Environmental Sensitivity to Oil Spills in Gulf Shores, AL

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Content

Introduction

The region of interest for this study is Gulf Shores, AL, a major tourist destination in the southeastern United States. The motto for this well-kept secret, known for its fishing and laid back culture, is "Gulf Shores- A Water Way of Life." The city is 20 % water by area and has a population of 5044[3]. The biodiversity in Gulf Shores is tremendous as the marshes, swamps, estuaries, and bays are home to over 7500 unique species of fish, mammals, reptiles, plants, and invertebrates.[2]

The motivation for this study is the BP Oil Spill Crisis in the Gulf of Mexico which has had a significant effect on the biological and economic resources of Gulf Shores[3]. Biologically, oiling from the spill and chemical releases from cleanup efforts have disrupted sensitive marine and terrestrial habitats. Economically, revenue from tourism has dropped significantly since the beginning of the spill.

The GIS applications used to complete this study were ArcGIS 10 and a web-based GIS application called ERMA, which stands for the Environmental Resource Management Application. ERMA was designed by the National Oceanic and Atmospheric Administration (NOAA), the US Environmental Protection Agency (EPA), and the University of New Hampshire Coastal Response Research Center for the specific purpose of responding to the Gulf Oil Spill Crisis. The data set used for analysis in ArcGIS was the Environmental Sensitivity Index (ESI) Dataset for Alabama.

The goal of this study is to provide an analysis of the resources at risk in the event of an oil spill in Gulf Shores. The analysis has two parts: a general characterization of high-risk areas and a case study of how the BP Oil Spill affected the environmental resources in Gulf Shores. A comparison can be drawn between the high risk areas in the first section of the report and the specifics of the BP case study in the second section. Finally, an analysis of the usefulness of a desktop GIS like ArcGIS 10 and a web-based GIS like ERMA is provided.

General Analysis Using ArcGIS to Interpret NOAA ESI Data

The NOAA Office of Response and Restoration has published an Environmental Sensitivity Index (ESI) Dataset for the purpose of responding to oil spills in the United States. ArcMap10 was used to import and analyze the Alabama geodatabase provided. The dataset consists of vector objects describing geographic, socioeconomic, and hydrologic features. ESI data provide information on shoreline habitats, sensitive biological resources, and human use resources. Also, ESI tools were developed by NOAA for use in GIS to facilitate analysis of the data.

The data were collected from 1977-2006. The coordinate system used is GCS North American 1983 with a datum of NAD 1983. The extent of the study area is shown in Figure 1. The northeast border of the study area is (87.587° W, 30.373° N), and the southwest border is (87.509° W, 30.195° N). The study area was a rectangle of 575 mi^2.

Figure 1: Gulf Shores, AL Study Area

The shoreline habitats data are ranked based on their ecological sensitivity. The scale of risk is assigned 1-10 based on several criteria: exposure to waves and tidal energy, ease of restoration, biological productivity, shoreline slope, ease of cleanup, and substrate type. Shoreline habitats are expressed as lines and polygons in GIS. Figure 2 shows a map of the study area with its associated high-risk shorelines and habitats.

Figure 2: High Risk Shoreline Habitats

Figure 2 shows the lines and polygons of shoreline habitats in the study area that are at the highest risk level, shown in warm colors. From the ESI layers, “esi lines” and “esi polygons”, only the highest risk areas were selected using the select by attributes tool in ArcGIS. New layers were created in ArcGIS to display only the high risk areas. A statistical analysis was performed using the “shape_area” and “shape_length” fields of each of the layers to get the sum of the perimeter and area of the high risk areas with respect to the total. It was found that 80% of ALL shoreline habitats in the study area were classified as high risk.

Sensitive biological resources are classified by species into 6 categories by the ESI data set including marine mammals, terrestrial mammals, birds, fish, invertebrates, and reptiles. Sensitivity is based on breeding, concentration, life stage analysis, acute sensitivity to oil, and population dynamics. These categories are represented by polygons which show areas where these species live Figure 3 shows polygons for terrestrial mammals, reptiles, fish, and invertebrates. A larger compendium of data is represented in a table called a” bio_file” which represent the sensitivity of over 7500 individual species. Thus, a tool “Query a Biological Layer” has been developed in which a biological layer can be queried to generate a report that lists sensitive individual species present in the area of interest, noting those which are threatened or endangered. Figure 3 includes the report generated by the ESI tool which shows that 196 sensitive species are present in the study area, 17 of which are threatened or endangered.

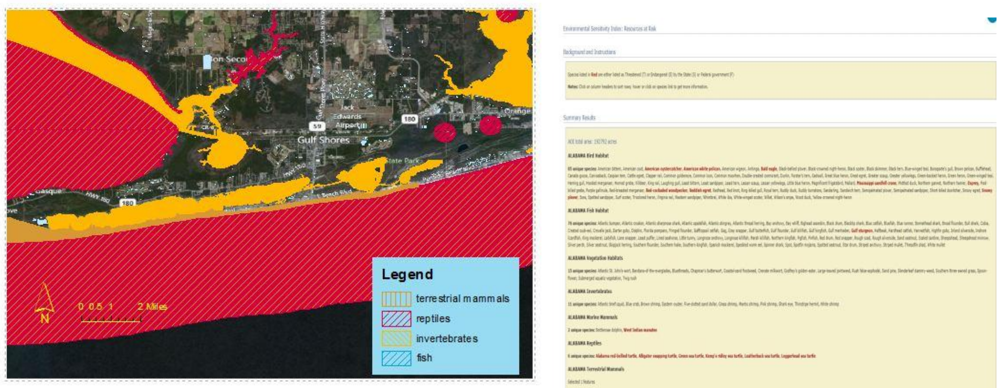

Figure 3: Sensitive Biological Resources

Human use resources are the entities of societal benefit that are commercially or recreationally relevant. High-use shorelines and protected resources constitute the majority of this category. For example, a historic site, marina, beach, or a surface water intake may be classified as a human use resource. Figure 4 shows the human use resources in the study area. In the geodatabase, human use resources are represented as illustrative point symbols.

Figure 4: Human Use Resources in Gulf Shores

ArcGIS was used to select the attributes of the human use resources by area to select those that were relevant. Figure 4 shows 69 human use resources in our study area: 57 archaeological sites, 4 historic sites, 3 public beaches, 2 boat ramps, and 1 airport. The illustrative symbol for the archaeological sites is an arrowhead; other symbols are used in a similar way. Not included in this map are the Gulf State National Park and the Bon Secour Wildlife Refuge which are represented by polylines in a separate layer.

The ESI data show that Gulf Shores, AL is a very environmentally sensitive area. The area is extremely biodiverse with a wide variety of of human activity occurring throughout the region. If an oil spill event were to occur, the beaches and inland water features would experience significant negative effects.

Specific Analysis: Case Study of the BP Oil Crisis in Web-Based GIS- ERMA

On 20 April 2010, the BP Deepwater Horizon offshore drilling platform exploded, taking the lives of 11 people and seriously injuring another 17 individuals.[4] However, the tragedy did not stop there; the well failed and oil began gushing into the Gulf of Mexico. The BP Oil Spill Crisis constituted the largest release of oil into a water body in United States History. The well was capped on 15 July 2010 to stop the flow of oil into the Gulf of Mexico. As a result of the spill, many communities with shorelines along the Gulf of Mexico are at risk for damage to resources. Among these communities is Gulf Shores, AL.

Environmental concerns related to oil and cleanup chemicals (dispersants) have resulted from the BP Oil Spill Crisis. Chemical and biological parameters have been monitored by such national organizations as the US EPA and NOAA. Observational data and modeling efforts have been compiled into a dataset represented into ERMA, a web-based GIS.

ERMA is a publicly available tool which offers a central data hub, easy visualization, and a point and click user interface. The purpose of ERMA is to get information in the hands of environmental responders and managers so that they make educated decisions about cleanup efforts. My purpose for ERMA is to identify the extent of oiling experienced in Gulf Shores, highlight relevant toxicological risks, and show the environmental effects that were experienced.

The extent of oiling in Gulf Shores was mild in comparison to what it could have been had no response efforts been undertaken. Had dispersants not been applied, the surface oiling experienced along the Gulf Coast could have been significantly greater. Figure 5 shows an ERMA representation of the cumulative oiling index in days, represented in gray scale courtesy of West, Inc. The figure indicates that areas along Gulf Shores' beaches experienced oiling up to 20% of the time throughout the life of the spill.

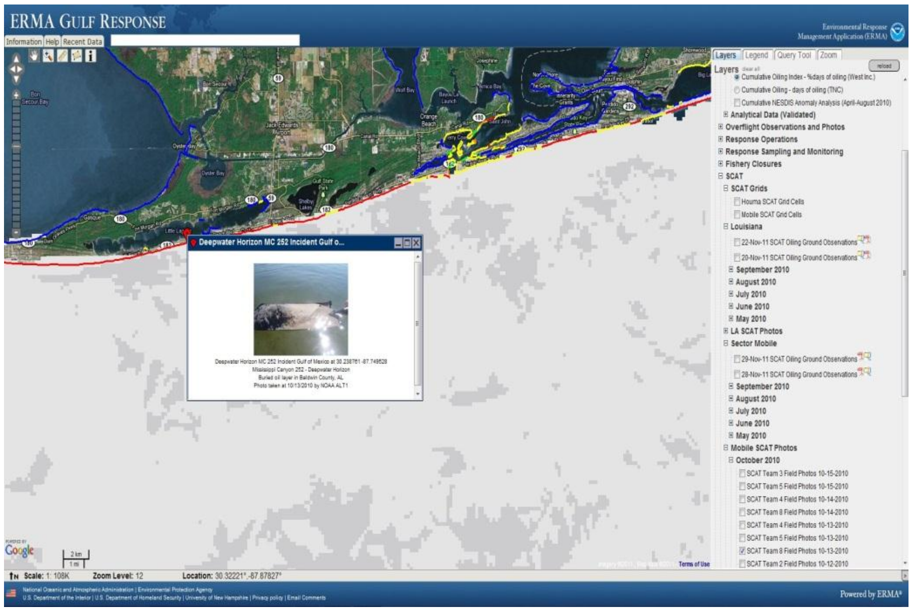

Figure 5: Observed Oiling in Gulf Shores, AL

Also included in Figure 5 are the cumulative maximum oiling index (reported on 23 April 2011) and a photo of burned oil at one of the beaches in Gulf Shores, AL on 13 October 2010. These observational data were provided by the US EPA. The cumulative maximum oiling index symbolizes heavy oiling with warm colors, light oiling with cool colors. Observation shows that the beaches in Gulf Shores, AL experienced heavy oiling, but the inland water features experienced no oiling.

Also, the EPA has reported data related to toxic chemicals such as polyaromatic hydrocarbons (PAHs) and dispersants. Figure 6 shows point locations of samples where toxic thresholds of PAH's and/or a combined index of toxic chemicals have exceeded regulatory standards. The areas circled in red show locations where chemical thresholds are exceeded. Also included in Figure 6 are observations of wildlife (birds, turtles, dolphins, and whales) by the US Fish and Wildlife Service (USFW). The black and orange represent animals that were killed due to oiling.

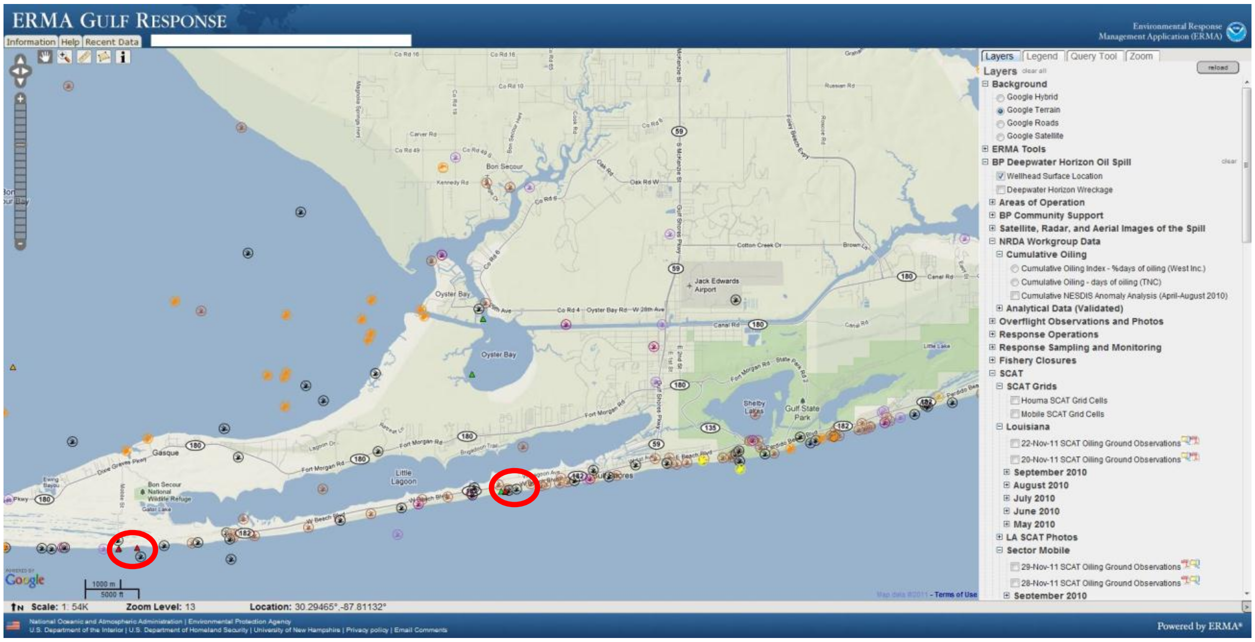

Figure 6: Toxicological Effects of Chemical Exposure

As Figure 6 shows, there were a significant number of animal species affected and killed by the oil spill. The exact number is unknown due to the limited toolset in ERMA such that data layers cannot be queried, selected, or analyzed. No clear relationship exists between where the chemical thresholds were exceeded and where animals were killed by oiling. A combination of heavy oiling and wind current to the east probably carried dead animals to the shores where observed oiling was light. Since the sampling locations were spaced far apart at the scale of this study, it would be very difficult to determine a correlation between areas of chemically determined toxicity and dead, oiled animals.

Finally, the effect of oiling on the local community has not been catastrophic. In fact, in a statement by a local citizen of Foley, AL (5 miles N of the study area) had this to say about his experience during the BP Oil Spill Crisis, "[The] water was beautiful the entire summer, few tar balls some days, no sheen. THE BEST FISHING I'VE EVER SEEN. All fishing was shut down but I did some incredible catch and release on a beach with NO ONE ON IT IN JULY AND AUGUST...amazing. No sores, no dead fish, no dead birds, crabs...it was really pretty wonderful."

Conclusions and Comparisons

The results of this study show that Gulf Shores, AL is indeed an environmentally sensitive area to oiling. In fact, 80 % of the shorelines and habitats are classified as high risk. Tourism and fishing have been affected significantly by the impact of the Gulf Oil Spill Crisis to the resources in Gulf Shores. The NOAA ESI dataset predictions of environmentally sensitive areas mesh well with the observed data from the case study. Observed data show chemical and biological depreciation of environmental resources in Gulf Shores as a result of the BP Oil Spill Crisis. The effects on the shoreline habitats over a long time scale are not known.

A natural comparison arises from this study between desktop GIS softwares like ArcGIS 10 and web-based GIS softwares like the ERMA. Table 1 summarizes the advantages and disadvantages of each of these types of technologies.

Table 1: Comparison of Desktop and Web-Based GIS Technologies

Desktop GIS (ArcGIS10)	Web-Based GIS (ERMA)
Pros	Pros
Great for General Analysis	Great for Specific Analysis
Large Toolkit	Data: Already Compiled and Assimilated
Years of Experience and Development	Public Access
Huge Possibilities and Scope	Ease of Use
Cons	Cons
Obtaining and Assimilating Data	Developed over a Short Period
Requires General Software Knowledge	Limited Toolset for Analysis

Table 1 can be summarized in that the user exerts more effort in a desktop GIS, but the developer exerts more effort in a web-based GIS.

References

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4) "Remembering the Dead from Deepwater Horizon", ABC News, 25 May 2010 <http://abcnews.go.com/WN/bp-oil-spill-transocean-holds-memorial-11-lost/story?id=10739080#.TtlRl2OVrlY>