Thriving Communities 1 Final Report

Project Title: Enhancing Community Resilience and Optimizing Oil Spill Response through the Participatory Design of a Decision Support System
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- Jake Nelson, Arizona State University

I. PROJECT SUMMARY (from proposal)

In the United States, there is a growing interest in the vulnerability of complex social, economic and environmental systems. For example, consider the impacts of the BP Deepwater Horizon oil spill of 2010. In addition to the release of ~4.5 million barrels of oil into the Gulf of Mexico (GOM), eleven workers on the platform died, the spill lasted nearly three months, and at its peak, almost 87,000 square miles of fishable waters were closed. With 537,000 ocean sector employees and nearly $98 billion in gross domestic product (GDP) tied to these waters, the impacts of the Deepwater Horizon explosion and oil spill on the U.S. economy, environment, and hundreds of communities ringing the GOM was significant.

Questions pertaining to the resilience of coastal communities, broadly defined (e.g., social, economic, environmental, cultural), are important when developing mitigation strategies for extreme events. So too are the operational challenges associated with allocating and dispatching human resources, equipment and supplies to areas impacted by a disaster.

The purpose of this project is to develop a new, open source, decision support system (DSS) that will minimize the environmental, economic and social impacts of oil spills by optimizing the allocation of response crews and equipment, in both the marine and terrestrial environment. The DSS will be developed using the principles of participatory design, engaging stakeholders and community leaders throughout the process to ensure usability, as well as meeting planning and response needs in the field. The DSS will offer a number of newly developed, spatially and temporally explicit mathematical programming models that will drastically enhance oil spill response efficiency and efficacy. The DSS will be informed, at least in part, by the Blowout and Spill Occurrence Model (BLOSOM), although it will

accept and process input from other modeling packages. BLOSOM will be used to generate hundreds of deep water and ultra-deep water oil spills, with varying conditions and parameters, to identify which locations are most susceptible to oiling and associated damage. These spill scenarios will also be used to inform the embedded optimization models for dispatching containment and mitigation teams. The DSS will have access to a comprehensive suite of high-resolution demographic, environmental and socioeconomic data that can be used to develop vulnerability metrics and allied response metrics for communities along the GOM. Lastly, the DSS will have significant data wrangling and geovisualization capabilities, allowing for the flexible exploration of alternative planning scenarios, model solutions and response plans to tailor mitigation efforts at both the local and regional levels.

The proposed research is both important and innovative. First, it will directly address the resilience of communities along the GOM and help frame the complex interactions between offshore oil and gas operations and local social, economic, and environmental systems. Second, rather than fostering a culture of reaction, the DSS and embedded scenario planning tools will allow communities to proactively plan for extreme events and develop response strategies that minimize the impacts of spills. Finally, the open source design of the DSS ensures broad distribution and participation.

II. PROJECT SUMMARY (from final report)

The project team worked to develop an open-source decision support system that helps responders minimize an oil spill's environmental, economic, and social impacts by optimizing the deployment of response crews and equipment. By incorporating information from relevant stakeholders and mathematically modeling different oil spill scenarios, this system is intended to help coastal communities proactively plan effective responses to deep and ultra-deep water oil spills. Four major research milestones were reached. First, we developed a mathematical model that guides tactical responses to oil spills by minimizing costs associated with response efforts, but ensures that oil cleanup targets (e.g., amount of oil to be removed) are met. Second, we developed a complimentary spatial optimization algorithm that allocates exclusion booms to minimize spill effects to the most vulnerable/sensitive shorelines, while simultaneously minimizing the total costs associated with dispatching booms. Third, we developed a standalone mathematical model that facilitates the optimal geographic pre-positioning of tactical response equipment along the Gulf Coast, minimizing cost. Finally, we developed the Tactical Analysis and Coordination for Oil Spills (TACOS) Suite. TACOS integrates two of the three mathematical models and provides a range of additional spatial and temporal visualization tools.

III. PROJECT RESULTS

Accomplishments

The project team worked to develop an open-source decision support system that helps responders minimize an oil spill's environmental, economic, and social impacts by optimizing the deployment of response crews and equipment. By incorporating information from relevant stakeholders and community leaders and mathematically modeling different oil spill scenarios, this system is intended to help coastal communities proactively plan effective responses to deep and ultra-deep water oil spills. Four major research milestones were reached. First, we developed a mathematical model that guides tactical responses to oil spills by minimizing costs associated with response efforts, but ensures that oil

cleanup targets (e.g., amount of oil to be removed) are met. Second, we developed a complimentary spatial optimization algorithm that allocates exclusion booms to minimize spill effects to the most vulnerable/sensitive shorelines, while simultaneously minimizing the total costs associated with dispatching booms. Third, we developed a standalone mathematical model that facilitates the optimal geographic pre-positioning of tactical response equipment along the Gulf Coast, minimizing cost. Finally, we developed the Tactical Analysis and Coordination for Oil Spills (TACOS) Suite. TACOS is a web-based, open source toolbox that integrates two of the three mathematical models and provides a range of additional spatial and temporal visualization tools for scenario exploration.

Implications

Simply put, we are "all in" on the GRP and the challenges faced by the region. Collectively, we had an absolute blast working on these problems. As a result of this project, we are expanding our network of collaborators to pursue additional opportunities with the GRP that are unrelated to oil spills, but are still relevant to community resilience and vulnerability.

It is difficult to gauge what the implications of the project result will be for the research or practices of others. It is simply too early. Once all of the project papers appear in print and people get a chance to see the models and use the TACOS suite, we will have a much better idea of the implications.

It is important to note, however, that tactical response models for oil spills were basically left for dead in the late 1980s and early 1990s. We have reinvigorated this line of research, leveraging advances in computing power, to highlight that computationally wicked problems addressing spill response can be solved, exactly. More importantly, the developed models are efficient, flexible and extendable. [FR 3.2]

Unexpected Results

As we mentioned in our annual report last year, we have been completely caught off-guard by the responses we have received regarding our research publications and associated public presentations. It has been an overwhelmingly positive experience and we believe it will likely lead to additional projects and collaborations in the future. For whatever reason, the work we are conducting for this project has captured the imagination of our colleagues, industry, or the public. Colleagues are interested, we field countless questions after research presentations, people are offering alternative ideas to us that are worth exploring, etc. We feel very lucky to have struck these chords… and all of us are very excited to get TACOS out there for use, even if it isn't perfect.

Project Relevance

The following audiences would be most interested in the results of this project:

- Researchers
- Educators
- Community Leaders
- Local Government Officials
- State Government Officials
- Federal Government Officials
- Non-Profit Private Sector
- For-Profit Private Sector

Our work is cross-cutting, open source, visually appealing and mathematically rigorous. There really are no limits as to who might use these tools or benefit from their insight. Researchers will appreciate the innovative models and availability of our source code. TACOS will provide educators an opportunity to highlight how spill modeling and geovisualization tools can help address strategic and tactical planning issues. Community leaders and government officials, at all levels, have the opportunity to use the tools and explore ways to improve resilience. Finally, both the non-profit and for-profit sectors can implement these tools, free of charge, to address the challenges associated with spills in deep and ultra-deepwater environments.

Education and Training

Number of students, postdoctoral scholars, or educational components involved in the project:

- Undergraduate students: 0
- Graduate students: 3
- Postdoctoral scholars: 0
- Other educational components: 0

IV. DATA AND INFORMATION PRODUCTS

This project produced data and information products of the following types:

- Data
- Information Products
- Scholarly publications, reports or monographs, workshop summaries or conference proceedings
- Websites or data portals
- Models or simulations
- Software packages or digital tools, or other interactive media

DATA

Data Management Report:

See attached Data Management Report.

Relationships between Data Sets:

There are far too many datasets to detail individually. However, all of the data intersect coastal environments and include a range of environmental, ecological, and infrastructure data, as well as outputs related to BLOSOM spill simulations.

Additional Documentation Produced to Describe Data:

Data dictionary

Other Activities to Make Data Discoverable:

Our team is still undertaking these efforts. Fortunately, most of the data are self-explanatory and consist of geospatial layers that can be used with any commercial or open source GIS package. In other instances, much of the original data concerning environmental, ecological or infrastructure systems were produced by other agencies (e.g., NOAA). Pointers to these data are provided for those interested.

Once the final research publications appear in print, all of these data will be promoted on a persistent website to ensure that others can access and reuse the data in the future.

Sensitive, Confidential, or Proprietary Data:
N/A

INFORMATION PRODUCTS

Information Products Report:
See attached Information Products Report.

Citations for Project Publications, Reports and Monographs, and Workshop and Conference Proceedings:
R., Chandra, P., Grubesic, T.H. and J.R. Nelson. A Visual Analytics System for Oil Spill Response and Recovery. (Submitted, IEEE Computer Graphics and Applications).

Grubesic, T.H., Nelson, J. and R. Wei. A Strategic Planning Approach to Protect Environmentally Sensitive Coastlines from Oil Spills: Benchmarks and Application. (Submitted, Marine Policy).

Nelson, J. R., & Grubesic, T. H. (2018). Oil spill modeling: computational tools, analytical frameworks, and emerging technologies. Progress in Physical Geography: Earth and Environment, 0309133318804977.

Nelson, J. R., & Grubesic, T. H. (2018). Oil spill modeling: Risk, spatial vulnerability, and impact assessment. Progress in Physical Geography: Earth and Environment, 42(1), 112-127.

Grubesic, T., Wei, R., & Nelson, J. (2018). Protecting Sensitive Coastal Areas with Exclusion Booms during Oil Spill Events. Environmental Modeling & Assessment, 1-16.

Nelson, J. R., & Grubesic, T. H. (2018). The Implications of Oil Exploration off the Gulf Coast of Florida. Journal of Marine Science and Engineering, 6(2), 30.

Grubesic, T. H., Wei, R., & Nelson, J. (2017). Optimizing oil spill cleanup efforts: A tactical approach and evaluation framework. Marine pollution bulletin, 125(1-2), 318-329.

Nelson, J. R., & Grubesic, T. H. (2017). A repeated sampling method for oil spill impact uncertainty and interpolation. International Journal of Disaster Risk Reduction, 22, 420-430.

Nelson, J. R., Grubesic, T. H., Sim, L., & Rose, K. (2017). A geospatial evaluation of oil spill impact potential on coastal tourism in the Gulf of Mexico. Computers, Environment and Urban Systems.

Websites and Data Portals:
TACOS: http://104.196.253.120:8080/Blosom_1.4_HeatMap/Implementation/
Spill Data: https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0176683

TACOS Code: https://github.com/nelsojak/Gulf_2016
Project Website: http://csrpa.org/oil-spills.html

All content will be maintained indefinitely on GitHub and CSRPA.

Additional Documentation Produced to Describe Information Products:
Software manual

Other Activities to Make Information Products Accessible and Discoverable:
Our team is still undertaking these efforts. The public participation component of our project wrapped up in late October. We are still integrating comments from participants, cleaning up the software manual, and refining code for the TACOS suite. We anticipate that this will be completed by 12/31/2018. Once done, we will begin the process of promoting the information products, more formally. This will include several additional publications, research talks and potentially a webinar on their use (if there is enough public interest).

Confidential, Proprietary, Specially Licensed Information Products:
N/A

V. PUBLIC INTEREST AND COMMUNICATIONS

Most Unique or Innovative Aspect of the Project
Although the collaborative team debated this question, we believe the most innovative aspect of the project is the development of the spatial optimization models for spill cleanup and shoreline protection. These types of tactical responses, at least in practice, are extremely black-box and it is unlikely that they are optimized in any way. There are two reasons we suspect this. First we are not aware of any federal or state agencies that formally disclose operational goals for cleanup strategies. Nor are we aware of any documentation from the private sector that discloses these goals. Second, the academic literature regarding tactical response methodology has been left for dead for more than 30 years. There have been a handful of sporadic contributions to tactical response, but nothing that explicitly addresses the basic problems that we are exploring in this project.

Most Exciting or Surprising Thing Learned During the Project
We have been completely caught off-guard by the responses we've received for our research publications and associated public presentations. It has been an overwhelmingly positive experience and we believe it will likely lead to additional projects and collaborations in the future. For whatever reason, the work we are conducting for this project has captured the imagination of our colleagues, industry, or the public. Colleagues are interested, we field countless questions after research presentations, people are offering alternative ideas to us that are worth exploring, etc. We feel very lucky to have struck these chords. We are excited to make our final edits to the TACOS suite and release it for public use.

Most Important Outcome or Benefit of Project
We believe that the ability to model potential impacts of catastrophic spills and mount an efficient and effective tactical response will dramatically enhance the development of healthy and resilient Gulf

communities. In particular, the use of scenario planning, via simulation, will deepen our understanding of where the impacts of a spill will be realized and the relative sensitivity of entities (e.g., fish, shorelines, businesses, etc.) to that oil. The modeling framework we developed can then be used to craft strategies for mitigating the impacts of the spill and limiting the number and/or magnitude of oil-community interactions. Lastly, the development of TACOS will put these tools in the hands of decision makers. We know that many of these packages, for whatever reason, turn into "shelfware". We are doing everything we can to avoid this and the participatory design aspect of the project will help to make our SDSS meaningful, accessible, intuitive, and useable, while providing the geospatial intelligence required to make better strategic and tactical decisions.

Communications, Outreach, and Dissemination Activities of Project

https://twitter.com/asu_csrpa
https://publicservice.asu.edu/content/national-academies%E2%80%99-research-grant-funds-novelresponse-oil-spills
https://twitter.com/ASUPubAffairs
http://csrpa.org/oil-spills.html

Data Report

DataType	DigitalResourceType	Title	FileName	Creators	PointofContact	PublicationYear	RepositoryName	DOIorPersistentURL	Keywords	Publications
Geospatial	Geospatial (vector, raster, or gridded)	Impact Grid	Impact_Grid_v3.1.shp	Nelson, Jake	Jake Nelson	2016	https://repository.asu.edu/collections/301	DOI: 00003	impact, grid,	
Geospatial	Geospatial (vector, raster, or gridded)	TX LA Boatramps	BoatRamps_TXLA_bdry_new_OSCOM.shp	Wei, Ran	Jake Nelson	2016	https://repository.asu.edu/collections/301	DOI: 00005	Response, gulf, boat ramps	
Geospatial	Images	Days Oiled	DaysOiled.pdf	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Oil, Impact, Hydrocarbbon	
Geospatial	Images	OSCOM Clean	Figure5.tif	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Spill, Response, optimization, OSCOM	
Geospatial	Images	OSCOM Clean 2	Figure6.tif	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Spill, Response, optimization, OSCOM	
Geospatial	Images	Response Locations	ResponseLocations.pdf	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Spill, Response, optimization, OSCOM	
Geospatial	Images	Spill Behavior	SpillBehaviorOverTime.pdf	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Spill, Response, optimization, OSCOM	
Geospatial	Images	Total Impact - Intervention	TotalImpact3D_Intervention.pdf	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Sill, Impact, TIG, OSCOM	
Geospatial	Images	Total Impact - No intervention	TotalImpact3D_NoIntervention.pdf	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Spill, Response, optimization, OSCOM	
Geospatial	Images	Total Oil - Intervention	TotalOil3D_Intervention.pdf	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Spill, Response, optimization, OSCOM	
Geospatial	Images	Total Oil - No intervention	TotalOil3D_NoIntervention.pdf	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	Response, Gulf, TIG, Oil	
Geospatial	Tabular/Spreadsheet	Model Response and Performance 1	ModelPerformance.xlsx	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	Model Response and Performance 2	ModelPerformance2.xlsx	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00004	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	OSCOM 0602 solution	OSCOM_0602_sol.txt	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00002	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	OSCOM 0603 solution	OSCOM_0603_sol.txt	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00002	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	OSCOM 0604 solution	OSCOM_0604_sol.txt	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00002	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	OSCOM 0605 solution	OSCOM_0605_sol.txt	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00002	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	OSCOM 0606 solution	OSCOM_0606_sol.txt	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00002	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	OSCOM 0607 solution	OSCOM_0607_sol.txt	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00002	OSCOM, Optimization, modeling,	
Geospatial	Tabular/Spreadsheet	OSCOM 0608 solution	OSCOM_0608_sol.txt	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00002	OSCOM, Optimization, modeling,	
Geospatial	Geospatial (vector, raster, or gridded)	EBAM boming strategy 35	EBAM_Line_35.shp	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00006	EBAM, optimization, response, Mobile Bay	
Geospatial	Geospatial (vector, raster, or gridded)	EBAM boming strategy 60	EBAM_Line_60.shp	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00006	EBAM, optimization, response, Mobile Bay	
Geospatial	Geospatial (vector, raster, or gridded)	Mobile Bay - TIG	Shoreline_grids.shp	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00007	EBAM, optimization, response, Mobile Bay, TIG	
Geospatial	Tabular/Spreadsheet	EBAM Tradeoff	EBAM_tradeoff.xlsx	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00009	EBAM, optimization, response, Mobile Bay	
Geospatial	Geospatial (vector, raster, or gridded)	BLOSOM mid-Texas Spill 06.01 - 07.01	Transport-2015xxxT000000.shp	Nelson, Jake	Jake Nelson	2016	https://repository.asu.edu/collections/301	DOI: 00010	Optimization, modeling, BLOSOM, Oil Spill	
Geospatial	Geospatial (vector, raster, or gridded)	BLOSOM N-Texas Spill 06.01 - 07.01	Transport-2015xxxT000000.shp	Nelson, Jake	Jake Nelson	2016	https://repository.asu.edu/collections/301	https://github.com/nels	Optimization, modeling, BLOSOM, Oil Spill	
Geospatial	Tabular/Spreadsheet	BLOSOM Texas Spill Charateristics	TX_spillcharacteristics.txt	Nelson, Jake	Jake Nelson	2016	https://repository.asu.edu/collections/301	https://github.com/nels	BLOSOM, Spill, Extent, modeling	
Geospatial	Geospatial (vector, raster, or gridded)	Optimization Results TX 06.06-06.08	Transport_xxxx_cleaned.shp	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	https://github.com/nels	Optimization, modeling, BLOSOM, Oil Spill	
Geospatial	Geospatial (vector, raster, or gridded)	GNOME Nearshore Simulation (3 day)	Day_x_xxhr.shp	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00008	Optimization, nearshore, oil, spill, impact, GNOME	
Physical and Computational Sciences	Text	OSCOM Model parameters and equations	OSCOM_Models_v4.docx	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00001	OSCOM, Optimization, modeling,	
Geospatial	Images	EBAM 35 booming strategy	EBAM_Fig2.eps	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00009	EBAM, optimization, modeling, response	
Geospatial	Images	Ebam 60 booming strategy	EBAM_Fig3.eps	Wei, Ran	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00009	EBAM, optimization, modeling, response	
Geospatial	Images	GNOME 3 day spill progress	Spill_Progress.tif	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	DOI: 00009	EBAM, optimization, modeling, response, GNOME	

Geospatial	Geospatial (vector, raster, or gridded)	LA AL Nearshore Spill	Transport2-2015xxxxT000000.shp	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	https://github.com/nels	BLOSOM, Spill, Extent, modeling, Al, LA
Geospatial	Geospatial (vector, raster, or gridded)	LA Midshore spill	Transport2-2015xxxxT000000.shp	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	https://github.com/nels	BLOSOM, Spill, Extent, modeling, LA
Geospatial	Geospatial (vector, raster, or gridded)	LA Offshore	Transport2-2015xxxxT000000.shp	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	https://github.com/nels	BLOSOM, Spill, Extent, modeling, LA, Deepwater
Geospatial	Geospatial (vector, raster, or gridded)	Macondo	Transport2-2015xxxxT000000.shp	Nelson, Jake	Jake Nelson	2017	https://repository.asu.edu/collections/301	https://github.com/nels	BLOSOM, Spill, Extent, modeling, LA, Deepwater

Information Products Report

InfoProductType	DigitalResourceType	Title	FileName	Creators	PublicationYear	Publisher	RepositoryName	DOIorPersistentURL	DatasetReference
InfoProductType	*Software and Source Code*	*Gravity Simulations*	*AppleFalling.gravsim*	*Galieli, Galileo; Newton, Isaac*	*1701*	*Royal Society*	*Really Big Digital Repository for Models and Simulations*	*doi: 10.1000/grav.2000*	*doi: 10.1000/grav.1000, http://www.nodc.noaa.gov/cgi-bin/OAS/prd/accession/details/000000*
Models and Simulations	Software and Source Code	OSCOM Python code	OSCOM_LP.py	Wei, Ran	2017	ASU/Github	GitHub	https://github.com/nelsojak/Gulf_2016/	
Website or Data Portals	Software and Source Code	User Interface		Chandra, Prannoy	2017	ASU/Github	GitHub	https://github.com/nelsojak/Gulf_2016/	
GIS Application	Software and Source Code	Repeated Sampling Code	MonteCarlo.py	Nelson, Jake	2016	ASU/Github	GitHub	https://github.com/nelsojak/Gulf_2016/	
Scholarly Publication	Text	Optimizing Oil Spill Cleanup Efforts: A Tactical Approach and Evaluation Framework		Grubesic, Tony; Wei, Ran; Nelson, Jake	2017	Marine Pollution Bulletin		in press	in press
Scholarly Publication	Text	A Repeated Sampling Method for Oil Spill Impact Uncertainty and Interpolation		Nelson, Jake; Grubesic, Tony	2017	International Journal of Disaster Risk Reduction		http://dx.doi.org/10.1016/j.ijdrr.2017.01.014	
Scholarly Publication	Text	A Geographic Perspective for Protecting Sensitive Coastal Areas with Exclusion Booms during Oil Spill Events		Grubesic, Tony; Wei, Ran; Nelson, Jake	2017	Environmental Impact Assessment Review		under review	under review
Scholarly Publication	Text	Oil Spill Modeling: Risk, Spatial Vulnerability and Impact Assessment.		Nelson, Jake; Grubesic, Tony	2017	Progress in Physical Geography		In revision	in revision