Hazards project utilizes video imagery to measure wave runup and water level elevations at the shoreline of sandy beaches in order to better understand and predict elevated and storm-induced total water levels and the resulting erosion and coastal change. This proposal plans to operationalize and expand a webcam network along the southeastern US coastlines, and to develop, automate, and validate downstream processing of webcam data. This project would result in geo-rectified imagery from a number of coastal sites that could be used by the USGS to validate our Total Water Level (**https://coastal.er.usgs.gov/hurricanes/research/twlviewer/**) and Coastal Change Hazards (**https://marine.usgs.gov/coastalchangehazardsportal/**) models.

Researchers at the USGS SPCMSC have years of experience utilizing video imagery for studying nearshore processes and coastal change. This includes the establishment of stationary coastal monitoring stations at two locations along the central Florida Gulf coast at Madeira Beach and Sand Key, FL. Researchers conducted camera calibration surveys at each site in order to transform the image coordinates to real-world coordinates, thus allowing for quantitative measurements to be made from the imagery, such as wave runup position and shoreline position. USGS expertise and resources were volunteered to conduct a similar camera calibration survey at the Miami Beach, FL webcam as part of the pilot WebCAT project. The USGS SPCMSC would also offer in-kind support to the WebCOOS project, in the form of image processing expertise and camera calibration surveys where possible, to allow for the imagery to be used by others for quantitative observations. Supporting this project also supports the USGS SPCMSC's priorities to provide science and data for better understanding coastal change hazards, and therefore we will be invested in the achievement of this WebCOOS project and feel it would be widely beneficial to all if it were successful.

Sincerely,

Jenna Brown

Jenna Brown, PhD

Meteorological Development Laboratory
Office of Science and Technology Integration
National Weather Service, NOAA
SSMC2 – Room 10330 – W/STI-13
1325 East West Highway
Silver Spring, MD 20910-3283

December 18, 2019

Dear Ocean Technology Transition Project Reviewers:

I'd like to use this letter to extend my support for the proposal "Launching WebCOOS, Webcams for Coastal Observations and Operational Support".

As a member of the National Weather Service's Meteorological Development Laboratory (MDL), I serve as the project lead for the implementation of a new probabilistic rip current model. MDL supports this effort by coordinating a network of surf zone reporting by volunteer lifeguards, and by using the observations to validate and locally tune the model. These rip current reports, while invaluable, are often sparse spatially and temporally. They are also inherently subjective, in that they are based on lifeguards' visual assessments. Other sources of rip current observation data therefore need to be considered.

This proposal would address those observational shortcomings. My in-kind support role as a Principal Investigator (PI) will be to leverage MDL's existing rip current reporting efforts to compare webcam imagery to the rip reports. I will be coordinating closely with fellow PI and NOAA colleague, Greg Dusek (PhD) of the National Ocean Service, as he contributes his surf zone expertise to camera siting and image interpretation.

The work described in this proposal could help the National Weather Service's rip current detection and forecasting efforts in multiple ways. First, if investigators are able to develop a method to automatically identify the swift, seaward jets of water that characterize rip currents, MDL would be able to augment the lifeguards' reports with image observations where lifeguards are not present. This would aid our model validation efforts, and could potentially enhance the situational awareness of National Weather Service forecasters. The potential of using the images to estimate water flow speeds, moreover, could help define an empirical measure of rip current strength, which would also aid model validation and tuning.

It is for these potential benefits, which would help the NWS improve public beach safety, that I hope you consider funding this proposal.

Sincerely,

Michael E. Churma

Michael E. Churma
NOAA National Weather Service
Office of Science and Technology Integration
Meteorological Development Laboratory

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Center for Operational Oceanographic Products and Services
Silver Spring, Maryland 20910

December 16, 2019

Dear OTT Proposal Reviewers:

This letter is to detail my support for the proposal "Launching WebCOOS, Webcams for Coastal Observations and Operational Support".

Informing the public about potential coastal hazards is a critical component of the mission of NOAA and NOS. Yet, the ability to robustly observe coastal hazards like rip currents or high tide flooding at sufficient spatial and temporal scales remains a sizeable gap. Utilizing webcams to observe and even measure these coastal hazards has the potential to be a game-changer. I am the scientific lead of the transition of a new probabilistic rip current forecast model from NOS to NWS operations. We presently do not have sufficient rip current observations to validate and calibrate the rip current model at most coastal locations. Webcams have the potential to serve this vital role now, however both the camera network and downstream imagery tools must be operationalized for NWS to take advantage of this data in their validation and calibration process. As such, I am serving as an unfunded PI for this OTT proposal and strongly encourage the reviewers to consider supporting this project.

As part of my PI role, I will serve as the primary NOAA collaborator and will be leading the technical components of the project for rip current detection and inundation observations. I will ensure that the end products meet the requirements for rip current detection for model validation and will work closely with the visualization and computer vision experts from UC Santa Cruz to do so. Further, I will support other aspects of the project including camera siting, imagery processing and metadata and technical documentation. I anticipate this being a substantial in kind contribution, but believe the contribution dwarfs the potential benefit of an operational webcam network to NOS and NOAA operations.

In conclusion, I strongly encourage the reviewers to consider this project for funding. It meets a critical NOAA observation gap, and has the potential to support a wide-range of coastal hazard products and services. I'd be happy answer questions or provide additional input as needed.

Regards,

Dr. Gregory Dusek

Chief Scientist
Center for Operational Oceanographic Products and Services
NOAA National Ocean Service

NIEHS Center for Oceans and Human Health and
Climate Change Interactions at the University of SC

28 December 2019

Debra Hernandez
Director, Southeast Coastal Ocean Observing Regional Association
PO Box 13856
Charleston, SC 29422

Re: Letter in support of proposal to the NOAA Ocean Technology Transition Project 2020 Funding Opportunity entitled “Launching WebCOOS: Webcams for Coastal Observations and Operational Support”

Dear Ms. Hernandez,

On behalf of Dr. Paul Sandifer and myself, Co-Directors of the Center for Oceans and Human Health and Climate Change Interactions (OHHC^{2}I), in the Arnold School of Public Health (ASPH) at the University of South Carolina (USC) I am pleased to submit this letter supporting the role of our Community Engagement Core (CEC) in the above-referenced proposal.

The OHHC^{2}I, housed at the University of South Carolina, includes a collaborative partnership with the College of Charleston, the Citadel, Baylor University, and the University of Maryland Center for Environmental Science. OHHC^{2}I’s goal is to enhance knowledge of the role climate change may play in affecting bacterial infections and production of toxins from cyanobacteria, both of which may adversely affect human health. The role of our of our Community Engagement Core (CEC) within OHHC^{2}I, under the direction of Dr. Dwayne E. Porter, is to translate technical findings into informational products and decision-support tools, such as forecast models, to better inform coastal communities about both the environmental and the public of health risks associated with these organisms in our coastal waters. The public may be at risk to exposure to HAB toxins and microbes from seafood consumption, contact recreation and inhalation of air-borne toxins. Communicating these risks to prevent exposure is a primary mechanism for controlling these hazards.

Specific to this proposal, our Center’s CEC will bring strong relationship- and capacity-building experience with the engagement of our various community partners, and in particular underserved and Environmental Justice (EJ) coastal communities. Strong, existing relationships with organizations such as the Lowcountry Alliance for Model Communities and its Charleston Community Research to Action Board (LAMC/CCRAB) and the Interstate Shellfish Sanitation Conference (ISSC), in addition to newer connections with coastal municipalities such as the popular beach tourist destinations of Folly Beach, SC and the Town of Surfside Beach, SC as well as more inland coastal communities, such as Bluffton, SC will ensure that the informational products and decision-support tools developed via this proposed effort are both meeting the needs as expressed by the stakeholders and end users, and that these same groups are properly trained in the use of the decision-support tools. Building on current collaborations between SECOORA and our $OHHC^2I$ these groups are expected to use the developed informational products and decision-support tools which will use webcam video automated feature extraction techniques to assess each usage by the public, beach and surf zone conditions (e.g., rip currents and coastal inundation), and water quality for swimmer safety and shellfish harvesting, and to provide notifications to both the public and public health and public safety officials. These artificial intelligence, webcam systems provide the next generation of information to better quantify actual human exposure as well as assess these visual environmental hazards and will help us build the next generation of forecasts and predictions that will better inform and protect the public.

We are excited about this opportunity to collaborate with the team of researchers, stakeholders and end users assembled for this proposed project. If you need any additional information concerning our engagement and support please contact either myself, Dr. Sandifer or Dr. Porter.

Sincerely,

Geoffrey I. Scott

Geoffrey I. Scott, PhD
C0-Director
Center for Oceans and Human Health
and Climate Change Interactions
Clinical Professor and Chair
Department of Environmental Health Sciences
Arnold School of Public Health
University of South Carolina

Paul A. Sandifer

Paul A. Sandifer, PhD
Co-Director
Center for Oceans and Human Health
and Climate Change Interactions
Director,
Center for Coastal Environmental and
Human Health
College of Charleston

Cc: Dr. Dwayne E. Porter
Director, Community Engagement Core
Center for Oceans and Human Health and Climate Change Interactions
and
Professor and Associate Chair
Department of Environmental Health Sciences
Arnold School of Public Health
University of South Carolina

Centralized Data Management Office
National Estuarine Research Reserve System

22 Hobcaw Road
Georgetown, SC 29440

Dwayne E. Porter, PhD
Director
803.777.4615
porter@sc.edu

Melissa Ide
Deputy Director
843.904.9003
melissa@baruch.sc.edu

28 December 2019
Debra Hernandez
Director, Southeast Coastal Ocean Observing Regional Association
PO Box 13856
Charleston, SC 29422

Re: Letter in support of proposal to the NOAA Ocean Technology Transition Project 2020 Funding Opportunity entitled "Launching WebCOOS: Webcams for Coastal Observations and Operational Support"

Dear Ms. Hernandez,

On behalf of my colleagues associated with the NOAA NERRS Centralized Data Management Office (CDMO) I appreciate the opportunity to submit this letter in support of your proposal entitled "Launching WebCOOS: Webcams for Coastal Observations and Operational Support". Implementation and maintenance of robust data management and communications infrastructures are critical challenges for development of successful collaborative scientific initiatives. Case in point, the *NOAA Coastal Office Strategic Plan: 2014-2019* highlights the need for a strategy to "*Develop and support coastal observing networks and provide integrated data, tools, and information to decision makers for understanding, visualizing, and communicating the state of the nation's coastal and ocean natural resources, including thresholds at which ecosystem values and the services provided become reduced or lost*." (NOAA NOS Coastal Office, 2013). Thus, the development of the data and information management components of coastal observing system initiatives must address both core and cooperating programs' data and information exchange and meet the needs of the end users.

As you are well aware, a goal of NOAA's National Ocean Service is to increase *coastal intelligence* with a commitment to integrating scientifically-defensible data, models, and decision-support tools to improve the ability of decision makers scaling from federal agencies to the private individual. This will be achieved through the coordinated development of national and regional monitoring and systems meeting the data and information needs of multiple users via integrated data management on global, national, regional, and local scales.

In support of NOAA's goals of monitoring the health of our nation's coastal waters in support of increased *coastal intelligence*, a focus and strength of the NERRS is helping communities address local issues. The NERRS Coastal Training Program (CTP) consists of community-engagement training professionals from the reserve system working together to move coastal management priorities forward to address local needs and ensures the effective use of reserve-based science. The CTP targets professionals who make decisions about coastal resources. These might include elected officials, local government staff members (e.g., county, city, and town managers or planners), state agency personnel, business professionals and organizations, or state and regional professional associations.

In support of this proposed project the CDMO will:

1.) Work with the WebCOOS data management team to ensure access to high quality monitoring data and associated metadata collected as part of the NERRS System-wide Monitoring Program (SWMP), NERRS Science Collaborative (NSC) or reserve-specific monitoring activities that have been identified as important for WebCOOS model development, calibration and validation; and
2.) Assist with aligning and coordinating WebCOOS community engagement activities with CTP staff at local reserves to ensure engagement of all appropriate stakeholders and end users of WebCOOS developed informational products and decision-support tools.

We are excited about this opportunity to collaborate with the team of researchers, stakeholders and end users assembled for this proposed project. If you need any additional information concerning our engagement and support please do not hesitate to contact me.

Sincerely,

Melissa Ide

Melissa Ide
Deputy Director
NOAA NERRS Centralized Data Management Office

UNIVERSITY OF CALIFORNIA, SANTA CRUZ

BERKELEY · DAVIS · IRVINE · LOS ANGELES · MERCED · RIVERSIDE · SAN DIEGO · SAN FRANCISCO SANTA BARBARA · SANTA CRUZ

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December 7, 2019

NOAA OTT Review Panel

Dear Reviewer,

I write in support of this proposal Launching WebCOOS, Webcams for Coastal Observations and Operational Support. My research interest is in data analysis and visualization and have worked in various domains ranging from aeronautics to medical imaging, and from oceanography and meteorology to bioinformatics. I am also particularly interested how uncertainty is communicated for natural hazards. More recently, my work is focused on applying technology for social good. In this regard, I have been focusing my energy on projects involving modeling and simulation of wildfire propagation and forest regrowth, developing tools to aid first responders of active shooter incidents, and image and video based detection of rip currents.

I am very excited to be part of this team and look forward to contributing to the efforts on rip current detection. While I see that my main contributions in this proposal will be towards helping Greg Dusek validate rip current prediction models via automated analysis of video obtained from fixed mount webcams, I also see very exciting opportunity to bring the same technology to use smartphones as a platform. Not only can this directly empower beach goers to check for presence of rip currents with their smartphones, they can also become citizen scientists and help create a global database of rip current observations.

I hope the reviewers can also see the value and appreciate the impact that such a proposal can bring not only to the scientific and local communities but to a much broader audience as well.

Sincerely,

Alex Pang
Professor
pang@cse.ucsc.edu
(831) 459-2712
http://www.cse.ucsc.edu/˜pang

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service - Wilmington, NC
2015 Gardner Dr
Wilmington, NC 28405
January 10, 2020

MEMORANDUM FOR: NOAA-NWS CSTAR Program Managers

FROM: Donald Reid Hawkins
Science and Operations Officer
National Weather Service Wilmington, NC

SUBJECT: Letter of Support for the SECOORA's NOAA OTT project proposal "Launch WebCOOS, Webcams for Coastal Observations and Operational Support" with Debra Hernandez and Co-Investigators

The National Weather Service, Wilmington, NC, will support this project and collaborate with Debra Hernandez and participants if this proposal is accepted.

As a coastal NWS Forecast office rip currents, coastal erosion, and other beach hazards are a high priority to our mission to protect lives and property. If the new techniques and tools can be shown to be then these techniques and tools could significantly enhance our office's mission.

Appendix C: Curriculum Vitae

Name: Debra Lee Hernandez

Title: Executive Director
Southeast Coastal Ocean Observing Regional Association (SECOORA)

Professional Preparation:

Institution		Location	Major	Degree	Date
Undergraduate:	Clemson University	Clemson, SC	Civil Engineering	Bachelor of Science	1986
Graduate:	Clemson University	Clemson, SC	Civil Engineering	Master of Science	1987

Work Experience:
Ms. Hernandez currently serves as Executive Director of the Southeast Coastal Ocean Observing Regional Association (SECOORA). SECOORA is one of eleven regional partners in the U.S. Integrated Ocean Observing System and is a nonprofit operating in the states of NC, SC, GA and FL to coalesce the efforts of multiple observing interests and deliver user defined products that save lives, conserve the coastal and marine environment and support the economic vitality of our coastal regions. Since joining SECOORA she has been lead PI on several multi-year regional observing projects, as well as related marine policy and science programs. In total, she has 30 years of experience in coastal and ocean engineering, management and policy. Prior to joining SECOORA, Ms. Hernandez led her own consulting firm and worked in state coastal management as an environmental engineer and coastal policy expert. Her professional interests include improving the linkages between scientists and decision-makers, and facilitating discussions of public policy issues related to the coast and environment. She was also a licensed professional engineer for over 20 years.

Appointments:

2008 – Present	Executive Director, SECOORA, Charleston, S.C.
2006 – 2011	President, Hernandez and Company, LLC, Isle of Palms, S.C.
2000 – 2006	Director of Program and Policy Development, S.C. Department of Health and Environmental Control (DHEC), Office of Ocean and Coastal Resource Management (OCRM), Charleston, S.C.
1998 – 2000	Assistant Director of Planning, S.C. DHEC OCRM, Charleston, S.C.
1988 – 1998	Environmental Engineer / Manager of Non-point Source and Special Projects, S.C. DHEC OCRM, Charleston, S.C.

Publications:

1. The U.S. Integrated Ocean Observing System: Governance Successes and Lessons from Two Decades of Growth. Jessica Snowden, Debra Hernandez, Josie Quintrell, Alexandra Harper, Ru Morrison, Julio Morell, Lynne Leonard. Frontiers in Marine Science. 6:242. DOI: 10.3389/fmars.2019.00242
2. From the Oceans to the Cloud: Opportunities and Challenges for Data, Models, Computation and Workflows. Tiffany C. Vance, Micah Wengren, Eugene Burger, Debra Hernandez, Timothy Kearns, Nazila Merati, Kevin O'Brien, Jon O'Neil, Jim Potemra, Richard P. Signell, Kyle Wilcox. Frontiers in Marine Science. DOI: 10.3389/fmars.2019.00211
3. WebCAT: Piloting the development of a web camera coastal observing network for diverse applications. Gregory Dusek, Debra Hernandez, Mark Willis, Jenna A. Brown, Joseph W. Long, Dwayne E. Porter, Tiffany C. Vance. Frontiers in Marine Science. 6:353. DOI: 10.3389/fmars.2019.00353.
4. Integrating Environmental Monitoring and Observing Systems in Support of Science to Inform Decision-making: Case Studies for the Southeast. Chapter 22 in Coastal Ocean Observing Systems: Advances and Syntheses. Porter, D.E., J. Dorton, L. Leonard, H. Kelsey, D. Ramage, J. Cothran, A. Jones, C. Galvarino, V. Subramanian and D. Hernandez. Y. Liu, H. Kerkering and R. Weisberg (eds.). Elsevier Press. DOI:10.1016/B978-0-12-802022-7.00022-5
5. A Case History of the Science and Management Collaboration in Understanding Hypoxia Events in Long Bay, South Carolina, USA. D. Sanger, D. Hernandez, S. Libes, G. Voulgaris, B. Davis, E. Smith, R. Shuford, D.

Porter, E. Koepfler and J. Bennett, Environmental Management, Volume 46, Number 3, 340-350, DOI: 10.1007/s00267-010-9529-8

6. Integrating Environmental Monitoring and Observing Systems in Support of Science to Inform Decision-making: Case Studies for the Southeast. Chapter 22 in Coastal Ocean Observing Systems: Advances and Syntheses. Porter, D.E., J. Dorton, L. Leonard, H. Kelsey, D. Ramage, J. Cothran, A. Jones, C. Galvarino, V. Subramanian and D. Hernandez. Y. Liu, H. Kerkering and R. Weisberg (eds.). Elsevier Press. DOI:10.1016/B978-0-12-802022-7.00022-5
7. A Case History of the Science and Management Collaboration in Understanding Hypoxia Events in Long Bay, South Carolina, USA. D. Sanger, D. Hernandez, S. Libes, G. Voulgaris, B. Davis, E. Smith, R. Shuford, D. Porter, E. Koepfler and J. Bennett, Environmental Management, Volume 46, Number 3, 340-350, DOI: 10.1007/s00267-010-9529-8
8. Establishing A Minimum Standard for Collaborative Research in Federal Environmental Agencies, K. Matso, M. Dix, B. Chicoski, D. Hernandez, and J. Schubel, Integrated Environmental Assessment and Management, Manuscript Number: IEAM_2007-070
9. Land Use Planning and Its Potential to Reduce Hazard Vulnerability: Current Practices and Future Possibilities, A. Puszkin-Chevlin, D. Hernandez, J. Murley, Marine Technology Society Journal, Volume 40, Number 4, Winter 2006/2007.
10. Mitigating Shore Erosion Along Sheltered Coasts, National Research Council, Study Committee: J Benoit, C. S. Hardaway Jr, D. Hernandez, R. Holman, E. Koch, N. McLellan, S. Peterson, D. Reed, D. Suman, The National Academies Press, Washington, DC, ISBN-13:978-0-309-10346-6, 2007.
11. Evaluation of the Impacts of Dock Structures and Land Use on Tidal Creek Ecosystems in South Carolina Estuarine Environments, D. Sanger, A. F. Holland, D. Hernandez, Environmental Management, 33(3):385-400.
12. Lessons Learned from Hurricane Hugo, The South Carolina Engineer, Volume XLII, Summer, 1992.
13. Study of Ebb Tidal Shoal Dynamics, Proceedings, Beach Preservation Technology '88, pp. 365-373, 1988.

Synergistic Activities

2020, January 7-10	Delegate and Cross-Cutting Theme Champion, UN Decade on Ocean Science for Sustainable Development, North Atlantic Regional Workshop
2016 – present:	Integrated Ocean Observing System Association, Chair
2014 – present:	NOAA Southeast and Caribbean Regional Team
2012 – 2014:	National Academy of Sciences Panel to Review the National Climate Assessment
2008 – present:	Integrated Ocean Observing System Association Board
2006 – 2011:	National Academy of Sciences Ocean Studies Board
2005 – 2008:	Ocean Research and Resources Advisory Panel (ORRAP), Vice-Chair
2002 – 2004:	Coastal States Organization, Washington, D.C., Chair
2005 – 2010:	Coastal States Stewardship Foundation, Vice-Chair
2005 – present:	South Carolina Sea Grant Consortium Program Advisory Board
1995 – 1999	Isle of Palms City Council

Collaborators and Other Affiliations

Dr. Michael Crosby – Mote Marine Lab, Dr. Quinton White – JU, Dr. Conrad C. Lautenbacher, Jr., – GeoOptics, Dr. R. Dodge – NSU, Dr. D. Porter – USC, Dr. L. Leonard – UNC-W, Dr. H. Seim – UNC-CH, M. Conley – TNC, M. R. DeVoe – SC Sea Grant Consortium, Dr. H. Kelsey – U of Maryland, Dr. D. Savidge – SkIO, Dr. N. Shay – U of Miami, Dr. P. Sheng – UF, Dr. R. He – NCSU, Dr. Peter Hamilton – NCSU, Dr. R. Weisberg – USF, Dr. M. Luther – USF, Dr. M. Roffer – ROFFSTM, Dr. P. Halpin – Duke

Graduate Advisor: Dr. Earl Hayter, Clemson University, US Environmental Protection Agency

Member, The Oceanography Society and Marine Technology Society

Biographical Sketch

Dwayne E. Porter
Department of Environmental Health Sciences
Arnold School of Public Health
University of South Carolina
Columbia, SC 29208 USA
803.777.4615 (P) porter@sc.edu (E) 803.777.8769 (F)

Professional Preparation

University of South Carolina	Columbia, SC	Geographic Information Processing	PhD	1995
University of South Carolina	Columbia, SC	GIS and Remote Sensing	MS	1988
West Virginia University	Morgantown, WV	Spatial Analysis	BA	1985

Professional Appointments

2016-Present Professor, Department of Environmental Health Sciences, Arnold School of Public Health, and Marine Science Program, USC
2017-Present Director, Community Engagement Core, NIEHS Center for Oceans and Human Health and Climate Change Interactions
2014-Present Associate Chair and Director of Graduate Studies, Department of Environmental Health Sciences, Arnold School of Public Health
2007-2014 Chair, Department of Environmental Health Sciences, Arnold School of Public Health
2006-2007 Graduate Director, Department of Environmental Health Sciences, Arnold School of Public Health
2004-2016 Associate Professor, Department of Environmental Health Sciences, Arnold School of Public Health, and Marine Science Program, USC
1998-2004 Assistant Professor, Department of Environmental Health Sciences, Arnold School of Public Health, and Marine Science Program, USC
1993-Present Director, Geographic Information Processing Lab, and Research Associate, Baruch Institute for Marine and Coastal Sciences, USC
1994-Present Director, NOAA National Estuarine Research Reserve System Centralized Data Management Office, Georgetown, SC
1995-Present Senior Associated Faculty, Environment and Sustainability Program, School of Earth, Ocean and the Environment, USC

Current Funding

2019-2020 Florida Department of Environmental Protection. $31,449 as PI on "Florida Aquatic Preserves Continuous Water Quality Monitoring Training and Data Portal".
2019-2020 National Oceanic and Atmospheric Administration. $983,700 as PI on "Support of the National Estuarine Research Reserve System Centralized Data Management Office and Enhancements to the NERRS System-wide Monitoring Program".
2018-2020 Lake Wateree Association, Inc. $24,000 as PI on "Lake Wateree Water Quality Data Acquisition and Analysis".
2018-2022 National Institute of Environmental Health Sciences. $5,749,339 as Community Engagement Core Lead (PI Scott – USC) on "The Interactions of Climate Change on Oceans and Human Health: Assessment of Effects on Ocean Health Related Illness and Disease and Development of Prevention Strategies to Better Protect Public Health".
2018-2019 National Park Service. $5,000 as PI on "Compilation of Total Fecal Coliform, *E. coli*and *Enterococcus spp.* Sampling at Southeastern Coastal National Parks".
2018-2020 National Oceanic and Atmospheric Administration. $758,760 as PI on "Continuation of the National Estuarine Research Reserve System Centralized Data Management Office and Enhancement of the NERRS System-wide Monitoring Program".
2017-2019 National Oceanic and Atmospheric Administration. $70,722 as PI on "Florida Coastal Water Quality Monitoring Data Assessment, Access and Training".
2017-2019 National Oceanic and Atmospheric Administration. $1,127,502 as PI on "Continuation of the National Estuarine Research Reserve System Centralized Data Management Office and Enhancement of the NERRS System-wide Monitoring Program".

2016-2021 National Oceanic and Atmospheric Administration. $530,913 as PI on "Integrated Decision Support and Management Tools for Adaptive Public Health Practices: An Early Warning System for Swimming Beach and Shellfish Harvesting Waters".

2014-2020 National Oceanic and Atmospheric Administration. $337,644 (of $20,000,000 total) as a co-PI (PI Scavia – University of Michigan) on "A Collaborative Science Program for the National Estuarine Research Reserve System: Working with End Users Throughout the Applied Research Process".

Recent Relevant Publications (≥ 2013)

Neet, M., Ellis, J., Hart, Z., Scott, G., Friedman, D., Kelsey, H. and D.E. Porter. In press. The role of community engagement to address environmental and public health issues with environmental justice communities. *Encyclopedia of Water, Science, Technology. and Society*. Maurice, P. and Strickland, C. (eds.). Wiley Publishers.

Henderson, H.C, Hong, J., Friedman, D.B., Porter, D.E., Halfacre, A.C., and Scott, G.I. and J.R. Lead. In press. A content analysis of Internet resources about the risks of seafood consumption. *International Journal of Environmental Health Research*.

Dusek, G., D. Hernandez, M. Willia, J. Brown, J. Long, D.E. Porter and T. Vance. 2019. WebCAT: Piloting the development of a web camera coastal observing network for diverse applications. *Frontiers in Marine Science: Ocean Observation*.Vol. 6. Article 363.

Dorton, J., C. Galvarino, D.E. Porter and D. Hernandez. 2019. Integrating marine weather data, forecasts, and user assessments to upgrade the Marine Weather Portal. *Frontiers in Science*. DOI: 10.1109/OCEANS.2018.8604621.

Albadrani, M., R.Seth, S. Sarkar, D. Kimono, A. Mondal, D. Bose, D.E. Porter, G. Scott, B. Brooks, S. Raychoudhury, M. Nagarkatti,P. Nagarkatti,Y. Jule, A. Diehl and S. Chatterjee. 2019. Exogenous PP2A inhibitor exacerbates the progression of nonalchoholic fatty liver disease via NOX2-dependent activation of miR21. *American Journal of Physiology: Gastrointestinal and Liver Physiology*.317:G408-G428.

Sarkar, S.,D. Akoto, M. Al-Badrain, R. Seth, D.E. Porter, G, Scott, B. Brooks, M. Nagarkatti, P. Nagarkatti and S. Chatterjee. 2019 Environmental microsystin targets the microbiome and increases the risk of intestinal inflammatory pathology in underlying Nonalcoholic Fatty Liver Disease in a NOX2 dependent pathway. *Scientific Reports*. (2019)9:8742.

Sandifer, P.A., L.C. Knapp, T.K. Collier, A.L. Jones, R.P. Juster, C.R. Kelble, R.K. Kwok, J.V. Miglarese, L.A. Palinkas, D.E. Porter, G.I. Scott, L.M. Smith, W.C. Sullivan and A.E. Sutton-Grier. 2017. A conceptual model to assess stress-associated health effects of multiple ecosystem services degraded by disaster events in the Gulf of Mexico and elsewhere. *GeoHealth*, 1, DOI: 10.1002/2016GH000038.

Scott, G.I., D.E. Porter, G.T. Chandler, R.S. Norman, C.H. Scott, M. Uyaguari-Diaz, K. Maruya, S.B. Weisberg, M.H. Fulton, E.F. Wirth, J. Moore, P.L. Pennington, D. Schlenk, G.P. Cobb and N.D. Denslow. 2016. Antibiotics as CECs: an overview of the hazards posed by antibiotics and antibiotic resistance. *Frontiers in Marine Science*. 3(24): 1-24.

Neet, M., R.H. Kelsey, D.E. Porter, D. Ramage and A. Jones. 2015. Model performance results in Myrtle Beach, SC using Virtual Beach and R regression software. *South Carolina Water Resources Journal*. Vol. 2, Issue 1. pp. 80-85.

Porter, D.E., J. Dorton, L. Leonard, H. Kelsey, D. Ramage, J. Cothran, A. Jones, C. Galvarino, V. Subramanian and D. Hernandez. 2015. Chapter 22 - Integrating environmental monitoring and observing systems in support of science to inform decision making: case studies for the Southeast. *Coastal Ocean Observing Systems: Advances and Syntheses*. Y. Liu, H. Kerkering and R. Weisberg (eds.). Elsevier Press. pp.416-429.

Buskey, E., M. Bundy, M. Ferner, D. Porter, W. Reay, E. Smith and D. Trueblood. 2015. Chapter 21 - System-wide Monitoring Program of the National Estuarine Research Reserve System: research to address coastal management needs. Chapter in *Coastal Ocean Observing Systems: Advances and Syntheses*. Y. Liu, H. Kerkering and R. Weisberg (eds.). Elsevier Press. pp. 391-415.

Friedman, D.B., C. Toumey, D.E. Porter, J. Hong, G.I. Scott and J.R. Lead. 2015. Communicating with the public about environmental health risks: a community-engaged approach to dialogue about metal speciation and toxicity. *Environmental International*. 74(2015):9-12.

Ellis, J.H., Friedman, D.B., Puett, R., Scott, G.I. and D.E. Porter. 2014. A qualitative exploration of fishing and fish consumption in the Gullah/Geechee culture. *Journal of Community Health*. DOI 10.1007/s10900-014-9871-5.

Scott, G., M. Fulton, M. DeLorenzo, E. Wirth, P. Key, P. Pennington, D. Kennedy, D. Porter, G. Chandler, C. Scott, J. Michel and J. Ferry. 2013. The environmental sensitivity index and oil and hazardous materials impact assessments: linking pre-spill contingency planning and ecological risk assessment. *Journal of Coastal Research*. 81:69(100-113).

Joseph W. Long
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University of North Carolina Wilmington
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Professional Experience

August 2018 – present	Assistant Professor, University of North Carolina Wilmington, Wilmington, NC
Oct 2012 – July 2018	Research Oceanographer, U.S. Geological Survey St. Petersburg Coastal & Marine Science Center, St. Petersburg, FL
Oct 2009 – Sept 2012	Mendenhall Post-doctoral Fellow, U.S. Geological Survey St. Petersburg Coastal & Marine Science Center, St. Petersburg, FL
July 2009 –Sept 2009	Post-doctoral Research Assistant, College of Oceanic & Atmospheric Sciences, Oregon State University, Corvallis
Sept. 2002 – June 2009	Graduate Research/Teaching Assistant, School of Civil and Construction Engineering, Oregon State University, Corvallis
June 2000 – July 2002	Hydraulic/Water/Wastewater Engineer, Stearns and Wheler, LLC, Cazenovia, NY

Education

May 2000	B.S., Civil and Environmental Engineering, Clarkson University, Potsdam, NY
March 2005	M.Oc.Eng, School of Civil and Construction Engineering, Oregon State University, Corvallis, OR *Thesis Title: Offshore Controls on Nearshore Circulation*
May 2009	Ph.D., Civil Engineering, School of Civil and Construction Engineering, Oregon State University, Corvallis, OR *Dissertation Title: Modeling Shallow-Water Hydrodynamics: Rotations, Rips, and Rivers*

Awards & Professional Societies

- 2017 Keynote speaker XBeachX conference; Delft, The Netherlands
- Invited speaker AGU Fall Meeting 2014
- 2009 USGS Mendenhall Postdoctoral Fellowship
- Invited and fully sponsored to attend/present at the *2011 Marine Geosciences Leadership Symposium* held by the Consortium for Ocean Leadership, Washington D.C (April 2011).
- American Geophysical Union Outstanding Student Paper Award, Fall Meeting 2004
- American Geophysical Union Member (2002 – present)
- American Society of Civil Engineers (Assoc. Member) (2008 – present)

Refereed Journal Publications (*student author)

1. Dusek, G., Hernandez, D., Willis, M., Brown, J. A., **Long, J. W.**, Porter, D. E., & Vance, T. C. (2019). WebCAT: Piloting the development of a web camera coastal observing network for diverse applications. Frontiers in Marine Science, 6, 353.
2. *Santos, V. M., Wahl, T., **Long, J. W.**, Passeri, D. L., & Plant, N. G. (2019). Combining Numerical and Statistical Models to Predict Storm‐Induced Dune Erosion. Journal of Geophysical Research: Earth Surface, 124(7), 1817-1834.

3. *Ware, M., **Long, J. W.**, & Fuentes, M. M. (2019). Using wave runup modeling to inform coastal species management: An example application for sea turtle nest relocation. Ocean & Coastal Management, 173, 17-25.
4. *Torres‐Garcia, L.M., Dalyander, P.S., **Long, J.W.**, Zawada, D.G., Yates, K.K., Moore, C. and Olabarrieta, M., (2018). Hydrodynamics and Sediment Mobility Processes Over a Degraded Senile Coral Reef. Journal of Geophysical Research: Oceans. Passeri, D.L., Bilskie, M.V., Plant, N.G., Long, J.W. and Hagen, S.C., 2018. Dynamic modeling of barrier island response to hurricane storm surge under future sea level rise. Climatic Change, pp.1-13.
5. Passeri, D.L., **Long, J.W.**, Plant, N.G., Bilskie, M.V. and Hagen, S.C., (2018). The influence of bed friction variability due to land cover on storm-driven barrier island morphodynamics. Coastal Engineering, 132, pp.82-94.
6. Mickey, R., Long, J., Dalyander, P.S., Plant, N. and Thompson, D., (2018). A framework for modeling scenario-based barrier island storm impacts. *Coastal Engineering*, 138, pp.98-112.
7. Overbeck, J. R., **J. W. Long**, and H. F. Stockdon (2017), Testing model parameters for wave-induced dune erosion using observations from Hurricane Sandy, Geophys. Res. Lett., 44, 937–945, doi:10.1002/2016GL071991.
8. Wahl, T., N. G. Plant, and **J. W. Long** (2016), Probabilistic assessment of erosion and flooding risk in the northern Gulf of Mexico, *Journal of Geophysical Research: Oceans*, 121, 3029–3043, doi:10.1002/2015JC011482.
9. **Long, J. W.**, and H. T. Özkan-Haller (2016), Forcing and variability of nonstationary rip currents, J. Geophys. Res. Oceans,121, 520–539, doi:10.1002/2015JC010990.
10. Dalyander, P. S., Plant, N. G., **Long, J. W.**, & McLaughlin, M. (2015). Nearshore dynamics of artificial sand and oil agglomerates. *Marine pollution bulletin*, *96*(1), 344-355.
11. **Long, J. W.**, Plant, N. G., Dalyander, P. S., & Thompson, D. M. (2014). A probabilistic method for constructing wave time-series at inshore locations using model scenarios. *Coastal Engineering*, *89*, 53-62.
12. **Long, J. W**., de Bakker, A., & Plant, N. G. (2014). Scaling coastal dune elevation changes across storm-impact regimes. *Geophysical Research Letters*, *41*(8), 2899-2906.
13. Stockdon, H. F., D.M. Thompson, N.G. Plant, and **J.W. Long** (2014). Evaluation of wave runup predictions from numerical and parametric models. *Coastal Engineering*, *92*, 1-11.
14. Sherwood, C.R., **J.W. Long**, P. Dickhudt, P.S. Dalyander, D.M Thompson, and N.G. Plant (2014), Inundation of a barrier island (Chandeleur Islands, Louisiana, USA) during a hurricane: Observed water-level gradients and modeled seaward sand transport. *Journal of Geophysical Research: Earth Surface*, *119*(7), 1498-1515.
15. Dalyander, P.S., **J.W. Long**, N.G. Plant, and D.M. Thompson (2014), Assessing mobility and redistribution patterns of sand and oil agglomerates in the surf zone, *Marine Pollution Bulletin*, *80*(1), 200-209.
16. Plant, N.G., Flocks, J., Stockdon, H.F., **Long, J.W.**, Guy, K., Thompson, D.M., Cormier, J.M., Smith, C.G., Miselis, J.L. and Dalyander, P.S. (2014). Predictions of barrier island berm evolution in a time-varying storm climatology. *Journal of Geophysical Research: Earth Surface*, *119*(2), 300-316.
17. Nosal A.P., D.C. Cartamil, **J.W. Long**, M. Luhrmann M, N.C.Wegner, J.B. Graham (2012), Demographic composition, movement patterns, and putative causes of leopard sharks (Triakis semifasciata) aggregating in a marine reserve along the open coast of southern California, USA, *Environmental Biology of Fishes*
18. **Long, J.W.**, & N.G. Plant (2012). Extended Kalman Filter framework for forecasting shoreline evolution. *Geophysical Research Letters*, *39*(13).

19. **Long, J.W.**, and H.T. Özkan-Haller (2009), Low-frequency characteristics of wave group–forced vortices, *J. Geophys. Res*., 114, C08004, doi:10.1029/2008JC004894
20. **Long, J.W**., and H.T. Özkan-Haller (2005), Offshore controls on nearshore rip currents, *J. Geophys. Res*., 110, C12007, doi:10.1029/2005JC003018
21. Scott, C.P., D.T. Cox, T.B. Maddux, and **J.W. Long** (2005), Large-scale laboratory observations of turbulence of a fixed barred beach, *Meas. Sci. Technol*. 16, doi:10.1088/0957-0233/16/10/004

Published Scientific Reports & Conference Proceedings

1. Smith, C.G., **Long, J.W.**, Henderson, R.E., and Nelson, P.R., 2018, Assessing the impact of open-ocean and back-barrier shoreline change on Dauphin Island, Alabama, at multiple time scales over the last 75 years: U.S. Geological Survey Open-File Report 2018–1170, 20 p., https://doi.org/10.3133/ofr20181170.
2. Passeri, D.L., **Long, J.W.**, Jenkins, R.L., and Thompson, D.M., 2018, Effects of proposed navigation channel improvements on sediment transport in Mobile Harbor, Alabama: U.S. Geological Survey Open-File Report 2018–1123, 22 p., https://doi.org/10.3133/ofr20181123.
3. Jenkins, R.L., Dalyander, P.S., Penko, Allison, and Long, J.W., 2018, Laboratory observations of artificial sand and oil agglomerates: U.S. Geological Survey Open-File Report 2018–1010, https://doi.org/10.3133/ofr20181010.
4. Mickey, R.C., **Long, J.W.**, Plant, N.G., Thompson, D.M., and Dalyander, P.S., 2017, A methodology for modeling barrier island storm-impact scenarios (ver. 1.1, March 2017): U.S. Geological Survey Open-File Report 2017–1009, 17 p., https://doi.org/10.3133/ofr20171009.
5. Thompson, D.M., Dalyander, P.S., **Long, J.W.**, and Plant, N.G., 2017, Correction of elevation offsets in multiple co-located lidar datasets: U.S. Geological Survey Open-File Report 2017–1031, 10 p., https://doi.org/10.3133/ofr20171031.
6. Dalyander, P. S., **Long, J. W.**, Plant, N. G., McLaughlin, M. R., & Mickey, R. C., 2015. Field observations of artificial sand and oil agglomerates. Open-File Report, (2015-1057).
7. Doran, K. S., **Long, J. W.**, & Overbeck, J. R., 2015. A method for determining average beach slope and beach slope variability for US sandy coastlines. Open-File Report, (2015-1053).
8. Dalyander, P. S., Mickey, R. C., **Long, J. W.**, & Flocks, J. G., 2015. Effects of proposed sediment borrow pits on nearshore wave climate and longshore sediment transport rate along Breton Island, Louisiana. Open-File Report, (2015-1055).
9. Overbeck, J.R., **J.W. Long**, H.F. Stockdon, and J.J. Birchler, 2015. Enhancing Evaluation of Post-Storm Morphologic Response Using Aerial Orthoimagery from Hurricane Sandy. *Coastal Sediments 2015*: doi: 10.1142/9789814689977_0250
10. http://dx.doi.org/10.3133/ofr20151184.
11. Dalyander, P.S., Long, J.W., Plant, N.G. and Thompson, D.M., 2013. Appendix D: Use of Wave Scenarios to Assess Potential Submerged Oil Mat (SOM) Formation Along the Coast of Florida and Alabama (No. III). Gulf Coast Ecosystem Restoration Council.
12. Plant, N.G, **Long, J.W.**, Dalyander, P.S., Thompson, D.M., and Raabe, E.A., 2013, Application of a hydrodynamic and sediment transport model for guidance of response efforts related to the Deepwater Horizon oil spill in the Northern Gulf of Mexico along the coast of Alabama and Florida: U.S. Geological Survey Open-File Report 2012–1234, 46 p., http://pubs.usgs.gov/of/2012/1234/.

Alex Pang
Professor, Computer Science and Engineering Department
University of California, Santa Cruz, CA 95064

EMPLOYMENT HISTORY

2003–	Professor, Computer Science Department, University of California, Santa Cruz
1997–03	Associate Professor, Computer Science Department, University of California, Santa Cruz
1990–97	Assistant Professor, Computer Science Department, University of California, Santa Cruz

EDUCATION

Ph.D.	1990	University of California at Los Angeles, Computer Science
M.S.	1984	University of California at Los Angeles, Computer Science
B.S.	1981	University of the Philippines, Industrial Engineering – *magna cum laude*

Relevant Publications

1. Shweta Philips and Alex Pang, "Detecting and Visualizing Rip Currents Using Optical Flow", Eurographics Environmental Visualization '2016 workshop. Published as EuroVis 2016 - Short Papers, 2016. URI: http://dx.doi.org/10.2312/eurovisshort.20161155

2. Brad Eric Hollister, and Alex Pang "Visual Analysis of Transport Similarity in 2D CFD Ensembles", *Visualization and Data Analysis (VDA'16)*, pp. VDA-508.1–VDA-508.11.

3. Georg H Albrecht and Alex Pang, "Interactive High-Dimensional Data Analysis Using the "Three Experts"", *Visualization and Data Analysis (VDA'15)*, pp. 1–10.

4. Alex Pang, "Visualizing Uncertainty in Natural Hazards", in *Risk Assessment, Modeling and Decision Support: Strategic Directions Series: Risk, Governance and Society*, Vol. 14, edited by Ann Bostrom, Steven P. French, and Sara J. Gottlieb, Springer, 2008, XIV, Chapter 12, pp. 261–294. ISBN: 978-3-540-71157-5.

5. P.F.J. Lermusiaux, C.-S. Chiu, G. Gawarkiewicz, P. Abbot, A. Robinson, B. Miller, P.J. Haley, W.G. Leslie, S. Majumdar, A. Pang, and F. Lekien, "Quantifying Uncertainties in Ocean Predictions", Oceanography, a special issue on *Advances in Computational Oceanography*, March 2006, volume 19, number 1, pages 80–93.

Other Publications

1. Brad Hollister and Alex Pang “Bivariate Quantile Interpolation for Ensemble Derived Probability Density Estimates”, *International Journal for Uncertainty Quantification*, Volume 5, Number 2, 2015, pages 123-137.

2. Tino Weinkauf, Holger Theisel, Allen Van Gelder, and Alex Pang, “Stable Feature Flow Fields”, *IEEE Transactions on Visualization and Computer Graphics*, Volume 17, Number 6, June, 2011, pages 770–780.

3. David Kao, Marc Kramer, Alison Love, Jennifer Dungan and Alex Pang, “Visualizing Distributions from Multi-Return Lidar Data to Understand Forest Structure”, *The Cartographic Journal*, June 2005, volume 42, number 1, pages 35–47.

4. Vivek Verma and Alex Pang, “Comparative Flow Visualization”, *IEEE Transactions on Visualization and Computer Graphics*, volume 10, number 6, 2004, pp. 609–624.

5. Alex Pang, Craig Wittenbrink, and Suresh Lodha, “Approaches to Uncertainty Visualization”, *The Visual Computer*, Vol. 13, No. 8, 1997, pp. 370–390.

Synergistic Activities

1. “Remote Sensing of Rip Currents” presented at the Integrating Science Needs with Advanced Seafloor Sensor Engineering to Provide Early Warning of Geohazards (NSF Visioning Workshop), held in Oregon, July 2018.

2. Keynote speech at the Visualization and Data Analysis 2016 conference in San Francisco, February 2016.

3. Member of organizing committee for a Computing Research Association (CRA) workshop on “Uncertainty in Computation” held in 2014;

4. Member of organizing committee for International Uncertainty Visualization workshop held in 2014;

5. Organized a workshop on “Working with Uncertainty, Representation, Quantification, Propagation, Visualization, and Communication” with Chris Johnson, 2011; results were published in two special issues in *International Journal for Uncertainty Quantification* on Uncertainty, Representation, Quantification, Propagation, Visualization, and Communication, 2013.

6. Uncertainty Visualization: Techniques, Challenges and Directions, presented at the IEEE Visualization Tutorial Session, 2012.

Biographical Sketch — Kyle Wilcox

Kyle Wilcox will function as a project investigator and provide expertise on software engineering and assist in the development and testing of new functionality into the THREDDS codebase. Kyle Wilcox has over 12 years experience working in the ocean and environmental sciences, where he specializes in making environmental data easily discoverable through standardized web services such as CSW, SOS, and THREDDS. After earning a BS in Computer Science from the University of Rhode Island in 2006, he went to work for the NOAA Chesapeake Bay Office in Annapolis, MD, working on managing huge collections of modeled and observed data. He relocated back to his home state and started working for Applied Science Associates in 2009. While at ASA, Kyle led the software development team which was focused on the visualization, analysis and storage of large scale environment data. Kyle joined Axiom Data Science in November 2013. Throughout his career, Kyle has been involved in many IOOS related projects including the IOOS catalog (http://catalog.ioos.us/), six IOOS regional associations (MARACOOS, GLOS, SECOORA, CeNCOOS, AOOS and NERACOOS) and the Coastal & Ocean Modeling Testbed (http://testbed.sura.org/). Kyle is a member of the GeoPython (https://github.com/geopython) and PyOceans (https://github.com/pyoceans) organizations which both author Python software packages for serving, managing and accessing environmental and geospatial data.

Position and Address
Software Architect
Axiom Data Science, North Kingstown, RI

Professional Preparation
University of Rhode Island, Computer Science, BS 2006

Appointments

2013 – Present	Software Architect, Axiom Data Science, Providence, RI
2009 – 2013	Software Engineer/Project Manager, Applied Science Associates (ASA), Providence RI 2006 – 2009 IT Project Lead, NOAA Chesapeake Bay Office., Annapolis MD

Publications

Wilcox, K., Stone, B. (2018), SECOORA Data Portal. Integrating heterogeneous ocean data together and making it publically available, discoverable and accessible. Available at: https://portal.secoora.org/. Accessed 25 July 2018.

Bochenek, R.B., **Wilcox, K.**, Stone, B. (2018), IOOS Environmental Sensor Map. Develop community standards for sensor observations; make regional data nationally accessible for >30,000 real-time sensors. Available at: http://sensors.ioos.us/. Accessed 25 July 2018.

Bochenek, R.B., **Wilcox, K.**, Martin, R. (2018), Research Workspace. Web-based platform for collaboratively managing science projects through the entire data lifecycle. Available at: https://researchworkspace.com. Accessed 25 July 2018.

Vance, T., Sontag, S., **Wilcox, K.** (2016). Cloudy with a Chance of Fish: ArcGIS for

Server and Cloud-Based Fisheries Oceanography Applications. In Wright, D. (Eds.), Ocean Solutions, Earth Solutions (pp. 1-24). Redlands, CA: ESRI Press.
Signell RP, Fernandes F, **Wilcox K.** (2016). Dynamic Reusable Workflows for Ocean Science. Journal of Marine Science and Engineering. 4(4):68. doi:10.3390/jmse4040068

Wilcox, K., & Vance, T. (2015). Particle tracking in ocean and atmospheric studies. In L. Armstrong, K. Butler, J. Settelmaier, T. Vance, & O. Wilhelmi (Eds.), *Mapping and modeling weather and climate with GIS* (pp. 129-138). Redlands, CA: ESRI Press.

Vance, T., **Wilcox, K.**, Beegle-Krause, CJ., Schroeder, M. (2013, July). Modeling marine larval behavior using enhanced technologies. Paper presented at ESRI User Conference, San Diego, CA.

Wilcox, K., Crosby, A. (2013, July). LarvaMap - A python powered larval transport modeling system. Paper presented at SciPy, Austin, TX. Available at http://pyvideo.org/video/2074/larvamap-a-python-powered-larval-transport-mode-1.

Wilcox, K., Sontag, S. (2011, September). Bringing the oceans to life using OGC services and dynamic visualization. Paper presented at FOSS4G, Denver, CO.

Howlett, E., **Wilcox, K.**, Stuebe, D., Galvarino, C. (2010, June). Merging Web 2.0 Technologies with Cloud-Based Web Services to Address Ocean and Coastal Geospatial Applications. Paper presented at Com.Geo, Washington, DC.

Synergistic Activities

2015 – 2019 Architected systems to intelligently harvest environmental monitoring and modeling data from all around the world and standardize it under community based standards for use within the IOOS enterprise of systems.

2009 – 2013 Worked for the IOOS national office and two regional offices to catalog solutions for data streams and feeds, performing systems integration and support, and developing and supporting various Python libraries and tools for data access, manipulation, and visualization.

2010 – 2012 Managed logistics and requirements for the Dubai Coastal Ocean Observing System, including development of applications for integrating data from real-time meteorology and oceanography stations, HF radar, and video cameras.

2009 – 2012 Planner, system architect, and developer for NOAA's Coastal Ocean Modeling Testbed.

2008 – 2009 Optimized cloud architecture for scalability and cost efficiency for a small start up and their clients.

2007 – 2008 Project assessment, planning, design, development, and deployment of the cyberinfrastructure currently in use by the Chesapeake Bay Observing System (CBOS) to obtain, analyze, and share observational and modeled data with the public

Jenna A. Brown

Research Oceanographer **jennabrown@usgs.gov**
US Geological Survey **513-300-5797**
MD/DE/DC Water Science Center

A. Education

2002-2006 The Ohio State University, Columbus, OH
Bachelor of Science, magna cum laude, Civil Engineering, June 2006
2006-2009 University of Delaware, Newark, DE
Masters of Science, Civil Engineering, May 2009
2009-2014 Naval Postgraduate School, Monterey, CA
Doctor of Philosophy, Physical Oceanography, July 2014

B. Professional Experience

2014-present Research Oceanographer, U.S. Geological Survey, St. Petersburg Coastal & Marine Science Center, St. Petersburg, FL
2009-2014 Graduate Research Associate, Naval Postgraduate School, Monterey, CA
2006-2009 Graduate Research Assistant, University of Delaware, Newark, DE

C. Publications

Brown, J.A., J.H. MacMahan, A.J.H.M. Reniers, E.B. Thornton, A.L. Shanks, S.G. Morgan, and E.L. Gallagher (2019). Observations of Mixing and Transport on a Steep Beach, *Cont. Shelf Res*., doi.org/10.1016/j.csr.2019.03.009.

Dusek, G., D. Hernandez, M. Willis, **J.A. Brown**, J.W. Long, D.E. Porter and T. Vance (2019). WebCAT: Piloting the Development of a Web Camera Coastal Observing Network for Diverse Applications, *Front. Mar. Sci.*, doi.org/10.3389/fmars.2019.00353.

Brown, J.A., Thompson, D.M., and Long, J.W. (2018), Beach profile data collected from Madeira Beach, Florida: U.S. Geological Survey data release, https://doi.org/10.5066/F7T43S94.

Senechal, N., G. Coco, N. Plant, K.R. Bryan, **J.A. Brown**, and J.H. MacMahan (2018). Field Observations of Alongshore Runup Variability Under Dissipative Conditions in the Presence of a Shoreline Sandwave, *J. Geophys. Res.*, doi.org/10.1029/2018JC014109.

Harrison, S., **J.A. Brown,** H. Gibbons (2017, Aug - Oct). "Eyes on the Coast – Video Cameras Help Forecast Coastal Change." *Sound Waves*. Retrieved from https://www.usgs.gov/news/eyes-coast-video-cameras-help-forecast-coastal-change.

Brown, J.A., J.H. MacMahan, A.J.H.M. Reniers, and E.B. Thornton (2015). Field Observations of Surf Zone-Inner Shelf Exchange on a Rip-Channeled Beach, *J. Phys. Oceanogr.*, doi:10.1175/JPO-D-14-0118.1.

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D. Relevant Presentations

"Measuring Hydrodynamic Drivers and Coastal Response of Hurricane Irma on the Florida Gulf Coast", poster presentation, *American Geophysical Union Fall Meeting*, Washington, D.C, Dec 2018.

"Monitoring Coastal Change with Unmanned Aerial Systems at Madeira Beach, Florida", poster presentation, *American Geophysical Union Ocean Sciences Meeting*, Portland, OR, Feb 2018.

"Observations of Wave Runup and Overwash during a Storm Event", oral presentation, *American Geophysical Union Fall Meeting*, San Francisco, CA, Dec 2016.

"Extracting Maximum Total Water Levels from Video Brightest Images", poster presentation, *American Geophysical Union Ocean Sciences Meeting*, New Orleans, LA, Feb 2016.

"Mass Transport on a Steep Beach", oral presentation, *American Geophysical Union Ocean Sciences Meeting*, Honolulu, HI, Feb 2014.

BRITTANY BRUDER: CURRICULUM VITAE

a. Title: Coastal Research Engineer

b. Current Position, Department and Division:DB-4 Coastal Research Engineer, Coastal Observation and Analysis Branch, Coastal & Hydraulics Laboratory

c. Education:

- 2015 Ph.D. (Civil Engineering), Georgia Institute of Technology, Atlanta, GA, USA
    - GPA: 4.0/4.0
- 2011 M.S. (Civil Engineering), Georgia Institute of Technology, Atlanta, GA, USA
    - GPA: 4.0/4.0
- 2009 B.S. (Civil Engineering), Columbia University, New York City, NY, USA
    - GPA: 3.8/4.0
    - Magna Cum Laude

d. Relevant Professional Experience or Employment:

- 2017-Present: Coastal Research Engineer, Coastal Observation and Analysis Branch, Coastal & Hydraulics Laboratory
- 2015-2017: Postdoctoral Researcher, University of Delaware, Center for Applied Coastal Research
- 2011-2014: National Science Foundation Graduate Research Fellow

e. Relevant Publications:

- Bomminayuni, S., **Bruder, B.,** Stoesser, T. and Haas, K., 2012. Assessment of hydrokinetic energy near rose dhu island, georgia. Journal of Renewable and Sustainable Energy, 4(6), p.063107.
- **Bruder, B.**, Bomminayuni, S., Haas, K., & Stoesser, T. (2014). Modeling tidal distortion in the Ogeechee Estuary. *Ocean Modelling*, *82*, 60-69.
- Young, D.L., **Bruder, B**., Haas, K.A. and Webster, D.R., 2016. The hydrodynamics of surface tidal flow exchange in saltmarshes. Estuarine, Coastal and Shelf Science, 172, pp.128-137.
- **Bruder, B.**, Cristaudo, D., & Puleo, J. A. (2018). Smart surrogate munitions for nearshore unexploded ordnance mobility/burial studies. *IEEE Journal of Oceanic Engineering*.
- Puleo, J. A., Krafft, D., Pintado-Patiño, J. C., & **Bruder, B.** (2017). Video-derived near bed and sheet flow sediment particle velocities in dam-break-driven swash. *Coastal Engineering*, *126*, 27-36.
- Martins, K., Blenkinsopp, C. E., Power, H. E., **Bruder, B.**, Puleo, J. A., & Bergsma, E. W. (2017). High-resolution monitoring of wave transformation in the surf zone using a LiDAR scanner array. *Coastal Engineering*, *128*, 37-43.
- **Bruder, B.,** Renaud, A.D., Spore, N.J. and Brodie, K.L., 2018. Evaluation of Unmanned Aircraft Systems for Flood Risk Management: Field Experiment

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- Brodie KL, **Bruder B.**, Slocum RK, Spore NJ. Simultaneous Mapping of Coastal Topography and Bathymetry From a Lightweight Multicamera UAS. IEEE Transactions on Geoscience and Remote Sensing. 2019 May 30.
- **Bruder, B.,** Hathaway, K., Brodie, K. and Harrison, S., 2019. Design and Deployment of Mini-Argus Systems for Rapid Coastal Imaging (No. ERDC/CHL CHETN-IV-114). ERDC Vicksburg United States.
- Brodie, K., Spore, N., **Bruder, B.,** Renaud, A., Hesser, T., Wilhelm, V. and Hodgens, K., 2019. Post-Irma Unmanned Aircraft System (UAS) Coastal Storm Impact Surveys (No. ERDC/CHL CHETN-IV-116). ENGINEER RESEARCH AND DEVELOPMENT CENTER VICKSBURG MS VICKSBURG United States.
- Rodarmel, C.A., Lee, M.P., Brodie, K.L., Spore, N.J. and **Bruder, B**., 2019. Rigorous Error Modeling for sUAS Acquired Image-Derived Point Clouds. IEEE Transactions on Geoscience and Remote Sensing.

f. Research Achievement and Recognition Awards:

- 2019 ERDC Research and Development Achievement Award
- 2018 CHL Innovation Achievement Award
- 2018 ERDC Award for Outstanding Team Effort
- 2016 Best Ph.D. Thesis: Sigma Xi (University wide)
- 2015 Best Ph.D. Thesis: Department of Civil and Environmental Engineering
- 2014 C3E Women in Clean Energy Symposium Graduate Poster Competition: Technology Solution Winner

Appendix D: Data Sharing Plan

DATA MANAGEMENT PLAN

As a member of the Integrated Ocean Observing System (IOOS) and a certified Regional Information Coordination Entity (RICE), SECOORA has a mandate to collect, organize, and provide access to regional oceanographic data using community-developed standards. These data need to be easily understandable, electronically accessible and well organized to allow policy makers, researchers, managers, and the general public to make well-informed decisions. As such, SECOORA and its data management partner, Axiom Data Science, have considerable experience developing scientific data management infrastructure, and they provide experienced personnel to manage both data and metadata documentation according to federal quality control standards. This project will use the SECOORA data management infrastructure (developed and maintained by Axiom Data Science) to manage and share the data generated through this effort. This system uses the standards and best practices defined by the NOAA U.S. IOOS Data Management and Communications committee (IOOS, 2010). Among this infrastructure is an operational stack of open source software components developed by Axiom Data Science, with support from IOOS and SECOORA, that manages large numbers of continuous data feeds and a data catalog framework to integrate and disseminate a variety of data products. Webcam feeds will be ingested and consolidated through a continuous data system following community-developed standards and exposed via a public web-based portal for data exploration and distribution. Data will be standardized and stored with standards-compliant metadata to ensure data is applicable to a broad range of stakeholders and available for re-use in image analysis and rip current detections by project partners.

Data Types, Formats, and Metadata: This project will ingest and consolidate webcam data streams and make them publicly-available alongside AI/ML video processing outputs and derived data products. Data will be stored in non-proprietary formats to ensure re-use and long-term preservation. Imagery data may initially exist in proprietary or binary formats as primary-level data, depending on the source provider. Though the data may be in a state which can be easily utilized by the research team, in many cases the primary-level data is not in a form ready to be shared with the broader science community or integrated and visualized with other datasets. As such, the final format for the video streams will be a standardized web-optimized MPEG-4 video file using the H.264 video codec. Derived products (images, videos, presentations, etc.) will be stored in IOOS standard formats when one exists and well-known community standards when one does not. All derived products will be documented using FGDC-endorsed ISO metadata, as needed. Processing data into these open and self-describing formats will provide an additional examination of the data for any errors and inconsistencies. The result will be data that is readily available for data exploration, integration using AI/ML methods, and for archive submission.

Among the SECOORA data system infrastructure is the Research Workspace, a web-based scientific collaboration and data management tool used by researchers to secure and centralize project data, generate standards-compliant metadata, and ultimately elect data files and derived data products to be published openly on public data portals and in long-term data archives. Further, the Research Workspace includes an integrated Jupyter Notebook server instance, which has access to the real-time and historical webcam feeds for conducting the downstream processing of webcam data. Ultimately, the Research Workspace will be used as the gateway to publish derived data products generated using Jupyter Notebooks alongside the real-time and historical webcam data and associated metadata to data discovery portals, including the SECOORA and WebCOOS data portals

Comprehensive metadata using the latest national and international technology and community standards will be required for each dataset generated. The Research Workspace includes an integrated metadata editor, allowing researchers to generate metadata conforming to the FGDC-endorsed ISO 19110 and 19115-2 suite of standards. Axiom will provide technical assistance to project researchers to ensure robust and standards-compliant metadata are generated for both webcam feeds as well as derived products.

Data Access and Timeframes: The products developed in this project will be open source and licensed in the public domain. All raw data will be posted on the Research Workspace as soon as possible. All processed data, analysis results and data products will be added to the Research Workspace as soon as they are available, following data collection and conversion to open-standard formats, not later than three months after the completion to promote internal integration and to ensure the reproducibility of results.

As analysis matures, the processed data and derived products will be made available for public access together with metadata documentation. The data will be searchable and accessible for download to the public through the SECOORA and WebCOOS data portals. Through this system, the assembled and managed project data will be exposed through interoperability systems and user-interface tools that allow for data discoverability and exploration by a broader scientific and management community. The data system is composed of web-based applications and tools that provide access to data developed in HTML5 and various web-programming, user-interface frameworks. Users will be able to search data and products with all underlying systems working together to create a powerful and intuitive way to rapidly discover, access and use data.

Data Storage, Preservation, and Archiving: The Axiom data center and services are housed on highly redundant storage and compute resources at a data center in Portland, OR, and are geo-replicated using Amazon Glacier Cloud Archive Services. All databases and code repositories are routinely backed-up, and servers undergo routine maintenance to swiftly address security vulnerabilities. Servers containing source code and databases are located behind an enterprise-level firewall and are physically secure with environmental regulation systems, redundant power, and fire suppression. Axiom's HPC resources are composed of approximately 2500 processing cores staged in a series of interconnected blade arrays as well as 1.8 petabytes of storage. Dedicated disc-space in the amount of 30 TBs will be allocated for long-term storage of all preliminary and finalized data resources produced by this effort.

For long-term preservation, all final data and metadata will be transferred to a national data center. The planned archive for data collected by this effort is the NOAA's National Center for Environmental Information or via the Research Workspace's DataONE Member Node. The Research Workspace hosts an integrated system for automating dataset submission to the NSF-sponsored DataONE federation of data repositories and NCEI. The Research Workplace supports and issues Digital Object Identifiers (DOIs), so datasets can be confidentially referenced in the published literature. Datasets would be submitted for archive with technical support by Axiom staff to ensure appropriate use and compliance with the data center archive requirements.

Appendix E: Budget Narrative

SECOORA Budget Table

SOUTHEAST COASTAL OCEAN OBSERVING REGIONAL ASSOCIATION

Budget sheet covers a three-year period.

Project Title: WebCOOS

Principal Investigator(s): Debra Hernandez

Institution: SECOORA

BUDGET ITEMS		No. of Individuals	Man-Months		Grant Funds Year 1	Grant Funds Year 2	Grant Funds Year 3	Grant Funds Total
Salary and Wages			Grant	Match				
1. Principal Investigator (s) DH			1.00		$ 10,225	$ 10,532	$ 10,848	
2. Associate Investigator(s) JD								
3. Professionals - AW								
4. Research Associates								
5. Research Asst. Grad. Students								
6. Prof. School Students								
7. Pre-Bac. Students								
8. Secretarial/Clerical								
9. Technical-Shop								
10. Other								
TOTAL SALARIES and WAGES					$ 10,225	$ 10,532	$ 10,848	$ 31,604
Fringe Benefits - Formula =			26%		$ 2,659	$ 2,738	$ 2,820	$ 8,217
TOTAL SALARIES, WAGES and FRINGE BENEFITS					$ 12,884	$ 13,270	$ 13,668	$ 39,822
PERMANENT EQUIPMENT (list)								$ -
EXPENDABLE SUPPLIES, etc.								$ -
TRAVEL								$ -
1. Domestic					$ 10,000	$ 10,000	$ 15,000	$ 35,000
2. Foreign (requires prior approval)								$ -
PUBLICATION COSTS						$ 2,000	$ 5,000	$ 7,000
OTHER COSTS								$ -
UNCW - Long					$ 64,939	$ 66,290	$ 56,825	$ 188,054
USC - Porter					$ 85,145	$ 84,719	$ 87,501	$ 257,365
Axiom Data Science - Wilcox					$ 75,864	$ 70,006	$ 69,876	$ 215,746
UCSC - Pang					$ 74,852	$ 86,354	$ 90,037	$ 251,243
TBD Private sector camera operator					$ 30,000	$ 30,000	$ 30,000	$ 90,000
Project Coordination Contractor - Megan Treml					$ 15,000	$ 15,000	$ 15,000	$ 45,000
TOTAL DIRECT COSTS					$ 368,684	$ 377,639	$ 382,906	$ 1,129,229
INDIRECT COSTS	1. On campus - Formula =				$ 13,959	$ 3,023	$ 2,885	$ 19,867
	2. Off campus - Formula =				$ 382,643	$ 380,662	$ 385,791	$ 1,149,096
TOTAL COST								

SECOORA Budget Justification

The total request for this award is **$1,149,096**

Year 1 = $382,643 Year 2 = $380,662, Year 3 = $385,791

Salary + Fringe: Total Year 1 salary funds requested equals $10,225 for the PI D. Hernandez (1 month, $10,225). Total Year 2 salary funds requested equals $10,532 for the PI D. Hernandez (1 month). Total Year 3 salary funds requested equals $10,848 for the PI D. Hernandez (1 month). Fringe is calculated at 26% of salary (Year 1 $2,659, Year 2 $2,738, Year 3 $2,820). Salary plus fringe for Year 1-3 equals **$39,822.**

Travel: Total for Years 1-3 is $35,000 (Year 1 $10K, Year 2 $10K, Year 3 $15K). Travel support up to $5,000 is requested for PI Hernandez, contractor Treml, co-PI Wilcox and non-federal end users to attend Project Team meetings in Years 1 through 3; for PI Hernandez to attend an ocean science meeting including associated registration costs annually; and to support travel between project team members and end users at coordination and training meetings separate from the annual Project Team meetings. Funding of $5,000 annually is requested to support hotel venue, audio visual, food and beverage costs associated with annual team meetings. An additional $5,000 is requested in Year 3 for PI Hernandez, contractor Treml, co-PI Wilcox to attend an additional science meeting such as AGU to present project findings. Allowable charges will adhere to federal per diem guidelines as appropriate.

Other Costs: Publication Costs ($7,000) (Year 2 $2K, Year 3 $5K) are requested in order to publish work from this project in scientific journals.

Indirect: SECOORA charges 8.57% on all direct charges and the first $25,000 in contracts/subawards. Total indirect is **$19,867 (Year 1 $13,959, Year 2 $3,023, Year 3 $2,885.**

Budget justifications for subawards are below.

SUBAWARDS
UNCW– Dr. Long Total Costs: $188,054
Year 1 Total Costs: $64,939

Salary and Fringe: Principal Investigator – 1 month; $7222/month
Salary is requested for PI-Long to lead the development of algorithms to identify the extent of wave runup and occurrence of coastal dune erosion. He will also be responsible to mentoring a graduate student and working with the project team to ensure that the wave runup and dune erosion techniques are integrated into the final situational awareness platform. **Graduate Student** - 12 months; $1500/month. A full-time graduate student stipend for one masters student ($18,000) including academic year and summer effort, who will be enrolled at UNCW, will be co-advised by PI-Long. The student will be responsible for image processing and assisting in algorithm development.

Fringe Benefits: Fringe benefits for PI Long are calculated at 28.35% and fringe benefits for undergraduate and graduate student salary are 8.65%. Fringe total is $3,604.
Total Salary: $28,826

Equipment: Equipment costs of $6,000 are requested for the purchase of one desktop computer capable of processing high-resolution videos and extracting coastal features. Cost includes the purchase of monitors and other peripherals (keyboard, mouse, etc).

Expendable Supplies: $250 is requested hard drives (8TB) for data storage and backup.

Other Costs: Tuition Costs; Out-of-state graduate student tuition ($15,615) based on the 2019-2020 rate is included. The rate is based on a maximum of 8 credits per semester.

Indirect Costs: F & A is charged at UNCW's federally negotiated indirect cost rate, 49% of Modified Total Direct Costs (excluding tuition). Total IDC: $14,247

Year 2 Total Costs: $66,290

Salary and Fringe: Principal Investigator – 1 month; $7366month (includes 2% increase) Salary is requested for PI-Long to lead the development of algorithms to identify the extent of wave runup and occurrence of coastal dune erosion. He will also be responsible to mentoring a graduate student and working with the project team to ensure that the wave runup and dune erosion techniques are integrated into the final situational awareness platform. **Graduate Student** - 12 months; $1500/month. A full-time graduate student stipend for one masters student ($18,000) including academic year and summer effort, who will be enrolled at UNCW, will be co-advised by PI-Long. The student will be responsible for image processing and assisting in algorithm development.

Fringe Benefits: Fringe benefits for PI Long are calculated at 28.35% and fringe benefits for undergraduate and graduate student salary are 8.65%. Fringe total is $3,645.

Total Salary: $29,012

Expendable Supplies: $250 is requested hard drives (8TB) for data storage and backup.

Travel (Domestic): Funds are requested for PI Long and graduate student to attend the AMS meeting (5 days total) in Houston, TX in Year 2 to present results to agency, industry, and academic audiences. Trip includes airfare ($400/person), conference registration ($595/person), lodging ($192/person/night), and other miscellaneous allowable travel expenses. Total anticipated trip cost is $3,700.

Other Costs: Tuition Costs: Out-of-state graduate student tuition ($17,177) based on a 10% increase above the 2019-2020 rate is included. The rate is based on a maximum of 8 credits per semester.

Indirect Costs: F & A is charged at UNCW's federally negotiated indirect cost rate, 49% of Modified Total Direct Costs (excluding tuition). Total IDC: $16,151

Year 3 Total Costs: $56,825

Salary and Fringe: Principal Investigator – 1 month; $7514/month (includes 2% increase) Salary is requested for PI-Long to lead the development of algorithms to identify the extent of wave runup and occurrence of coastal dune erosion. He will also be responsible to mentoring a graduate student and working with the project team to ensure that the wave runup and dune erosion techniques are integrated into the final situational awareness platform. **Graduate Student** - 9 months; $1500/month. A full-time graduate student stipend for one masters student ($13,500) including academic year, who will be enrolled at UNCW, will be co-advised by PI-Long. The student will be responsible for image processing and assisting in algorithm development.

Fringe Benefits: Fringe benefits for PI Long are calculated at 28.35% and fringe benefits for undergraduate and graduate student salary are 8.65%. Total Fringe is $3,298.

Total Salary: $24,312

Expendable Supplies: $250 is requested hard drives (8TB) for data storage and backup.
Travel (Domestic): Funds are requested for PI Long and graduate student to attend a project meeting (3 days total) in Charleston, SC in Year 3 to integrate the deliverables with the project team. Trip includes mileage (175 miles) from Wilmington, NC to Charleston, SC, lodging ($183/person/night), and other miscellaneous allowable travel expenses. Total anticipated trip cost is $1,000.

Other Costs: Tuition Costs: Out-of-state graduate student tuition ($18,738) based on an increase above the 2019-2020 rate is included. The rate is based on a maximum of 8 credits per semester.

Indirect Costs: F & A is charged at UNCW's federally negotiated indirect cost rate, 49% of Modified Total Direct Costs (excluding tuition). Total IDC: $12,525

USC– Dr. Porter Total Costs: $257,365
Year 1 Total Costs: $85,145

Salary and Fringe: Principal Investigator – 0.50 sum. months ($9,333)**,** Research, Assoc.–1.25 months ($7,708)**,** Professionals–1.25 months ($7,500)**,** Graduate Student – 12 months ($20,000)

Personnel funds are requested to support the activities of PI Porter for project administration and overall project management. A portion of Porter's time will also be in support of community engagement activities. The latter activities will be done in conjunction with the NIEHS-supported Center for Oceans and Human Health and Climate Change Interactions housed at the University of South Carolina. Partial support of a systems analyst and programmer is requested for development, implementation and management of the "Situational Monitoring and Reporting

System" (SMRS) and for automated feature extraction algorithm development, validation and implementation. These two positions will complement and build upon ongoing SECOORA-supported water quality nowcasting activities. A Graduate Research Assistant (GRA) will be engaged in all aspects of the SMRS.

Fringe Benefits ($9,299) Fringe benefits are charged per State of South Carolina guidelines. Fringe for PI summer salary equals 30.09%. Insurance for the Professional is charged at the family rate and for the Research Associate is charged at the individual. USC HR staff calculated the required benefits for the informatics specialist base applicable state rates (see: https://sc.edu/about/offices_and_divisions/sponsored_awards_management/essential_reference_information/fringe_benefits.php). **Total Salary: $53,839**

Supplies: Funds totaling $3,000 are requested for basic IT supplies. Materials and supplies include all equipment and materials costing less than $5,000 per item. A workstation costing approximately $2,200 will be purchased. Example items include backup power supplies at $150 each, monitor at $175 each, and other supporting IT, data management and data development items. Funds will also be used as partial support for continuation of GIS site license.

Travel: Requested travel funds totaling $2,800 will partially support participation in offsite project meetings and meetings with community end users, and an annual PI meeting. Allowable charges will adhere to state and federal per diem guidelines as appropriate and is domestic.

Other Costs: Tuition Costs: $10,000 per year is requested for a tuition abatement for the GRA.

Indirect Costs ($15,506): IDC is calculated as 26.0% of allowable direct costs. This rate reflects USC's federally-approved IDC rate for off-campus research activities.

Year 2 Total Costs: $84,719

Salary and Fringe: Principal Investigator – 0.50 months summer support ($9,613)**, Research Associates** – 1.25 months ($7,939)**; Professionals** – 1.25 months ($7,725)**; Graduate Student** – 12 months ($20,000)

Fringe Benefits ($9,524): Fringe benefits are charged per State of South Carolina guidelines. Fringe for PI summer salary equals 30.09%. Insurance for the Professional is charged at the family rate and for the Research Associate is charged at the individual. USC HR staff calculated the required benefits for the informatics specialist base applicable state rates (see: https://sc.edu/about/offices_and_divisions/sponsored_awards_management/essential_reference_information/fringe_benefits.php).
Total Salary: $55,400

Expendable Supplies: Funds totaling $1,500 are requested for basic IT supplies. Materials and supplies include all equipment and materials costing less than $5,000 per item. Example items include backup power supplies at $150 each, monitor at $175 each, and other supporting IT, data management and data development items. Funds will also be used as partial support for continuation of GIS site license.

Travel: Requested travel funds totaling $2,400 will partially support participation in offsite project meetings and meetings with community end users, and an annual PI meeting. Allowable charges will adhere to state and federal per diem guidelines as appropriate. All travel will be domestic.

Other Costs: Tuition Costs: We are requesting $10,000 per year for a tuition abatement for the GRA.

Indirect Costs ($15,418): IDC is calculated as 26.0% of allowable direct costs. This rate reflects USC's federally-approved IDC rate for off-campus research activities.

Year 3 Total Costs: $87,501

Salary and Fringe: Principal Investigator – 0.50 summer months ($9,901)**,** Research Associates – 1.25 months ($8,177)**,** Professionals – 1.25 months ($7,957)**,** Graduate Student – 12 months ($20,000)

Fringe Benefits ($9,756):are charged per State of South Carolina guidelines. Fringe for PI summer salary equals 30.09%. Insurance for the Professional is charged at the family rate and for the Research Associate is charged at the individual. USC HR staff calculated the required benefits for the informatics specialist base applicable state rates (see: https://sc.edu/about/offices_and_divisions/sponsored_awards_management/essential_reference_information/fringe_benefits.php). **Total Salary: $57,009**

Expendable Supplies: Funds totaling $1,500 are requested for basic IT supplies. Materials and supplies include all equipment and materials costing less than $5,000 per item. Example items include backup power supplies at $150 each, monitor at $175 each, and other supporting IT, data management and data development items. Funds will also be used as partial support for continuation of GIS site license.

Travel: Requested travel funds totaling $3,000 will partially support participation in offsite project meetings and meetings with community end users, and an annual PI meeting. Allowable charges will adhere to state and federal per diem guidelines as appropriate. Travel will include presentation of project accomplishments at an appropriate conference. All travel will be domestic.

Other Costs; Tuition Costs: $10,000 per year is requested for a tuition abatement for the GRA.

Indirect Costs ($15,992): IDC is calculated as 26.0% of allowable direct costs. This rate reflects USC's federally-approved IDC rate for off-campus research activities.

Axiom– Kyle Wilcox Total Costs: $215,746

Year 1 Total Costs: $75,864

Salary and Fringe: Principal Investigator - Kyle Wilcox, Senior Software Engineer, is budgeted at 16 %FTE ($18560; 332.8 hours) to manage the technical personnel, to coordinate with the WebCOOS team on the DMAC strategy, and to attend all project meetings and management communications. Mr. Wilcox will also develop and enhance the WebCOOS ingestion system, integrate real-time and historical datasets, and develop and enhance the data quality applications according to data standards. **Research Associate** - Brian Stone, Software Engineer, is budgeted at 5 %FTE ($5850; 104 hours) to ingest data products to the WebCOOS portal or a common project platform for visualization and public access, and to assist with webcam visualization updates. Dave Foster, Software Engineer, is budgeted at 8 %FTE ($8960; 166.4 hours) to develop web services and process data into standard formats for access using interoperability services. Stacey Buckelew, Project Manager, is budgeted at 3 %FTE ($3150; 62.4 hours) to manage the project, budget, reporting, and to communicate with project partners. Shane St. Savage, Senior Software Engineer, is budgeted at 5 %FTE ($5336; 104 hours) to support the WebCOOS data system and manage the physical data center.

Fringe Benefits: $10,464- Fringe benefits are calculated at 25% to cover 401K, health insurance, and paid leave for staff salaries.
Total Salary: $52,320

Indirect Costs: Axiom Data Science's federally approved indirect cost rate requested is 45% MTDC (total direct costs, minus equipment, supplies, and subcontracts in excess of $25,000). IDC for Year 1 is **$23,544.**

Year 2 Total Costs: $70,006

Salary and Fringe: Principal Investigator - Kyle Wilcox, Senior Software Engineer, is budgeted at 16 %FTE ($19117; 332.8 hours) to manage the technical personnel, to coordinate with the WebCOOS team on the DMAC strategy, and to attend all project meetings and management communications. Mr. Wilcox will also develop and enhance the WebCOOS ingestion system, integrate real-time and historical datasets, and develop and enhance the data quality applications according to data standards. **Research Associate** - Brian Stone, Software Engineer, is budgeted at 5 %FTE ($6026; 104 hours) to ingest data products to the WebCOOS portal or a common project platform for visualization and public access, and to assist with webcam visualization updates. Dave Foster, Software Engineer, is budgeted at 6 %FTE ($6922; 124.8 hours) to develop web services and process data into standard formats for access using interoperability services. Stacey Buckelew, Project Manager, is budgeted at 2 %FTE ($2163; 41.6 hours) to manage the project, budget, reporting, and to communicate with project partners. Shane StSavage, Senior Software Engineer, is budgeted at 4 %FTE ($4397; 83.2 hours) to support the WebCOOS data system and manage the physical data center.

Fringe Benefits: $9,656- Fringe benefits are calculated at 25% to cover 401K, health insurance, and paid leave for staff salaries.
Total Salary: $48,280

Indirect Costs: Axiom Data Science's federally approved indirect cost rate requested is 45% MTDC (total direct costs, minus equipment, supplies, and subcontracts in excess of $25,000).

IDC for Year 2 is **$21,726.**

Year 3 Total Costs: $69,876

Salary and Fringe: Principal Investigator - Kyle Wilcox, Senior Software Engineer, is budgeted at 15 %FTE ($18460; 312 hours) to manage the technical personnel, to coordinate with the WebCOOS team on the DMAC strategy, and to attend all project meetings and management communications. Mr. Wilcox will also develop and enhance the WebCOOS ingestion system, integrate real-time and historical datasets, and develop and enhance the data quality applications according to data standards. **Research Associate** - Brian Stone, Software Engineer, is budgeted at 5 %FTE ($6206; 104 hours) to ingest data products to the WebCOOS portal or a common project platform for visualization and public access, and to assist with webcam visualization updates. Dave Foster, Software Engineer, is budgeted at 6 %FTE ($7129; 124.8 hours) to develop web services and process data into standard formats for access using interoperability services. Stacey Buckelew, Project Manager, is budgeted at 2 %FTE ($2228; 41.6 hours) to manage the project, budget, reporting, and to communicate with project partners. Shane StSavage, Senior Software Engineer, is budgeted at 4 %FTE ($4529; 83.2 hours) to support the WebCOOS data system and manage the physical data center.

Fringe Benefits: $9,638 Fringe benefits are calculated at 25% to cover 401K, health insurance, and paid leave for staff salaries.
Total Salary: $48,190

Indirect Costs: Axiom Data Science's federally approved indirect cost rate requested is 45% MTDC (total direct costs, minus equipment, supplies, and subcontracts in excess of $25,000). IDC for Year 3 is **$21,686.**

UCSC– Dr. Pang Total Costs: $251,243
Year 1 Total Costs: $74,852

Salary and Fringe; Graduate Student – Akila de Silva, 12 months, 50% time - $30,783**. Fringe Benefits** (rate of 2.10%): $647**. Total Salary (with fringe): $31,430**

Travel; The same conference can have both domestic and foreign venues. Both domestic and foreign travel are included because we also don't know ahead of time where a paper may get accepted. **Domestic - $1,300/year.** Sample conference venues: OSM/AGU and IEEE Visualization. Using OSM 2020 and IEEE Visualization 2019 as reference point: Registration: $525 | $800; Accommodation: $200/night | $170/night; Meals: $64/day | $66/day; Airfare: $120 | $350; Transfers: $250 | $260. **Foreign – $1,300/year.** Sample conference venues: OSM/AGU and IEEE Visualization. Using OSM 2020 and IEEE Visualization 2019 as reference point: Registration: $525 | $800; Accommodation: $200/night | $170/night; Meals: $64/day | $66/day; Airfare: $120 | $350; Transfers: $250 | $260

Other Costs: Publications - $1,400/year. Publication charges, using Journal of Coastal Research as an example: Publication charge: $700, Color figure charge: $700

Tuition Costs (Total Graduate Fees): $20,290

Indirect Costs: 54% on $35,430 = $19,132

<u>Year 2 Total Costs: $86,354</u>

Salary and Fringe; Principal Investigator Alex Pang, 0 months; Grad. Student - Akila de Silva, 12 months, 50% time ($36,971). **Fringe Benefits** (rate of 2.10%) $776. **Total Salary**: $37,747

Travel: Same as Year 1 ($2,600)

Other Costs : Publication Costs ($1,400), Tuition Costs: $22,064

Indirect Costs: 54% on $41,747 = $22,543

<u>Year 3 Total Costs: $90,037</u>

Salary and Fringe: Principal Investigator-Alex Pang, 0 months; Grad Student - Akila de Silva, 12 months, 50% time ($38,080). Fringe Benefits (rate of 2.10%): $800. Total Salary: $38,880

Travel: Same as Year 1 ($2,600)

Other Costs: Publication Costs ($1,400): Tuition Costs: $24,002

Indirect Costs: 54% on $42,880 = **$23,155**

<u>TBD – Private Sector Camera Operator:</u> Based on the costs of operating the cameras for the WebCAT project, and research with three commercial webcam providers, we estimate costs for annual operation of a webcam at $5,000 per camera per year.
<u>Total Costs: $90,000</u> <u>(Each Year $30K)</u>

<u>Project Coordination contractor</u>: Megan Treml is an existing SECOORA contractor with experience coordinating scientific projects. Her responsibilities as Project Coordinator will include scheduling monthly team calls, planning annual team meetings, working with project PIs to define user requirements and coordinate those requirements across the efforts of the funded partners. She will work with PI Hernandez to draft and update the Transition Plan as the project develops, and will plan the annual team meetings in coordination with project PIs. Effort will be 4 hours per week for 50 weeks annually at a rate of $75/hour, totaling **$45,000**.

BUDGET INFORMATION - Non-Construction Programs

OMB Approval No. 0348-0044

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. UNCW		$	$	$ 188,054.00	$	$ 188,054.00
2. Long						0.00
3.						0.00
4.						0.00
5. Totals		$ 0.00	$ 0.00	$ 188,054.00	$ 0.00	$ 188,054.00

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total (5)
	(1) Year 1	(2) Year 2	(3) Year 3	Year 3	
a. Personnel	$ 25,222.00	$ 25,366.00	$ 21,014.00	$	$ 71,602.00
b. Fringe Benefits	3,604.00	3,645.00	3,298.00		10,547.00
c. Travel		3,700.00	1,000.00		4,700.00
d. Equipment	6,000.00				6,000.00
e. Supplies	250.00	250.00	250.00		750.00
f. Contractual					0.00
g. Construction					0.00
h. Other	15,615.00	17,177.00	18,738.00		51,530.00
i. Total Direct Charges *(sum of 6a-6h)*	50,691.00	50,138.00	44,300.00	0.00	145,129.00
j. Indirect Charges	14,248.00	16,152.00	12,525.00		42,925.00
k. TOTALS *(sum of 6i and 6j)*	$ 64,939.00	$ 66,290.00	$ 56,825.00	$ 0.00	$ 188,054.00
7. Program Income	$	$	$	$	$ 0.00

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SECTION C - NON-FEDERAL RESOURCES				
(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
8.	$	$	$	$ 0.00
9.				0.00
10.				0.00
11.				0.00
12. TOTAL *(sum of lines 8-11)*	$ 0.00	$ 0.00	$ 0.00	$ 0.00

SECTION D - FORECASTED CASH NEEDS					
	Total for 1st Year	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
13. Federal	$ 64,939.00	$ 16,234.75	$ 16,234.75	$ 16,234.75	$ 16,234.75
14. Non-Federal	0.00				
15. TOTAL *(sum of lines 13 and 14)*	$ 64,939.00	$ 16,234.75	$ 16,234.75	$ 16,234.75	$ 16,234.75

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT				
(a) Grant Program	FUTURE FUNDING PERIODS (Years)			
	(b) First	(c) Second	(d) Third	(e) Fourth
16.	$ 66,290.00	$ 56,825.00	$	$
17.				
18.				
19.				
20. TOTAL *(sum of lines 16-19)*	$ 66,290.00	$ 56,825.00	$ 0.00	$ 0.00

SECTION F - OTHER BUDGET INFORMATION	
21. Direct Charges:	22. Indirect Charges: 49% minus tuition and equipment.
23. Remarks:	

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BUDGET INFORMATION - Non-Construction Programs

OMB Approval No. 0348-0044

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. USC		$	$	$ 257,365.00	$	$ 257,365.00
2. Porter						0.00
3.						0.00
4.						0.00
5. Totals		$ 0.00	$ 0.00	$ 257,365.00	$ 0.00	$ 257,365.00

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total
	(1) Year 1	(2) Year 2	(3) Year 3	Year 3	(5)
a. Personnel	$ 44,541.00	$ 45,877.00	$ 47,253.00	$	$ 137,671.00
b. Fringe Benefits	9,299.00	9,524.00	9,756.00		28,579.00
c. Travel	2,800.00	2,400.00	3,000.00		8,200.00
d. Equipment					0.00
e. Supplies	3,000.00	1,500.00	1,500.00		6,000.00
f. Contractual					0.00
g. Construction					0.00
h. Other	10,000.00	10,000.00	10,000.00		30,000.00
i. Total Direct Charges *(sum of 6a-6h)*	69,640.00	69,301.00	71,509.00	0.00	210,450.00
j. Indirect Charges	15,505.00	15,418.00	15,992.00		46,915.00
k. TOTALS *(sum of 6i and 6j)*	$ 85,145.00	$ 84,719.00	$ 87,501.00	$ 0.00	$ 257,365.00
7. Program Income	$	$	$	$	$ 0.00

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SECTION C - NON-FEDERAL RESOURCES				
(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
8.	$	$	$	$ 0.00
9.				0.00
10.				0.00
11.				0.00
12. TOTAL *(sum of lines 8-11)*	$ 0.00	$ 0.00	$ 0.00	$ 0.00

SECTION D - FORECASTED CASH NEEDS					
	Total for 1st Year	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
13. Federal	$ 85,145.00	$ 21,286.25	$ 21,286.25	$ 21,286.25	$ 21,286.25
14. Non-Federal	0.00				
15. TOTAL *(sum of lines 13 and 14)*	$ 85,145.00	$ 21,286.25	$ 21,286.25	$ 21,286.25	$ 21,286.25

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT				
(a) Grant Program	FUTURE FUNDING PERIODS (Years)			
	(b) First	(c) Second	(d) Third	(e) Fourth
16.	$ 84,719.00	$ 87,501.00	$	$
17.				
18.				
19.				
20. TOTAL *(sum of lines 16-19)*	$ 84,719.00	$ 87,501.00	$ 0.00	$ 0.00

SECTION F - OTHER BUDGET INFORMATION	
21. Direct Charges:	22. Indirect Charges: 26%
23. Remarks:	

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BUDGET INFORMATION - Non-Construction Programs

OMB Approval No. 0348-0044

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. Axiom		$	$	$ 215,746.00	$	$ 215,746.00
2. Wilcox						0.00
3.						0.00
4.						0.00
5. Totals		$ 0.00	$ 0.00	$ 215,746.00	$ 0.00	$ 215,746.00

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total
	(1) Year 1	(2) Year 2	(3) Year 3	Year 3	(5)
a. Personnel	$ 41,856.00	$ 38,624.00	$ 38,552.00	$	$ 119,032.00
b. Fringe Benefits	10,464.00	9,656.00	9,638.00		29,758.00
c. Travel					0.00
d. Equipment					0.00
e. Supplies					0.00
f. Contractual					0.00
g. Construction					0.00
h. Other					0.00
i. Total Direct Charges *(sum of 6a-6h)*	52,320.00	48,280.00	48,190.00	0.00	148,790.00
j. Indirect Charges	23,544.00	21,726.00	21,686.00		66,956.00
k. TOTALS *(sum of 6i and 6j)*	$ 75,864.00	$ 70,006.00	$ 69,876.00	$ 0.00	$ 215,746.00
7. Program Income	$	$	$	$	$ 0.00

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SECTION C - NON-FEDERAL RESOURCES				
(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
8.	$	$	$	$ 0.00
9.				0.00
10.				0.00
11.				0.00
12. TOTAL *(sum of lines 8-11)*	$ 0.00	$ 0.00	$ 0.00	$ 0.00

SECTION D - FORECASTED CASH NEEDS					
	Total for 1st Year	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
13. Federal	$ 75,864.00	$ 18,966.00	$ 18,966.00	$ 18,966.00	$ 18,966.00
14. Non-Federal	0.00				
15. TOTAL *(sum of lines 13 and 14)*	$ 75,864.00	$ 18,966.00	$ 18,966.00	$ 18,966.00	$ 18,966.00

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT				
(a) Grant Program	FUTURE FUNDING PERIODS (Years)			
	(b) First	(c) Second	(d) Third	(e) Fourth
16.	$ 70,006.00	$ 69,876.00	$	$
17.				
18.				
19.				
20. TOTAL *(sum of lines 16-19)*	$ 70,006.00	$ 69,876.00	$ 0.00	$ 0.00

SECTION F - OTHER BUDGET INFORMATION	
21. Direct Charges:	22. Indirect Charges: 45%
23. Remarks:	

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BUDGET INFORMATION - Non-Construction Programs

OMB Approval No. 0348-0044

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds Federal (c)	Estimated Unobligated Funds Non-Federal (d)	New or Revised Budget Federal (e)	New or Revised Budget Non-Federal (f)	New or Revised Budget Total (g)
1. UCSC		$	$	$ 251,243.00	$	$ 251,243.00
2. Pang						0.00
3.						0.00
4.						0.00
5. Totals		$ 0.00	$ 0.00	$ 251,243.00	$ 0.00	$ 251,243.00

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY (1) Year 1	(2) Year 2	(3) Year 3	Year 3	Total (5)
a. Personnel	$ 30,783.00	$ 36,971.00	$ 38,080.00	$	$ 105,834.00
b. Fringe Benefits	647.00	776.00	800.00		2,223.00
c. Travel	2,600.00	2,600.00	2,600.00		7,800.00
d. Equipment					0.00
e. Supplies					0.00
f. Contractual					0.00
g. Construction					0.00
h. Other	21,690.00	23,464.00	25,402.00		70,556.00
i. Total Direct Charges *(sum of 6a-6h)*	55,720.00	63,811.00	66,882.00	0.00	186,413.00
j. Indirect Charges	19,132.00	22,543.00	23,155.00		64,830.00
k. TOTALS *(sum of 6i and 6j)*	$ 74,852.00	$ 86,354.00	$ 90,037.00	$ 0.00	$ 251,243.00
7. Program Income	$	$	$	$	$ 0.00

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SECTION C - NON-FEDERAL RESOURCES				
(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
8.	$	$	$	$ 0.00
9.				0.00
10.				0.00
11.				0.00
12. TOTAL *(sum of lines 8-11)*	$ 0.00	$ 0.00	$ 0.00	$ 0.00

SECTION D - FORECASTED CASH NEEDS					
	Total for 1st Year	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
13. Federal	$ 74,852.00	$ 18,713.00	$ 18,713.00	$ 18,713.00	$ 18,713.00
14. Non-Federal	0.00				
15. TOTAL *(sum of lines 13 and 14)*	$ 74,852.00	$ 18,713.00	$ 18,713.00	$ 18,713.00	$ 18,713.00

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT				
(a) Grant Program	FUTURE FUNDING PERIODS (Years)			
	(b) First	(c) Second	(d) Third	(e) Fourth
16.	$ 86,354.00	$ 90,037.00	$	$
17.				
18.				
19.				
20. TOTAL *(sum of lines 16-19)*	$ 86,354.00	$ 90,037.00	$ 0.00	$ 0.00

SECTION F - OTHER BUDGET INFORMATION	
21. Direct Charges:	22. Indirect Charges: 54%
23. Remarks:	

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