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Potential Impact of the *Deepwater Horizon* Oil Spill on Commercial Fisheries in the Gulf of Mexico

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ABSTRACT: *Given the economic and social importance of fisheries in the Gulf of Mexico large marine ecosystem (LME), it is imperative to quantify the potential impacts of the Deepwater Horizon oil spill. To provide a preliminary perspective of the consequences of this disaster, spatial databases of annual reported commercial catch and landed value prior to the spill were investigated relative to the location of the fisheries closures during July 2010. Recent trends illustrated by this study suggest that more than 20% of the average annual U.S. commercial catch in the Gulf has been affected by postspill fisheries closures, indicating a potential minimum loss in annual landed value of US$247 million. Lucrative shrimp, blue crab, menhaden, and oyster fisheries may be at greatest risk of economic losses. Overall, it is evident that the oil spill has impacted a highly productive area of crucial economic significance within the Gulf of Mexico LME. This study draws attention to the need for ongoing and thorough investigations into the economic impacts of the oil spill on Gulf fisheries.*

Impacto potencial del derrame petrolero *Deepwater Horizon* en las pesquerías comerciales del Golfo de México

RESUMEN: En virtud de la gran importancia económica y social que tiene la actividad pesquera en el gran ecosistema marino (GEM) del Golfo de México, es indispensable cuantificar los potenciales impactos del derrame petrolero *Deepwater Horizon*. Con la finalidad de tener una perspectiva preliminar de las consecuencias de este siniestro, se investigaron datos espaciales anualizados de la captura comercial y valor desembarcado antes del derrame en relación a la localización de las vedas espaciales durante julio de 2010. Las tendencias actuales que se ilustran en este trabajo sugieren que más del 20% de la captura comercial anual promedio en la parte del golfo correspondiente a los EEUU, ha sido afectada por vedas establecidas después del derrame, lo que indica una pérdida mínima en valor de desembarque de $247 millones de dólares. Las pesquerías más rentables como el camarón, cangrejo, sábalo y ostión pueden estar en riesgo de sufrir pérdidas económicas. En general, se vuelve evidente que el derrame ha impactado un área altamente productiva de primera importancia económica dentro del GEM del Golfo de México. La presente contribución llama la atención en la necesidad de desarrollar investigaciones vigentes y profundas sobre los impactos económicos del derrame petrolero en las pesquerías del golfo.

Introduction

The explosion of the Deepwater Horizon offshore drilling rig on April 20, 2010, initiated the world's largest known accidental oil spill in the Gulf of Mexico Large Marine Ecosystem (LME), a region valued for its high productivity and lucrative fisheries (Adams et al. 2004; Sherman and Hempel 2008). Estimates of the quantity of oil, natural gas and associated methane, and chemical dispersants released as a result of this calamity have been plagued by uncertainty. The U.S. Government–appointed team of scientists—the Flow Rate Technical Group—estimated that a total of 4.9 million barrels of oil was released from the Macondo well,[1] though an independent study suggested that the amount was between 4.16 and 6.24 million barrels (Crone and Tolstoy 2010). According to British Petroleum's (BP) records, approximately 1.8 million gallons[2]

[1] "U.S. Scientific Teams Refine Estimates of Oil Flow from BPs Well Prior to Capping", August 2, 2010, http://www.restorethegulf.gov/release/2010/08/02/us-scientific-teamsrefine-estimates-oil-flow-bps-well-prior-capping

[2] "One Year Later Press Pack", April 4, 2011, http://www.restorethegulf.gov/release/2011/04/10/one-year-later-press-pack

of dispersant was applied at the site of the leak, as well as the sea surface, though the validity of this amount has been questioned. Complex oceanographic processes have made it difficult to determine the current and future distribution of these substances from the surface to the sea floor and the duration of their persistence in the marine environment. With no clear picture yet, there is no immediate answer to questions concerning short- and long-term impacts on habitats and marine organisms in the path of this disaster.

Uncertainty regarding the extent of damage to the Gulf of Mexico and the capacity for species and associated markets to recover is particularly troubling for commercial fisheries. Though it is difficult to predict the impacts of an oil spill of this magnitude on the future of fisheries in the region, we can infer possible effects by investigating broader patterns. This study presents an analysis of the prespill spatial distribution of commercial fisheries catch and landed value in the Gulf of Mexico LME relative to the postspill fisheries closure in an effort to evaluate potential economic losses.

Methods

To understand the ecological and economic implications of fisheries on a global scale, the Sea Around Us Project in the Fisheries Centre at the University of British Columbia has developed and maintains databases of spatially allocated fisheries data (Watson et al. 2004; Pauly 2007; Sumaila et al. 2007). These global databases of catch and corresponding landed value were utilized in this study. Commercial landings statistics, reported to the United Nations Food and Agriculture Organization (FAO) by national (e.g., National Oceanic and Atmospheric Administration [NOAA]) fisheries management entities, include the taxonomic identity of the catch, the reporting year, the country reporting the catch, as well as the FAO statistical area from which the catch was taken. Compiled catch data extending from 1950 to 2005 have been allocated by the Sea Around Us Project to a system of rectangular spatial cells measuring 0.5° latitude by 0.5° longitude according to a rule-based procedure. Information regarding the biological distribution of the reported taxa (including depth and latitudinal limits, proximity to critical habitat, and primary productivity), as well as fishing patterns and access agreements of the reporting country were used to restrict and prioritize those cells from which the catch was most likely to have originated. This process enables the production of maps illustrating the catch rate (tons per square kilometer per year) by taxonomic group and region (e.g., exclusive economic zone [EEZ], LME, high seas area) from 1950 to 2005.

Ex-vessel price information (i.e., the price that fishers receive when they sell their catch) has been compiled according to taxa, year, and country and assigned to all landings records in the global catch database. To allow comparisons across countries, prices were converted to U.S. dollars for all years using official currency exchange rates and converted to real values using consumer price index (CPI) data. Prices were then multiplied by spatially allocated landings data to facilitate the visualization of spatial and temporal trends in landed value.

For the purpose of this study, the catch and landed value databases were queried to investigate recent patterns in the Gulf of Mexico LME. For each of the 606 spatial cells within this LME, average annual taxon-specific total catch and landed value was computed for the period extending from 2000 to 2005. The location of the fisheries closure (as of July 22, 2010) in relation to georeferenced average annual catch and landed value was investigated to provide clues regarding potential economic losses to commercial fisheries in the region (Figure 1). Spatial cells were proportionally allocated to six zones (i.e., the commercial fisheries closure within the United States EEZ, the remaining portion of the U.S. EEZ open to commercial fishing, the Mexican EEZ, the Cuban EEZ, and two high seas areas), and total catch and landed value statistics were computed for each. Additionally, the average annual catch and landed value of the five most valuable species in the U.S. EEZ during 2000–2005 (i.e., brown shrimp [*Farfantepenaeus aztecus*], white shrimp [*Litopenaeus setiferus*], blue crab [*Callinectes sapidus*], Gulf menhaden [*Brevoortia patronus*], and Eastern oyster [*Crassostrea virginica*]) were calculated for each zone (Table 1). Detailed data for each spatial cell used in this analysis are available on the Sea Around Us Project website.[3] Discrepancies between annual catch and landed value statistics reported here and those reported by national fisheries management entities likely result from over- or underallocation to spatial cells as well as differences in pricing methodologies.

Results and Discussion

Over 100 species of fish, crustaceans, molluscs, and other invertebrates, primarily inhabiting the highly productive continental shelf area, are commercially fished in the Gulf of Mexico. During 2000 to 2005, total annual reported commercial landings within the entire LME averaged approximately 850,000 tons, producing approximately US$1.38 billion in annual landed value (Table 1). The largest proportion of this catch and landed value (77% and 74%, respectively) originated within the 200 nautical mile limit of the U.S. EEZ, followed by landings and associated landed value within Mexican waters (22% and 26%, respectively; Figure 1). The composition of the total annual catch within the LME was dominated by Gulf menhaden (52%), and the remaining annual catch came from Eastern oysters (13%), brown shrimp (5%), white shrimp (4%), and blue crab (4%). Due to high consumer demand and associated prices, landings of brown and white shrimp generated the greatest landed value (17% and 16% of the annual total within the LME, respectively), followed by blue crab (15%), Gulf menhaden (12%), and Eastern oysters (8%; Table 1).

[3] http://www.seaaroundus.org

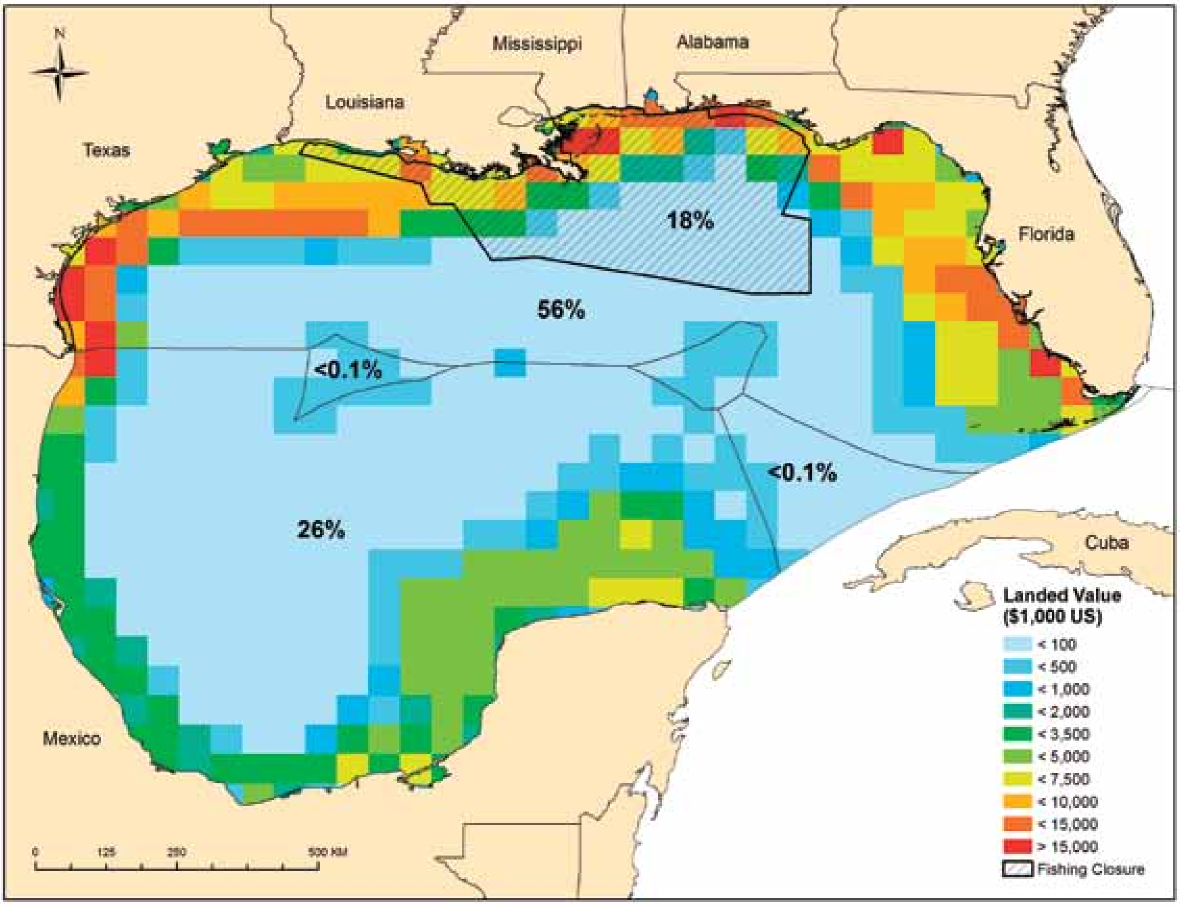

Figure 1. Spatial distribution of the average (2000–2005) annual landed value of reported commercial fisheries catches in the Gulf of Mexico LME. The area closed to commercial fishing (including both federal and state within the U.S. EEZ as of July 22, 2010) accounts for approximately 18% of the total value of landings within the LME. The remainder of the U.S. EEZ still open to fishing accounts for 56%, and Mexican waters account for 26% of total landed value. Less than 0.1% of the annual landed value is derived from the two high seas areas and Cuban waters.

On May 2, 2010, twelve days following the explosion of the *Deepwater Horizon* oil rig, the U.S. National Oceanic and Atmospheric Administration (NOAA), as well as the states of Florida, Alabama, Mississippi, and Louisiana, began to declare portions of federal and state waters closed to commercial fishing in an effort to protect seafood safety and ensure consumer confidence.[4] As of July 22, 2010, over 10% of the total surface area of the Gulf of Mexico LME and approximately 24% of the U.S. Gulf EEZ and territorial state waters were closed to commercial fishing operations. During 2000 to 2005, habitats located within the boundaries of the closed area yielded commercial catches comprising approximately 17% of the total annual tonnage and 18% of the total annual value of reported landings within the Gulf of Mexico LME (Figure 1).

The visible extent of the oil spill and resultant closures indicates that consequences will be greatest for U.S. fisheries. On average, 22% of the annual U.S. commercial catch in the Gulf and 24% of the corresponding annual landed value were derived from the area closed to fishing, representing a potential minimum annual loss of $247 million. Though the majority of U.S. catch within the boundaries of the fisheries closure was composed of Gulf menhaden, landings of brown and white shrimp generated the greatest value (12% of the annual U.S. total in the Gulf), followed by blue crabs (4%), Gulf menhaden (3%), and eastern oysters (1%; Table 1). Economically valuable invertebrate fisheries may be most at risk due to the fact that relatively sessile, benthic organisms are likely to suffer higher initial rates of mortality and exhibit long recovery times as a result of exposure to oil-saturated habitats compared to more mobile fish species (Teal and Howarth 1984; Carls et al. 2001; Culbertson et al. 2007, 2008a).

This study does not pretend to address the full range of biological and economic consequences of the *Deepwater Horizon* oil spill on fisheries in the Gulf of Mexico. It is assumed here that the effects of the spill will be confined spatially to

[4] http://sero.nmfs.noaa.gov/deepwater_horizon_oil_spill.htm

TABLE 1. Average (2000–2005) annual commercial fisheries catch and landed value by zone within the Gulf of Mexico LME, including total and taxa-specific estimates (BS = brown shrimp, WS = white shrimp, BC = blue crab, GM = Gulf menhaden, EC = Eastern oyster).

		Catch (1,000 tons)						Landed value (US$1,000,000)					
Zone	Area (1,000 km²)	Total	BS	WS	BC	GM	EO	Total	BS	WS	BC	GM	EO
U.S., open	550	513	29	25	20	343	51	767	175	152	134	126	47
U.S., closed	167	147	10	10	6	93	16	247	57	64	39	34	15
Mexico	741	191	1	1	6	9	45	358	5	3	29	3	45
Cuba	57	0	0	0	0	0	0	1	0	0	0	0	0
High Seas	36	1	0	0	0	0	0	1	0	0	0	0	0
Total LME	1,550	852	40	35	32	445	111	1,376	219	219	202	163	106

the extent of the fisheries closures within U.S. waters and will only last one year. However, the Gulf of Mexico LME is a hydrographically dynamic system, and the existence of a large subsurface oil plume provides evidence that impacts are likely to extend beyond the visible surface boundaries (Camilli et al. 2010). Most marine organisms, including those mentioned here, exhibit daily and seasonal, small- and large-scale migrations both laterally and vertically. Species may be directly impacted by physical contact with contaminants, as well as indirectly affected via the fouling of important nursery and spawning habitats and trophic interactions (Jackson et al. 1989; Peterson et al. 2003). The ability of critical coastal habitats, including salt marshes and mangroves, to act as long-term reservoirs of oil due to buried hydrocarbon deposits can extend exposure and subsequent biological recovery times by up to 40 years (Culbertson et al. 2007, 2008a, 2008b). The capacity of habitats and species to recover from the effects of oil, methane, and dispersants may have already been compromised due to preexisting sources of stress, including nutrient-laden freshwater discharge from the Mississippi River resulting in periodic oxygen-depleted "dead zones" (O'Connor and Whitall 2007; Rabalais et al. 2007), as well as bycatch and habitat destruction due to extensive trawling (Vidal-Hernandez and Pauly 2004; Wells et al. 2004). Additionally, impacts on ecosystems and reductions in the quantity and quality of fisheries resources translate to a variety of economic impacts, including losses in revenue, profit, wages, and jobs. Therefore, the possible future loss to commercial fisheries in the United States is suggested as a minimum estimate and provides a preliminary perspective given pre–oil spill trends. This analysis includes only reported commercial landings; illegal, unreported, and unregulated (IUU) fishing as well as lucrative recreational fishing is not considered.

Despite limitations associated with the spatial resolution of the databases, this study indicates that the oil spill is clearly impacting an area of crucial economic importance within the Gulf of Mexico. Continued analyses such as those presented here should shed light on an uncertain future.

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References

Adams, C. M., E. Hernandez, and J. C. Cato. 2004. The economic significance of the Gulf of Mexico related to population, income, employment, minerals, fisheries and shipping. Ocean & Coastal Management 47:565–580.

Camilli, R., C. M. Reddy, D. R. Yoerger, B. A. S. Van Mooy, M. V. Jakuba, J. C. Kinsey, C. P. McIntyre, S. P. Sylva, and J. V. Maloney. 2010. Tracking hydrocarbon plume transport and biodegradation at *Deepwater Horizon*. Science Express 330:201–204

Carls, M. G., M. M. Babcock, P. M. Harris, G. V. Irvine, J. A. Cusick, and S. D. Rice. 2001. Persistence of oiling in mussel beds after the *Exxon Valdez* oil spill. Marine Environmental Research 51:167–190.

Crone, T. J., and M. Tolstoy. 2010. Magnitude of the 2010 Gulf of Mexico oil leak. Science 330:634.

Culbertson, J. B., I. Valiela, Y. S. Olsen, and C. M. Reddy. 2008a. Effect of field exposure to 38-year-old residual petroleum hydrocarbons on growth, condition index, and filtration rate of the ribbed mussel, *Geukensia demissa*. Environmental Pollution 154:312–319.

Culbertson, J. B., I. Valiela, E. E. Peacock, C. M. Reddy, A. Carter, and R. VanderKruik. 2007. Long-term biological effects of petroleum residues on fiddler crabs in salt marshes. Marine Pollution

Bulletin 54:955–962.
Culbertson, J. B., I. Valiela, M. Pickart, E. E. Peacock, and C. M. Reddy. 2008b. Long-term consequences of residual petroleum on salt marsh grass. Journal of Applied Ecology 45:1284–1292.
Jackson, J. B. C., J. D. Cubit, B. D. Keller, V. Batista, K. Burns, H. M. Caffey, R. L. Caldwell, S. D. Garrity, C. D. Getter, C. Gonzalez, H. M. Guzman, K. W. Kaufman, A. H. Knap, S. C. Levings, M. J. Marshall, R. Steger, R. C. Thompson, and E. Weil. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science 243:37–44.
Pauly, D. 2007. The Sea Around Us Project: Documenting and communicating global fisheries impacts on marine ecosystems. Ambio 34:290–295.
Peterson, C. H., S. D. Rice, J. W. Short, D. Esler, J. L. Bodkin, B. E. Ballachey, and D. B. Irons. 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302:2082–2086.
Sherman, K., and G. Hempel, editors. 2008. The UNEP Large Marine Ecosystem Report: a perspective on changing conditions in LMEs of the world's regional seas. UNEP Regional Seas Report and Studies No. 182, United Nations Environment Programme, Nairobi, Kenya.
Sumaila, R., A. D. Marsden, R. Watson, and D. Pauly. 2007. A global ex-vessel fish price database: construction and applications. Journal of Bioeconomics 9:39–51.
Teal, J. M., and R. W. Howarth. 1984. Oil spill studies: a review of ecological effects. Environmental Management 8:27–44.
Vidal-Hernandez, L., and D. Pauly. 2004. Integration of subsystem models as a tool toward describing feeding interactions and fisheries impacts in a large marine ecosystem, the Gulf of Mexico. Ocean and Coastal Management 47:709–725.
Watson, R., A. Kitchingman, A. Gelchu, and D. Pauly. 2004. Mapping global fisheries: sharpening our focus. Fish and Fisheries 5:168–177.
Wells, R. J. D., J. H. Cowan, and W. F. Patterson. 2008. Habitat use and the effect of shrimp trawling on fish and invertebrate communities over the northern Gulf of Mexico continental shelf. ICES Journal of Marine Science 65:1610–1619.