Auburn University Response Capabilities regarding Deepwater Horizon Oil Spill

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AUBURN UNIVERSITY RESPONSE CAPABILITIES REGARDING DEEPWATER HORIZON OIL SPILL

Responding to the Deepwater Horizon Oil Spill

In light of the catastrophic oil spill in the Gulf of Mexico, Auburn University, as a sea and land grant institution with decades of research in the region, is prepared to bring a broad array of expertise to bear in assessing and mitigating the impact of what is potentially the most significant environmental disaster in U.S. history.

Auburn University researchers have the capacity to respond to a range of issues arising from an oil spill of this magnitude. These capabilities include but are not limited to:

Containment and Clean-up

Auburn University's Department of Mechanical Engineering is focusing its expertise on the design of mechanical devices and materials science looking into immediate and near term solutions for the containment and cleanup effort stemming from the April 2010 BP oil platform disaster oil spill.

Auburn University's Department of Mechanical Engineering stands uniquely qualified to rapidly develop and design hardware, and enjoys a close working relationship with many industrial and commercial partners in on-going research and development contracts and grants. In addition, mechanical devices and materials that could help prevent future loss of life and mitigate environmental threats in the near and far term have been given immediate attention. The department of mechanical engineering looks to work with industry partners along with government agencies, laboratories and regional institutions of higher education in stemming current and future losses of life and environmental habitats. For additional information contact: Daniel Harris, harridk@auburn.edu, 334-844-3337

Environmental Assessments

Coastal wetlands are highly critical in providing habitat for fauna and flora, hurricane mitigation, carbon sequestration, pollutant filtration, and in sustaining local to regional economies. However, extensive contact with oil from the spill will destroy the biological integrity and key functions of these important systems. Unfortunately, we know very little about resistance and resiliency of our coastal wetlands under the circumstances of the current disaster. To fully understand the environmental impacts caused by oil exposure and to support future remediation, baseline data should be collected as soon as possible. Some of the largest baseline data gaps are likely related to coastal wetlands which may retain oil for years following the disaster.

Dr. Graeme Lockaby (Associate Dean for Research, School of Forestry and Wildlife Sciences, Director of the Center for Forest Sustainability) proposes leading a team to evaluate damage and recovery rates by establishing integrated studies of key functions such as the population dynamics of aquatic and terrestrial fauna, coastal vegetation productivity and species composition, changes in carbon sequestration, biogeochemistry, and surface and groundwater hydrology. His team can develop pre-disturbance, baseline data sets so that oil induced changes and recovery trajectories can be clearly estimated. Dr. Chris Anderson, a wetland ecologist and colleague of Dr. Lockaby, is willing to participate in the assessment and monitoring of wetland impacts. For further information, contact: Graeme Lockaby, lockabg@auburn.edu, 334-844-1054.

Researchers in the Civil Engineering department are working with diverse team of researchers within Auburn University and outside experts to develop a rapid response plan to help Alabama authorities to deal with possible beach and coastal water contamination problems. Their team is fully equipped to provide the

following support: 1) collect and analyze field samples of water, sediment and oil samples in several ecologically sensitive areas, 2) provide bulk characterization of the oil slick to understand its chemical characteristics, its initial weathering patterns, and the potential biodegradability of various chemical components in the slick, 3) provide a rapid assessment of toxicity effects of various oil components and dispersants, 4) conduct microcosm/mesocosm experiments to track the evolution of the microbial population and its response to the oil slick, 5) design and operate necessary chemical or bioremediation methods needed for the long-term restoration of impacted beaches, 6) simulation of oil slick in coastal waters, and 7) conduct a large-scale environmental impact study to assess the long-term environmental and economic impacts of the oil spill on the Gulf Shore region. For additional information, contact: Dr. Prabhakar Clement, 334-844-6288, clemept@auburn.edu

Dr. Russell Wright (Extension Fisheries) and Dr. Dennis Devries (Fisheries) have expertise in the broad area of aquatic ecology. Frequently, their work is focused on fish ecology. They have worked in aquatic systems for 25-30 years, and have just recently completed a long-term project in the Mobile-Tensaw Delta, the estuary where the Alabama and Tombigbee rivers meet the saline waters of Mobile Bay. Their collections represent the largest and longest ongoing sampling effort of fishes in the Delta, and would make a valuable baseline data set should oil move that far upstream. Even if oil doesn't move directly into the Delta, the use of the Delta as a nursery for a wide array of fish species (e.g., southern flounder, menhaden, bay anchovy) means that fish move into and out of the Delta regularly, and thus contaminants may still make their way into the Delta ecosystem. The Mobile-Tensaw Delta is unique among estuaries along the Gulf Coast, and even though the threat to Alabama's Mobile Delta would take longer to play out than the more imminent threat to Alabama's coastline, effects in the Delta would be extremely far reaching and long term.

The Mobile Delta constitutes one of the largest and longest delta systems in North America, covering as much as 55 km in length from the confluence of the Tombigbee and Alabama rivers to Mobile Bay, and ranging from 10-15 km in width. Drs. Wright and Devries' sampling has taken place along the eastern side of the Delta, from below the causeway (D'Olive Bay) to upstream of I-65 (Tensaw Lake). Sampling occurred approximately monthly from 2002 through 2009, and included collection of fishes, zooplankton, and water quality samples. Drs. Wright and Devries propose an immediate collection of additional samples in the Delta, or even further downstream off of Mobile Bay, in areas such as around Fairhope or within Weeks Bay on the east side of Mobile Bay, or in the Fowl River or Dog River on the west side of the Bay. Collection of these additional samples will require external funding. For additional information, contact: Dennis Devries, devridr@auburn.edu, 334-844-3337

Dr. Jack Feminella (Biological Sciences) has been quantifying stream biota (fish and invertebrates) and habitat in several tributaries of Wolf Bay (Baldwin County, Alabama) since 2008. The study sites are upstream of tidal effects, but there is some opportunity to use this as baseline data for a longer-term monitoring study of impacts from the Gulf oil spill. For example, there are several "euryhaline" fishes that migrate up streams from Wolf Bay, which may be affected by the spill. Dr. Feminella has historical data (mid 1990s) on effects of salinity and temperature on growth and production of a fresh water invertebrate (burrowing mayfly) inhabiting seasonally saline reaches of the Lower Mobile River. As with the Wolf Bay Project, this could provide a baseline for a post-spill impact study in a riverine environment close to the Gulf.

Dr. Ah Jeong Son (Civil Engineering) works with biosensors and DNA methods to assess the toxicological response of microbial populations to external chemical stresses.

Dr. Yucheng Feng (Agronomy & Soils) has expertise in biodegradation and bioremediation of petroleum hydrocarbon contamination. She proposes to treat residual oil via biostimulation and/or bioaugmentation. To stimulate indigenous hydrocarbon degrading bacteria, supplementation of nitrogen and phosphorus in a stable

water-in-oil formulation is desirable. If needed, hydrocarbon-degrading bacteria can be inoculated into the contaminated area to speed up the degradation process.

Drs. Robert Boyd, Mike Wooten and Troy Best (Biological Sciences) have expertise in the coastal ecology of dune ecosystems for both plants and animals. They have had past grants and contracts with the U.S. Fish and Wildlife Service and have documented expertise in preparing habitat conservation plans and species recovery plans and can bring that expertise to bear now in the Gulf Coast Region.

Dr. Anthony Moss (Biological Sciences) is currently studying the microbial dynamics in Mobile Bay. He proposes examining microbial dynamics in perturbed environments, including storm damage, and anthropogenic damage, as well as an evaluation of microbial redistributions as a function of the oil impact, examining the ctenophores, jellyfish and other invertebrate animals. He will attempt to understand the effects of such perturbations on microbes that affect marine coastal health, as well as human health microbes and evaluate the impact on tourism, game fish, coastal animals such as stingers like Chrysaora (sea nettle), as well as trophic transfer of microbes—in effect, all aspects of the invertebrate microbial effects (microbes carried by the jellyfish and other invertebrates) and the consequences on the invertebrates themselves.

Dr. Stephen Kempf (Biological Sciences) currently has an ongoing project concerned with the stress related to the loss of symbiots in coral symbioses. Since his lab has considered the histology and ultrastructure of coelenterate species for a number of years and he has experience with both healthy and stressed coelenterates, his lab could immediately examine and assess the condition of coelenterate (including coral) tissues. This assessment would provide information on the nature and extent of damage caused by exposure to crude oil.

Dr. Scott Santos (Biological Sciences) could provide assistance in the generation and analysis of SSU 454 pyrosequencing tags for tracking how microbial (both pro-and eukaryotic) community structure is altered by the spill and toward recovery.

Remediation

Currently, the primary focus of British Petroleum's activity is on stopping the oil leak itself. However, once the leak has been repaired there will be significant quantities of leaked oil to be addressed. Bioremediation is one mechanism available to address this issue. Ocean water is typically low in nutrients, which will limit the rate of biodegradation. However, nutrients can be added to increase microbial activity. A stable water-in-oil formulation containing nitrogen and phosphorus was used in Alaska to speed up biodegradation after the Exxon Valdez oil spill. Auburn University's Department of Civil Engineering has several ongoing efforts in the area of bioremediation as well as considerable expertise. Associated researchers would be interested in conducting screening experiments to study the efficiency of various types of chemicals and microbial amendments that could be used for remediating contaminated beaches. Based on these screening experiments, they could design a bioremediation plan for dealing with beach contamination problems.

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Dr. Sang-Jin Suh (Biological Sciences) is a microbiologist with expertise in working with oil degrading *Pseudomonas* bacteria. *Pseudomonas putida* was the first living organism to be patented for its oil degrading ability. *Pseudomonas aeruginosa* degrades oil as well as *P. putida* and is a good bacterium for remediation of

oil spills because it survives and thrives in various environments including marine, fresh water and soil. Dr. Suh has characterized oil degrading *P. aeruginosa* in the past and is currently conducting research on enhancing the production of rhamnolipids which are required for efficient degradation of oil and hydrocarbons by this bacterium. Dr. Suh has *P. aeruginosa* strains that overproduce rhamnolipids and is in the process of further improving these strains to maximize oil degradation.

Dr. Ron Neuman (Chemical Engineering) has authored a proposal to develop a predictive, mechanistic model for demulsifying crude oil emulsions stabilized by beach sands. He proposes to develop practical methods to alter the hydrophobic nature of sand particles at the water-oil interface to that of a hydrophilic state by adsorption of appropriate surface active molecules.

The current oil spill in the Gulf of Mexico will require an integrated program to prioritize and address oil cleanup. Auburn University, working with a variety of commercial firms, has the capacity to develop protocols for the various methods of oil spill remediation that capture and remove oil from both onshore and offshore venues. These protocols will insure that the remediation is accomplished in a timely and cost-effective manner that results in the minimal impact on the environment and a continuation of commercial fishing and tourism activities that provide significant revenue for the state of Alabama.

The use of solidifiers in this effort will be paramount as solidifiers have the ability to capture oil floating in open water and to remove hydrocarbon sheen from coastal waters and estuaries. A solidifier of interest is CIAgent© (C.I. Agent Solutions, Louisville, Kentucky), a non-toxic, non-hazardous, non-corrosive, non-carcinogenic, environment friendly petroleum based blend of polymers, used to immobilize petroleum and related petrochemical emergency releases on land and water. This proprietary blend is listed in the EPA National Contingency Plan Product Schedule as a "Solidifier" for use on oil spills in the navigable waters of the United States. The long chain molecular structure strongly associates with liquid hydrocarbons upon contact, producing an inert solid rubber-like mass that floats on water, allowing rapid recovery with low-cost devices. Solidified oil can be burned for fuel or sent to landfills for disposal. For more information, contact: Tom Hanley, hanley@auburn.edu, 334-844-7773.

Public Health

The Alabama Water Watch (AWW) program (based at Auburn University) has historical water quality data from 35 citizen groups on the Alabama coast who have monitored about 420 sites over the last 15 years and submitted 20,500 data records to the AWW office. This information could be used to evaluate impacts of the spill. In addition, Dr. Bill Deutsch has an EPA research project to look at water quality issues along several states of the Gulf Coast. He is currently working with about 60 active AWW groups statewide, and collaborates with many environmental groups and governmental agencies. They are prepared to post information about the spill, health risks, etc. on the AWW website as well as use their listserv and other means of communication to let people know about the spill and appropriate responses.

Hydrodynamic modeling of contaminated areas

Drs. Jose Vasconcelos and Dr. Xing Fang (Civil Engineering) have the capability to model the fate and transport of oil spills within estuaries and also in the rivers. In addition, they can also look at the implication of oil spills on the submarine waters discharged at the beach face boundary.

Dr. Prabhakar Clement (Department of Civil Engineering) has previously worked for the Battelle Pacific North West National Laboratory, where he has managed large remediation projects related to petroleum spills and chlorinated solvent spills in groundwater aquifers. As a consultant, he has also conducted environmental impact assessment studies for petro-chemical plants. His current research efforts in the remediation area are funded by the Department of Energy (DOE) and Department of Defense (DOD). He has authored numerous

research articles related to bioremediation design and groundwater modeling. He is the lead author of the widely used DOE bioremediation simulation software RT3D. He also conducts physical experiments using laboratory-scale sand tank models to study water and solute flow across costal boundaries. These physical models can be used for testing the feasibility of remediation technologies and nutrient/oil-dispersant amendment strategies.

Drs. Clement (Civil Engineering) and Navin Twarakavi (Agronomy and Soils) have access to computer modeling frameworks that can be used to study and predict the weathering patterns of oils, its interactions with various dispersants, and related density modifications. They can also conduct lab-scale microcosm experiments to study the dissolution patterns.

Impact on Wildlife

The Southeastern Raptor Center (located at Auburn University's College of Veterinary Medicine) has responded to a request from the U.S. Fish and Wildlife Service to provide wildlife assistance for species that may be impacted. If requested, professional staff from the Southeastern Raptor Center will be sent as first responders. Staff members have experience in handling and treating injured birds of prey, and in removing oil from birds.

Drs. Craig Guyer and Mary Mendonca (Biological Sciences) have experience with big turtles and are willing to help collect and de-oil them. They could provide tanks needed to nurse the turtles back to health and help mobilize the personnel from the salt-water aquarium room to assist. Dr. Mendonca has extensive expertise working with endocrine disruptors and biomarkers of stress in birds. She also has expertise in working with sea turtle reproduction, physiology and ecology. She is extremely familiar with sea turtle husbandry, maintenance and health. Her current research includes a project on reproductive and stress physiology of turtles in estuarine river systems in Mississippi. She is willing to go to the site and lead teams to collect samples and measure biomarkers for stress.

Dr. Ken Halanych (Biological Sciences) currently has a National Science Foundation grant to look at tube worms living in Mississippi canyon. Dr. Halanych would be interested in looking at animal fauna living in the sediment and at the corresponding bacterial component. He has genomic skills and could evaluate how the microbial community structure is influenced by the oil.

Dr. Gary Hepp (Wildlife Sciences) is an avian ecologist who works with waterfowl and marshbirds. The oil spill will have catastrophic impacts to birds that use these habitats for breeding, migrating and wintering. Many species in the Gulf region are currently engaged in breeding activities and impacts of the oil spill could result in increased mortality and reproductive failure for many of them. Coastal Alabama and other areas of the Gulf coast provide important migrating and wintering habitats for a diverse assemblage of avian species. Birds are an important part of the coastal ecosystem and they can be used to monitor the relative health of the system as it recovers from this environmental perturbation. Dr. Hepp is available for consultation.

Dr. Stephen "Ash" Bullard (Fisheries) examines impacts on coastal and aquatic wildlife. He is associated with the Aquatic Parasitology Laboratory and has ongoing projects involving the use of parasites as bioindicators of marine health. He can speak to the oil spill's impact on fish and shellfish health. Dr. Bullard can be reached at: (334)844-9278, ash.bullard@auburn.edu, http://www.ag.auburn.edu/fish/directory/faculty/bullard.php.

Impact on Seafood

The recent oil spill has the potential to alter bacterial populations in marine systems resulting in an increased threat of pathogens in human food sources of marine origin. Therefore, Dr. Laura Suh (Biological Sciences) proposes to monitor within the oil spill path marine bacteria in fish and shellfish that cause human illnesses in order to prevent human consumption of contaminated seafood.

Dr. Stephen Kempf (Biological Sciences) has a currently funded project concerned with the nervous system of oyster larvae. The oil spill may directly impact the oyster project by making it difficult or impossible to get oyster larvae from the Auburn University Shellfish Lab on Dauphin Island. The spill may damage or destroy the larvae produced seasonally which are necessary to support the Gulf's oyster industry. This, combined with oil induced death of current oyster beds, could devastate the Gulf oyster industry. Dr. Kempf is available for consultation.

Dr. Bill Walton (Extension Fisheries) has expertise related to marine invertebrate aquaculture, fisheries management and restoration, with an emphasis on oysters, blue crabs and shrimp. His ongoing work includes assessment of oyster habitat and survival along the Alabama coast (including the effects of the Deepwater Horizon oil spill) experimental testing concerning the importance of geographic origin of oyster broodstock, and an oyster aquaculture demonstration project, which may serve as an opportunity for displaced commercial fishermen. Dr. Walton is available for consultation.

Equipment Availability

The Civil Engineering Department has three Gas Chromatographs fitted with various detectors and has the capability to measure hydrocarbon. In addition, Dr. Navin Twarakavi (Agronomy and Soils) has a Gas Chromatograph. Therefore, Auburn University can quantify water quality parameters such as TPH, TOC, BOD and all other relevant indicators. Dr. Clifford Lange (Civil Engineering) routinely characterizes waste residues discharged from petrochemical plants and can help characterize field samples of crude oil and crude-contaminated waters. Dr. Twarakavi (Agronomy and Soils) is working with biodiesels to characterize various components. He can assist with the partitioning characteristics of the non-aqueous phase (NAPL) oils.

Athena Clark, Director, United States Geologic Survey Alabama Water Science Center Auburn University Montgomery indicates that her office is on standby to collect samples. They have access to two small boats equipped to collect sediment samples from shallow regions and have indicated they are willing to work in collaboration with Auburn University.

Dr. Stephen Szedlmayer's (Seagrant, Fisheries) research over the last 20 years has addressed the fisheries, ecology and behavior of marine fishes. These studies have included age and growth, reproduction, early-life-history, predator-prey relations, diet analyses, movements, behavioral interactions, stock assessment and in general the effects of habitats both natural and artificial on the fish and invertebrate populations in the northern Gulf of Mexico. The majority of Dr. Szedlmayer's work has been conducted in the northern Gulf of Mexico and adjacent waters. He averages approximately 60 days per year offshore with most trips completed in a single day. However, he has the vessels and capacity for extended days offshore. His laboratory is located on the coast at the Gulf Coast Research and Extension Center, Alabama Agricultural Experiment Station (Fairhope, AL). He has a building for offices and a 4,000-gallon closed seawater system for laboratory experiments. The office/lab is equipped with full access to the internet, computers, advanced microscopes, and other miscellaneous laboratory equipment and supplies. Perhaps the greatest advantage of his program is the research vessel, *Mary Lou*. This vessel is 44 ft (35 ton) and was custom built for their research needs. Also available is a 35 ft vessel that is suitable for use in offshore studies. Dr. Szedlmayer has capabilities for SCUBA visual surveys, sidescan surveys, bandit rig sampling, trawl sampling, trap sampling, and so forth. He can provide STD samples with a hydrolab remote sonde, and has the equipment for extensive telemetry sampling.

Over the years they have built and surveyed more than 500 artificial reefs, which have resulted in numerous publications on fish communities and artificial reefs.

A Systems Approach to Address Future Oil Spill Crisis

The recent event in the Gulf of Mexico indicates the need for a systems approach to anticipate occurrences and develop operating procedures that will eliminate or minimize the impact of oil spills in an ocean environment. The diverse expertise available in a comprehensive research university and the objective nature of a public university provide the necessary attributes for Auburn University to take leadership role in this planning and analysis process.

The proposed concept has three components: (a) cataloguing of the condition of the structure, sea bed, surrounding ocean and oil characteristics, (b) identification of possible failure scenarios, and (c) operating procedures appropriate for each failure condition. An Auburn team working with both regulatory agencies and oil industries has the capacity to establish a comprehensive database for all the off-shore oil wells and their operating conditions including depth, pressure, temperature, ocean current and weather. Based on this database, the team can determine possible scenarios for failure and compare those with historic data for these installations. The final task is to develop standard operating procedures in response to these failure modes and to identify the infrastructure needed to implement these responses. Although this will not mitigate the immediate problem in the BP spill, it will help prevent future events and reduce their impact. Auburn Point of Contact: Ralph Zee, zeeralp@auburn.edu, 334-844-2301

Socioeconomic Issues – see attached paper

Fisheries and Allied Aquaculture – see attached paper

Alabama Cooperative Extension System – response and capabilities described in attached paper

Socioeconomic Implications

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There are three broad definitions of community—geographic area, common ties, and social interaction (Hillery 1982) and they are embedded in complex adaptive social-ecological systems. Human systems influence the environment and the environment influences human systems through continual feedbacks. Large-scale environmental disasters, whether they are natural (e.g., Hurricane Katrina) or technological (e.g., BP oil spill in the Gulf of Mexico) in origin, can disrupt or destroy a community (Gill & Picou 1998). Thus, it is important to understand the tipping points that can change the character of a community and its ability to function. Resiliency, or the magnitude of disturbance a system can absorb and still maintain functional characteristics, is a useful framework for analyzing community sustainability (Berkes, Colding and Folke 2003).

Community sustainability is dependent on its ability to access and mobilize a range of capitals--built capital, financial capital, political capital, cultural capital, human capital, social capital, and natural capital (Flora & Flora 2008). For instance, while investment in technological solutions may repair some physical damage, Adger et al. (2005:1038) finds that the ability of a community to reorganize and bounce back after disaster is dependent on institutions for collective action and robust governance systems (i.e., human, cultural, social and political capital). Within these categories there are a number of critical indicators that can be identified as important to community sustainability and resilience. Additionally, there are other indicators that communities

themselves may find as critical to their own sustainability (Beckley, Parkins & Stedman 2002). These indicators should be developed to reflect the interests of communities in specific locations (places) and communities with similar interests (common identity) (Donoghue & Sturtevant 2008). Additional indicators should also be defined by the communities themselves.

An immediate need that can be provided to government planning agencies and private sector response groups is an estimation of actual and potential damages to the local, state and regional economies. A rapid damage estimation response could take several forms and could be for specific industries, such as potential damages, lost revenues, and lost markets to the oyster industry, shrimp fishery, sport fisheries, property value impacts, among others (Hanson, Hatch and Clonts, 2002). Ecosystem damage will affect each of these, especially in their potential to regenerate and supply future fish/shellfish populations. In the longer term, the multiplier or ripple effects (input/output models) of such damages could be the basis for determining the potential economic impact for Alabama from this oil spill. There is a wide array of available research (Mitchell and Carson, 1989) from the Exxon Valdez oil spill in Alaska which set guidelines for economic analysis of such disasters (Arrow et al., 1993) and from the Katrina hurricane disaster (Gaddis et al., 2007) which may provide recent and geographically relevant impacts.

Indicators and measures will be needed across temporal and spatial scales to identify trends at different levels and over different time scales. There will be rapid assessment needs and the need to provide long term monitoring, as there is a high likelihood of lasting social and ecological effects of the oil spill. The following are a small sample of key indicators with likely implications for community sustainability and resilience.

Communities of interest with economic indicators:

- Commercial
    - Fisherfolk (shrimp, oyster, fish, crab)
    - Processors of fish/shellfish, and associated workers
    - Trucking and delivery businesses
    - Retail (fish, seafood, bait)
    - Working waterfronts (boat builders, repair facilities for engines, nets, seafood, associated real estate)
    - Seafood restaurants
    - Port facilities, marinas (import/export of trade goods, transportation and navigation, pleasure boating)
- Recreational
    - Fishing/boating/sailing
    - Charter boat industry
    - Ecotourism
    - Beach activities
    - Recreational permit sales
- Tourism
    - Hotels, rental homes, restaurants, outlet store shopping, tour operators, guides, and other retail
    - Processing sectors
- Residential
    - Real estate (property values)
    - Government (tax base, efficiency and effectiveness of response)

Social indicators:

- Quality of life (psychological and physical wellbeing)
- Community/public health and access to other social services
- Education
- Sense of place (place satisfaction, dependence, and meaning)
- Community cohesion (social capital, government and governance)

Ecological indicators:

- As related to other economic and social indicators
- Value of wildlife (option, bequest, existence; stated or revealed preferences)
- Value of ecosystems (option, bequest, existence; stated or revealed preferences)
- Value of impaired ecosystems resulting in lost reproduction potential for important commercial fish/shellfish species

References

Adger, W. N., T.P. Hughes, C. Folke, S.R. Carpenter and J. Rockstrom. (2005) Social-ecological resilience to coastal disasters. Science 309:1036-1039.

Arrow, K., R. Solow, P. R. Portney, E. E. Learner and H. Schuman. (1993) Report of the NOAA Panel on Contingent Valuation, Federal Register 58(10):4601-14.

Berkes F., J. Colding, C. Folke. (2003) Navigating social-ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge, 393 pp.

Beckley, T., J. Parkins and R. Stedman. (2002) Indicators of forest-dependent community sustainability: the evolution of research. The Forestry Chronicle Sept/Oct V28, N 5: 626-636.

Donoghue E. and V. Sturtevant. (2008) Forest community connections. Resources for the Future, Washington D.C., 280 pp.

Flora, C.B. (1999) Quality of life versus standard of living. Rural Development News 22:1-3.

Flora, C.B. and J.L. Flora. (2008) Rural Communities: Legacy and Change. Boulder, Colo.: Westview Press.

Gaddis, E.B., B. Miles, S. Morsea, and D. Lewis. (2007) Full-cost accounting of coastal disasters in the United States: Implications for planning and preparedness." Ecological Economics. V63, N2-3 (August): 307-318.

Gill, D.A. and J.S. Picou. (1998) Technological disaster and chronic community stress. Society & Natural Resources 11:795-816.

Hanson, T.R., L.U. Hatch, and H.C. Clonts. (2002) Reservoir water level impacts on recreation, property, and nonuser values. Journal of the American Water Resources Association. August, V38, N4:1-12.

Hillery, G.A. (1982) A Research Odyssey: Developing and Testing a Community Theory. New Brunswick, NJ: Transaction Books.

Mitchell, R.C. and R.T. Carson. (1989) Using Surveys to Value Public Goods – The Contingent Valuation Method. Washington, D.C.: Resources for the Future.

The fisheries in the northern Gulf of Mexico and the effects of the Deepwater Horizon oil spill accident.

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The Marine Fish Laboratory, Department of Fisheries, Auburn University, located at the Gulf Coast Research and Extension Center, Fairhope, Alabama, has been very active in fishery studies of red snapper and many other marine fishes for over 20 years. Over the years we have conducted trawl surveys, tagging studies, age-catch analyses, hatchery stocking studies, ultrasonic tracking studies, diet analyses, reef fish surveys, oil and gas platform studies, natural reef habitat studies, and benthic reef invertebrate surveys (using gill nets, drop nets, bandit rigs, video surveys, rotenone sampling, long-line surveys, trawl surveys, fish trap surveys, SCUBA visual surveys, video surveys, digital camera surveys). We have also examined the functional ecology of artificial reefs by examining the effects of predation and epifaunal influences on red snapper and other reef fish species. Specifically, we are the only group that has conducted any fishery independent age distribution surveys of adult red snapper in the northern Gulf of Mexico (from 1998 to 2003, we collected over 4,000 adult red snapper for analyses). We have carried out extensive juvenile fish surveys on artificial reefs with over 500 artificial reefs built and surveyed since 1998. Recently (5 May 2010) we sampled red snapper populations at the very edge of the oil spill area (Lat 29 degrees, 55 min, at the border of the present emergency closure south of 29 degrees, 54 min) in the northern Gulf of Mexico. We collected over 100 red snapper and samples are being analyzed for mercury and pre-oil spill hydrocarbons.

Based on our 20 years experience, we believe our fisheries studies are by far the most appropriate of any research effort or group in the entire Northern Gulf for addressing the possible effects of this recent oil spill. We have the personnel, training, vessels, and equipment for extensive faunal surveys from coastal waters to the deeper waters at the location of the present oil spill.

The collection of this important information and its comparison with previous data collected over the past 20 years will provide critical data sets needed to manage our coastal and marine shelf environment and critically evaluate the real impacts of this recent oil spill accident.

Alabama Cooperative Extension System Response to Oil Spill

The Alabama Cooperative Extension System has professional staff in each of the state's 67 counties and seven regional research and extension centers, including two coastal centers. This network of professionals is positioned to provide response and recovery efforts—short- and long- term—in our coastal counties and throughout the state as the ripple effects of the spill move inland.

More than 7,000 volunteers were registered in the state's volunteer data base by May 12. The volunteers must receive safety training before they will be allowed to participate in the cleanup efforts. Working in tandem with the Mississippi-Alabama Sea Grant office and through British Petroleum's training contractor, Extension can provide hazardous materials and safety training to volunteers and to scientists participating in onsite data collection. Extension agents can provide the hazardous materials training throughout the state, reducing the training load in Mobile and Baldwin counties.

As the disaster unfolds, there will be need for expertise in coping with the social and economic repercussions of lost jobs and lost ways of life. As witnessed by the Exxon Valdez disaster in Alaska, the recovery is decades-long. Extension can help communities work through the losses and rebuild.

Extension's communicators have excellent relationships with communicators throughout country. They are currently collaborating with Extension communicators and Sea Grant communicators in the Gulf Coast region to develop and disseminate research-based objective messages to the public on a variety of topics surrounding the oil spill and its effects. Communications will most likely include social media venues such as blogs, twitter and Facebook. Extension will also use Extension Disaster Education Network (EDEN) and eXtension to disseminate information and education.

Other Extension capabilities are included in the Environmental Assessments, Public Health, Impact on Seafood, and Equipment Availability sections of this paper.

- Immediate Steps Taken
    - Training
        - Jim Todd investigate HAZMAT training
        - Get extension employees trained in HAZMAT response
        - Professors trained coming down
        - "Train the trainer" programs for agents
        - Open training to extension across the gulf
    - Communication (sea grant website)
        - Responded or responding to multiple media requests for information
        - Responded or responding to multiple requests for information from commercial fishermen, seafood dealers, and general public
        - ACES website linked
        - Oyster gardening website linked
        - AUMERC website linked
        - Other agency recommendations
        - Information to stakeholders and general public
            - Potential blog updates from coastal agents
    - Seafood Safety, Environmental Effects & Impacts on Fisheries

        - Collection of samples of oyster tissues for pre-spill toxin levels from waterbodies not sampled by AL Dept of Public Health or AL Marine Resources Division but considered important by local water quality groups (e.g., Wolf Bay, Perdido Bay, Little Lagoon) as a baseline for any impacts
        - Collection of samples of oyster tissues for pre-spill toxin levels from private oyster leases (done with full QA/QC protocols) as a baseline for any impacts, above and beyond the samples collected by ADPH

Deployment of live oysters at 9 coastal sites along the AL coastline (and 1 in the Grand Bay National Estuarine Research Reserve, MS) to begin quantitative assessment of initial effects of spill on oyster survival and growth

- Short to Medium Term Steps Planned
    - Training
        - Possible training in any HACCP training for seafood dealers
    - Communication (sea grant website)
        - Rapid response ACES publications to address community requests
            - E.g., Effects of spills on seafood and how consumers are protected
        - Information to stakeholders and general public
            - Ongoing blog updates from coastal agents
    - Seafood Safety, Environmental Effects & Impacts on Fisheries
        - Collection of samples of oyster tissues over time from waterbodies not sampled by AL Dept of Public Health or AL Marine Resources Division but considered important by local water quality groups (e.g., Wolf Bay, Perdido Bay, Little Lagoon)
        - Collection of samples of oyster tissues over time for toxin levels from private oyster leases (done with full QA/QC protocols)
        - Subsequent deployments of live oysters at coastal sites along the AL coastline (and 1 in the Grand Bay National Estuarine Research Reserve) to measure effects of spill on oyster survival and growth over time
        - Work with local authorities to identify areas safe to open to harvest
        - Work with seafood industry to educate public about steps taken to protect consumers
- Long Term Steps Planned
    - Training
        - Aquaculture training for displaced commercial fishermen and other water-dependent individuals
    - Communication (sea grant website)
        - ACES extension publications
        - Information to stakeholders and general public
            - Ongoing blog updates from coastal agents
    - Seafood Safety, Environmental Effects & Impacts on Fisheries
        - Additional sample collection as warranted
        - Work with local authorities to identify areas for aquaculture areas
        - Assist fishermen and public agencies with recovery of coastal fisheries
        - Assist environmental groups and agencies with recovery of oyster habitat

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