DOI Strategic Sciences Working Group
Mississippi Canyon 252/Deepwater Horizon Oil Spill
Progress Report

9 June 2010

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Executive Summary

Introduction and Objectives

The Mississippi Canyon 252/Deepwater Horizon (MS252) oil spill has resulted in an extraordinary and complex scientific effort. The Department of the Interior (DOI) is a critical partner in the overall federal government's scientific response.

The DOI established a small Strategic Sciences Working Group. The Working Group has several tasks: 1) quickly gather relevant scientific information, 2) use this information and expert scientific opinion to develop alternative scenarios concerning the cascading consequences of the MS252 oil spill during the emergency response, mid-term, and long-term recovery period, 3) share the results with DOI leadership, and 4) test the usefulness of such strategic science working groups for other major environmental incidents.

The Working Group included federal and non-federal scientists from a wide range of disciplines (see Appendix 1 for a list of current group participants). The Working Group reports to Dr. Marcia McNutt, Director, US Geological Survey and is led by Dr. Gary Machlis, Science Advisor to the Director, National Park Service. The Working Group held its initial session 23-28 May 2010 in Mobile, Alabama.

Organizing Framework

The MS252 oil spill has potentially significant consequences for the ecological, economic, and social systems of the Gulf of Mexico (GOM). The Working Group developed a scenario framework adapted from the scientific literature on natural hazards response. The scenario framework describes the stress to be expected on the impacted region over several key time horizons.

Methods

The methodology used by the Working Group involved three main steps: 1) establish a set of alternative scenario parameters, 2) using a subset of the scenario parameters, develop a detailed "chain of consequences" that illustrate important cascading effects, and 3) for each element in the chain of consequences, assign a level of scientific uncertainty.

The Working Group developed four key scenario parameters: a) estimated flow rate for MS252 oil release, b) estimated time to containment of the oil release, c) time horizon, and d) geographic and spatial units of interest. For each scenario, the Working Group could select a specific combination of parameters, varying the flow rate, time to containment, time horizon, and spatial unit as appropriate.

The Working Group developed each scenario via sharing of expert opinion and in-depth discussion. Working Group members consulted the scientific literature and colleagues with specialized scientific knowledge. Scenarios were entered into a graphic software program for display.

Preliminary Results: Three Scenarios

In its initial session, the Working Group developed three alternative scenarios. Scenarios 1 and 2 were selected by the Working Group; Scenario 3 was requested by the DOI Mobile Incident Commander as a scenario particularly useful to DOI leadership in planning for long-term recovery.

Scenario 1

Scenario 1 examined the time period from oil flow containment to the beginning of recovery, during which it is expected that stress in the system would continue to build (though at a slower rate). The geographic focus for this scenario was the ocean zone of the northwest biodiversity quadrant of the Gulf of Mexico, which includes Louisiana and Texas. The results are shown on pages 13-17.

Scenario 2

Scenario 2 examined the time horizons for short-term and long-term recovery, when MS252 oil spill-related stress to the system is expected to be declining. The geographic focus for this scenario was the coastal zone of the northwest biodiversity quadrant of the Gulf of Mexico. The results are shown on pages 18-23.

Scenario 3

Scenario 3 examined the time horizons for short-term and long-term recovery, when MS252 oil spill-related stress to the system is expected to be declining. The scenario used the oil release estimates established by the DOI Flow Rate Technical Group, which were released while the Working Group session was underway. The geographic focus for this scenario was the littoral zone of the northwest biodiversity quadrant of the Gulf of Mexico. The results are shown on pages 24-29.

Lessons Learned

At the end of the 5-day initial session, members of the Working Group suggested a wide range of lessons learned. These lessons are relevant to both continued work related to the MS252 oil spill and future emergencies and events. They include the importance of: 1) diverse scientific disciplines and expertise, 2) skilled team leadership, 3) access to scientific information, 4) modest staff support, and 5) consistent communication with DOI Incident Commanders and DOI leadership.

Applications

At the end of the 5-day session, members of the Working Group suggested a wide range of possible applications for the Working Group scenarios. The use of a Strategic Sciences Working Group can:

1. Help identify critical decision points for DOI leadership and resource managers during late emergency and early recovery phases of an event.

2. Help identify and prioritize possible interventions by decision makers and resource managers to ameliorate negative impacts and foster positive recovery responses.

3. Help identify critical information needs and knowledge gaps for decision makers and resource managers.

4. Provide useful insight and information to decision makers conducting risk analyses associated with emergency incidents and events.

5. Inform decision makers and resource managers of “potential surprises” associated with cascading effects of emergency incidents and events.

6. Help identify future monitoring requirements, techniques, and technologies to inform Inventory and Monitoring programs, Natural Resource Damage Assessments (NRDA), Incident Command Teams, Operational Leadership preparation, and research programs.

7. Help prioritize immediate, mid-term, and long-term future research needs.

8. Provide the conceptual framework for development of quantitative predictive models of coupled natural-human system response to major disruptions.

Recommendations

The following recommendations are based on the experience of the first session of the Working Group:

1. The Unified Commands (National, Houston, Robert, Houma, Mobile, St. Petersburg, Miami) that have not yet been briefed on the Working Group’s results should be briefed as soon as possible.

2. DOI leadership should be briefed on the Working Group’s results as soon as possible.

3. The Working Group should be convened in a second session, to: a) refine the technique, b) further advance the existing scenarios based on additional input and new information, and c) complete additional scenarios focused on long-term recovery.

4. Additional scientists from relevant disciplines should be added to the Working Group, including scientists from agencies outside DOI.

5. Modest additional staff support should be provided to the Working Group, in order to make its work as efficient and timely as possible. A temporary 1 FTE detail from a DOI agency would be appropriate, and could be based in Washington DC and supervised by the Working Group lead scientist.

6. A proposal to establish a long-term capacity for strategic sciences should be developed and presented to DOI leadership.

Conclusion: A Strategic Sciences Approach to Major Environmental Incidents

In addition to the specific applications described above, the strategic sciences working group technique has utility for broad strategies to deal with the challenges of the MS252 oil spill. Based on the initial scenarios of the Working Group, there may be an important opportunity to initiate the restoration phase *concurrent* with the emergency phase, and by doing so, more quickly and effectively achieve recovery of the coupled natural-human system of the region. This is a policy decision and will reflect the broad range of policy inputs that include science, legal requirements, and long-term public interest.

There may be a unique and valuable role for strategic science approaches and techniques, as the DOI learns from the MS252 oil spill and prepares for future major environmental incidents.

For More Information

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Introduction

The Mississippi Canyon 252/Deepwater Horizon (MS252) oil spill has resulted in an extraordinary and complex engineering and scientific effort. Multiple agencies and disciplines are involved in applying science to understanding the spill, developing responses, and planning for recovery. Department of the Interior (DOI) bureaus require significant scientific input to the immediate, midterm, and long-term management of DOI natural and cultural resources affected by the spill. The DOI is also a critical partner in the overall federal government's response.

In events like the MS252 oil spill, the capacity of government, industry, and the scientific community to collaboratively and proactively prepare for and manage complex contingencies is essential. Effective response can be assisted by interdisciplinary systems-level efforts to develop science-based scenarios that identify potential cascading consequences. In addition, such efforts can: 1) assist managers and DOI leadership in making emergency response decisions, 2) help guide short and long-term monitoring strategies, 3) help prioritize mid- and long-term research needs, and 4) assist the DOI and its partners in long-term recovery efforts.

Objectives and Tasks

On 19 May 2010 the Department of the Interior established a small Strategic Sciences Working Group, with the objective of rapidly providing DOI leadership with science-based analyses of how the MS252 oil spill may impact the ecology, economy, and people of the Gulf of Mexico. The Working Group was not to conduct a scientific investigation, but rather to provide a rapid scientific assessment of potential consequences of the spill that could provide usable knowledge to decision makers.

The Working Group convened to accomplish several tasks: 1) quickly gather relevant scientific information, 2) use this information and expert scientific opinion to develop alternative scenarios concerning the cascading consequences of the MS252 oil spill during the emergency response, mid-term, and long-term recovery/restoration period, 3) share the results of this work with DOI leadership, and 4) test the usefulness of such strategic science working groups for other major environmental events.

The Working Group met 23-28 May 2010 in Mobile, Alabama. This progress report describes: 1) the organizing framework, 2) the methods used, 3) several developed scenarios, 4) potential applications, 5) lessons learned during the Working Group's activities, and 6) recommendations for possible next steps.

Structure of the DOI Strategic Sciences Working Group

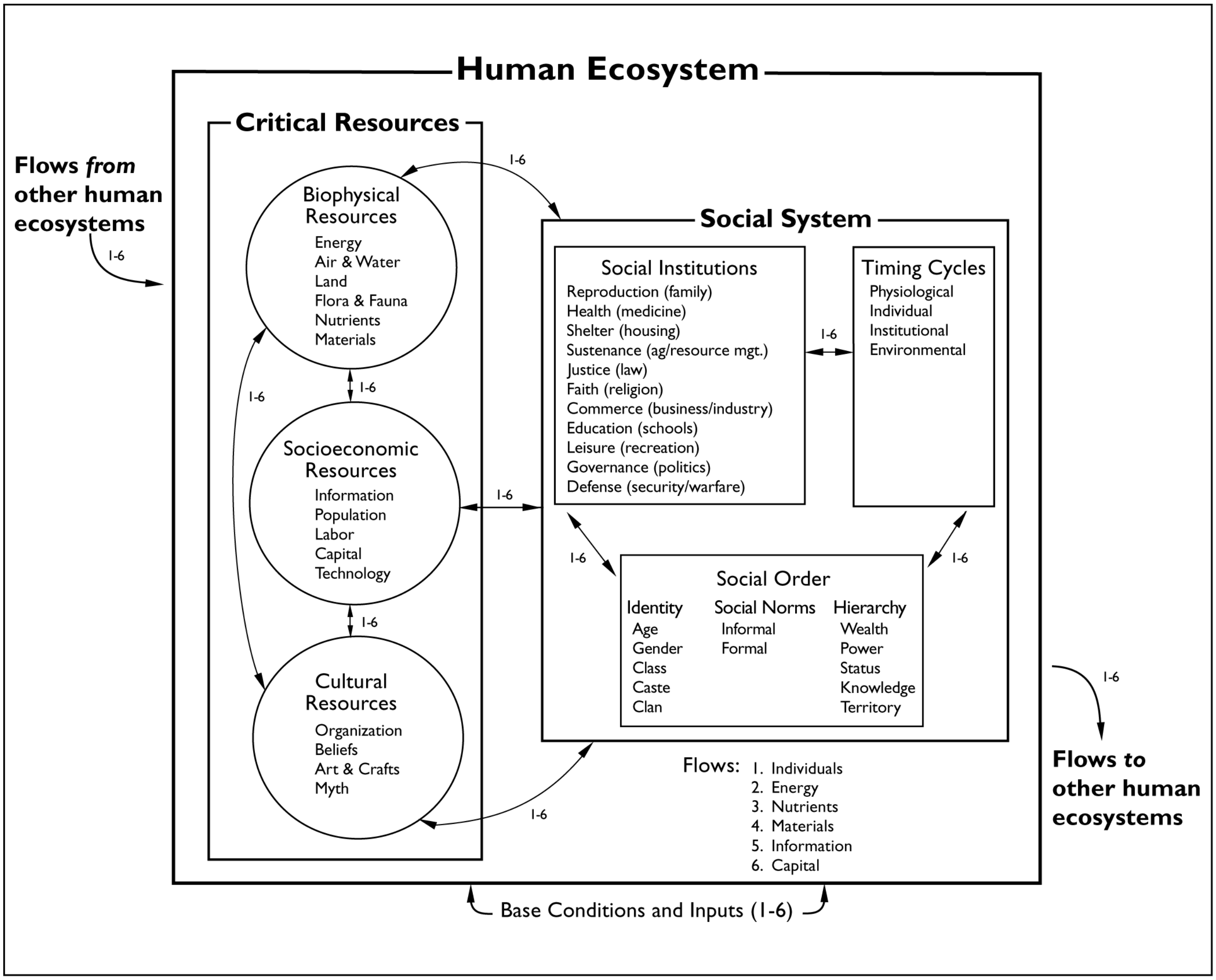
The Working Group is an informal group of federal and non-federal scientists (see Appendix 1 for a list of current group participants). Scientists from a wide range of relevant disciplines are included, as well as a mix of federal, academic, and non-governmental organizations. The Working Group reports to Dr. Marcia McNutt, Director, US Geological Survey, and is led by Dr. Gary Machlis, Science Advisor to the Director, National Park Service.

The Working Group is independent of the Incident Command System (ICS), and the Natural Resource Damage Assessment (NRDA). Members of the Working Group participate as individuals and provided independent expert opinion. Participants have declared no conflict of interest or appearance of conflict of interest.

Organizing Framework

The MS252 oil spill has potentially significant consequences for the ecological, economic, and social systems of the Gulf of Mexico (GOM). The Working Group treated the region of potential impact as a *coupled natural-human system* (Liu et al. 2007, Gunderson and Holling 2002), and approached the task of scenario building from this interdisciplinary view. Hence, scenarios were not limited to separate biological, economic, and/or social consequences, but also included how these consequences interact in shaping the possible trajectories of the overall system.

Many alternative conceptual models of coupled natural-human systems are available. One is the human ecosystem model (Machlis et al, 1997; 2005). The model is reasonably detailed, includes both biophysical and socioeconomic variables, is explicit regarding flows, and has an emerging record of application (Machlis et al, in press). The model has been applied to a variety of complex environmental challenges, including United Nations “state of the environment reporting,” National Science Foundation Long Term Ecological Research (LTER) projects, Asian mega-city response to natural hazards, and environmental consequences of warfare. Figure 1 shows the general human ecosystem model. It includes a set of critical resources, social institutions, timing cycles, and social order, as well as key flows between subsystems.



The Structure of Human Ecosystems, V.05.2, Machlis et al (2005)

Figure 1. Human Ecosystem Model

The model was introduced to the Working Group. The Working Group expanded the list of biophysical variables to cover biophysical conditions specific to the MS252 oil spill. This list (which includes several overlapping categories) is shown in Table 1. The Working Group used the conceptual model as an informal checklist of possible relationships to ensure that key elements of the coupled natural-human system were considered for inclusion in the scenarios.

Table 1. Selected Additions to the Human Ecosystem Model, Biophysical Resources

Flora/Fauna	Energy	Land
plankton	wind	wetlands
nekton (all kinds)	solar	uplands
megafauna	tidal	beaches
picoplankton	electricity/natural gas	barrier islands
birds	current	
fish	wave energy	
submerged aquatic vegetation		
marine mammals	**Water**	**Materials**
turtles	fresh water	wood
coral	salt water	soil
terrestrial wildlife	surface	rock
terrestrial animals	salinity	metal
domesticated animals	temperature	calcium carbonate
insects	depth	plastic
forests	turbidity	
mangroves		
grass beds		

In addition to a coupled natural-human system conceptual model, the Working Group developed a scenario framework adapted from the scientific literature on natural hazards response (see for example, Haas et al. 1977, Kates et al 2006). The scenario framework includes a general trend line of coupled natural-human system stress over time divided into several key time horizons. The framework is shown in Figure 2.

Within this scenario framework, baseline (pre-event) stress in the GOM was identified as increasing prior to the MS252 oil spill. This reflects numerous identified trends: nutrient loading, expansion of the seasonal hypoxic area (“dead zone”), wetland loss and land subsidence, invasive floral and faunal species, climate change, increased fishing pressures, continuing effects of major hurricane damage in previous years, national and regional economic recession, and other factors (Tibbets 2004, Rabalais et al 2001, Burley et al 2007, Castillo and Moreno-Asasola 1996).

At the time of the MS252 spill (T_0, identified in Figure 2 as the “DWH event”), system stress began to rapidly accumulate, initiating a period of significant system disruption. At some point in the time horizon (T_1), the oil flow is contained. After containment (defined as substantially complete reduction of uncontrolled oil release), system stress continues to rise due to a series of lagged effects (such as landfall of previously released oil and/or chronic toxicity to sensitive ecosystem components). At some time in the future (T_2), system stress begins to decline (the “deflection point”) due to a combination of reduced inputs of stressors, natural and social resilience in the coupled natural-human system, active emergency and recovery responses by national, state, and local entities, and other factors.

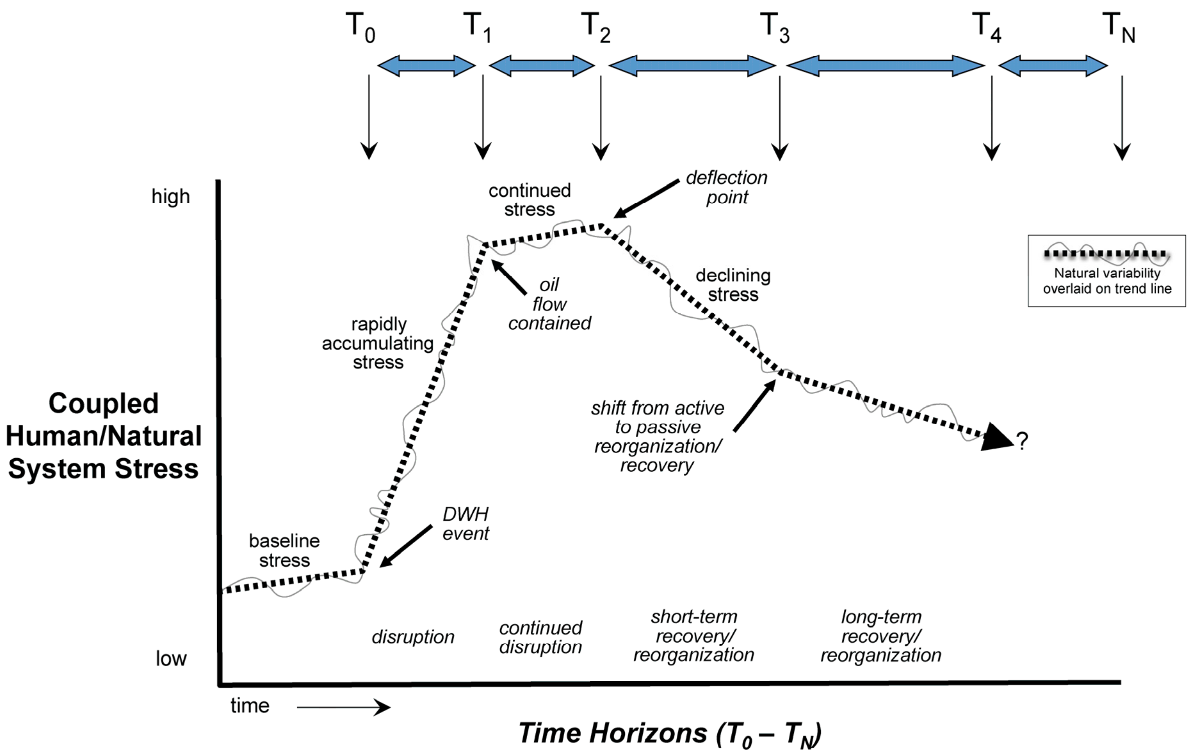


Figure 2. Scenario Conceptual Framework

Further along the time horizon (T_3) the stress trend further deflects, as short-term recovery/reorganization (with its active responses) gives way to long-term recovery and passive response, such as water quality improvements or economic re-development without substantial government or industry intervention. T_4 and T_N represent longer-term time horizons needed for long-term recovery. These time horizons are not necessarily linear, and may vary significantly in duration (measured in days, months, or years).

In this scenario framework it is assumed that recovery often involves some reorganization of the system rather than a full return to the pre-existing state (Holling 1973). Baseline stress in these future horizons is largely unknown at present. Figure 2 illustrates that natural variability is overlaid upon general stress trends, and that care should be taken to distinguish between responses to the MS252 event and natural variability or “noise” in system responses (Adger et al 2005).

Methods

There are numerous alternative approaches to constructing science-based scenarios (for a review, see Chernack et al 2001); scenario planning has been widely used in the oil industry (see for example Schoemaker et al 1992). During major incidents and natural hazard events (where response time is critical and many key factors are unknown), scenario planning offers several advantages, particularly its capacity to rapidly, systematically, and creatively examine possible futures that are complex and uncertain. Peterson et al note:

"…Scenarios are alternative, dynamic stories that capture key ingredients of our uncertainty about the future of a study system. Scenarios are constructed to provide insight into the drivers of change, reveal the implications of current trajectories, and illuminate options for action (Peterson et al 2003:360)."

The approach taken by the Working Group involved three main steps: 1) establish a matrix of alternative scenario parameters, 2) using a specific subset of the scenario parameters, develop a detailed "chain of consequences" that illustrate important cascading effects, and 3) for each element in the chain of consequences, assign a level of scientific uncertainty. In this use, "chain of consequences" refers to a set of cascading causal relationships, and does not imply that all possible relationships have been identified. The steps for building the scenarios are described below.

1. Establish a matrix of alternative scenario parameters.

The Working Group developed four key scenario parameters: a) estimated flow rate for MS252 oil release, b) estimated time to containment of the oil release, c) time horizon, and d) geographic and spatial units of interest.

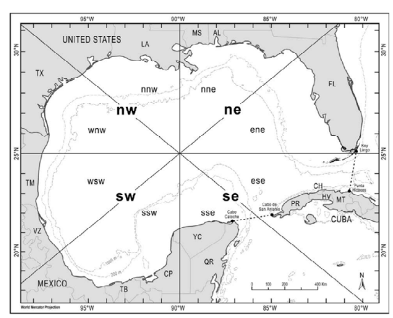
Four alternative flow rates were established. The first three were: a) 5,000 bbl/day, which was the initial flow rate established by NOAA and adopted by British Petroleum, b) 40,000 bbl/day, which was the mid-range estimate proposed by Professor Ian MacDonald based on video analyses, and c) 100,000 bbl/day, which was the high range estimate proposed by MacDonald. On 27 May 2010, the DOI Flow Rate Technical Group established a more refined estimate of oil release of 12,000-19,000 bbl/day, and this range was immediately added by the Working Group as a fourth alternative flow rate.

As the Working Group began its scenario building, the MS252 oil spill had not been contained. Hence, estimated time to containment was a necessary scenario parameter. Three alternative time frames were established. These were: a) 40 days to containment, an approximate estimate for mechanical containment via modifications to the riser, b) 100 days to containment, an approximate estimate to containment via a relief well, and c) 160 days to containment, an approximate estimate of the end of the two highest months of hurricane activity in the GOM.

The Working Group established distinct time horizons (T_1-T_4, T_N) to help focus the scenarios on specific time periods during the emergency response, short-term, and long-term recovery. The time horizons are shown in Figure 2, and could be applied to a specific scenario's construction in varying combinations (i.e. T_0-T_2, or T_2-T_4).

The Working Group established several geographic and/or spatial units to help focus the alternative scenarios and provide useful information to decision makers. These units included: a) vertical life zones (adapted from Robison 2009), b) major ecosystem types (adapted from Maguire 2005), c) socio-political and administrative units from local village to parish, county, and state (adapted from Sheppard et al 2004), and d) Gulf of Mexico Biodiversity Quadrants (Felder and Camp 2009). Table 2 identifies the specific units of analysis and illustrates the Biodiversity Quadrants.

Table 2. Geographic/Spatial Units for Scenario Parameters

Vertical Life Zones (Robison 2009)	**Administrative Boundaries** (Sheppard et al. 2004)
above surface/terrestrial surface epipelagic mesopelagic epibenthic benthic underlying geology	village parish/county state national international
Ecosystem Types (Maguire 2005)	**Biodiversity Quadrants, Gulf of Mexico** (Felder et al 2009)
open ocean shelf littoral estuaries coastal inland/terrestrial	northwest northeast southwest southeast 

The combination of these alternative scenario parameters created a matrix shown in Table 3. For a particular scenario, the Working Group could select a specific combination of parameters, varying the flow rate, time to containment, time horizon, and spatial unit as appropriate. This approach also allowed for continued adaptation to new information, as was the case when more accurate flow rate estimates became available or when oil landfall patterns shifted.

Table 3. Matrix of Alternative Scenario Parameters

Flow Rate (bbl/day)	Days to Containment (days)	Time Horizon ($T_0 – T_N$)	Geographic/Spatial Units
5,000	40	T_1	vertical life zones
12,000-19,000	100	T_2	ecosystem types
40,000	160	T_3	administrative boundaries
100,000		T_4	biodiversity quadrants

2. Using a specific subset of the alternative scenario parameters, develop detailed "chain of consequences" scenarios that illustrate important cascading effects of the MS252 oil spill upon the coupled natural-human system.

The Working Group established a common method of scenario building. First, scenario parameters were selected from the matrix shown in Table 3. Next, an initial condition resulting from the selected scenario parameters was established, such as "x amount of oil in the midwater life zones in the NE biodiversity quadrant." From the initial condition, the group developed a set of cascading consequences via sharing of expert opinion and in-depth discussion. Lead Scientist Machlis facilitated the work. Working Group members consulted the scientific literature via the internet and colleagues via phone as the cascading consequences were being developed. These cascades were informally drawn on whiteboards and simultaneously entered into a graphic program called SmartDraw (Hemera Technologies, Inc. San Diego, CA). SmartDraw enabled the Working Group to quickly modify and expand upon existing cascades.

The Working Group first developed a trial scenario to evaluate both the usefulness of the alternative parameters and the process to be followed in developing the chain of consequences scenarios. The Working Group then selected several scenarios to develop using the method described above. Given that the matrix of parameters could result in a large number of possible scenarios (too many to construct given time constraints), Working Group members selected two scenarios (S1 and S2) that reflected very different time horizons and spatial units, in order to help evaluate the scenario methodology. The third scenario (S3) was requested by the DOI Mobile Incident Commander (Jon Jarvis) as a scenario useful to DOI leadership in planning for long-term recovery.

3. For each element in a chain of consequences scenario, assign a level of scientific uncertainty.

A key element of the Working Group's task was to assign preliminary levels of scientific uncertainty to each of the cascading consequences. These reflect both the state of knowledge for complex and significant disruptions in coupled natural-human systems (which can vary from substantial scientific certainty to unstudied and unknown relationships), the state of knowledge for the specific system (GOM) and its system functions and processes, as well as the need to provide decision makers with a practical method of assessing levels of uncertainty for policy and decision making.

Following Weiss (2003) several alternative scales were considered: a) legal standards of proof, b) informal scientific levels of certainty, c) Bayesian probabilities, and d) the climate-change specific scale adopted by the Intergovernmental Panel on Climate Change (IPCC). The Working Group adapted the Weiss scale of informal scientific uncertainty, as it is well-suited to scenario building and allows for systematic refinement as new information becomes available (a key characteristic of the MS252 event). In the Working Group adaptation, several of the Weiss scale categories were aggregated for ease of use. Table 4 illustrates Weiss' original scale and the Working Group's adaptation.

Table 4. Levels of Scientific Uncertainty Scale

DOI Strategic Sciences Working Group Categories	Weiss's (2003) Informal Scientific Categories
5 – certain	certain
4 – reasonably certain	very probable + reasonably certain
3 – probable	likely + probable
2 – plausible	possible + probable (more info needed for firm conclusions)
1 – unlikely	unlikely (supported, but not entirely ruled out)
0 – not possible	not possible (violates established laws)
nk – not known	insufficient information to ascribe level of certainty

Following the development of a specific scenario, the Working Group established uncertainty levels (0-5, and not known) for each cascading consequence within the scenario. Individual Working Group members with appropriate expertise provided expert opinion bolstered by review of the available literature and contacts with additional subject matter experts. Lead scientist Machlis established the preliminary level of certainty based on these individual opinions, and in cases where opinions disagreed, applied the precautionary principle and selected the lower level of certainty. As new information was developed or became available, uncertainty levels were revised as appropriate.

In addition to the concept of uncertainty, each element in a chain of consequences scenario would be associated with a level of significance. Significance was informally defined by the Working Group as having the potential to cause substantive, measurable, and lasting impacts on the chain of consequences in the scenario. No element was included in the analysis unless it met this minimum standard, with the rationale being that with limited time, the Working Group should focus on significant relationships. No formal hierarchy was developed for significance (as was done for uncertainty), although intuitively some elements were thought to be more highly significant than others.

Preliminary Results: Three Scenarios

During its initial session (23-29 May 2010) the Working Group developed three alternative scenarios. The scenarios should be considered preliminary results. Not all possible relationships were identified in each scenario.

Each scenario has three key elements: 1) the scenario parameters, 2) the cascading effects on the coupled human-natural system, displayed as a chain of consequences, and 3) for each cascading consequence, an assigned scientific uncertainty level.

Scenario 1

Scenario 1 examined the time period from oil flow containment to the beginning of recovery, during which it is expected that stress in the system would continue to build (though at a slower rate) because of lagged effects in the system (particularly migration of oil slicks to coastal areas and concentration of oil at shorelines). The scenario parameters assumed 40,000 bbl/day oil release and 100 days to containment (note that this scenario was developed prior to the release of the Flow Rate Technical Group's refined estimate). The geographic focus for this scenario was the northwest biodiversity quadrant of the Gulf of Mexico, which includes Louisiana and Texas. The scenario is shown in Figure 3.

Cascades of consequences were based on the 100-day containment of oil and no additional releases of oil, natural gas, or dispersants. At this point in time (T_2 in Figure 2), substantially lowered water quality in the geographic area of focus (Biodiversity Quadrant NW) was considered to be certain. Several direct consequences that might follow from lowered water quality were identified: 1) reduced habitat quality, 2) ongoing emergency response efforts, 3) reduced recreational visitation to affected areas, 4) widespread distribution of oil (and dispersant) in the midwater regions of the ocean, 5) large areas of the GOM with oil surface slicks, 6) oil deposition on marine reefs (which are biodiversity hot spots), and 7) patchy but widespread oiling of the coastline in that geographic area.

Several illustrative highlights emerge from this scenario:

- Of the seven direct consequences, scientific certainty levels were high (levels 4 or 5) for six of them, with oiling of the reefs deemed probable (level 3).
- Stress and mortality on migratory bird species as a cascading consequence of reduced habitat quality is of potentially high significance, but had a low level of scientific certainty (level 2).
- Emergency response efforts have potential consequences created by clean up actions as well as increases in occupational exposure associated with those efforts.
- Midwater plumes of oil mixed with dispersants have potential effects on bacterial blooms and hence oxygen depletion, but had a low level of scientific certainty (level 2).
- Both surface slicks and oiling of coastline were seen as potentially major forms of impacts with many cascading consequences.

- Closure of fisheries are likely to have substantial consequences for the coupled human-natural system, and may include increased seafood imports, increased illegal fishing, and consequent human consumption of contaminated fish.

Scenario 2

Scenario 2 examined the time horizons for short-term and long-term recovery (T_2-T_4), when MS252 oil spill-related stress to the coupled human-natural system is expected to be declining. The scenario parameters assumed 40,000 bbl/day oil release and 100 days to containment (note that this scenario was developed prior to the release of the Flow Rate Technical Group's refined estimate). The geographic focus for this scenario was the coastal zone of the northwest biodiversity quadrant of the Gulf of Mexico, which includes Louisiana and Texas. The scenario is shown in Figure 4.

Several illustrative highlights emerge from this scenario:

- Consequences of human efforts to aid recovery of the system include improved beach conditions (reasonably certain, level 4); improved wetland conditions were evaluated as unlikely (level 1).
- It is probable (level 3) that continued cleanup efforts will lead to elevated long-term occupational exposure, and plausible (level 2) that there might be increased long-term health problems resulting from that exposure.
- Increased natural resource restoration activities during the short-term and long-term recovery periods provide opportunities for increased volunteerism and new educational opportunities.
- Repeated re-release of sequestered oil triggered by storms and hurricanes are a cascading consequence of considerable significance, and evaluated as reasonably certain (level 4), as are decreased recreational fishing and hunting.
- Major socioeconomic and cultural responses (such as decreased recreational and commercial fishing), were identified, along with their cascading consequences (from migration to lowered tax revenue and social services). The Working Group did not have time in the initial session to estimate degrees of uncertainty for this category of consequences.

Scenario 3

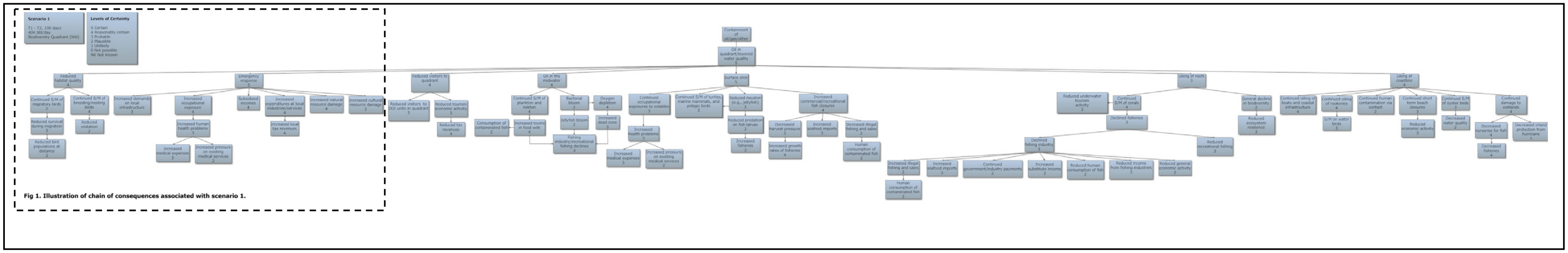
Parameters for the third scenario developed during the initial Working Group session were suggested by the DOI Mobile Incident Commander (Jon Jarvis). Scenario 3 examined the time horizons for short-term and long-term recovery (T_2-T_4), when MS252 oil spill-related stress to the coupled human-natural system is expected to be declining. The scenario parameters assumed 12,000-19,000 bbl/day oil release and 100 days to containment. The geographic focus for this scenario was the northwest biodiversity quadrant of the Gulf of Mexico, which includes Louisiana and Texas. In addition the scenario focused on the littoral zone, defined broadly as spanning from the land-water interface to the edge of the continental shelf. The scenario is shown in Figure 5.

Several illustrative highlights emerge from this scenario:

- Sustained ecosystem responses during recovery can be expected to include general increased survival of biota.
- Delayed mortality of flora, particularly in the wetlands, is a probable consequence, and if extensive, could impair both fisheries recovery and resistance to hurricane damage, with cascading consequences on the re-release of sequestered oil.
- Re-release of sequestered oil triggered by storms and hurricanes is reasonably certain (level 4) to lead to a resumption of stress (though of different severity) in the coupled human-natural system.

Anticipated recovery by oysters may be slow, and may result in long-term displacement of some oyster harvesters.

- Delayed stress on cultural communities (including Isleanos, Acadians, and Houma Indians) is reasonably certain (level 4).
- Institutional adjustments, particularly related to regulation as well as reorganization of government systems, are reasonably certain (level 4).



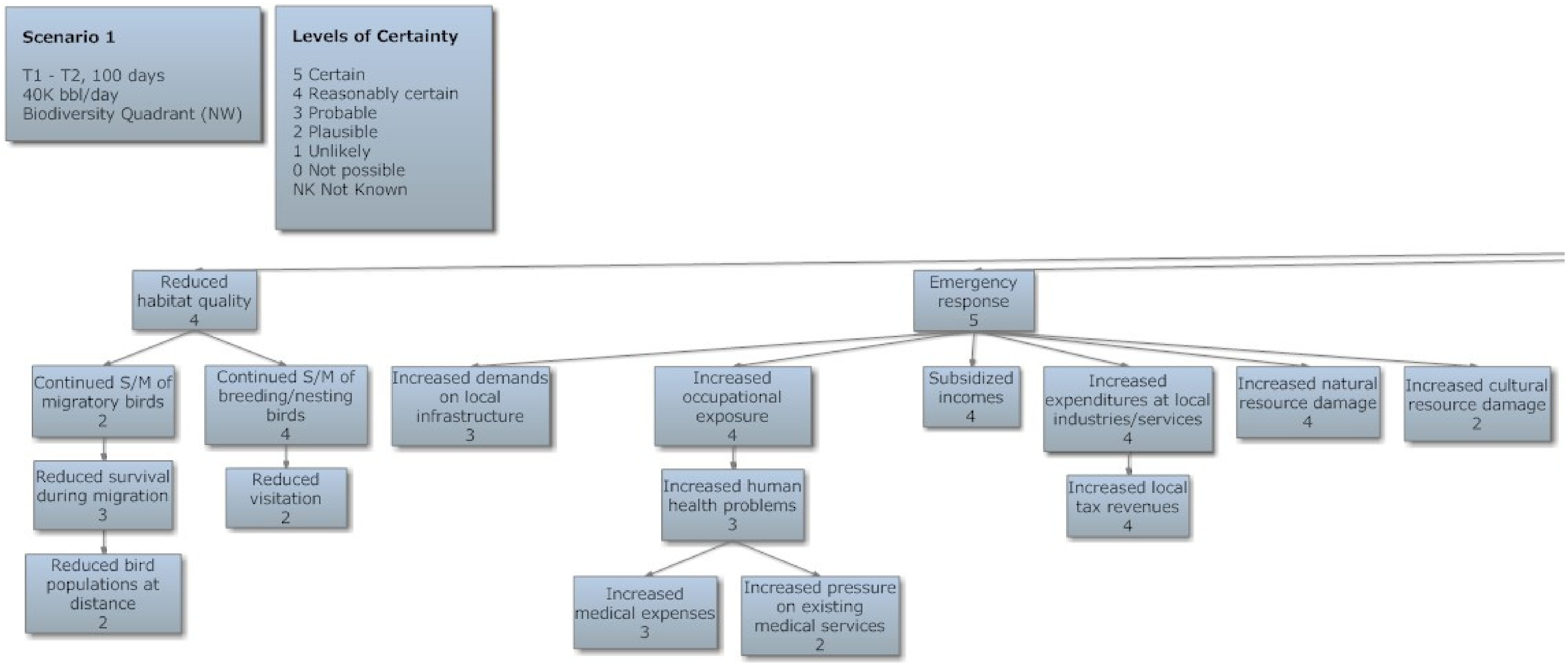


Figure 3. Illustration of chain of consequences associated with scenario 1.

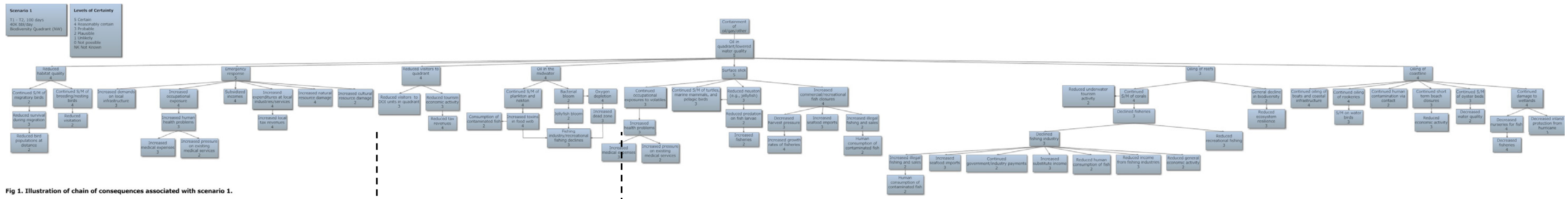
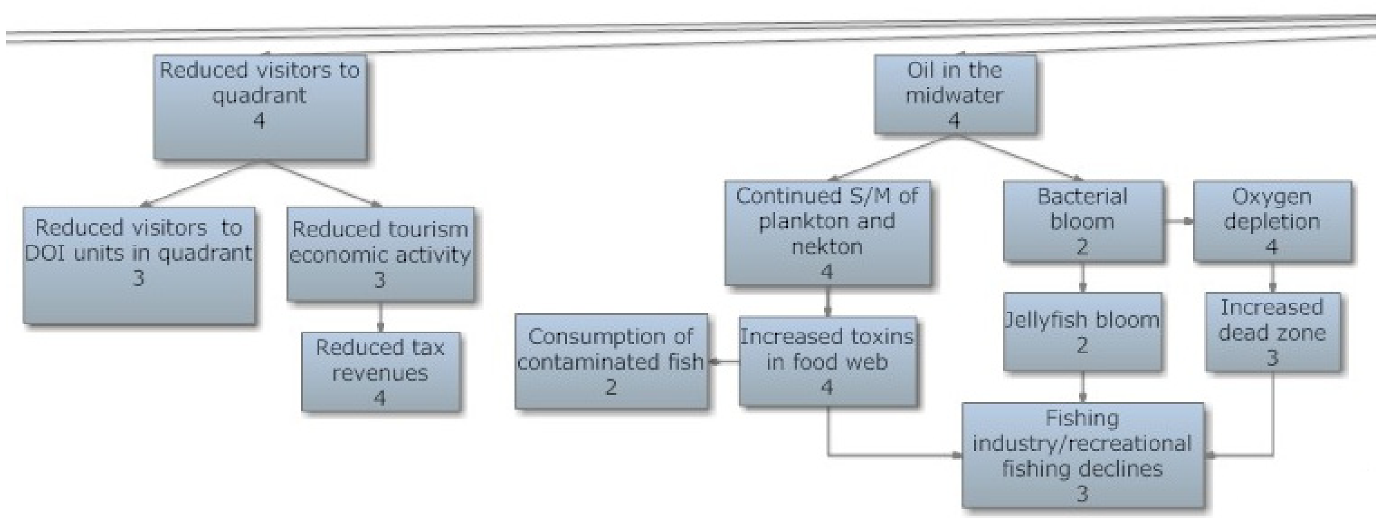
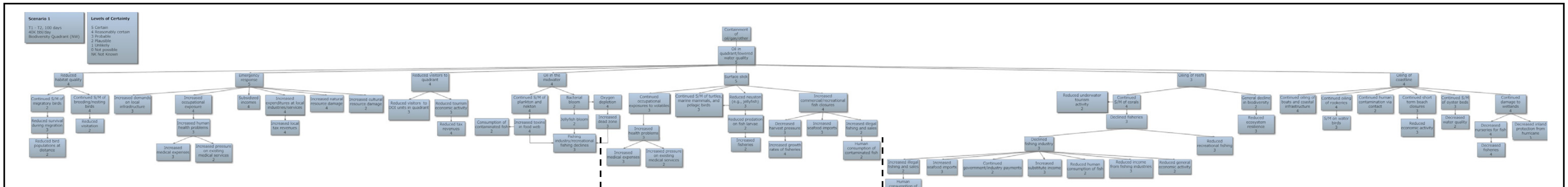


Fig 1. Illustration of chain of consequences associated with scenario 1.





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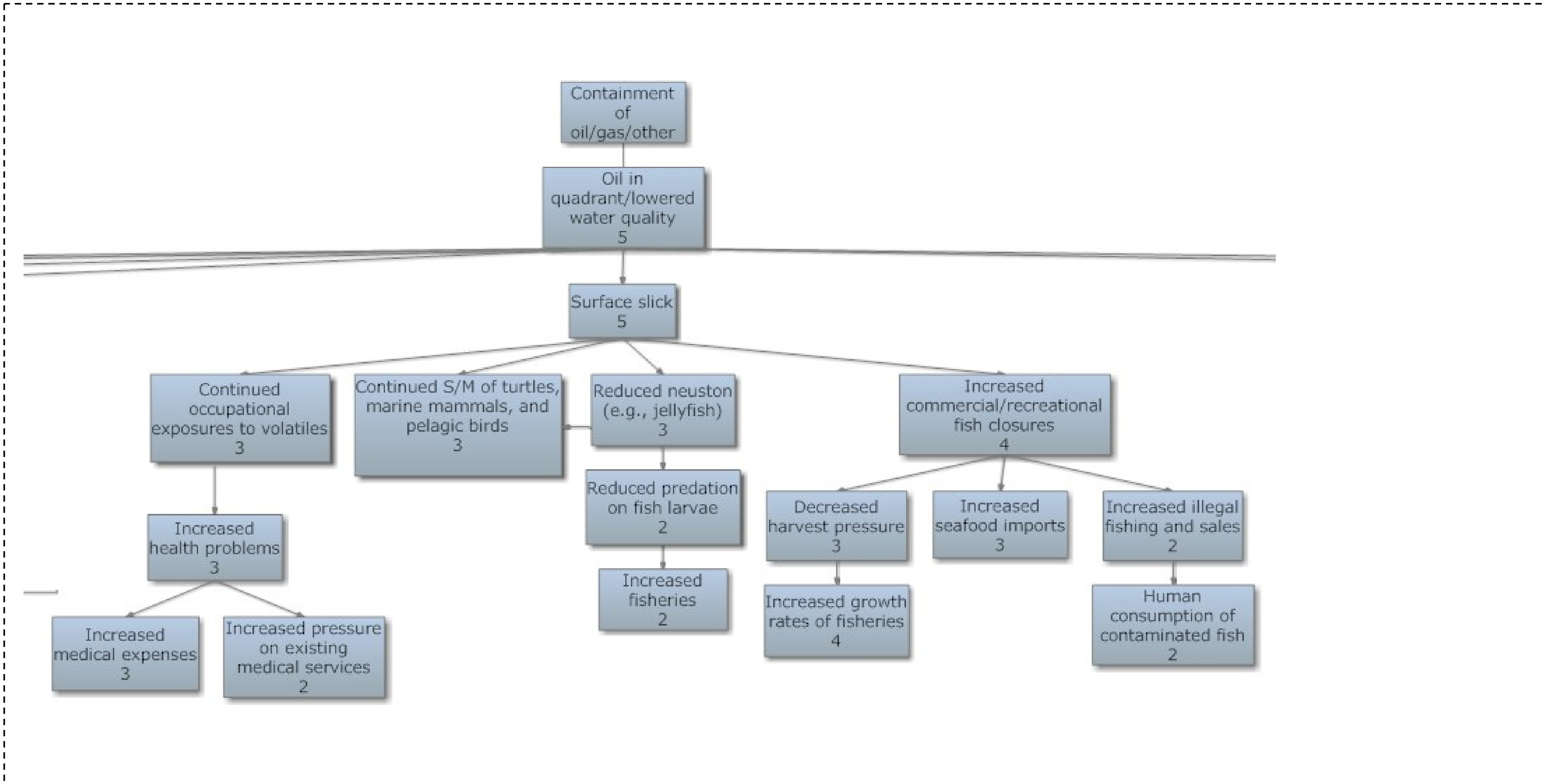


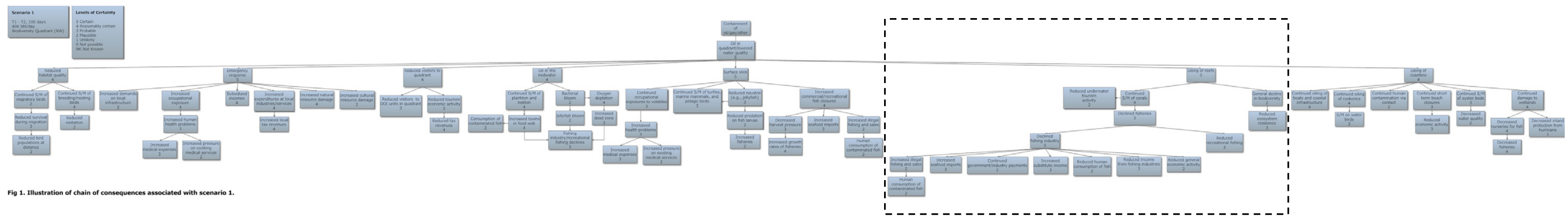
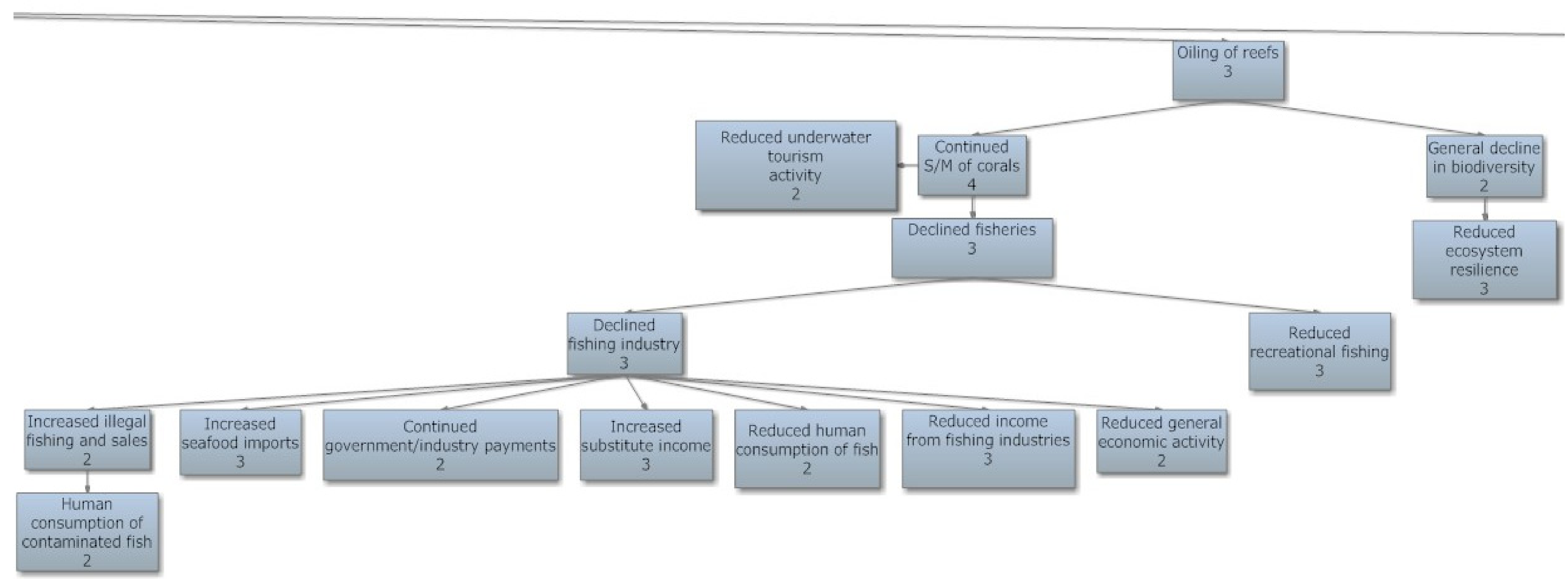
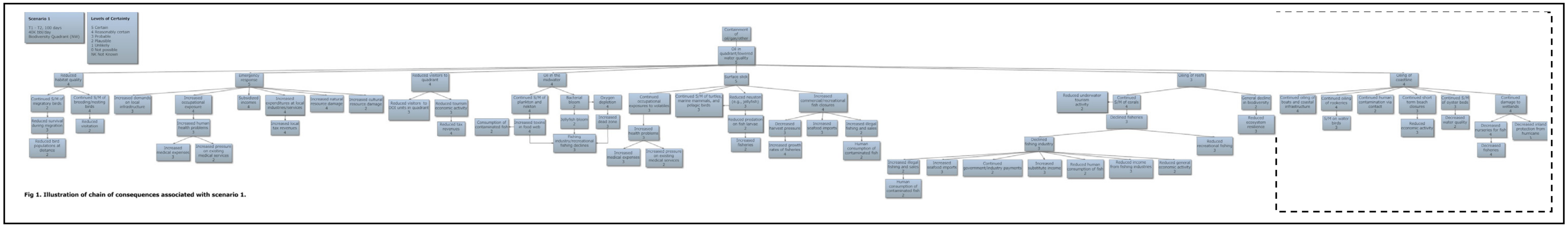


Fig 1. Illustration of chain of consequences associated with scenario 1.

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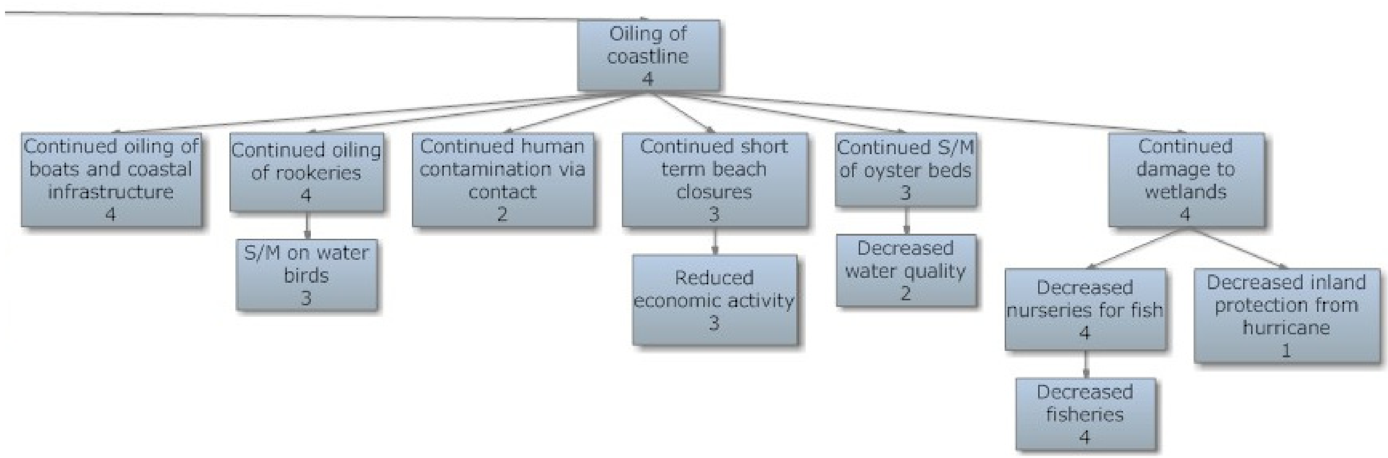

Oiling of coastline 4
Continued oiling of boats and coastal infrastructure 4
Continued oiling of rookeries 4
S/M on water birds 3
Continued human contamination via contact 2
Continued short term beach closures 3
Reduced economic activity 3
Continued S/M of oyster beds 3
Decreased water quality 2
Continued damage to wetlands 4
Decreased nurseries for fish 4
Decreased fisheries 4
Decreased inland protection from hurricane 1

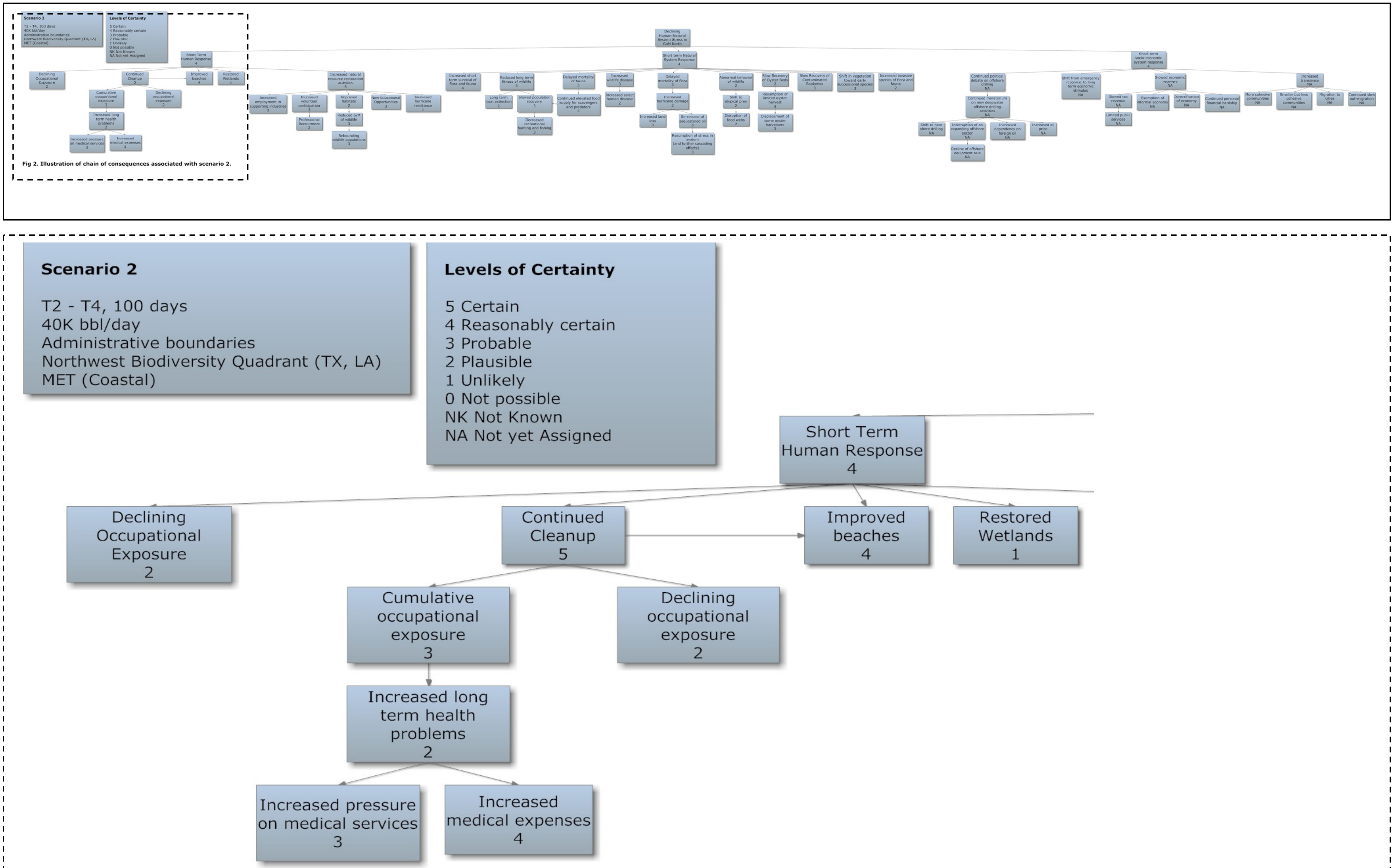


Figure 4. Illustration of chain of consequences associated with scenario 2.

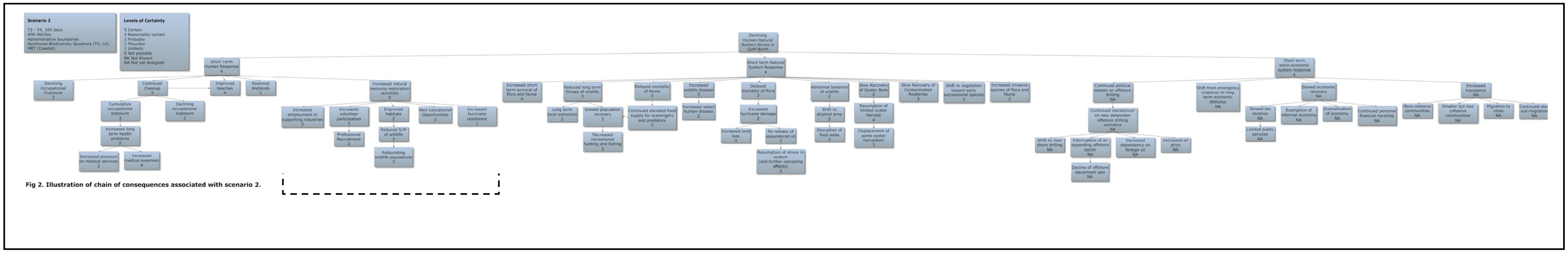
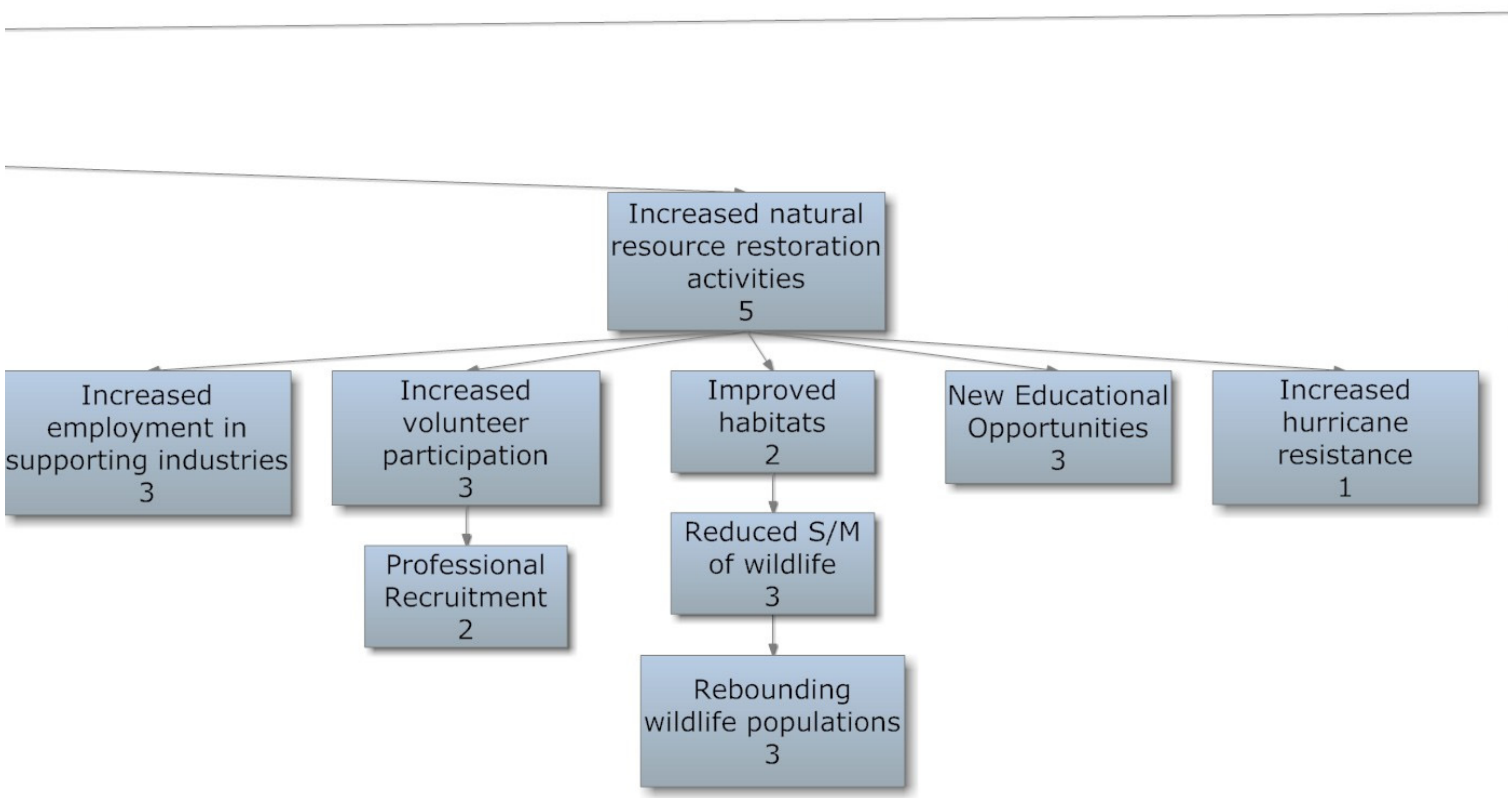
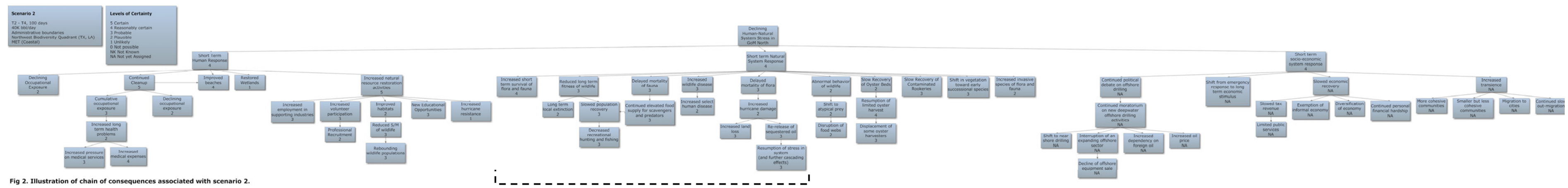


Fig 2. Illustration of chain of consequences associated with scenario 2.





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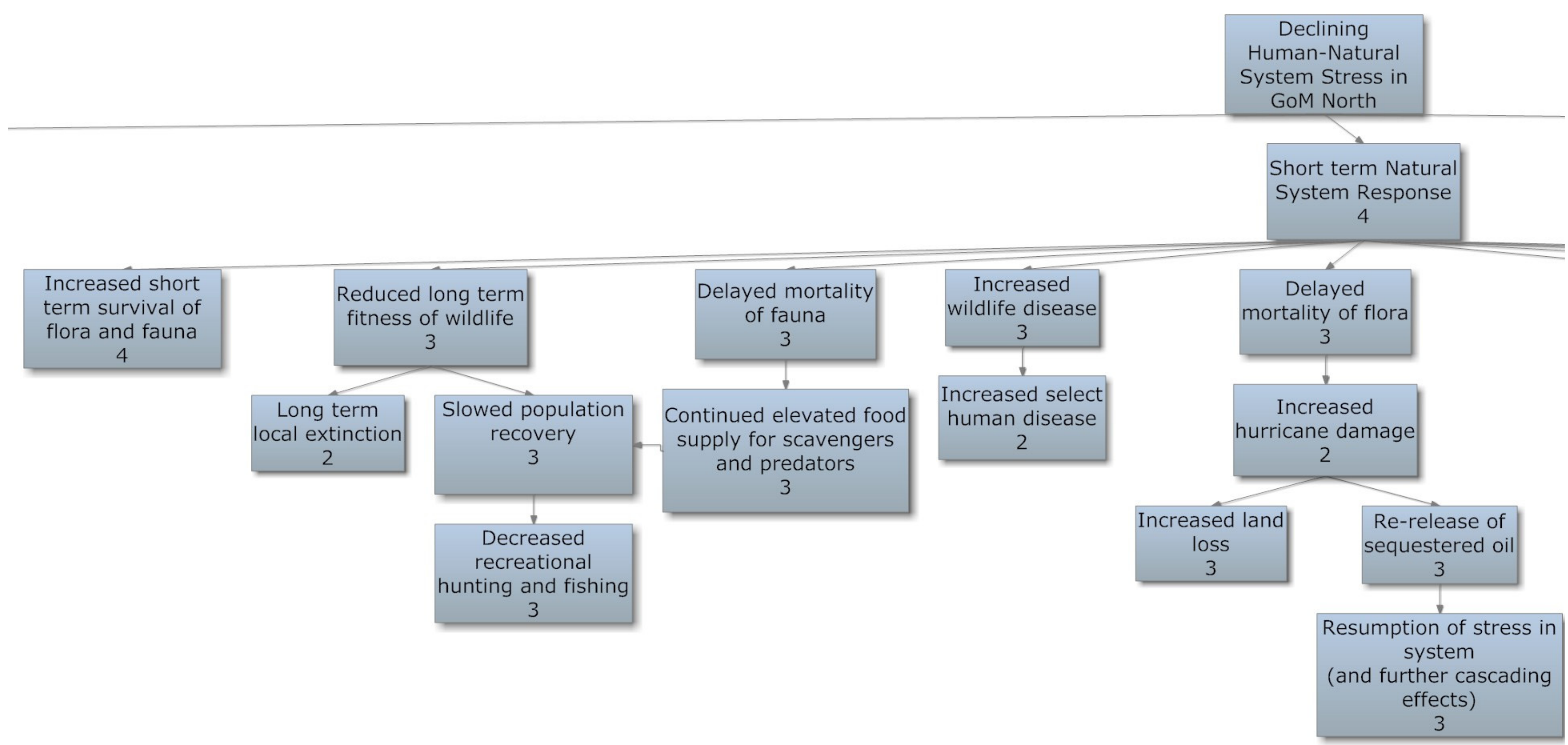

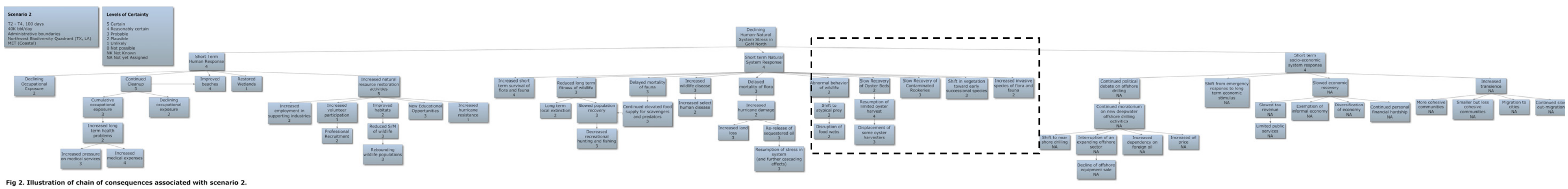

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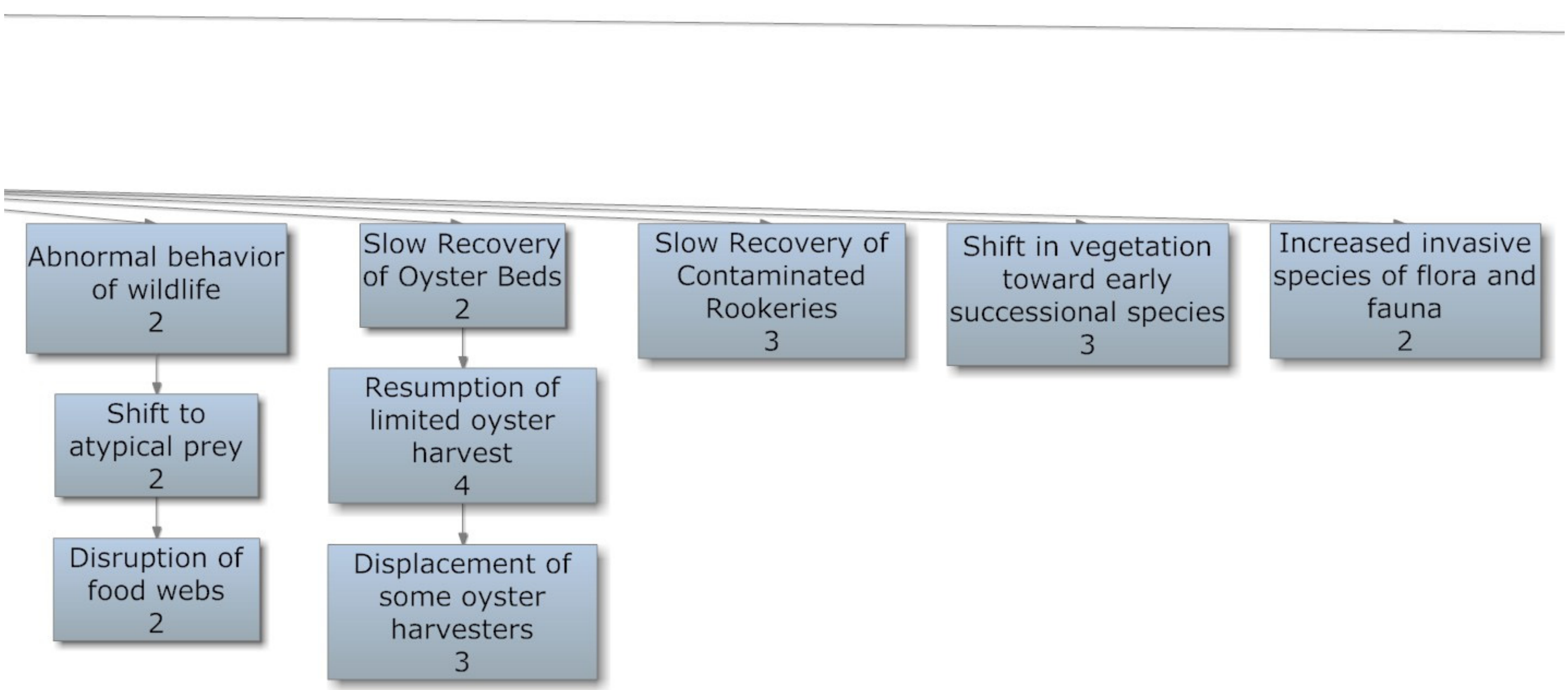

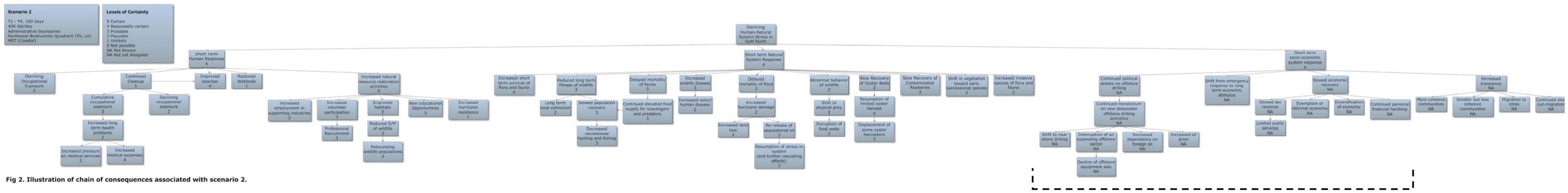

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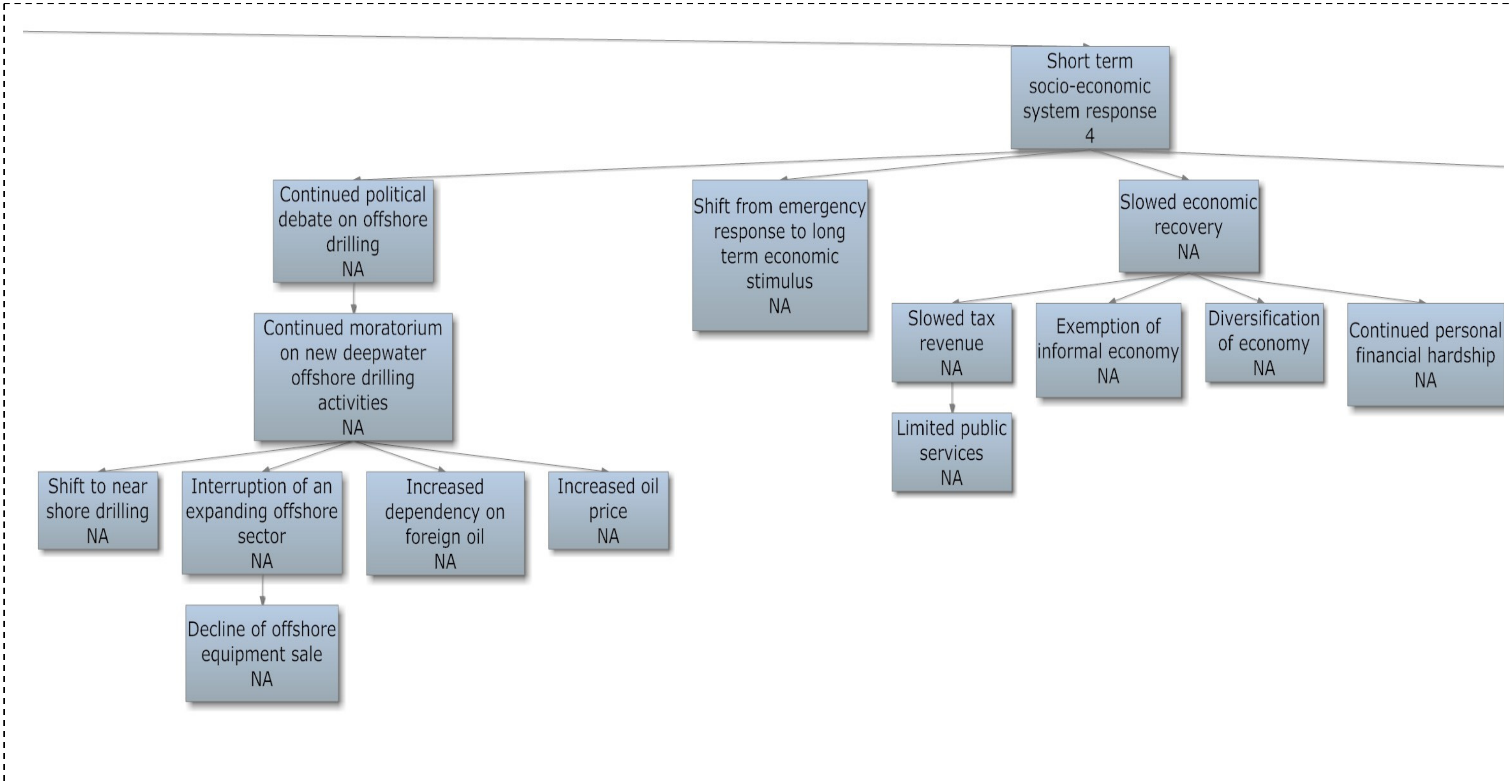

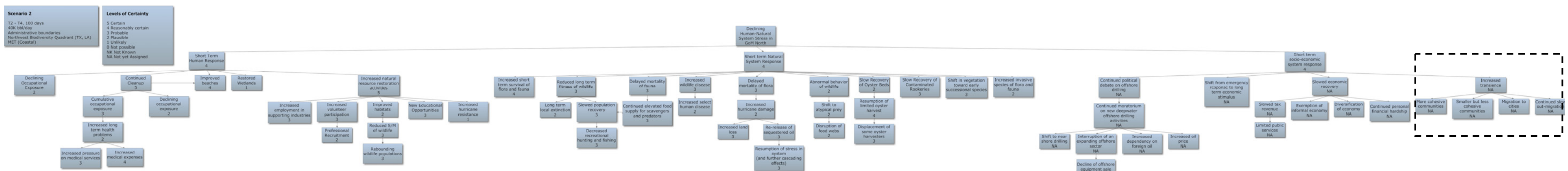

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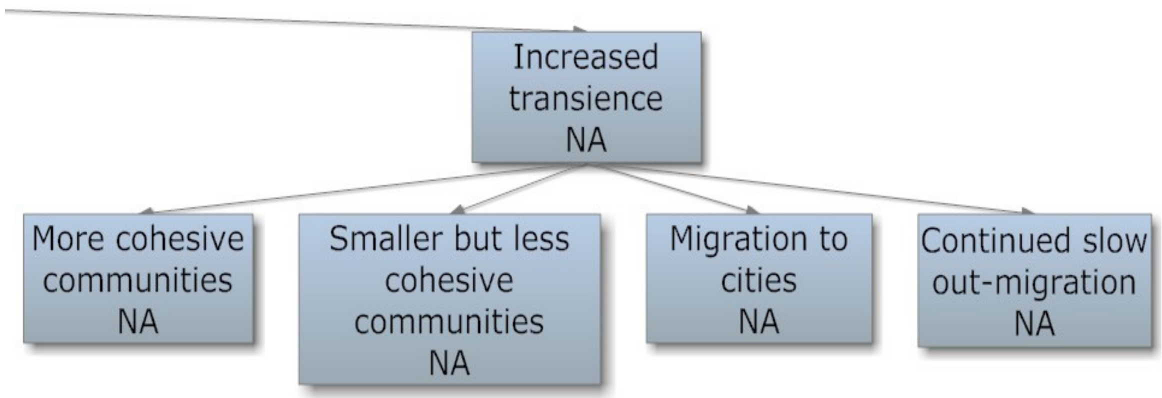
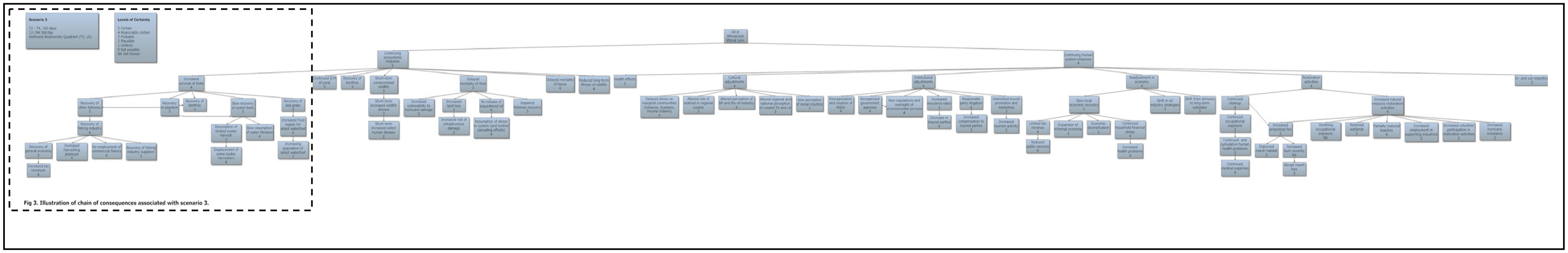




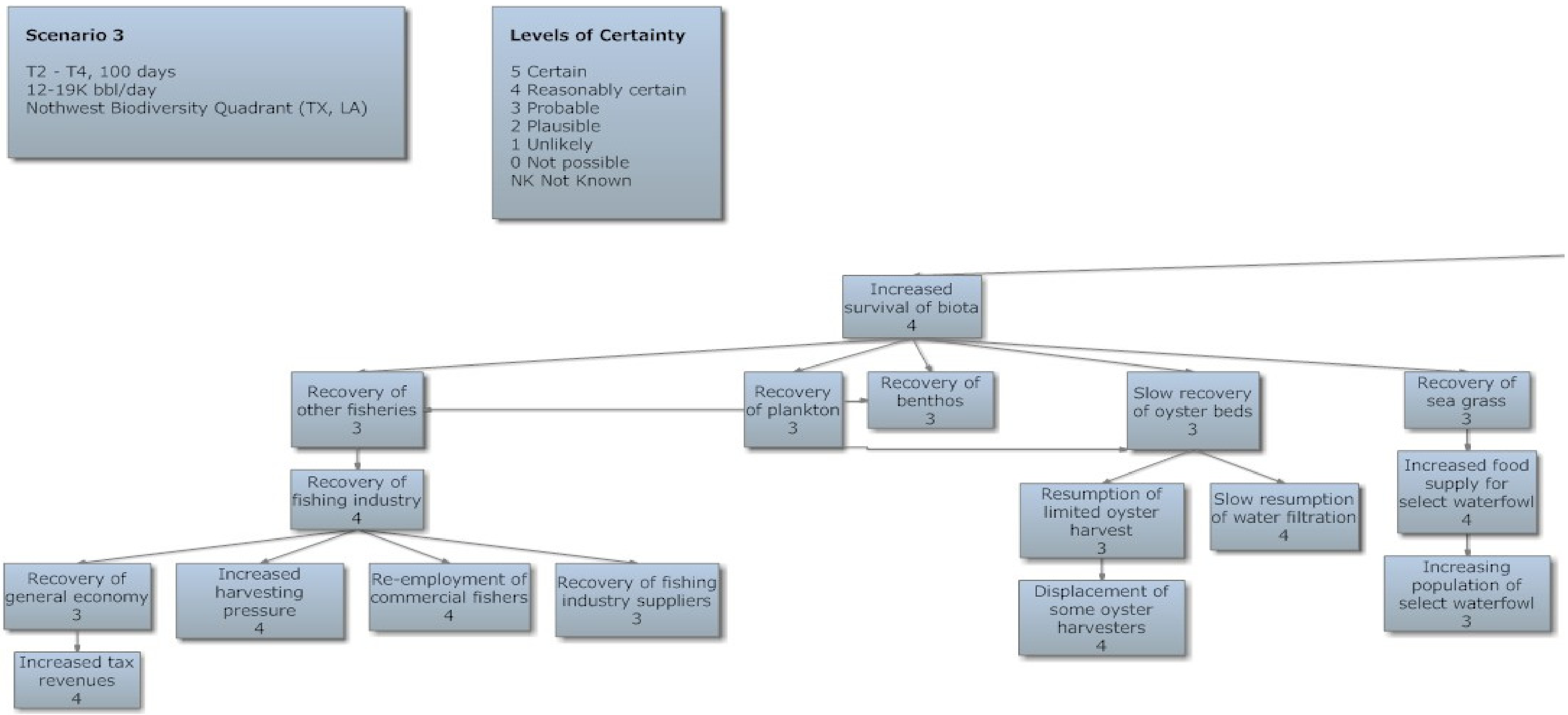


Figure 5. Illustration of chain of consequences associated with scenario 3.

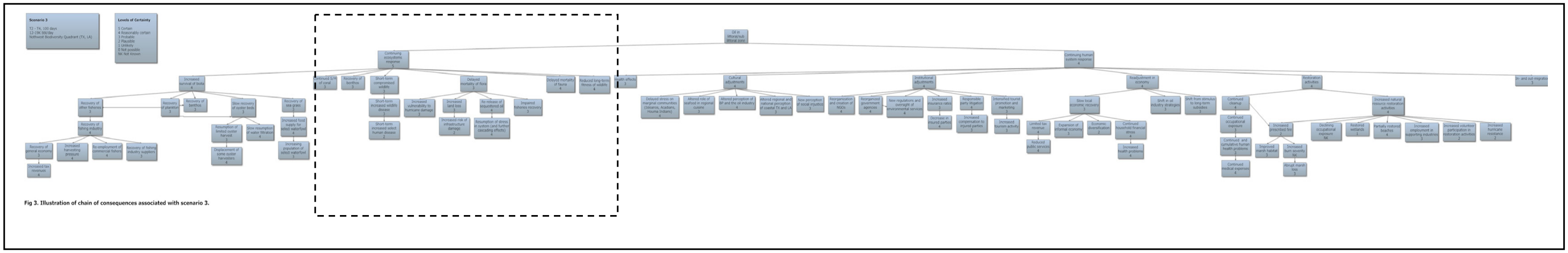
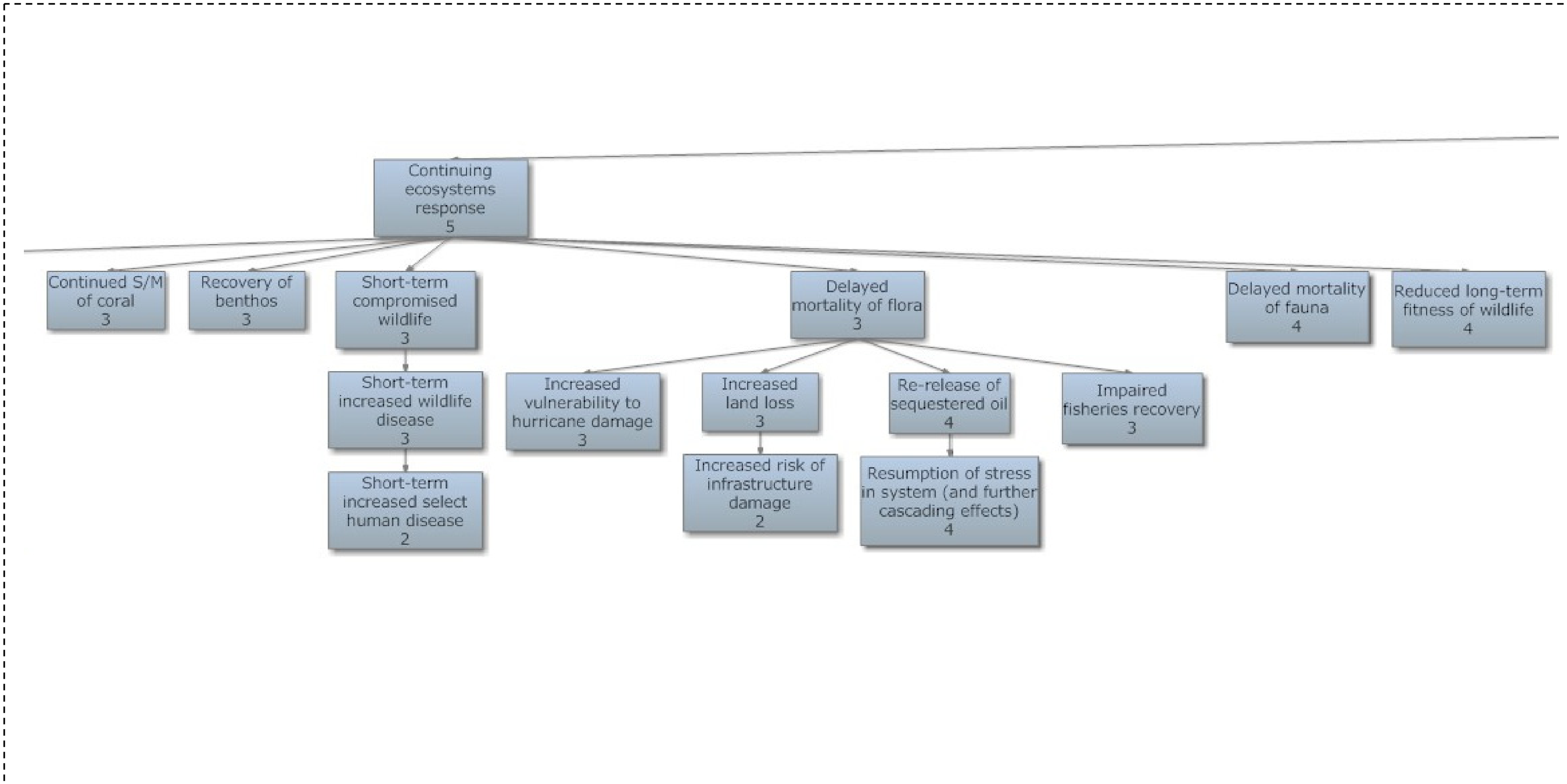


Fig 3. Illustration of chain of consequences associated with scenario 3.



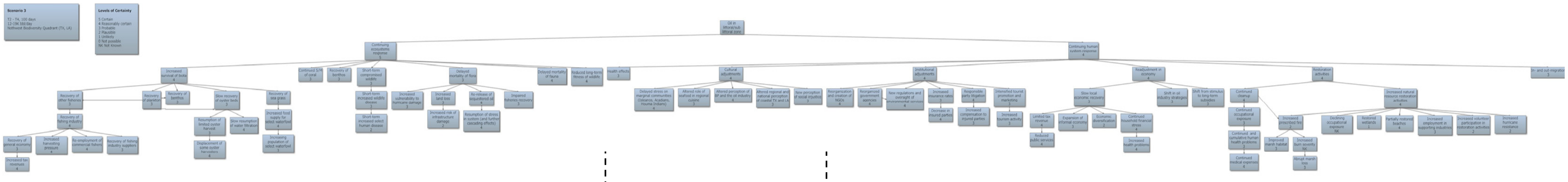
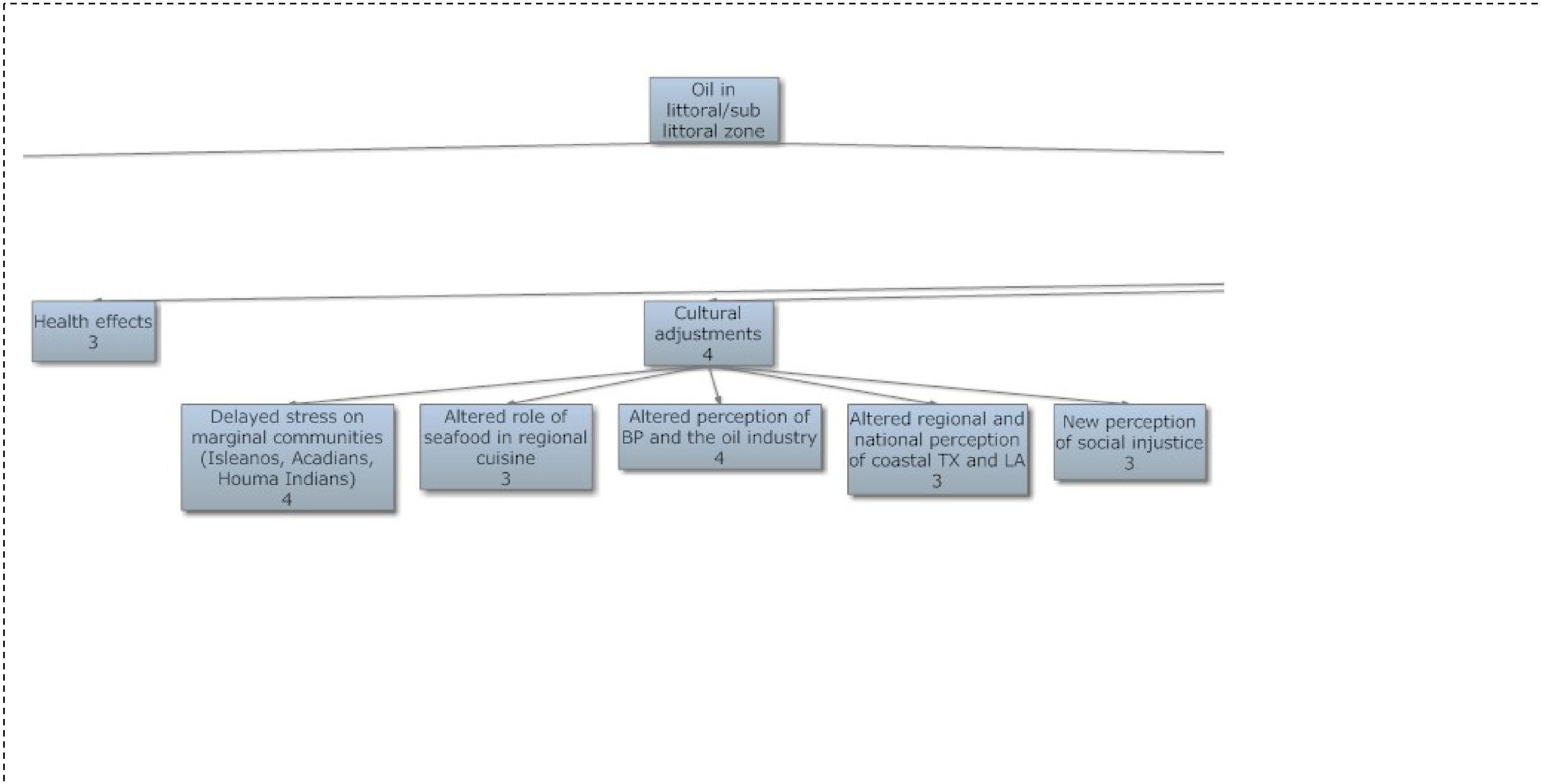


Fig 3. Illustration of chain of consequences associated with scenario 3.



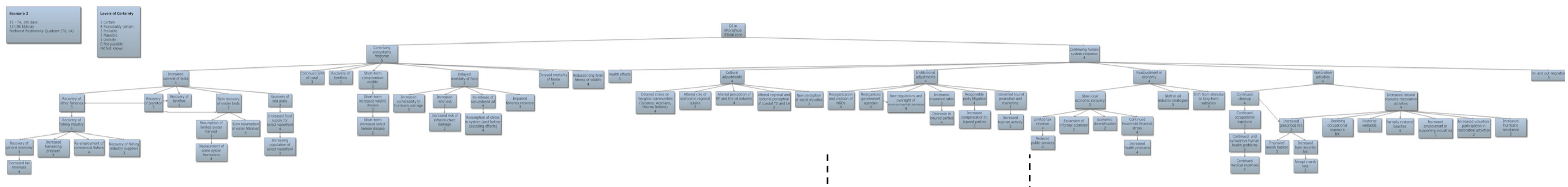
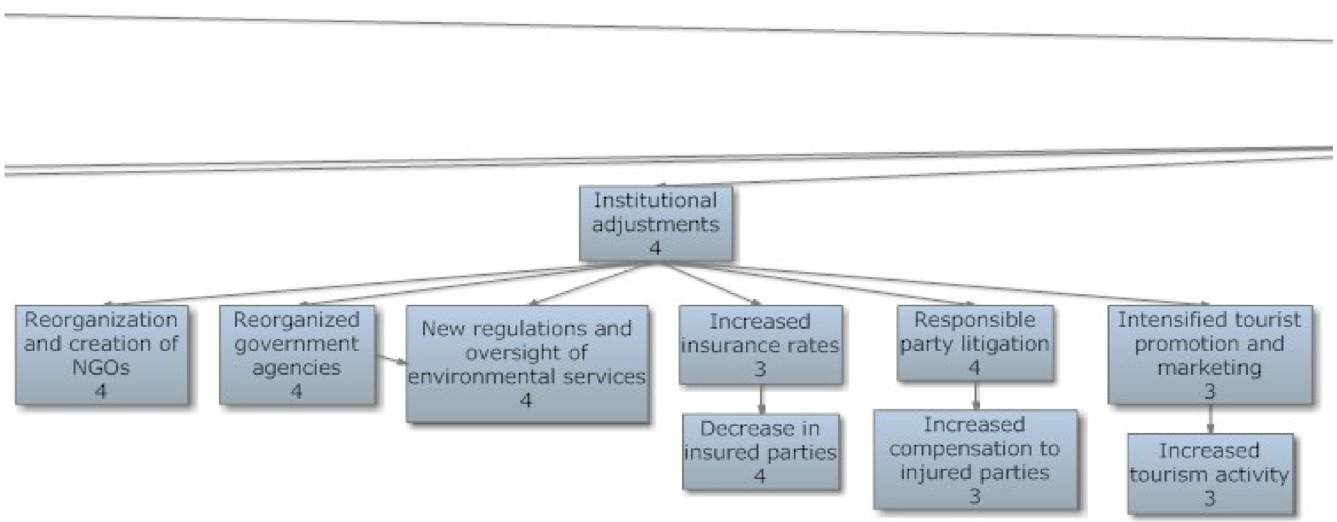


Fig 3. Illustration of chain of consequences associated with scenario 3.



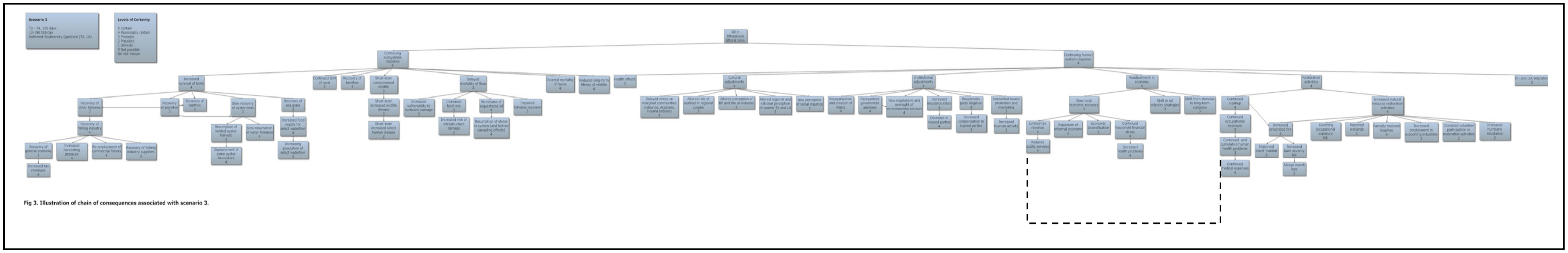
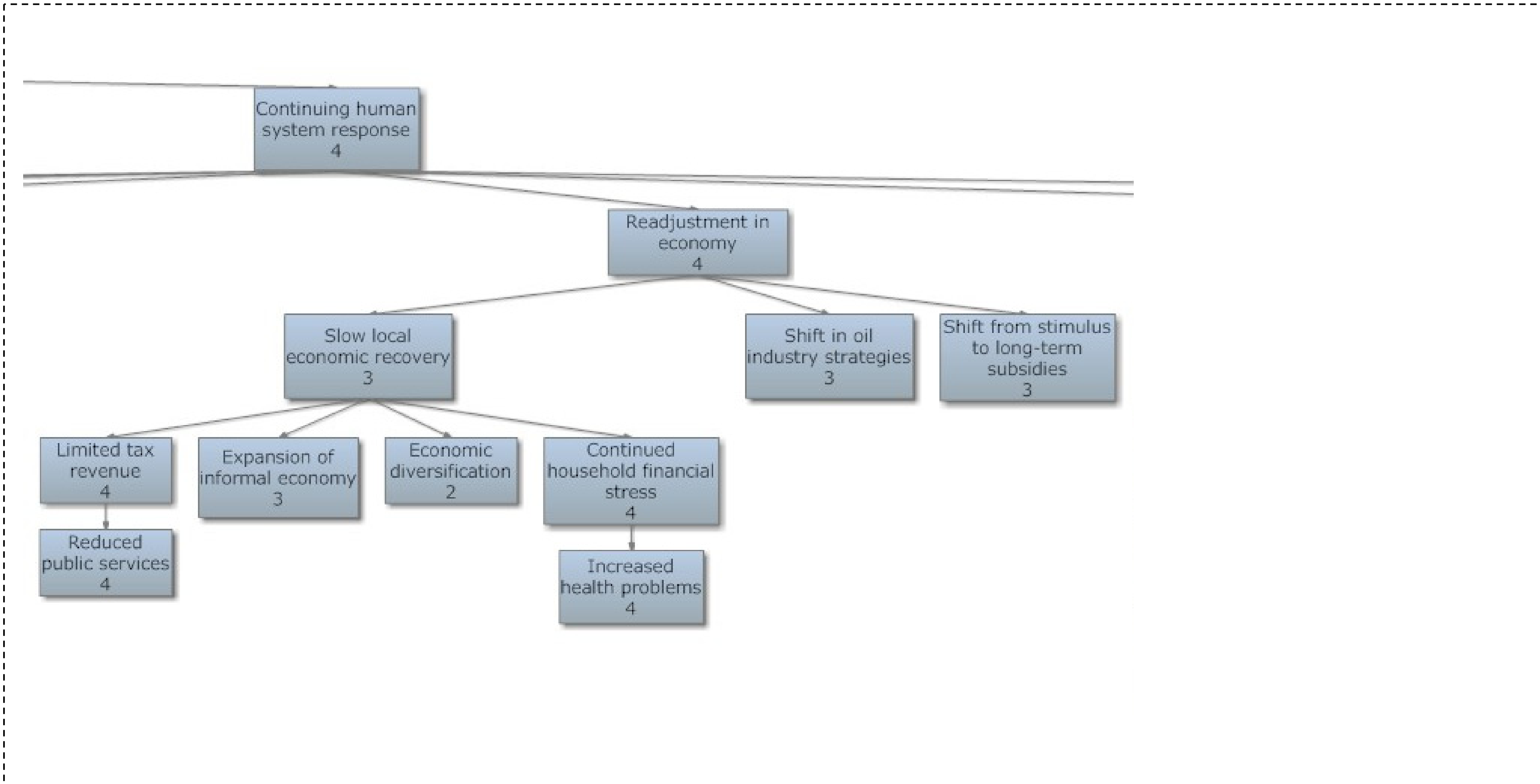
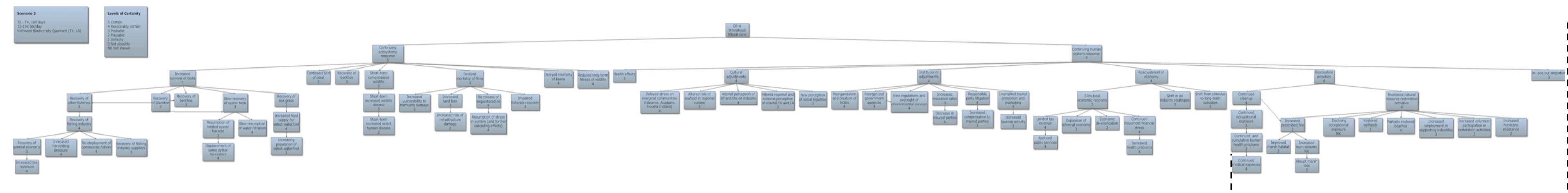


Fig 3. Illustration of chain of consequences associated with scenario 3.





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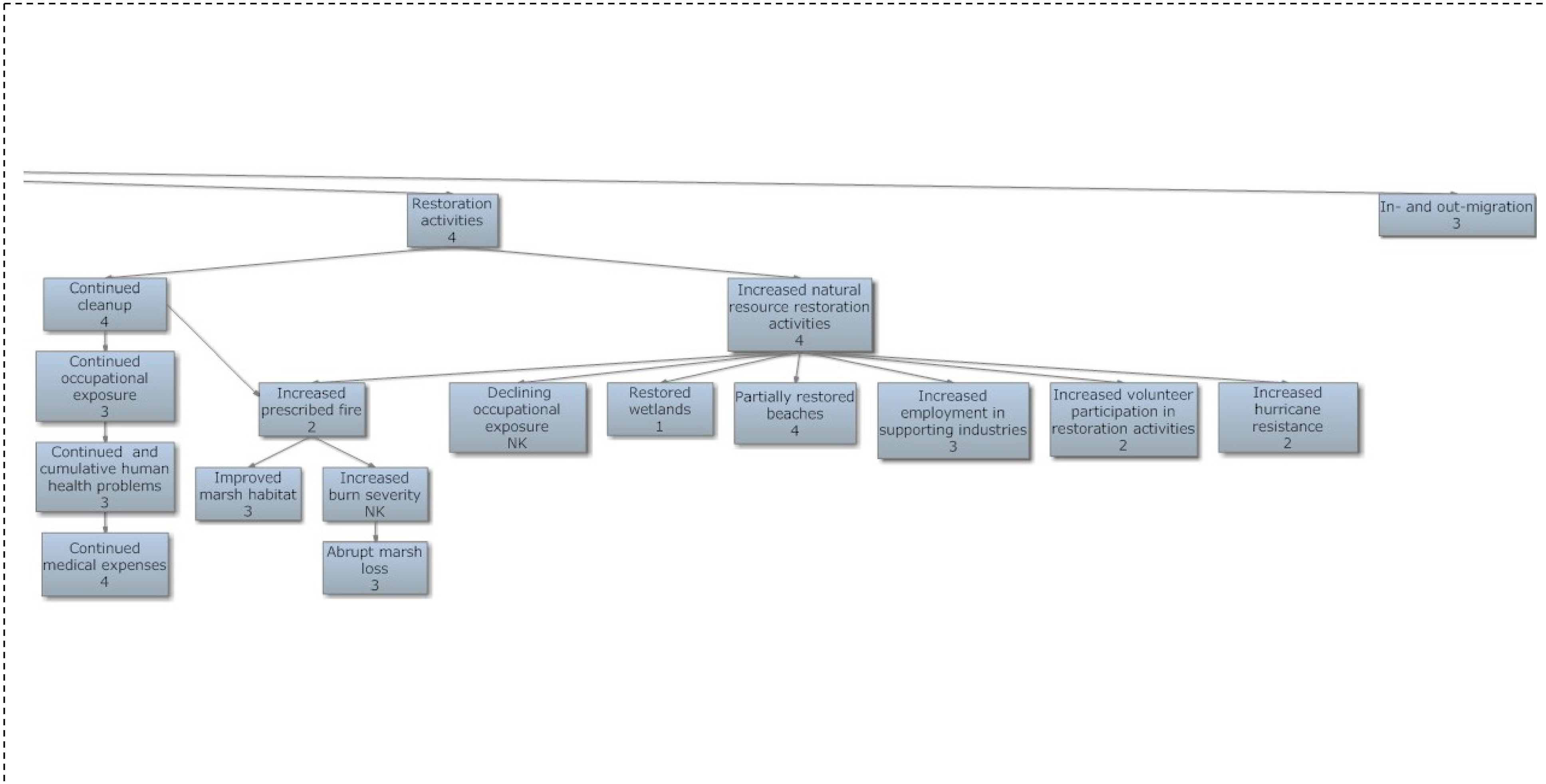

Lessons Learned

The rapid establishment and innovative scope of tasks associated with the Working Group provides an important opportunity for assisting science response efforts (monitoring, research, and impact modeling) to the MS252 oil spill and other major incidents/events. Lessons learned during the first week of the Working Group's activities could help guide future sessions, as well as guide the long-term development of DOI strategic science capabilities for emergency situations. At the end of the 5-day initial session, members of the Working Group suggested a wide range of lessons learned. These lessons are relevant to both continued work related to the MS252 oil spill and future emergencies and events. The lessons learned are listed below, not in order of importance.

Lessons learned for continued MS252 oil spill work

1. An appropriate and adequate mix of scientific disciplines is critical to success, particularly given the focus on coupled natural-human systems associated with the MS252 event.

2. Individual team members need to have scientific expertise in their specific field or discipline, a combination of theoretical and applied knowledge, and the capacity for interdisciplinary work. At least some of the team members need to have knowledge of the specific coupled natural-human system.

3. The team leader needs to have specific skill and preparation in facilitating interdisciplinary scenario building and guiding quickly established scientific teams.

4. Staff support at a modest level is essential, including logistics, IT, and data management support.

5. Web-based, real-time information access is essential for team productivity and effectiveness.

6. Consistent communication with the DOI Incident Commanders is a key element in delivering scenario results as usable knowledge for decision makers.

Lessons learned for future emergency/incident use of strategic sciences working groups

1. Advance planning is necessary to select, prepare, and establish strategic sciences working groups for future emergencies, and to integrate these working groups into federal response efforts.

2. A roster of scientists with specific expertise in scenario building, coupled natural-human systems, and "emergency sciences" should be developed, to help populate similar working groups with appropriate skills and experience.

3. The methodology needs to be developed prior to the event, so that the Working Group can immediately turn to scenario building, and be quickly operating with minimal customization of terminology, technique, and training.

4. The scenario technology needs to be tested and ready; dedicated information technology support is essential to efficient and effective progress.

5. Administrative procedures to quickly “stand up” and operate strategic sciences working groups should be pre-arranged for maximizing speed and efficiency.

6. A briefing/communication process should be established so that scenario results are quickly delivered to decision makers as usable knowledge.

Applications

The products of the Strategic Sciences Working Group can have specific application to emergency response and long-term recovery efforts associated with the MS252 oil spill. At the end of the 5-day session, members of the Working Group suggested a wide range of possible applications. These applications are relevant to both the MS252 oil spill and to future emergencies and events.

1. Help identify critical decision points for DOI leadership and resource managers during late emergency and early recovery phases of an event.

Each of the scenarios has an associated chain of consequences; the scenarios provide a set of critical decision points with associated levels of scientific uncertainty. DOI leadership and resource managers can use the scenarios to pinpoint key decision points (such as creation of berm islands, boom positioning, rehabilitation of birds, or hiring of locals for oil cleanup) and focus increased attention on those associated with low levels of scientific uncertainty.

2. Help identify and prioritize possible interventions by decision makers and resource managers to ameliorate negative impacts and foster positive recovery responses.

The scenarios provide decision makers and resource managers a list of possible intervention points (such as when migratory birds begin to be stressed or killed, midwater contamination reaches critical levels, tourism reservations are canceled, and/or tax revenues begin to decline). Decision makers and resource managers can focus attention on key interventions likely to have substantive impact on reducing negative impacts (such as re-release of sequestered oil) and increasing resilience and positive recovery responses (such as improved monitoring and targeted income support). This is particularly useful during the long-term recovery period, and could help accelerate effective recovery.

3. Help identify critical information needs and knowledge gaps for decision makers and resource managers.

As each of the consequences of a scenario is associated with a level of scientific uncertainty, the scenarios can help identify those consequences that require additional information, research, monitoring, or scientific assessment. For example, relatively high uncertainty associated with the oil spill's impact on large-scale algal blooms highlights additional information needs critical to understanding the relationship between the MS252 event and the GOM "dead zone".

4. Provide useful insight and information to decision makers conducting risk analyses associated with emergency incidents and events.

Similar to #1 above, the scenarios can be used (along with the scientific uncertainties associated with each consequence) to inform general and specific risk analyses conducted by decision makers and resource managers. An example is risk analyses associated with berm island construction, or wetlands burning as a tool of marshland recovery.

5. Inform decision makers and resource managers of "potential surprises" associated with cascading effects of emergency incidents and events.

In some cases, the scenarios can reveal potential surprises that might be initially overlooked by decision makers and resource managers. Examples related to the MS252 event might include consumption of illegal seafood and its cascading human health effects, fishing closures leading to rebound of previously stressed fish populations, or the impact of re-introducing compromised birds into migratory bird populations.

6. Help identify future monitoring requirements, techniques, and technologies to inform Inventory and Monitoring programs, Natural Resource Damage Assessments (NRDA), Incident Command Teams, Operational Leadership preparation, and research programs.

The scenarios and their chains of consequences can be used to identify potential new monitoring requirements, as well as techniques and technologies to measure over time key variables in the coupled natural-human system. Related to the MS252 oil spill, this might include advance monitoring technologies for midwater pollution, new protocols for monitoring re-release of sequestered oil, and/or long-term health monitoring for occupational exposure or financial stress associated with the spill. Such advances can support ongoing inventory and monitoring programs, help develop future NRDA protocols, and contribute to Incident Command training.

7. Help prioritize immediate, mid-term, and long-term future research needs.

The scenarios and chain of consequences associated with each scenario are identified with approximate levels of scientific uncertainty. These evaluations can help prioritize research needs by identifying important but not yet well understood relationships. For example, the relationship between the oiling of marshland, resulting ecosystem stress, and future repeated landfall hurricanes is not fully understood, but represents a key mid-term and long-term research need. In the case of the MS252 spill, the results can be integrated into the current DOI science planning process, provide input to federal government-wide science planning, as well as contribute to regional science plans prepared by and for the academic community.

8. Provide the conceptual framework for development of quantitative predictive models of coupled natural-human system response to major disruptions.

The objective and tasks of the DOI Strategic Sciences Group did not include the development of quantitative predictive models of coupled natural-human systems; such efforts require significant and additional time, people, and data resources. However, the combination of the organizational framework (the human ecosystem model and the scenario framework) and the chain of consequences can be used as a preliminary step in quantitative model building. Use of basic STELLA modeling techniques might be particularly well-suited to initial efforts; Bayesian network models reflect another possible alternative.

Recommendations

As appropriate to this type of federal/nonfederal science group, the Working Group did not develop specific recommendations for the DOI. The following recommendations reflect the views of the lead scientist from the DOI (Machlis), and are based on the experience of the first session of the Working Group.

1. The Unified Commands (National, Houston, Robert, Houma, Mobile, St. Petersburg, Miami) that have not yet been briefed on the Working Group's results should be briefed as soon as possible.

2. DOI leadership should be briefed on the Working Group's results as soon as possible.

3. The Working Group should be convened in a second session, to a) refine the technique, b) further advance the existing scenarios based on additional input and new information, and c) complete additional scenarios focused on long-term recovery.

4. Additional scientists from relevant disciplines should be added to the Working Group, including scientists from agencies outside DOI.

5. Modest additional staff support should be provided to the Working Group, in order to make its work as efficient and timely as possible. A temporary 1 FTE detail from a DOI agency would be appropriate, and could be based in Washington DC and supervised by the Working Group lead scientist.

6. A proposal to establish a long-term capacity for strategic sciences should be developed and presented to DOI leadership.

Conclusion: A Strategic Sciences Approach to Major Environmental Incidents

In addition to the specific applications described above, the strategic sciences working group technique has utility for broad strategies to deal with the challenges of the MS252 oil spill. Colten et al (2008) provides historical and comparative evidence that recovery of a coupled natural-human system after a disaster generally follows the pre-disaster trajectory with the disaster accelerating and/or amplifying previous trends. The scenario framework used by the Working Group (Figure 2 above) for the MS252 oil spill reflects this common and repeated pattern.

A comparison with other regional disruptive events is insightful. Kates et al. (2006) have described the sequence of regional response phases following Hurricane Katrina. These include: 1) *emergency* (during which resources are damaged or destroyed), 2) *restoration* (during which resources are preserved or repaired, and 3) *reconstruction* (during which resources are rebuilt or replaced). Overlaying these Katrina response phases onto the scenario framework for the MS252 oil spill (see Figure 6) reveals a potentially important gap (shaded area) between the emergency and recovery phases.

There may be an important opportunity to initiate the restoration phase *concurrent* with the emergency phase, and by doing so, more quickly and effectively achieve recovery of the coupled natural-human system of the region. Additional analysis by the Strategic Sciences Working Group and others may reveal specific times, locations, and interventions that could have the most beneficial effects. This is a policy decision and will reflect the broad range of policy inputs that include science, legal requirements, and long-term public interest.

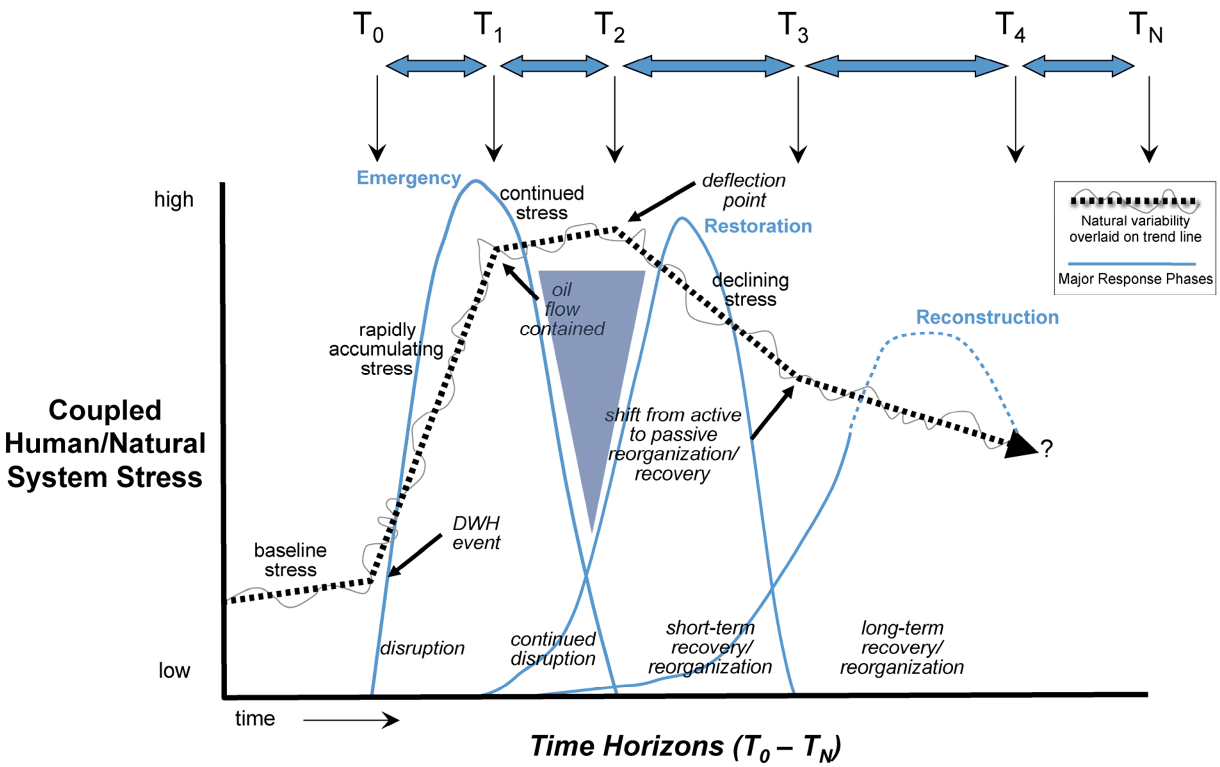

Figure 6. Conceptual model of major response phases overlaid on the time horizons associated with the MS252 Oil Spill. The time scale is not linear.

In addition, the strategic sciences working group concept is well-suited to provide scientific assistance to preparations, emergency response, and recovery efforts related to other emergency incidents, including large-scale oil spills, bioterrorism attacks, hurricanes, earthquakes, significant wildfires, floods, and other hazard events. There may be a unique and valuable role for this concept and technique, as the DOI learns from the MS252 oil spill and prepares for future major environmental incidents.

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APPENDIX 1

DOI Strategic Sciences Working Group Members

DOI Strategic Sciences Working Group Members

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APPENDIX 2

Daily Briefing Statements Prepared for DOI Incident Commanders by DOI Strategic Sciences Working Group

24 – 28 May 2010

DOI Strategic Sciences Working Group
Daily Briefing Statement
5:00 PM
24 May 2010

Background
The Department of the Interior has established a small DOI Strategic Sciences Working Group, with the objective of providing DOI leadership with best available scientific information on how the oil spill will impact the ecology, economy, and people of the Gulf of Mexico. The working group is meeting in Mobile, AL 24-28 May 2010.

Day One Activities
The group met, introduced each other, and reviewed operational logistics. Machlis discussed technical tasks for the group and a general schedule. The rules of engagement were presented:
(a) members of the group are sharing their individual expertise; (b) no consensus is involved; (c) the group's focus is on alternative scenarios and not management recommendations.

As part of its scenario development, the group will use formal levels of uncertainty that would be associated with each element of potential scenarios. Adapted from Weiss 2003, the categories are (a) not possible; (b) unlikely; (c) plausible; (d) probable; (e) reasonably certain; and (f) certain.

The scenarios will use four major time horizons with event phases between each time horizon. Time horizon 1 begins with the start of the Deepwater Horizon event and is a phase of rapidly accumulating stress on the coupled human-natural system. Time horizon 2 begins when oil flow is contained and is a phase of continued stress on the coupled human-natural system. Time horizon 3 begins with short-term recovery/reorganization and is a phase of declining stress on the coupled human-natural system. Time horizon 4 is long-term recovery/reorganization and is a phase of continued declining stress on the coupled human-natural system.

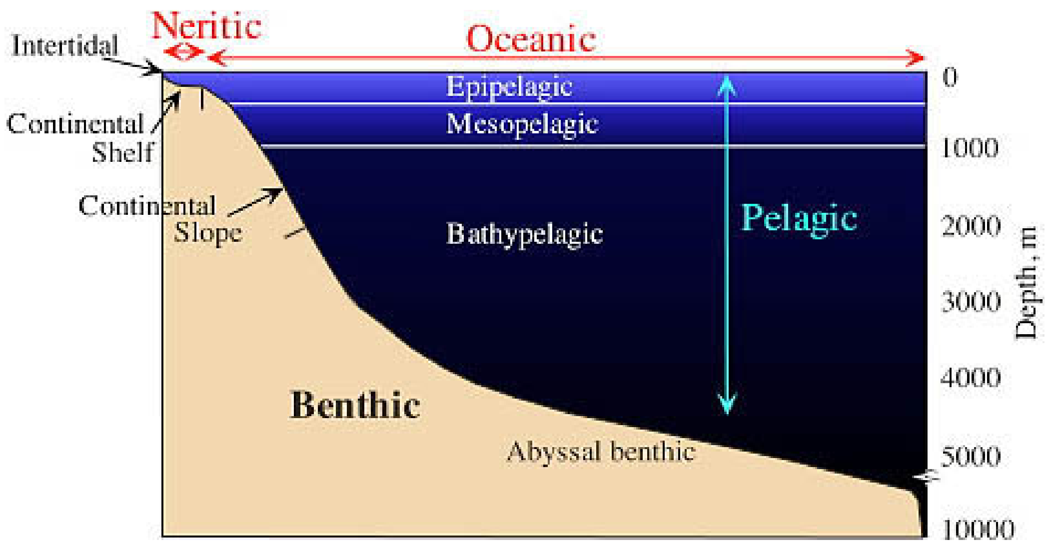
The scenarios will use several spatial units. These include vertical life zones, ecosystem types, administrative boundaries, and biodiversity quadrants for the Gulf of Mexico.

The scenarios will use several initial drivers, to be updated as new data emerge. These drivers include:
(a) containment; (b) low estimate flow; (c) mid estimate flow; and (d) high estimate flow.

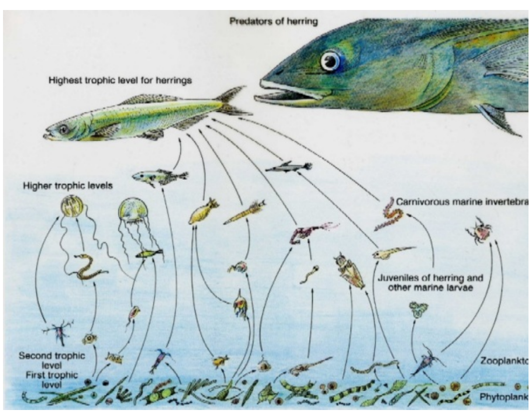
Science Insight
Each day the brief will include an example of scientific insight useful to understanding the consequences of the incident upon the ecology, economy, and people of the Gulf of Mexico.

The open ocean, or pelagic zone, is the largest habitat on the planet. "*This vast realm contains what may be the greatest number of animal species, the greatest biomass, and the greatest number of individual organisms in the living world*" (Robison, 2009).

The open ocean is that region beyond the edge of the continental shelf at approximately 200 m. The depth zones of the water column are the epipelagic or upper 200 m where there is sufficient light for photosynthesis; the mesopelagic between 200 m and 1000 m where, in clear water, sunlight diminishes approximately 10-fold for every 75 m of decent, until all visible light disappears below 1000 m. The bathypelagic zone extends below 1000 m down to the bottom or 4000 m. Animals living on the bottom are living in the epibenthic zone and those living in the bottom are living in the benthic zone.



Because the open ocean is a world without hiding places, animals vertically migrate downward into the dark depths during the day and only venture into food-rich surface waters under cover of darkness. This results in what some consider the most massive animal migration pattern on the planet (Widder 2010). This behavior pattern has been described as affording animals enormous dispersal capabilities because differential current patterns cause animals traveling up from deep waters into surface currents or from surface waters into deep currents to be carried long distances horizontally. The significance of this, given the potential for large subsurface plumes of oil, is that enormous populations of midwater vertical migrators are likely to be exposed to these putative oil plumes at some point.



Vertical migrators include plankton such as dinoflagellates and copepods, the base of the food web, all the way up the food chain to top-level predators such as fish, dolphins and whales.

Robison, B.H. 2009 Conservation of deep pelagic biodiversity. Conservation Biology 23(4): 847-858.

Widder, E.A. 2010 Bioluminescence in the ocean: Origins of biological, chemical and ecological diversity. Science 238:704-708

Proposed Conference Call with DOI Incident Commanders
There is interest among DOI Incident Commanders in asking for specific scientific information and insights. Lead Scientist Machlis proposes a daily conference call at 3:00 PM beginning Tuesday, 25 May through Friday 28 May 2010.

Next Steps
Tomorrow's work schedule includes populating the coupled natural-human model with specific variables and initial scenario building.

Contact: Dr. Gary Machlis, Lead Scientist, DOI Strategic Sciences Working Group, gary_machlis@nps.gov, 202.746.8877

DOI Strategic Sciences Working Group
Daily Briefing Statement
5:00 PM
25 May 2010

Background
The Department of the Interior has established a small DOI Strategic Sciences Working Group, with the objective of providing DOI leadership with best available scientific information on how the oil spill will impact the ecology, economy, and people of the Gulf of Mexico. The working group is meeting in Mobile, AL 24-28 May 2010.

Day Two Activities
The group met and reviewed the previous day's work.

An example scenario was created to test the process of scenario development used by the working group. The test scenario was used to develop a "chain of consequences" with uncertainty levels associated with each cascading effect. The test scenario examined the cascading effects of oil flow on the mesopelagic and bathypelagic vertical life zones through socioeconomic impacts to the fishing industry, healthcare services, and other socioeconomic variables. Members of the working group critiqued the test scenario and made minor improvements in the scenario-building technique. Nine preliminary scenarios (S1-S9) were selected for analysis based on a range of likely to plausible conditions.

A poster of maps was created to visually display combinations of biophysical and socioeconomic parameters and conditions in the Gulf of Mexico. These maps include terrestrial and oceanic topography; oil platforms; fishing closure areas; vulnerable fishing communities; ocean currents, southeast winds, Mississippi River flow; globally important bird areas most at risk; habitat areas of particular concern; Marine Protected Areas; National Wildlife Refuges, units of the National Park System, and other federal lands; situation status map; near-shore surface oil forecast; biodiversity quadrants; Gulf Stream; median household income of coastal counties; and weather.

A 3:00 PM conference call with DOI Incident Commanders was held. The working group and Dr. Marsha McNutt participated.

Science Insight
Two issues of interest/concern were discussed by the working group. Estimates of flow are usually reported in amounts of oil, but BP has announced that approximately half the flow is oil and half is natural gas. The reference can be found at http://www.nytimes.com/interactive/2010/05/01/us/20100501-oil-spill-tracker.html Concern is related to how these estimates were derived and their impact on various scenarios. The second issue is more general: it is apparent that there are critical scientific knowledge and data collection gaps about this unprecedented event. Predictive ability would be improved by filling in these gaps.

Conference Call with DOI Incident Commanders
The daily conference call is scheduled for 3:00 PM CST Wednesday, 26 May 2010. The toll free conference call number and pass code are the same as Tuesday, 25 May 2010 (in email to DOI IC Commanders).

Next Steps
Tomorrow's work schedule includes development of scenarios S1-S5 and preparation for the Thursday briefing of the Mobile Unified Command.

Contact: Dr. Gary Machlis, Lead Scientist, DOI Strategic Sciences Working Group, gary_machlis@nps.gov, 202.746.8877

DOI Strategic Sciences Working Group
Daily Briefing Statement
5:30 PM
26 May 2010

Background
The Department of the Interior has established a small DOI Strategic Sciences Working Group, with the objective of providing DOI leadership with best available scientific information on how the oil spill will impact the ecology, economy, and people of the Gulf of Mexico. The working group is meeting in Mobile, AL 24-28 May 2010.

Day Three Activities
The group reviewed and critiqued the previous day's work. The time horizons were finalized to include five time intervals beginning at the Deepwater Horizon disruption and going forward.

Four basic steps for developing scenarios were practiced: (1) selection of conditions for the scenario; (2) creation of a list of assumptions; (3) development of a chain of consequences; and (4) assignment of a level of certainty for each consequence.

S1 was completed and distributed to the group.

The working group met with DOI Incident Commander Jon Jarvis and discussed progress to date. Jarvis requested development of a scenario focused on short and long term recovery, as well as alternative response options, science gaps, and monitoring needs.

DOI Incident Commander Jarvis participated in the Daily Conference Call.

The group will begin development of S2 this evening.

Science Insight
The Deepwater Horizon event represents a classic example of the rapidly escalating challenges presented to the socioeconomic system as it responds to an exceptionally large disruptive event of unknown duration. There is not a linear relationship between numerous, small-scale incidents (such as repeated 500-gallon storage tank leaks) and a single large, infrequent incident like the Deepwater Horizon. The volume of oil released by 200 storage tank failures or even ten modest tanker leaks may equal the releases from a deepwater oil platform failure, but the cumulative social and economic disruptions caused by the smaller events do not equal the total disruptions and social responses to the single large event. A small event with known duration may prompt a visit by the fire marshal, compel the remediation of soil contamination, and cause a modest and finite loss of profit by the station owner. Both the scale and duration of such small events are limited, and even a series of repeated identical events are manageable (Costonguay 2007, Colten et al. 2008, Mileti 1999).

Large-scale continuing events may present an entirely different scale of challenges. For example, a deep-water oil platform failure can release millions of gallons of oil at a considerable distance from shore, be located at the outer edge of technical capabilities, and continue stressing systems for an extended period of time (Costonguay 2007, Colten et al. 2008, Mileti 1999). Importantly, it is not just the size of the event, but the increased scale of impacts caused by prolonged release and uncertainty that can cause harm. The Deepwater Horizon incident represents such an event.


Typical small-scale environmental incident

References
Castonguay, Stephane. 2007. "The Production of Flood as Natural Catastrophe: Extreme Events and the Construction of Vulnerability in the Drainage Basin of the St. Francis River (Quebec), Mid-Nineteenth to Mid-Twentieth Century." *Environmental History* 12(4): 820-844.

Colten, Craig E., Robert W. Kates, and Shirley Laska. 2008. Community Resilience: Lessons from New Orleans and Hurricane Katrina. Oak Ridge, Tenn.: Community and Regional Resilience Institute.

Mileti, Dennis. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States*. New York: Joseph Henry Press.

Conference Call with DOI Incident Commanders
The daily conference call is scheduled for 3:00 PM CST Thursday, 27 May 2010. The toll free conference call number and pass code are the same as Tuesday, 25 May 2010 (in email to DOI IC Commanders).

Next Steps
Tomorrow's work schedule includes continued development of S2, drafting of the preliminary final report, and preparation and conduct of the briefing of the Mobile Unified Command (scheduled for 1:00 PM CST).

Contact: Dr. Gary Machlis, Lead Scientist, DOI Strategic Sciences Working Group, gary_machlis@nps.gov, 202.746.8877

DOI Strategic Sciences Working Group
Daily Briefing Statement
5:30 PM
27 May 2010

Background
The Department of the Interior has established a small DOI Strategic Sciences Working Group, with the objective of providing DOI leadership with best available scientific information on how the oil spill will impact the ecology, economy, and people of the Gulf of Mexico. The working group is meeting in Mobile, AL 24-28 May 2010.

Day Four Activities
The group reviewed the previous day's work. The group continued work on S2 and prepared a detailed briefing/power point presentation on its objectives, methods, and products.

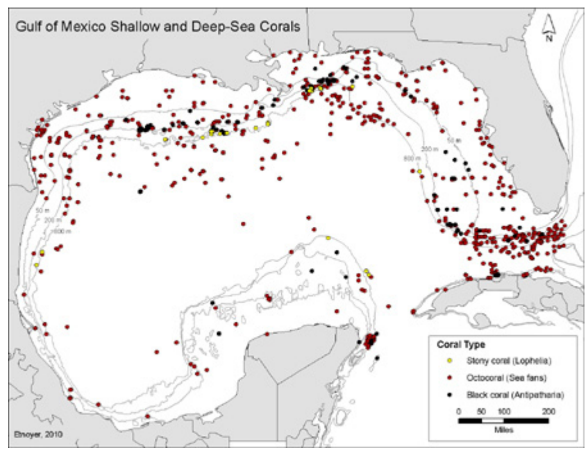
A briefing was held for the Mobile Unified Command, hosted by Jon Jarvis, and presented by Gary Machlis.

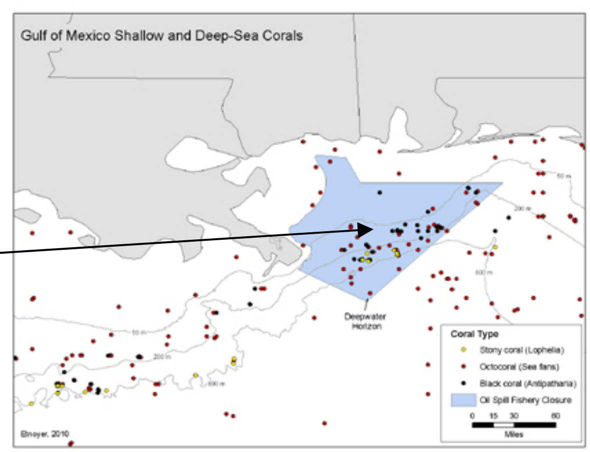
The daily conference call was held with Dan Kimball, Incident Commander for the Florida sector.

An outline for the final report was completed; each section was assigned to group members to be drafted individually.

Science Insight
Impacts on Shallow and Deep Reefs
The maps at right show the known locations of black corals, octocorals and stony corals, as of 2009. The top map shows locations gulf wide. The bottom map shows locations in relation to the Deepwater Horizon spill and the NOAA fisheries closure boundary. These reefs provide critical habitat for many commercial fisheries.

One area of concern is the impact of the combination of oil and Corexit on corral, given experimental studies demonstrating that this mixture caused an 85% reduction in photosynthesis by symbiotic zooxanthellae, while either oil or dispersant alone had no effect (Cook and Knap, 1983).





Cook, C.B. and A.H. Knap (1983) Effects of crude oil and chemical dispersant on photosynthesis in the brain coral *Diploria strigosa*. Marine Biology 78:21-27.

Conference Call with DOI Incident Commanders
The daily conference call is scheduled for 3:00 PM CST Friday, 28 May 2010. The toll free conference call number and pass code are the same as Tuesday, 25 May 2010 (in email to DOI IC Commanders).

Next Steps
Tomorrow's work schedule includes: (1) completion of S2; (2) drafting of S3; and (3) preparation of the preliminary final report. Friday, 28 May 2010 is the last day of the Working Group's activities in Mobile, AL.

Contact: Dr. Gary Machlis, Lead Scientist, DOI Strategic Sciences Working Group, gary_machlis@nps.gov, 202.746.8877

DOI Strategic Sciences Working Group
Daily Briefing Statement
5:30 PM
28 May 2010

Background
The Department of the Interior has established a small DOI Strategic Sciences Working Group, with the objective of providing DOI leadership with best available scientific information on how the oil spill will impact the ecology, economy, and people of the Gulf of Mexico. The working group is meeting in Mobile, AL 24-28 May 2010.

Day Five Activities
The group completed their work on S2 and S3.

A briefing was held for DOI staff engaged in NRDA. The briefing was delivered by Machlis.

The daily conference call was held at 3:00 PM.

The group discussed the outline of a final report. Participants provided their individual insights on the lessons learned from this exercise and the application of such “emergency science” for this and other major incidents. Numerous lessons learned and applications were identified.

Machlis will prepare the draft report to be distributed to Dr. McNutt and the DOI Incident Commanders.

Today concludes the Working Group’s current operation.

Next Steps
Working Group members travel to home locations. Machlis prepares initial draft report. A briefing by Drs. McNutt and Machlis for Chief of Staff and Assistant Secretary Strickland and Deputy Secretary Hayes may be scheduled.

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