

## **PRESS ALERT**

**September 19, 2010**

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### **Press Material DOI Strategic Sciences Working Group**

#### **Background**

Shortly after the April 2010 Deepwater Horizon oil spill began, the Department of the Interior leadership created an inter-disciplinary Strategic Sciences Working Group of scientists (see attached biographies) from federal, academic, and non-governmental organizations. The purpose of the working group is to develop science-based assessments of the long-term effects of the spill on the ecology, economy, and people of the Gulf of Mexico. The group first met in Mobile, Alabama in May 2010 for several days of scenario-building based on expert opinion and the available scientific literature.

The results of the working group are a series of scenarios designed to provide information useful to decision makers, resource managers and other professionals responsible for the response and recovery associated with the Deepwater Horizon oil spill. The results are not designed to replace or direct pre-existing procedures such as the Natural Resource Damage Assessment.

The first results of the working group are described in an article published in the August 27, 2010 issue of *Science*, entitled, "Scenario-Building for the Mississippi Canyon 252/Deepwater Horizon Oil Spill" (see attached), and a progress report entitled "DOI Strategic Sciences Working Group Mississippi Canyon 252/Deepwater Horizon Oil Spill Progress Report", available at [http://www.usgs.gov/oilspill/docs/SSWG\\_Progress\\_Report\\_09june10.pdf](http://www.usgs.gov/oilspill/docs/SSWG_Progress_Report_09june10.pdf).

#### **The Second Session**

As a result of its first session, Secretary of the Interior Salazar has directed the group to continue its work, and scenario-building sessions of the Working Group will continue at a second session September 18-24<sup>th</sup>, in New Orleans, Louisiana. During this second session, the working group will refine the technique, further advance the existing scenarios based on additional input and new information, and complete additional scenarios focused on mid to long-term recovery of the Gulf of Mexico as a coupled natural-human system.

#### **Next Steps**

After the working group completes its task in New Orleans, a progress report will be prepared within 30 days. The report will be peer reviewed following USGS guidelines. The report will then be distributed to key stakeholders including federal and state agencies, academic groups, non-governmental organizations, and the New Orleans Unified Command. In addition, briefings will be provided to the Department of the Interior leadership and its partners. The purpose of the briefings is to present the scenarios and describe how they can be useful in recovery planning for the Gulf of Mexico. A third working group session is planned for early 2011.

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## DOI Strategic Sciences Working Group Biographies

Machlis, Gary

Lead Scientist

National Park Service

In September 2009, Gary Machlis was appointed the first Science Advisor to the Director for the National Park Service. He is playing a key role in advancing science within the NPS, advising the NPS director on science policy and programs, and working with the Department of the Interior leadership, NPS managers and stakeholders as well as the scientific community. Machlis received his B.S. and M.S. in forestry at the University of Washington, and his Ph.D. in human ecology at Yale University. He is Professor of Conservation at the University of Idaho, where he has taught courses in protected area management, human ecology, and science policy since 1979. From 1995-2003 he served as the NPS Visiting Chief Social Scientist, and from 1998-2006 as the National Coordinator of the Cooperative Ecosystem Studies Unit (CESU) Network. Machlis has worked internationally on a range of complex ecological issues—including giant panda conservation in China, wildlife management in Kenya, climate change and its consequences for Asian urban centers, tourism impacts in the Galapagos archipelago and the ecology of warfare. Dr. Machlis currently leads the Department of the Interior Strategic Science Working Group that is developing science-based scenarios for the Deepwater Horizon oil spill. Gary is an elected Fellow of the American Association for the Advancement of Science's (AAAS) and a member of its National Committee on Opportunities for Women and Minorities in Science.

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Newman, Jason

Assistant Team Leader

National Park Service

Jason Newman is currently serving on a detail as the Assistant Team Leader for the Department of the Interior, Strategic Sciences Working Group. In his permanent capacity with the National Park Service he serves as the Park Planner for the Statue of Liberty National Monument and Ellis Island Immigration Museum. Before working with the National Park Service, Jason was with Jones Lang LaSalle, a global real estate services firm managing interior fit-out projects in Connecticut and New York. From 2004-2008 he served as a Transportation Planner and Program Manager with the Federal Highway Administration, Michigan and Connecticut Divisions. Jason received his B.A. in Sociology at Stony Brook University, New York and a M.A. in Urban and Regional Planning at the University at Albany, New York.

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Colten, Craig                                      Carl O. Sauer Professor                                      Department of Geography and  
Anthropology, Louisiana State University

Craig E. Colten is the Carl O. Sauer Professor in the Department of Geography and Anthropology at Louisiana State University. He has more than 25 years experience researching the geographic and historical context of hazards in the environment. His recent work has focused on the Hurricane Katrina and resilience in the Gulf Coast. His books include The Road to Love Canal (1996), An Unnatural Metropolis (2005), and Perilous Place, Powerful Storms (2009). Currently he serves as editor of the Geographical Review.

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Cross, Jeff                                      Chief, Ocean & Coastal Resources  
Branch in the Natural Resource Program  
Center                                      National Park Service

Jeffrey Cross is Chief of the Ocean and Coastal Resources Branch in the Natural Resource Program Center of the National Park Service. The Branch provides technical assistance and leadership in natural resource programs to 80 ocean and coastal parks across 26 states and territories. Dr. Cross has served in various resource management positions in NPS and US Forest Service for 10 years. Prior to that, he was the director of NOAA Fisheries' James J. Howard Marine Sciences Laboratory in New Jersey and director of Southern California Coastal Water Research Project. He has a Ph.D. in marine fisheries from the University of Washington.

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Forsythe, Barry                                      USFWS Liaison to USEPA Region VI                                      U.S. Fish & Wildlife Service

Dr. Barry Forsythe is the U.S. Fish and Wildlife Service's Liaison to the Superfund Division of the U.S. EPA Region VI (Dallas, TX). He provides technical support to EPA in the ecological risk assessment and clean-up of contaminated sites in Arkansas, Louisiana, Oklahoma, Texas, and New Mexico. In addition, Dr. Forsythe provides technical expertise for the USFWS in response to natural disasters and oil spills. He has served prominent roles in response to Hurricanes Katrina and Rita. Recently Dr. Forsythe has been involved in response activities for the DM932 barge oil spill in New Orleans and the Deepwater Horizon MC252 spill in the Gulf of Mexico. Dr. Forsythe is an adjunct faculty member at Texas Tech University. He received his B.S. in biology from Southeast Missouri State University (1990) and M.S. (1992) and Ph.D. (1996) in Environmental Toxicology, from Clemson University.

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Grace, James

Senior Research Ecologist

U.S. Geological Survey

Jim is a former Professor at LSU in Biology, author of over 140 publications and 4 books. He is the Millennium Award Winner for Scientific Research by the Society of Wetland Sciences and has won several other awards for his work in the analysis of ecological systems. His expertise is primarily in the analysis of causal networks and he has applied this body of knowledge to studies of climate change, wildland fire, ecological restoration, urban planning, and numerous other topics.

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Hay, Jenny

Graduate Student

Department of Geography and  
Anthropology, Louisiana State University

Jenny Hay currently studies geography at Louisiana State University in Baton Rouge, Louisiana. She earned her B.A. in Geography: Natural Resource Management from the University of Texas at Austin in 2006, and M.S. in Geography from Texas State University-San Marcos in 2008. Previous work experience includes commercial property management and real estate development as well as consulting for Texas cities and counties implementing housing and disaster grants. She serves as Secretary for the Geography and Anthropology Society as well as President of the Hill Farm Community Garden, both student organizations at LSU. Research interests include historic preservation, perception of space, and disaster recovery.

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Platt, Joshua

Director of Product Marketing

SmartDraw

Joshua is the Director of Product Marketing at SmartDraw, and has worked to define how the creation of visuals can be automated so everyday computer users can create professional quality visuals that adhere to sound graphic design principals. He is the co-creator of the company's patents, and continues to explore new solutions to encourage the use of visual communication in the workplace. He is also a champion of Goal-Directed Design and the AGILE method and speaks at user experience conferences around the globe.

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Plumb, Glenn                      Acting Chief, Yellowstone Center for  
Resources  
Chief, Branch of Aquatic and Wildlife  
Resources    National Park Service

Since 1998, Glenn has served in several natural resource positions at Yellowstone National Park, and recently became the NPS Wildlife Program Manager within the NPS Biological Resource Management Division located in Fort Collins, CO, to address key wildlife issues across the NPS system, such as migration, population management, energy development, and climate change adaptation.

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Schuster, Rudy                      Branch Chief, Policy Analysis & Science  
Assistance    U.S. Geological Survey

Dr. Schuster is a social scientist whose area of focus is the attitudes, processes, and behaviors related to how humans manage, protect, value, and use our natural resources; this area of study is referred to as the Human Dimensions of Natural Resource Management. Dr. Schuster is Chief of the USGS Policy Analysis and Science Assistance Branch. His work is directed toward integrating natural science, social science, economic, and institutional analyses of conservation policies and management practices to help resource managers make informed decisions and resolve resource management conflicts. In addition to participation in the Strategic Sciences Working Group (SSWG), Dr. Schuster is a member of the USGS team tasked by Secretary Salazar to conduct a Science Gap Analysis related to outer continental shelf oil and gas development on the Arctic Beaufort and Chukchi Seas. Results of the Science Gap Analysis will inform decisions on oil and gas development in these areas. Dr. Schuster represented social and economic science as a writing team member of the USGS DWH oil spill science response plan. He also has experience working on integrated social and natural science teams addressing threats to coupled human and natural systems posed by climate change. His climate change work is directed toward understanding human system resilience and vulnerabilities in an uncertain climate. The same constructs of uncertainty, resilience and vulnerability are integral to understating how the Gulf Coast human system will respond to the DWH spill.

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Shaw, Susan                      Founder/Director - Marine Environmental  
Research Institute (MERI)                      MERI

Dr. Susan Shaw is a marine toxicologist, author, explorer, and founder/director of the Marine Environmental Research Institute (MERI [www.meriresearch.org](http://www.meriresearch.org)). She is known for two decades of pioneering research documenting the effects of hundreds of man-made chemicals in the ocean environment. She is credited as the first scientist to show that flame retardant chemicals used in consumer products have contaminated marine mammals and commercially important fish stocks in the northwest Atlantic Ocean. Her research has influenced policy decisions in the US and abroad, including the Maine legislature's decision to ban the neurotoxic flame retardant decabromodiphenyl ether (Deca), and the subsequent US phase-out of the chemical. An outspoken and influential voice on ocean pollution, Shaw dove in the Gulf of Mexico oil slick in late May 2010 and observed first-hand how oil and dispersants were impacting life in the water column. The experience prompted her to launch an independent region-wide investigation on the effects of oil and chemical dispersants in the food web. She serves on the International Panel on Chemical Pollution, a select group of scientists advising policymakers on the management of toxic chemicals in developed and developing countries. The recipient of numerous awards, Shaw has recently been nominated to be a Woodrow Wilson Visiting Fellow.

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Widder, Edith (Edie)                      CEO, President & Senior Scientist                      Ocean Research & Conservation  
Association

Edith Widder is a biologist and deep-sea explorer who combines expertise in oceanographic research and technological innovation with a commitment to reversing the worldwide trend of marine ecosystem degradation. A specialist in bioluminescence, she has been a leader in helping to design and invent new submersible instrumentation, and equipment to enable unobtrusive deep-sea observations. In 2005 Widder left Harbor Branch Oceanographic Institution where she had worked for 16 years to co-found the Ocean Research & Conservation Association an organization dedicated to the study and protection of marine ecosystems and the species they sustain through development of innovative technologies, science-based conservation action and public education. While translating complex scientific issues into engineerable solutions, Dr. Widder is fostering greater understanding of ocean life as a means to better, more informed ocean stewardship. In September of 2006, based on her work with ORCA, she was awarded a prestigious MacArthur Fellowship from the John D. and Catherine T. MacArthur Foundation.

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Woit, Rachel

Research Assistant

University of Idaho

Rachel Woiita graduated from the University of Idaho with a master's degree in Natural Resources. Rachel has conducted social science research examining the relationship between risk perception and preparedness (among backpackers in Glacier National Park) and is currently conducting national park service research.

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### Science Article Describes Scenario-Building Technique Used to Assist Planning for Recovery from BP Deepwater Horizon Oil Spill

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08/26/2010

**WASHINGTON, D.C.** – Some of America's best scientists are helping develop an innovative scenario-building technique to plan environmental and economic recovery from the Gulf of Mexico oil spill, according to an article in this week's *Science*.

Shortly after the April 2010 spill, Secretary of the Interior Ken Salazar created an inter-disciplinary Strategic Sciences Working Group of scientists from federal, academic, and non-governmental organizations to develop a science-based assessment of the long-term effects of the spill on the ecology, economy, and people of the Gulf of Mexico.

The results of the working group are designed to provide information useful to decision makers, resource managers and other professionals developing and managing the existing response plans--such as the Natural Resource Damage Assessment (NRDA) leaders and staff. The results are not designed to replace or direct these pre-existing procedures.

The first results of the working group are outlined in the *Science* essay, "Scenario-Building for the Mississippi Canyon 252/Deepwater Horizon Oil Spill," to be published in the magazine on August 27. The essay was co-authored by Dr. Gary Machlis, Science Advisor to National Park Service Director Jon Jarvis, and Dr. Marcia McNutt, Director of the U.S Geological Survey. Dr. Machlis serves as Lead Scientist on the Working Group, and Dr. McNutt oversees the group's activities.

The focus of the *Science* article is the scenario-building technique. The scenarios in the article are considered preliminary results and have already changed since the article was written based on new information on parameters such as flow rates and time periods, which have changed with events in the Gulf and continuing research by scientists. The technique, however, is helping to identify possible policies and actions to reduce negative impacts of the spill and speed up and sustain the recovery process.

"We are treating the ecology, economy, and people impacted by the spill as a whole," emphasized Team Leader Machlis, "and our challenge has been to understand what is happening and what might happen from that broad perspective."

One scenario in the Science article examined how long-term decline of plants, particularly in the wetlands, is a probable consequence of the spill, and if extensive, could impair both fisheries recovery and resistance to hurricane damage, with further consequences from the re-release of “sequestered” oil. Other scenarios dealt with impacts upon the oyster fishery, health issues of workers, impacts on the tourism industry, and more.

“Team members come from many scientific disciplines, with experience on oil spills and other environmental events, and many are from the local region”, said USGS Director McNutt. “All of those on this DOI team have worked hard to understand the long-term impacts—what we call ‘cascading effects’ —of the spill and opportunities for sustainable recovery.” (The team includes modelers, ecologists, oceanographers, social scientists, and other experts.)

The group first met in Mobile, Alabama for five intense days in May 2010, for scenario-building based on expert opinion and the available scientific literature; the group will reconvene in New Orleans in September.

Since its first session, the working group has briefed the Mobile Unified Command, Department of Interior officials, NRDA staff, and others involved in Gulf restoration and recovery.

Secretary Salazar has directed the group to continue its work. Scenario-building sessions of the working group will continue at the September meeting, and additional, updated scenarios will be prepared. Work will be ongoing at least through the fall. Hence, it is a “work in progress.”

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# Scenario-Building for the Deepwater Horizon Oil Spill

Gary E. Machlis<sup>1\*</sup> and Marcia K. McNutt<sup>2</sup>

In May 2010, the U.S. Department of the Interior (DOI) established a Strategic Sciences Working Group (SSWG) to assess how the Deepwater Horizon (DH) oil spill may impact the ecology, economy, and people of the Gulf of Mexico (GOM). It included scientists from diverse disciplines and federal, academic, and nongovernmental organizations. The SSWG was not to conduct a scientific investigation, but to provide rapid scientific assessment of potential consequences of the spill that could provide usable knowledge to decision-makers.

Such teams are not common to formal government response efforts. Most scientific activity at early stages of the spill was tactical, e.g., documenting preimpact conditions, monitoring oil transport, assessing resource damage, and supporting technical decisions associated with oil containment. Interdisciplinary and comprehensive analyses of consequences were not integral to these tactical efforts. The SSWG was a strategic and experimental response initiated by DOI, novel to the DH spill for its combination of (i) independence from standard response structures [e.g., the Incident Command System (ICS) and Natural Resource Damage Assessment (NRDA)]; (ii) collaborative engagement of federal and nonfederal scientists; (iii) rapid scenario-building within a interdisciplinary framework; (iv) assignment of scientific uncertainties; and (v) potential application to mid- and long-term recovery. The SSWG assembled in Mobile, Alabama, within 36 hours of establishment and developed initial scenarios 23 to 28 May 2010. A full description of the methodology and scenario results is available in the group's first technical report (1).

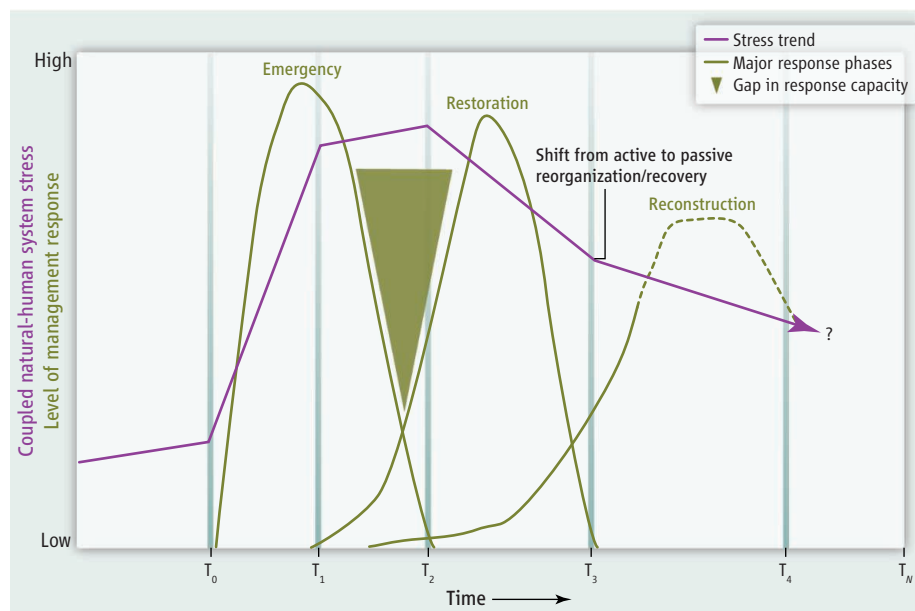
## Organizing Framework

During major incidents such as the DH oil spill, response time is critical, conditions change rapidly, quantitative models and/or

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Interdisciplinary science-based scenarios can assist responses to the Gulf oil spill and similar environmental crises.



**Conceptual scenario framework.** This shows system stress, time horizons, major management response phases, and the potential gap in response capacity. [Adapted from (1)]

their requisite data may be unavailable, and many key factors are unknown. Scenario-building, originally developed for the military (2) and adapted by large-scale firms and others, offers several advantages, particularly its capacity to systematically examine possible futures and cascading consequences that are complex and uncertain (3, 4). Unlike quantitative modeling or risk assessment, scenarios identify alternative futures rather than predict new-state conditions. Limitations include constraints due to available expert opinion and lack of theory (4).

There are numerous approaches to constructing science-based scenarios (3). For the oil spill, the SSWG adapted and applied a specific, coupled natural-human systems model to identify key variables (5) and developed a conceptual framework adapted from the natural hazards literature to reflect the DH oil spill (6, 7). Scenarios were not limited to discrete physical, chemical, biological, economic, and/or sociocultural consequences but included how these consequences interact in shaping possible trajectories of the overall system.

The scenario framework (see the figure) incorporates system stress over key time horizons

through recovery. Baseline stress in the GOM was treated as increasing before the DH oil spill, due to nutrient loading, expansion of the seasonal hypoxic area, wetland loss, land subsidence, invasive species, climate change, fishing pressures, effects of past hurricane damage, and national and regional economic recession (8–11). At the time of the DH explosion ( $T_0$ ; 20 April 2010), system stress began to rapidly accumulate. After oil flow containment ( $T_1$ ; well shut-in occurred 15 July 2010) system stress may continue to rise due to lagged effects, e.g., landfall of previously released oil and/or chronic toxicity to sensitive ecosystem components. At  $T_2$ , system stress begins to decline because of a combination of reduced inputs of stressors, resilience in the coupled natural-human system, and emergency and recovery responses. Long-term recovery ( $T_3$ ,  $T_4$ , to  $T_N$ ) involves some reorganization of the system rather than full return to preexisting states (12); future baseline stress is largely unknown. Natural variability is overlaid on general stress trends (13).

## Building the Scenarios

The SSWG rapid assessment involved establishing a matrix of alternative scenario param-

eters, using parameter subsets to develop a detailed “chain of consequences,” and assigning a level of uncertainty to each element in each chain. The SSWG developed four key parameters, based on expert opinion and data from ICS briefings: (i) estimated flow rate for DH oil release [5000; 12,000 to 19,000; 40,000; or 100,000 barrels (bbl)/day]; (ii) estimated time to containment of the oil release (40, 100, or 160 days); (iii) time horizons ( $T_1$  to  $T_4$ , and  $T_N$ ); and (iv) geographic and spatial units of interest (vertical life zones, major ecosystem types, sociopolitical and administrative units, and GOM biodiversity quadrants) (14–17). This approach allowed for adaptation to new information, such as revised flow-rate estimates or oil landfall data. Beginning with specific scenario parameters, group members examined variables in the coupled natural-human system model, developed chains of consequences, and integrated these into an overall scenario. Online literature searches and input from additional subject-matter experts were also used. The SSWG applied a scale of informal scientific certainty (18), well-suited to scenario-building, that allows for rapid refinement as new information becomes available. The SSWG established uncertainty levels for each cascading consequence. Where opinions diverged, the precautionary principle dictated assignment of the lower level of certainty.

### A Recovery Scenario

Scenario S3, constructed 27 May 2010, was requested by the DOI Mobile Incident Command. It employed estimates by the ICS Flow Rate Technical Group released that morning (other scenarios used higher flow estimates), and oil landfall patterns reported for the previous 48 hours. S3 examined time horizons for short-term and long-term recovery ( $T_2$  to  $T_4$ ), assumed 12,000 to 19,000 bbl/day oil release, and 100 days to containment. Geographic focus was the littoral zone in the northwest biodiversity quadrant of the GOM, including Louisiana and Texas. Several highlights emerged, for example: (i) Delayed mortality of wetland flora is probable and could impair fisheries recovery and resistance to hurricane damage, with cascading consequences from rerelease of sequestered oil; (ii) rerelease of sequestered oil triggered by storms and hurricanes is reasonably certain to lead to a resumption of stress in the coupled natural-human system; (iii) recovery by oysters may be slow and is likely to result in long-term displacement of some oyster harvesters; (iv) delayed stress on cultural communities, e.g., Isleños, Acadians, and United Houma [Indian] Nation, is reasonably certain; (v)

institutional adjustments related to regulation and reorganization of government systems are reasonably certain.

### Applications to the DH Oil Spill

The SSWG scenarios provide decision-makers with possible intervention points (e.g., when mid-water contamination reaches critical levels and/or tax revenues begin to decline). Decision-makers can focus attention on key interventions likely to reduce negative impacts (e.g., rerelease of sequestered oil) and/or increase resilience and positive recovery responses (e.g., improved monitoring or targeted income support). The scenarios reveal potential surprises that might be initially overlooked by decision-makers (e.g., fishing closures leading to rebound of previously stressed fish populations or the impact of re-introducing compromised birds into migratory bird populations). The scenarios can identify potential new monitoring needs (e.g., advanced monitoring technologies for mid-water pollution, new protocols for monitoring rerelease of sequestered oil, and/or long-term monitoring for occupational exposure or financial stress). Such advances can support ongoing inventory and monitoring programs, inform modeling efforts, help develop future NRDA protocols, and contribute to incident command training. Chains of consequences with their approximate levels of scientific uncertainty can help prioritize research and policy needs by identifying important, but not yet well understood, relations (e.g., the relation between landfall hurricanes, oiling of marshland, and ecosystem stress).

### A Strategic Sciences Approach

Science is only one of many inputs into policy during a complex event such as the DH oil spill. Beyond technical problem analyses (e.g., evaluating “kill” methods for shutting the DH well), the influence of a particular scientific assessment upon policy is partial, given the range of inputs, interests, and institutions involved.

Comparison of the DH spill with other regional disruptive events may be insightful. Three response phases following Hurricane Katrina were (i) emergency, (ii) restoration, and (iii) reconstruction (19). Although Hurricane Katrina and the DH oil spill differ in substantial ways (e.g., high loss of life and severe infrastructure damage), overlaying generalized response phases onto the scenario framework (see the figure) reveals a potential gap in capacity between emergency and recovery phases, which, for the DH oil spill, is likely a period of continued increase

in system stress. Elements of the restoration phase should be initiated concurrently with the standing down of the emergency, so as to more quickly and effectively achieve recovery of the coupled natural-human system. Timely development and implementation of restoration plans are essential. Further SSWG scenario-building focused on recovery is currently under way [another SSWG session is scheduled 20 to 24 September in New Orleans, with updates available at (20)] and includes additional subject matter experts, decision-support tools, and refined scenario techniques. We believe there is a valuable role for this strategic approach to science and policy interaction as the federal government learns from the DH oil spill, plans and implements GOM recovery, and prepares for future environmental crises.

### References and Notes

1. Department of the Interior, “Strategic Sciences Working Group Progress Report, 9 June 2010” (Department of the Interior, Washington, DC, 2010); [www.usgs.gov/deepwater\\_horizon/](http://www.usgs.gov/deepwater_horizon/).
2. H. Khan, *Thinking About the Unthinkable* (Horizon Press, New York, 1965).
3. T. J. Chermack, S. A. Lynham, W. E. A. Ruona, *Futures Res. Q.* **7**, 7 (2001).
4. G. D. Peterson, G. S. Cumming, S. R. Carpenter, *Conserv. Biol.* **17**, 358 (2003).
5. G. E. Machlis, J. E. Force, W. R. Burch Jr., *Soc. Nat. Resour.* **10**, 347 (1997).
6. J. E. Haas, R. W. Kates, M. J. Bowden, *Reconstruction Following Disaster* (MIT Press, Cambridge, MA, 1977).
7. R. W. Kates, C. E. Colten, S. Laska, S. P. Leatherman, *Proc. Natl. Acad. Sci. U.S.A.* **103**, 14653 (2006).
8. J. Tibbetts, *Environ. Health Perspect.* **112**, A282 (2004).
9. N. N. Rabalais, R. E. Turner, W. J. Wiseman Jr., *J. Environ. Qual.* **30**, 320 (2001).
10. D. Burley, P. Jenkins, S. Laska, T. Davis, *Organ. Environ.* **20**, 347 (2007).
11. S. A. Castillo, P. Moreno-Casasola, *J. Coast. Conserv.* **2**, 13 (1996).
12. C. S. Holling, *Annu. Rev. Ecol. Syst.* **4**, 1 (1973).
13. D. Wang, N. D. Weaver, M. Kesarwani, X. Dong, J. Rockstrom, *Science* **308**, 1036 (2005).
14. B. H. Robison, *Conserv. Biol.* **23**, 847 (2009).
15. J. J. Maguire, Fisheries topics: Ecosystems: Types of ecosystems [online] (Fisheries and Aquaculture Department, FAO, Rome, 2005); [www.fao.org/fishery/topic/3320/en](http://www.fao.org/fishery/topic/3320/en)
16. E. S. Sheppard, R. McMaster, *Scale and Geographic Inquiry: Nature, Society, and Method* (Blackwell, Malden, MA, 2004)
17. D. L. Felder, D. K. Camp, Eds., *Gulf of Mexico Origin, Waters, and Biota: Volume 1, Biodiversity* (Texas A&M Univ. Press, College Station, TX, 2009).
18. C. Weiss, *Law Probab. Risk* **2**, 25 (2003).
19. C. E. Colten, R. W. Kates, S. Laska, *Community Resilience: Lessons from New Orleans and Hurricane Katrina* (Community and Regional Resilience Institute, Oak Ridge, TN, 2008).
20. U.S. DOI, Deepwater Horizon Response, [www.doi.gov/deepwaterhorizon/index.cfm](http://www.doi.gov/deepwaterhorizon/index.cfm).
21. The authors thank members of the DOI SSWG: C. Colten, S. Dalton, J. Grace, J. Eitel, J. Hay, G. Plumb, E. Widder, and R. Woita. Additional assistance, advice, and review were provided by A. Castle, J. Cross, J. Jarvis, J. McKendry, S. Kimball, B. Werkheiser, colleagues of SSWG members, and anonymous reviewers.

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