Update Report

Period: 2/1/2014 - 1/31/2015

Project: R/RCE-2 - *Planning for Coastal Community Resilience to Tsunamis Using Transportation and Disaster Recovery Modeling*

STUDENTS SUPPORTED

Huling, Derek, hulingd@students.wwu.edu, Western Washington University, Geography, status: new, field of study: Geography, advisor: Scott Miles, degree type: MA, degree date: 2015-09-01, degree completed this period: No
Student Project Title: *none*
Involvement with Sea Grant This Period:
RA
Post-Graduation Plans: *none*

Maura, Rowell, mkrowell@uw.edu, University of Washington, Civil Engineering, status: new, field of study: Civil Engineering, advisor: Anne Goodchild, degree type: PhD, degree date: 2015-12-01, degree completed this period: No
Student Project Title: *none*
Involvement with Sea Grant This Period:
RA
Post-Graduation Plans: *none*

CONFERENCES / PRESENTATIONS

Tsunami transportation initial outreach meeting in Raymond, WA., SG-sponsored, 10 attendees, 2014-12-01

ADDITIONAL METRICS

P-12 Students Reached:	**P-12 Educators Trained:**
Participants in Informal Education Programs:	**Volunteer Hours:**
Acres of coastal habitat protected, enhanced or restored:	**Resource Managers who use Ecosystem-Based Approaches to Management:**
Annual Clean Marina Program - certifications:	**HACCP - Number of people with new certifications:**

ECONOMIC IMPACTS

No Economic Impacts Reported This Period

SEA GRANT PRODUCTS

No Sea Grant Products Reported This Period

HAZARD RESILIENCE IN COASTAL COMMUNITIES

Name of coastal community	County	Number of resiliency trainings / technical assistance services *provided*	Was community hazard resiliency improved (e.g., via changes in zoning ordinances)?
	Pacific County	1	No

ADDITIONAL MEASURES

Number of stakeholders modifying practices: 0

Have met with Coast Seafoods to discuss their recovery issues, recovery practices, and general business practices (relative to transportation). Have meetings arranged with additional aquaculture stakeholders.

Sustainable Coastal Development

# of coastal communities: 0

PARTNERS

Partner Name: Coast Seafoods Company, type: Industry and Business, scale: International

Partner Name: Pacific County Economic Development Council

Partner Name: Pacific County Emergency Management, type: Government, scale: Local

Partner Name: Port of Ilwaco, WA

IMPACTS AND ACCOMPLISHMENTS

Title: **Preparing for a tsunami: Washington Sea Grant research lays the groundwork for long-term recovery scenarios in coastal communities**
Type: accomplishment
Description:
Relevance: Pacific County, at Washington's southwest corner, is relatively isolated and uniquely exposed to the effects of a large offshore subduction earthquake and accompanying tsunami. Its population and infrastructure are almost entirely coastal, with many residents occupying low-lying Long Beach Peninsula. The damage and disruption from an earthquake and resulting tsunami would require not only emergency response, but also intensive long-term recovery efforts. Because of limited human resources and technical capacity, communities have largely neglected such recovery planning.

Response: WSG-funded research is modeling the disruptive effects of a seismic disaster on Pacific County's critical transportation systems and subsequent recovery and reconstruction by synthesizing loss estimates, computer simulations, and community input. Creating a conceptual design and coding a prototype simulation of home reconstruction, the project shows the number of homes that could be rebuilt in place and how many would have to be relocated. Confirming the capabilities of their modeling framework, researchers began gathering stakeholder input.

Results: Stakeholders articulated the need to model multiple scenarios and identified a number of important issues to be considered in the modeling, from the availability of construction materials to the relocation of the elderly and the responses of large county employers. Even in its early stages, the project has stimulated unprecedented awareness and discussion of the challenges ahead in recovering from a seismic disaster.
Recap:
Recap: Washington Sea Grant-supported research is modeling long-term recovery scenarios and needs following earthquake and tsunami damage in an isolated and exposed coastal county.
Comments:
Primary Focus Area: HCE
Associated Goals: Communities prepare, respond, and adapt to coastal hazards and climate change. (RCE)
Partners:
Coast Seafoods Company
Pacific County Economic Development Council
Pacific County Emergency Management
Port of Ilwaco, WA
Related Partners: *none*

PUBLICATIONS

No Publications Reported This Period

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

No Leveraged Funds Reported This Period

UPDATE NARRATIVE

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NARRATIVE

PROJECT OBJECTIVES, CHANGES, AND CHALLENGES

The objectives of the project have been modified in consultation with Washington SeaGrant (WSG) as a result of the project kickoff phone call with Pacific County emergency management, WSG, and the project team, as well as a formal project scope review meeting with Penny Dalton (WSG) and Jamie Mooney.

The most significant modification was the elimination of the proposed socio-behavioral experiment, related to Objectives 2 and 5 of the original proposal. This was to consist of the design and execution of a workshop-based data collection strategy to understand how stakeholders approached recovery planning without (workshop 1) and with (workshop 2) the information and tools generated from this project. It was realized that there was perception from some stakeholders that the project would conduct recovery planning, which is not the case. It was also decided that it was inappropriate to subject Pacific County stakeholders to the experimental design, wanting to avoid any harm to relationships through unmet expectations. In place of the socio-behavioral experiment, we are employing a more informal needs-based approach to the project. Rather than workshops conducted to implement a socio-behavioral experiment, informal needs assessment and product evaluation meetings have been and will be conducted with stakeholders as necessary. Results of these meetings will not be quantified (e.g., with questionnaires) and analyzed in any form way, as originally proposed.

The second most significant change or potential change relates to conducting loss estimation for Pacific County related to a Cascadia Subduction Zone earthquake and tsunami—something originally proposed. As a result of the above phone call and meeting, it was decided that it is better to ensure data consistency with other analytical initiatives focused on Pacific County—in particular, loss estimation analysis by FEMA and Washington State Emergency Management Division. As a result, the project team has postponed consideration of conducting loss estimation specific in favor of waiting to understand how input data needs for project models will fit with existing (or pending) data (being) developed by other stakeholders. At this point, it's not expected that the project team will do loss estimation. This, together with eliminating the socio-behavioral experiment, allows for more detailed model needs assessment and development. As result, less model implementation activity has occurred to date than originally expected. This is to understand how the modeling scope can be expanded and customized, as well as made more transferable to future similar applications.

The project team has experience two noteworthy challenges. The first is the delay the project start date resulting from the delay in project funding. The second relates to the difficulty that Pacific County stakeholders had in expressing their needs or interests regarding possible recovery modeling at the first needs development meeting. Pacific County emergency managers have not focused on recovery planning up to this point and so cannot easily articulate what type of modeled information or scenarios will be useful. Stakeholders were able to express to some degree what their expectations were for recovery and what were likely to be the biggest factors influencing their recovery. However, stakeholders focused a great deal on issues that were of a shorter-time scale than recovery or on the most extreme potential recovery scenarios. We plan to address this issue by partially developing the project simulation models based on current assumptions and judgment, present initial results to stakeholders in hopes of facilitating further articulation of needs and issues, and completing project-related simulation development prior to final presentation to stakeholders.

DATA DEVELOPMENT

Data for individual household units have been simulated by combining address data, land use data, and block-level 2013 American Community Survey data (U.S. Census). Addresses were taken from Pacific County's GIS database. Residential addresses were extracted. This list was randomly sampled with replacement to create a list of occupied housing units. These units were randomly assigned demographic attribute values based on the average value within each census block. The simulation models will be run for many realizations to minimize the effects of randomly assigning household characteristics to specific addresses and other probabilistic representation of input parameters.

For transportation modeling, each household unit is currently characterized by eleven assigned attributed: (1) household size, (2) number of vehicles, (3) number of household members under 5, (4) number of household members between 5 and 10, (5) number of household members between 11 and 17, (6) number of working adults, (7) address, (8) assigned elementary school, (9) assigned middle/high school, (10) assigned central business district (CBD), and (11) assigned farm district. Children between 5 and 10 attend elementary school and children between 11 and 17 attend middle/high school. The schools, CBD, and farm center are assigned according to zip code. All household characteristics are coded as a percentage of either the total population or the total occupied housing units so the numbers will change if either parameter changes. CBD locations are set as city hall or the post office. Additional attributes will be developed as development of the long-term recovery simulation model progresses.

Transportation Simulation

The transportation simulation represents an average day during a given season (school year and summer). It includes passenger vehicle and freight vehicle trips. Passenger vehicle trips are limited to school, work, and shopping trips. Freight vehicle trips are limited to select industries and major freight facilities (e.g., ports, warehouses). Trips are calculated using shortest distance and aggregated to describe the county's overall transportation demand. We are currently scoping the model to focus on oyster farming, cranberry farming, and logging. At this point, the major facilities have been located in order to simulate the freight transportation generated by these industries. We will simulate trips between these major facilities at varying levels for given scenarios.

Multiple post-disaster transportation scenarios are being developed: (1) bridge reconstruction scheduling, (2) U.S. Route 101 and 105 reconstruction scheduling, aquaculture supply chain disruption, cranberry supply chain disruption, and lumber supply chain disruption, as well as scenarios related to household, school, and CBD dislocation or relocation. A simulated scenario will be produced after each change to the transportation network, population, and/or commercial makeup of the county.

There are 62 bridges in Pacific County. Taking the subset of scenario-based damaged bridged, a number of permutations of bridge reconstruction schedules will be analyzed. The pre-disaster transportation flow is used to identify the most critical bridges and prioritize those in the subset of permutations chosen. To hasten data and model development, bridges will initially be assumed to have equal repair/replacement cost and timelines. The simulation will be run after each bridge is reconstructed; the change in travel time and routes will be tracked. We will present the schedules that have the lowest maximum travel time (between two bridge reconstructions) and the lowest overall travel time (between first and last bridge reconstruction). The U.S. 101 and 105 disruption scenarios will identify which sections are most critical.

To date, we have generated household units and personal trips. Household units generate personal travel trips (school trips, work trips, and shopping trips). The route from each household to the corresponding school, place of work, and CBD (for shopping) is determined using Network Analyst in ArcGIS. School and work trips are assumed to take place between 0800 and 1000 (the morning peak period) and the reverse trips take place between 1600 and 1800 (the afternoon peak period). All persons going to the same location (multiple school children attending the same school) from one household unit will be assumed to travel together in both directions. All working adults and school-aged children are assumed to work/attend school Monday through Friday and travel during the morning and afternoon peak periods. The trips are overlaid to find the most utilized road segments but congestion is not accounted for. Shopping trips will take place throughout the day.

Long-Term Recovery Simulation

A simulation model of long-term recovery is being developed that can inform the transportation simulation model to investigate some post-disaster scenarios and potentially be informed by the transportation simulation model to investigate other scenarios. A different simulation approach has been adopted and prototyped than originally proposed. The decision to do this was based on the types of issues, factors, and concerns raised by Pacific County stakeholders. The decision was also made in order to maximize generalizability and flexibility in tailoring the model as stakeholder needs are better articulated.

We are developing a spatially explicit process-based discrete event simulation (PBDES) modeling framework that is intended to support the specification of tailored post-disaster recovery scenarios. The elements of PBDES include the simulation environment (scope and exogenous inputs), modeled entities (e.g., households and FEMA), entity attributes (e.g., owner vs. renter), entity states (e.g., house occupied

vs. house unoccupied), processes (e.g. house reconstruction or household relocation), events (e.g., insurance claim settlement), event durations, and resources (e.g., construction workers or savings account). Events related to one or more processes can trigger other events, changes to entity states, and the interruption of processes. Process interactions occur via triggers or state-changes tied to the same events and competition for resources. Three general types of resources can be conceived: 1) resources that can only be accessed by an individual (e.g., house or bank accounts), 2) shared resources that can be used by a limited number of entities or processes at a time (e.g., claims adjusters), and 3) resources that are exchanged as a homogeneous, undifferentiated stock (e.g., money or machine parts).

Some simulation parameters include the possible qualitative and quantitative states that entities can take on. For example, a house might go through the following states during a recovery process: damaged/unoccupiable, damaged/inspected, damaged/occupied, and undamaged/occupied. Other parameters quantify event durations and resource magnitudes. Durations and magnitudes will be represented by probability distributions to characterize associated uncertainties. (This will necessitate running and averaging many realizations of the simulation.) Event duration and resource magnitude parameters will either be assumed as part of scenario development (e.g., to explore the availability of fewer workers or jobs) or based on time series data from other disasters already compiled by team members for a separate project.

Process interactions between scoped entities (e.g., households, infrastructure providers, employers, schools) and recovery stakeholders (e.g, lenders, FEMA, construction companies) will be operationalized as temporally discrete events that occur relative to spatial units greater or equal to census blocks within Pacific County. For example, household relocation will be represented as movement between Pacific County census blocks or movement out of Pacific County.

A prototype recovery simulation has been coded using the open source SimPy discrete event simulation library for Python. The prototype represents household home reconstruction as requiring a building inspection event and a reconstruction loan disbursement event. The simulation defines one or more household units. Each household with a damaged home requests a building inspection. The time in which the building receives an inspection is dependent on the number of building inspectors in the simulation environment (human resources). Households with damaged homes also submit an application for a reconstruction loan, which can only be processed after an inspection. The number of loan officers available for processing applications influences the time that the loan is disbursed.

The simple prototype confirms the potential of PBDES to flexibly model long-term recovery in Pacific County by defining and integrating a range of entities, events, and resources based on stakeholder needs, data availability, and project team judgment. Simulation development for modeling household recovery will continue. The immediate focus will be on improving representation of household reconstruction and relocation to include a broader and richer variety of entities, events, and resources. Focus will then shift to integration with the transportation simulation model. Development of the PBDES will then continue, focusing next on business facility reconstruction and relocation. Time permitting, simulation of household (re)employment and/or school attendance will be investigated.

Pacific County Stakeholder Modeling Needs

As described above, few specific modeling needs were articulated by stakeholders in our first meeting. The most explicit was the ability to run multiple scenarios to see what brings the county “to the brink.” (Actual quote.) However, many issues were brought up that can inform model development. Briefly, these include 1) effect of the availability of post-disaster buildable land, 2) recovery of coastal properties, 3) reconstruction of second homes, 4) out-migration because of infrastructure service loss, 5) out migration of elderly, 6) out migration of families with school children, 7) out migration of higher income and professional households, 8) housing for low-income aquaculture and agriculture workers, 9) access to insurance and loans, 10) home reconstruction by people on fixed incomes, 11) access to construction workers and materials, 12) influence of disruptions to the Astoria bridge, US 101, and US 105, and 13) decisions and performance of Weyerhaeuser, Ocean Spray, Pacific Group, Coast Seafoods Company, and Shoalwater Tribe.