FINAL PROJECT OUTCOMES REPORT

The Safe Beaches and Shellfish Project is the first project of the New England Sustainability Consortium (NEST) (www.newenglandsustainabilityconsortium.org). NEST began in 2013 as an ambitious effort to build research capacity by integrating strengths of multiple small universities and colleges in Maine and New Hampshire and by combining and growing these strengths through new collaborative research partnerships. With the addition of a second project in 2015, The Future of Dams, NEST has expanded to include Rhode Island institutions.

Research thrusts. This Safe Beaches and Shellfish Project addressed water quality and public health issues of importance to many coastal communities regionally and nationally.

1. Early, active, and iterative engagement with diverse stakeholders resulted in a broad suite of impacts from this work and advancements in the theory and practice of sustainability science discipline. For example, a decision support system (DSS) is under development based on an integrative conceptual model linking bacterial source, delivery, and residence time processes. The DSS uses a suite of water quality datasets and analytical tools developed in partnership with state agencies, nonprofits, and individuals.
2. **Coast-wide research** focused on patterns and relationships among coupled natural and social systems that influence the resilience of beaches and shellfish. Coast-wide analysis of coupled social and natural processes, decision making, and use and production of science were combined to improve understanding of system interactions that contribute to high levels of microbial pathogens and indicator bacteria in coastal waters and influence system responses.
3. **Place-based research** employed a multi-case study design to provide deep understanding of social and biophysical phenomena in places and at scales relevant to stakeholders and informative to coast-wide understanding.

Intellectual Merit

A **conceptual model** brought together the social-ecological systems research focused on sources, delivery, and residence time with parallel consideration of factors that influence connections between scientific knowledge and decision-making. This conceptual model served as an important boundary object to coordinate across six different disciplines spanning the natural and social sciences: hydrogeomorphology, environmental communication and sustainability science, marine biology and oceanography, microbiology, spatial information sciences, and macro-ecology.

Decision support systems (DSS) provided information to individuals, municipal officials, state and national coastal programs, aimed at management of both beach and shellfish resources. The portfolio included products (data, maps, tools, models); interactions to better understand information needs and design decision support processes; and knowledge-action systems or networks comprised of individuals, organizations, communication networks, and supporting institutional structures.

To prevent human illness from pathogenic Vibrio species affecting shellfish **methods were developed to detect the actual pathogenic strains of Vibrio species** and a patent application was filed for a new assay

to detect *V. parahaemolyticus* in oysters. Forecasting models of the incidence and concentrations of pathogenic vibrios in regional shellfish harvest areas were developed to inform harvest management practices to reduce risks of vibrio-borne illness associated with raw shellfish consumption.

A model for prediction of watershed microbial contamination along the Maine coast, including a new high-resolution topographic map of the coastline delineating boundaries of watersheds and drainage networks, was developed. A hydrodynamic and particle tracking model was developed with stakeholders to enable investigation of estuarine parameter space with different combinations of environmental forcings.

At the conclusion of the project in July 2016, 42 peer-reviewed publications had been published and 25 manuscripts are in review or development. Thirty-two competitive, peer-reviewed awards had been received, representing $30,235,968 in follow-on funding to extend research efforts initiated by the project.

Broader Impacts

Stakeholder engagement: The Safe Beaches and Shellfish Project supported research that is relevant to diverse coastal decision makers by providing analyses, information, data, and models and building shared research capacity. Researchers and stakeholders collaboratively refined the questions, methods, and the identification of potential solutions, such as the development of the DSS and the identification of management trigger levels for beach and shellfish bed closures. Research data is publicly available on the NH EPSCoR Data Discovery Center (https://ddc.unh.edu/). Relationships were developed or strengthened with stakeholders from 35 state agencies, municipalities, non profit organizations and businesses.

Research training: Developing a cadre of young scientists with a strong disciplinary foundation as well as interdisciplinary sensibilities is a focus of NEST. Students collaborated with scientists from different disciplines and interacted with key stakeholders to better understand how sustainability science can help inform and address coastal environmental concerns. This project provided training for six post-doctoral associates, 41 graduate students and 53 undergraduates, across eight institutions.

Curriculum development: Cross-disciplinary courses on applied sustainability science were offered to students in both states via real-time videoconferencing. Keene State College developed a new academic course focused on genomic analysis, including a novel bioinformatics class for both biology and computer science majors. University of New England students were trained on methods for conducting stakeholder engagement in the context of sustainability science within an undergraduate curriculum.