Nichole Price - Bigelow

Seafood Security in a Changing Ocean

Nichole Price – Bigelow Laboratory

Doug Rasher, Nick Record, Steve Archer, Mike Lomas, David Emerson – Bigelow Laboratory

Nick Battista, Susie Arnold, Heather Deese – Island Institute

Heather Leslie, Damian Brady – Umaine

Senior Research Scientist
Director of the Center for Venture Research for Seafood Solutions nprice@bigelow.org
207 315 2567 x306

Bigelow | Laboratory for Ocean Sciences

Marine Tech & Aquaculture, Environmental Tech, Biotech

➢ Problem: Rapid global change (particularly in GoM), limited shoreline infrastructure and access, and dependence on few fisheries species stifle economic development and threaten cultural, ecological, and financial sustainability of working waterfront

➢ **Focus Areas, Actions, and Impacts:**

1. **Mechanistically understanding multiple stressors and applying knowledge**
   o Research and industry-compatible monitoring network
   o Simulation and synthesis modeling for forecasting and risk assessment
   ✓ **Impact: potential to restore fisheries, exploit new opportunities, and be resilient/adaptive to change**

2. **Assessment/enhancement of nutritional value balanced with risk to human safety**
   o Establish biotech centers for seafood sector for value-added production and processing
   o Expand scope of testing programs for biosecurity and human safety
   ✓ **Impact: improved confidence in Maine brand, new products and infrastructure**

3. **Workforce development to diversify fisheries**
   o Accessible continuing education for aquaculture-related techniques targeted to ME residents
   o Establishment of STEM programs, curricula, and teacher-training for aquaculture in K-12
   ✓ **Impact: retention of jobs and knowledge in aquaculture in ME**

Proposed Work Packages, Tasks, and Synergies

WP1: Research & Development
Bigelow Laboratory, UMaine, (Colby College, Jackson Lab, SMCC, etc.)

- T1.1 Develop biosecure strains of native seaweeds and shellfish with adaptive capacities to climate change
- T1.2 Create predictive toolbox to estimate impacts of water quality, biosecurity, HABs, and global change for aquacultured and wildharvested species
- T1.3 Quantify relative nutritional value and 'safety' of Maine seafood products as compared to imported products
- T1.4 Evaluation of standing stock availability of existing and emerging fisheries
- T1.5 Use state-of-the-art genomics approaches to inform T1.1, and to expand utility/marketability of marine products to nutraceutical and pharmaceutical industries
- T1.6 Lean on existing databases for sharing information

WP2: Market Analysis
UMaine (GMRI)

- T2.1 Determine GoM social and ecological carrying capacity for aquaculture
- T2.2 Develop aquacultured product markets (particularly seaweed)
- T2.3 Financial risk assessments for global change impacts, HABs, water quality impairments to fisheries
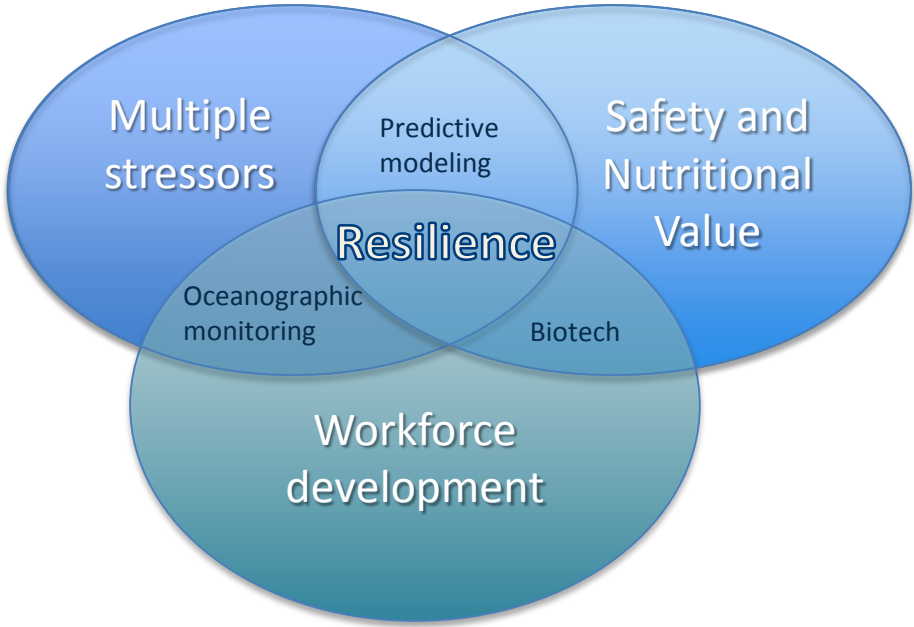
WP3: Ocean Stewardship
Bigelow Laboratory, UMaine, Island Institute (CMBG)

- T3.1 Workforce training programs
  - 3.1.1 STEM K-12
  - 3.1.2 Continuing Education
  - 3.1.3 Professional Development
- T3.2 Public education and awareness

WP4: Futures Investment
Bigelow Laboratory, UMaine (Bowdoin, Schoodic)

- T4.1 Establishment of 'Restorative Aquaculture Investment for Scholarship, & Enterprise' (RAISE?)
  - 4.1.1 Start-up support for new companies
  - 4.1.2 High-school, undergraduate, graduate, and continuing education programs and financial aid
- T4.2 Carbon and nitrogen credits?
- T4.3 Infrastructure development for GoM working waterfront
  - 4.3.1 Processing facilities
  - 4.3.2 Supply chain infrastructure improvements to increase traceability and consumer confidence
  - 4.3.3 Telemetered oceanographic sensor arrays to monitor water quality (e.g., pH, T, N, S, O_2 and ESP) and create early warning systems

Multiple stressors

Predictive modeling

Safety and Nutritional Value

Resilience

Oceanographic monitoring

Biotech

Workforce development

Ali Abedi - UMaine

Broadband Wireless Access and Sensing (BWISE)

Need: NSF Press Release (16-085) "nearly **350 million** smart phones, connected tablets and wearable devices in use -- more than **double** the number from a decade ago -- carrying more than **100,000 times** the traffic they supported in 2008."

On July 15, 2016, the National Science Foundation (NSF) announced that it will invest more than **$400 million** over the next seven years to support fundamental wireless research and to develop platforms for advanced wireless research.

- Broadband is essential for a globally competitive economy
- Maine's economy heavily relies on tourism, forestry, aquaculture and marine industries and a large number of small businesses.
- The fiber optic backbone is already in place and it is time to connect the last mile using new wireless technology that is suitable for sparsely populated Maine with its challenging hilly and forested terrain and a long coast line.

Research Goal & Objectives:

- Propose to develop new paradigms for expanding wireless access in sparsely populated rural areas.
    - Due to high demand in dense urban areas, minimal to no attention has been paid to sparsely populated rural areas.
- **Challenges:** Hilly terrain, year-round forest foliage changes, and extreme temperature variations combined with snow and highly humid summers, makes Maine the most challenging environment for reliable broadband wireless.
- **Opportunities:** At the same time, wireless sensing yields new opportunities to monitor and study Maine natural resources (i.e. forest and ocean).
- **Research objectives**:
    a. Radio wave propagation research for rural environments
    b. Wireless access systems in support of tourism and small businesses
    c. Wireless sensor networks in support of forestry and marine industries

Partners:
- **Academic (20 faculty):** UMaine (ECE, CIS, SFR), USM, UMFK, Thomas, Bowdoin.
- **State:** Network Maine, Connect Maine.
- **Industry:** Axiom, Dielectric, Shively labs.

Contact: ali.abedi@maine.edu

BWISE

Douglas Bousfield - UMaine

Forest Nanomaterials in Advanced Manufacturing

Using low value wood for high value purposes

Production
- Yields
- Process
- Costs

PERFORMANCE BioFilaments
AMERICAN PROCESS
INNVENTIA
BLUE GOOSE BIOREFINERIES INC.™
CelluForce
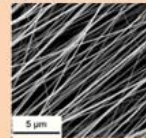
Foams
- Acoustic
- Structural
- Thermal
- ...

Paakko et al., Soft Matter, 2008
melodea

Continuous Fibers
- Reinforcement
- Textiles
- Woven
- ...

Dong et al., 2012   5 μm

Tissue Engineering
- Scaffolds
- Bandages
- Ligament
- Blood Vessels
- Drug Delivery

Deng et al.

Flexible Electronics
- Self Powered
- Display
- Solar
- LED
- ...

Pioneer
Yano et al.

Separators/Barrier
- Filtration
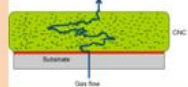- Batteries
- Pumps
- ...

Rheology Modifier
- Paints
- Cosmetics
- Food
- Adhesives
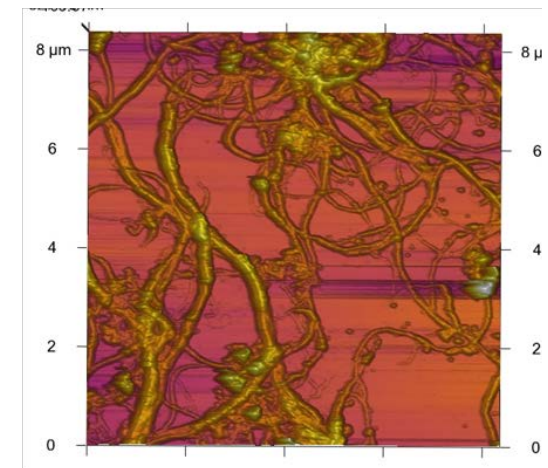
Specialty Packaging

Herrera et al.
Vartiainen et al.

Specialty Cements
- Foamed
- Panel
- Siding
- ...

Cao et al.

Courtesy Dr. Robert Moon USFS

**Sustainable
Recyclable
Compostable**

Goals and Themes

To develop nanomaterials derived from low-value wood for advanced manufacturing

- Advanced Infrastructure
- Biomedical devices
- Smart packaging

- Production and characterization
- Rapid prototyping and commercialization
- Economic-social-education impacts

Infrastructure that will lead to innovation, new products, and new companies in Maine
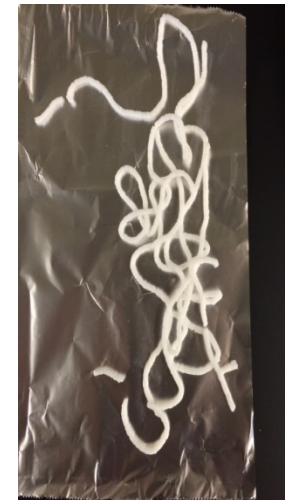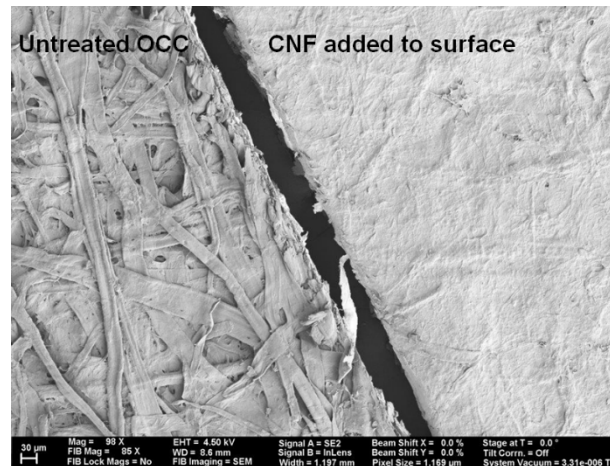
David Emerson - Bigelow
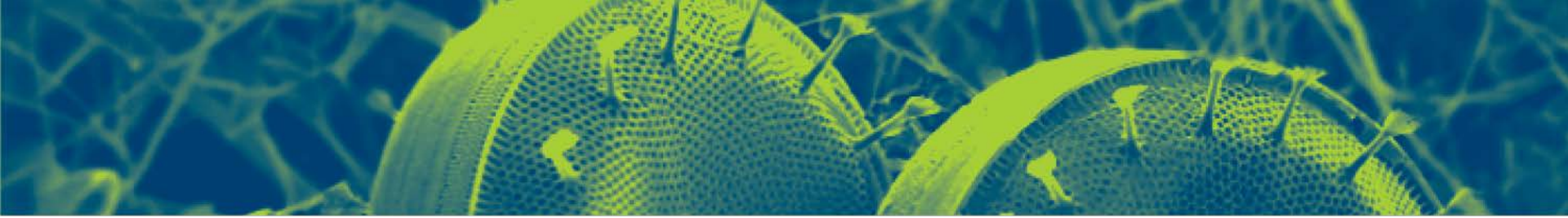
Aquatic Health and Big Data Initiative

David Emerson, Senior Research Scientist, Bigelow Laboratory

Partners:

Bigelow Scientists

University of Maine Faculty

Colby College Faculty

Bigelow | Laboratory for Ocean Sciences

Intellectual Merit

Theme: The capacity to collect and synthesize environmentally relevant biological and physical data will reveal patterns and dynamics crucial to understanding aquatic health issues, mitigation of problems, and forecasting for sustainable aquatic ecosystems.

- Aquatic Health Impacts -examples: Climate effects, Harmful algal blooms, Invasive species, Emerging pathogens, Water quality tracking.
- Utilization of 'Big Data' will drive future research questions and approaches – not only in ecosystem analysis, but other areas such as climate change impacts, biotechnology, and aquaculture.
- Coupling of physical data with 'omics' data for ecosystem analysis.
- Development of artificial intelligence/machine learning applications for ecosystems analysis and biotechnology.
- Leverage of NSF large scale data initiatives: e.g. OOI, NEON, Earthcube
- Development of core competency to ensure scientific competitiveness at Bigelow & Partner Institutions (Bigelow science metrics, 19 PI's; 5 yr average: 56 publications/yr; 4,000 citations in 2016).
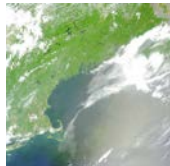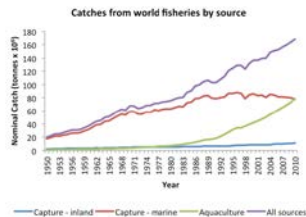
Broader Impacts

Societal Impact: Improvements in our ability to monitor, predict, and mitigate environmental problems that threaten economic and recreational use of Maine's aquatic ecosystems.

- Education of students/teachers/faculty in integrated data analysis, including application of artificial intelligence/machine learning approaches.
- Hiring of new faculty/scientists who utilize 'Big Data' and focus on cross-disciplinary approaches relevant to aquatic health that include new paradigms of ecosystem analysis.
- Empowerment of professionals in modern data techniques and tools who are engaged in all aspects of aquatic health and biotechnology.
- Development of bespoke approaches to data analysis and utilization that can be marketed and used broadly by both for profit and nonprofits, nationally and internationally, for problems related to aquatic health.

José Fernández-Robledo - Bigelow

Intellectual Merit

- Overarching theme
  - Marine Biotechnology/Biotechnology
- Focus areas
  - Bioinformatics
    - Sequencing, pipelines, databases
  - Genetic systems development
    - Gene function, guide breeding programs (e.g. tolerance, bioremediation)
  - Genome bio-prospecting
- Integration
  - Education (undergraduates, graduate)
  - Workforce development
  - Stakeholders
- Economic impact
  - State of the art STEM pipelines
  - Intellectual property

Broader Impact

Organizations

- UMaine, ARI
- Colby College, SMCC
- MDIBL, Jackson Laboratory
- Maine Bioscience

Services

- Basic research (hypothesis driven)
- Bioremediation
- Selective breeding
- Ecosystem support
- Seafood security

Maine Aquatic Resources

Maine Marine Biotechnology Hub

Toolbox

- Bioinformatics
- Genetics
- Biochemistry
- Cell biology
- Microbiology
- Ecology
- …?

Products

- Aquaculture
  - Fish/mollusks
  - Algae
- Feed
- Health (drugs)
- Food supplements
- Industrial products and processes
- Intellectual property

Images: ian.umces.edu

Cindy Isenhour - UMaine

Adaptive Planning for Resource-Based Economies in a Time of Rapid Environmental Change

Fresh Water   Tourism

Forests

Fisheries

Farms

Adaptive Planning for Resource-Based Economies in a Time of Rapid Environmental Change

ITERATIVE STAKEHOLDER ENGAGEMENT

Observation & Measurement   Decision Support   Adaptive Management

Lenard Kaye &
Mohsen Shahinpoor - UMaine

- Maine's aging demographic has created the imperative to establish a statewide R&D infrastructure supporting age-related research

- This initiative maps to one of NSF's 10 "big ideas" (working at the human-technology frontier)

- Aging has been named an emerging area of excellence at the University of Maine and is now a UMS-wide initiative

- An impressive range of interdisciplinary and inter-professional academic and community stakeholders comprise Project SAIL

- Universities, research labs, businesses, towns, older adult facilities, and community health and human service programs are already joining forces and modeling innovative collaboration

- Research objectives: 1) maximize individual productivity; 2) minimize institutionalization and the need for costly long-term care; 3) prevent and mitigate the impact of illness and injury; and 4) promote community integration, social engagement, full accessibility, personal independence, vitality, mobility, elder friendly communities, and citizen safety

- Remote patient monitoring
- Physical fitness, mobility, and gait enhancement devices
- Vital sign and medication management monitoring
- Quality of life robotics
- On-line cognitive fitness and assessment tools
- Automated transportation and vehicular systems
- Behavioral/Cognitive health apps
- Smart body wearables
- Driving augmentation devices
- Assistive technologies
- Monitoring frailty index

- Remote training and supervision technologies
- Disease management tools
- Smart communication devices
- Proprioceptive environmental sensors
- Data and information management and dissemination systems
- Multifunctional smart materials
- Emergency detection and response systems

Reduce costs → Extend workforce → Create new jobs/industries
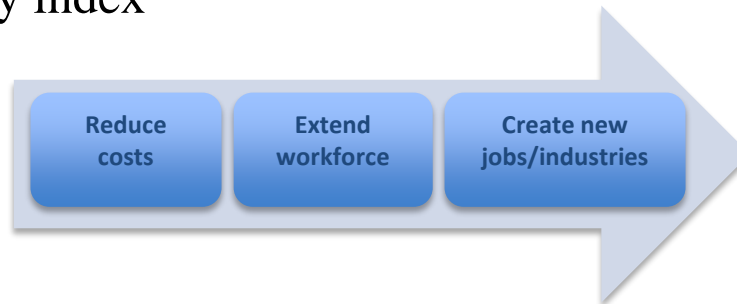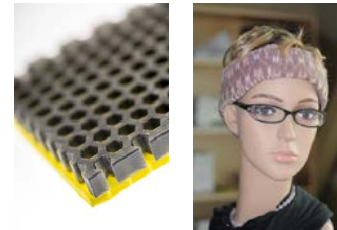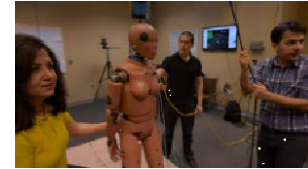
Longevity economy = $13.5 trillion by 2032

SUCCESSFUL AGING FOR INDEPENDENT LIVING
SAIL

Heather Leslie - UMaine

Building Knowledge and Capacity to Sustain Maine's Marine Economy

THE UNIVERSITY OF MAINE
1865

Heather Leslie
Darling Marine Center &
School of Maine Sciences
Heather.Leslie@maine.edu

MAINE EPSCoR

Developing Knowledge and Capacity to Enable Maine's Fish and Forest-Dependent Economies to Grow and Thrive

This developing concept reflects ideas of 37 individuals from 9 different institutions, including universities, colleges, private research institutions, and private businesses.

including at least 16 distinct units within UMaine

Three themes will guide research, education, and engagement

1. RESILIENCE AND ADAPTATION. What replicable strategies enable fish and forest dependent communities to be resilient and adapt to changing environmental and economic conditions?

2. SUSTAINABILITY. What must we do to ensure that Maine seafood and forest products are environmentally sustainable, in the face of changing conditions?

3. INNOVATIVE, DISTRIBUTED OBSERVING SYSTEMS. How do we gather, synthesize and apply information in ways that sustain both human communities and the ecosystems on which they depend?

Bruce Maxwell - Colby

Robotics

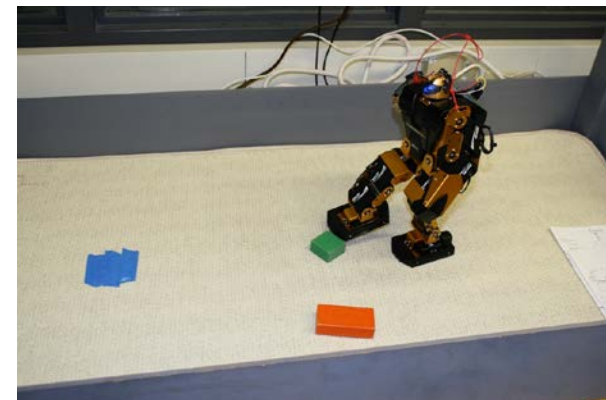- The robotics field is expanding rapidly
  - **In-home robots**
  - **Drones**
  - **Autonomous vehicles**
  - **Cooperative robots**

- Many opportunities for robots in rural areas

- Goal is to increase the flow of Maine students into robotics

- Collaborative ubiquitous robots are the focus of the NSF CISE IIS National Robotics Initiative 2.0

Cooperative Robots

Social Robots

Bio-mimetic Robots

Robotics

- ## Activities

  - **Work with students on social robots: tour-guides and remote avatars**

  - **Work with students to explore robot-robot communication**

  - **Work with students to study sensor and control systems for bio-mimetic robots**

- ## Broader Impacts

  - **Robots can improve productivity and safety**

  - **Maine has many applications for both in-home and outdoor robots**

  - **The proposal would support and expand robotics education in Maine, building on a core of faculty at Colby College and potentially Bowdoin College and U. Maine.**

  - **Robotics research and education requires physical hardware and high-performance computing power for machine-learning related tasks, resources that enable many other applications.**

Mohamad Musavi - UMaine

Engineering & Computing Education Center of Excellence

Inspired by NSF EPSCoR Track III, NSF INCLUDES, NSF IUSE, NSF MSP, NSF Noyce, & UMaine Seed Grant Awards

University of Maine Colleges of Engineering, Education & Human Resource, and Liberal Arts and Sciences, Maine Center for Research in STEM Education (RiSE), Division of Life Long Learning, & 4-H programs: M. Musavi, A. Friess, K. Tillbury, A. Abedi, Bruce Segee, Caitlin Howell, J. Artesani, M. Mahoney, Susan McKay, Harlan Onsrud, Michael Wittmann, Laura Wilson

University of Southern Maine: M. Jankowski

Community Colleges: representatives

K-12 Schools: Cary James, Anita Bernhardt, & others

Orgs: Maine, Math, and Science Alliance: Ruth Alen-Kernish
Educate Maine: Jason Judd, Angela Oechslie
Maine Development Foundation

Gov: Maine Department of Education & Department of Transportation

Industry: IDEXX, CMP, Emera Maine, Bangor Savings Bank, & others

Challenges to Maine High Tech Economy

Economic Impact

$57.6B Maine GDP
0.8% of Maine workforce is Engr
8% of Maine GDP is Engr related
**$560K**/Engr impact

Significant gap

86% STEM jobs are in Engr+C
32% STEM degrees are in Engr+C
47th in Engr BS degrees production
2000 Engr+C gap in 5 years

Lack of K-12 Edu

5 high schools have Engr related courses
21% of high schools have C courses

Lack of Diversity

84% U.S. Sci & Engr jobs are white or Asian males
Minorities surpass whites among new borns,

World Six Largest Economies
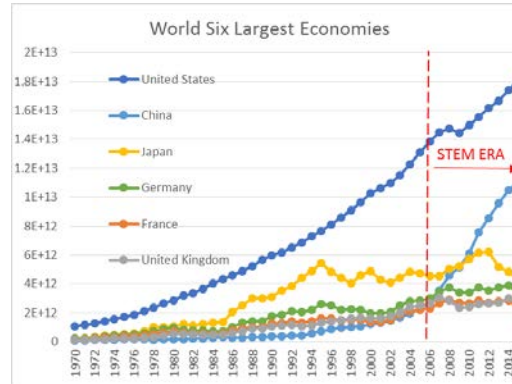
50% of all BS degrees in China are in E/S
33% of all BS Degrees in US are in E/S
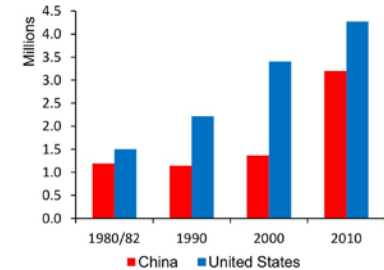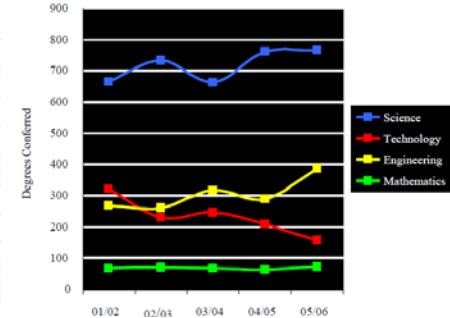

Science, Technology, Engineering, Mathematics

Fig. 1. Labor force in S/E, 1980/1982–2010. In the 1980/82 category, 1980 represents the United States, and 1982 represents China.

Goal: Develop state-wide capacity and infrastructure in Engineering and Computing Education

Constituents

| K-12 Schools | Comm Colleges | Univ. | Orgs | Industry | Gov |

Collective Impact

| Common Agenda | Backbone Organization | Shared Measures | Mutual Activities | Continuous Communications |

Research Agenda

| Develop Engr+C Interventions | Develop Teacher Training in Engr+C | Develop M.S. in Engr+C Education | Develop Teaching Certification in Engr+C |

Result

By 2025, every K-12 student will have ENGINEERING & COMPUTING literacy

IMPACT

| SOCIETY: Hundreds of schools & thousands of K-20 students | ECONOMY: Increasing Maine GDP by supporting innovation based economy | WORKFORCE: Creating Maine high tech workforce. | INFRASTRUCUTRE: Sustainable research & educational programs |

David Townsend - UMaine

Townsend et al.: **Understanding and Dealing with Extreme Environmental Variability in Maine and our Ocean:**

Maine and the Gulf of Maine are directly in the path of forces that promote change and variability in our Marine, Freshwater & Terrestrial environments:

The scientific evidence is incontrovertible: *From Maine's forests to the sea, we are witnessing unprecedented swings in important phenomena;*

✓ *We need to understand what is happening, and prepare for what is coming.*

Major Storm Tracks
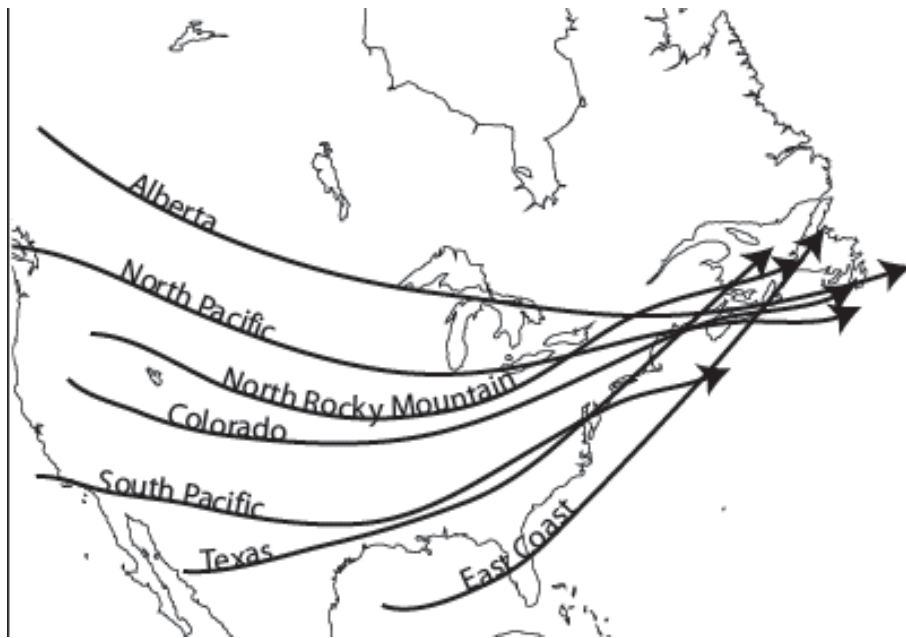
They all converge on Maine and the Gulf of Maine

Major Ocean Currents

Cold, Less Saline Low-nutrient Labrador Current

Warm, Salty High-nutrient Gulf Stream
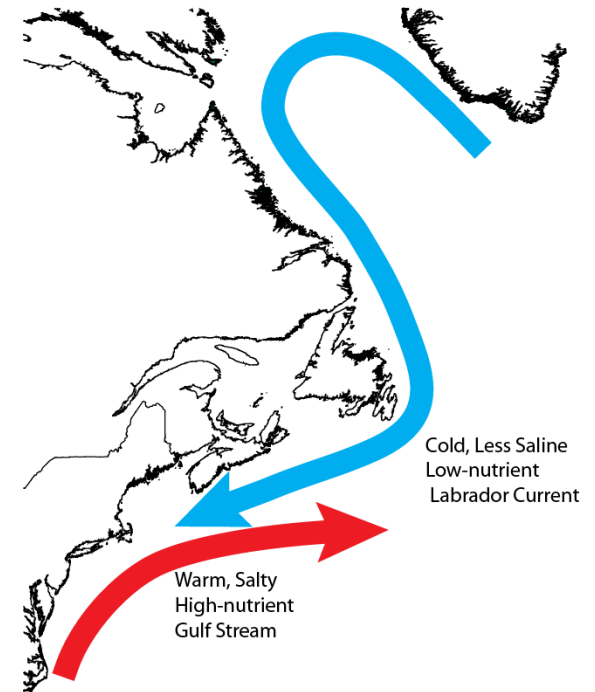
Understanding and Dealing with Extreme Environmental Variability in Maine and our Ocean:

- Next-generation observing system**_S_**:
  - ✓ To guard our *Forests, Freshwaters and Ocean* — to protect & develop Maine's natural resource-based economies;
  - ✓ Directed research into outstanding questions *(e.g., why is the GoM so acidic? Is it changing? What about ocean temps? Steric sea level & coastal erosion? Lobsters? Red tides & FW cyanobacteria? Etc.)*
- Economic development:
  - ✓ Develop new/improved sensors (*and commercialize*);
    - CO_2, O_2, pH, Total Alkalinity (TA not yet available);
    - Others…(?)
  - ✓ Develop new platform technologies (*and commercialize*);
    - *New buoy designs/engineering;*
    - *New lake and river sensor platforms;*
    - *New data transmission/management (handling "Big Data");*
  - ✓ Create the nation's *first* "NIST-certified" National Sensor Calibration Center;
  - ✓ Create the nation's *first* Training/Education Program for Observing System Operators;
- Stakeholder engagement & Pairing observing system data and new knowledge with decision support…

Aaron Weiskittel & Daniel Hayes - UMaine

Complex interactions among forest ecosystems, economies, and rural communities: Interdisciplinary research to quantify and enhance system resilience
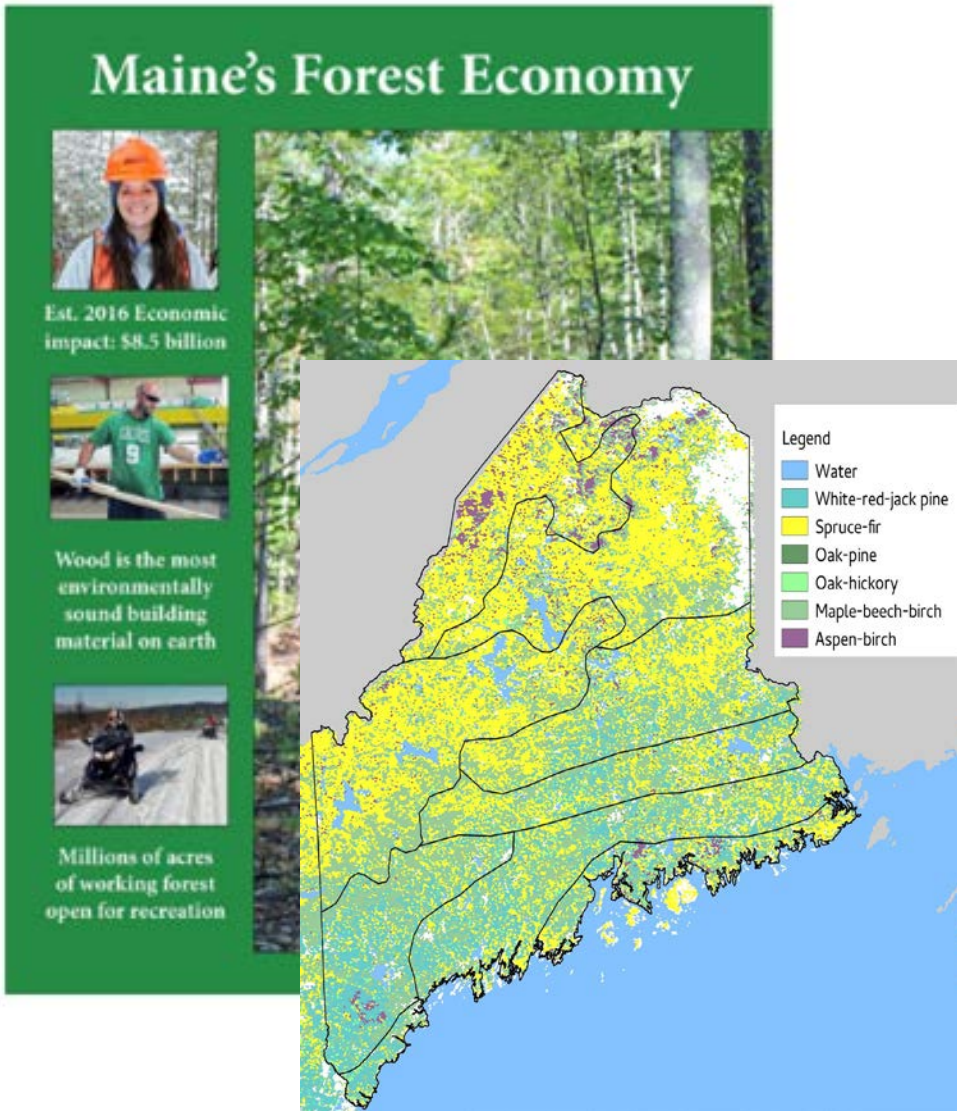
Aaron Weiskittel, Brian McGill, Jonathan Rubin, Kate Beard, Ali Abedi, Bridie McGreavy, Sarah Nelson, Peter Nelson, Dan Hayes, Jason Johnston, Ryan Wallace

aaron.weiskittel@maine.edu
581-2857

daniel.j.hayes@maine.edu
581-2863

Importance of Forests in Maine

Maine's Forest Economy

Est. 2016 Economic impact: $8.5 billion

Wood is the most environmentally sound building material on earth

Millions of acres of working forest open for recreation

Legend
- Water
- White-red-jack pine
- Spruce-fir
- Oak-pine
- Oak-hickory
- Maple-beech-birch
- Aspen-birch
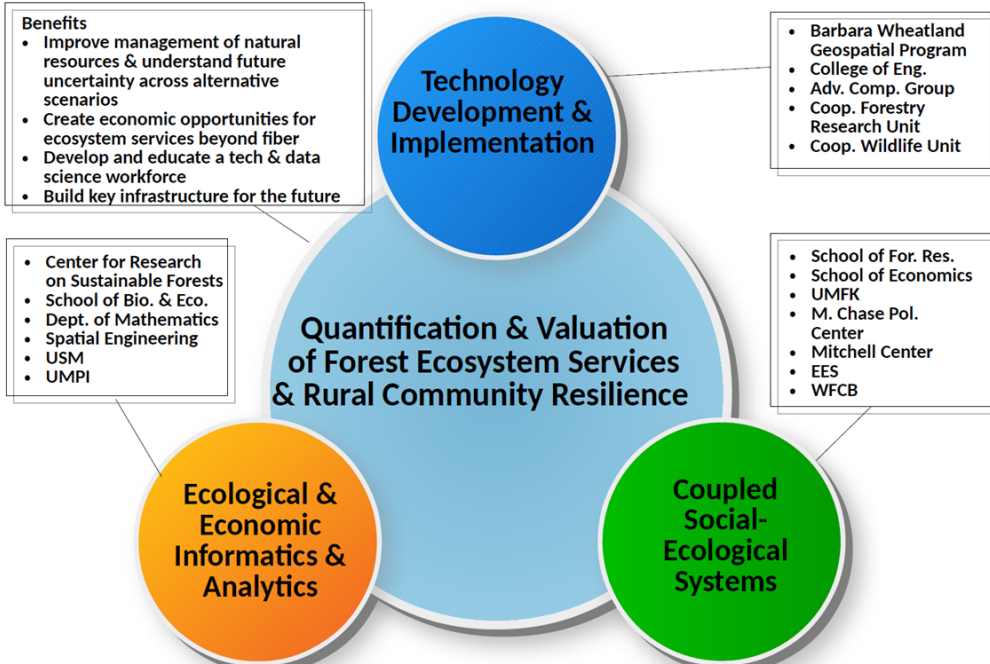
- Forest product sector annually contributes $8-10 billion to Maine's economy

- Represents 6% of the state's GDP (one of the highest in the US)

- Maine was declared a Federal economic disaster zone in August 2016 after closure of five pulp mills

- Significant global capital interest in ecosystem services

- Big data and technology are changing natural resource management

Benefits
- Improve management of natural resources & understand future uncertainty across alternative scenarios
- Create economic opportunities for ecosystem services beyond fiber
- Develop and educate a tech & data science workforce
- Build key infrastructure for the future

Technology Development & Implementation

- Barbara Wheatland Geospatial Program
- College of Eng.
- Adv. Comp. Group
- Coop. Forestry Research Unit
- Coop. Wildlife Unit

- Center for Research on Sustainable Forests
- School of Bio. & Eco.
- Dept. of Mathematics
- Spatial Engineering
- USM
- UMPI

Quantification & Valuation of Forest Ecosystem Services & Rural Community Resilience

- School of For. Res.
- School of Economics
- UMFK
- M. Chase Pol. Center
- Mitchell Center
- EES
- WFCB

Ecological & Economic Informatics & Analytics

Coupled Social-Ecological Systems

Integrated and Extensive UMS Collaborations that Address a Statewide Need