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Environmental Justice and the Spatial Distribution of Oil-Related Infrastructure in Lafourche Parish, Louisiana

Scott A. Hemmerling and Craig E. Colten

The Minerals Management Service (MMS), a federal agency that oversees offshore oil production, is in a unique position among federal agencies in that their projects take place on the Outer Continental Shelf (OCS), away from human habitation, and yet are required under the amended Outer Continental Shelf Lands Act to consider all social and health impacts of their activities, both direct and indirect. This mandate was extended even further by Executive Order 12898, which requires all federal agencies to consider the environmental-justice consequences of any proposed action. Because offshore production has numerous indirect consequences extending across a wide network of onshore facilities, traditional environmental-justice methodologies produce an incomplete picture of the impacts of OCS-related activities. To accurately gauge the total impacts of OCS-related activities, it is necessary to view environmental justice in a more systematic way. The methodology developed in this study allows MMS to view the cumulative environmental-justice impacts of their activities on minority and low-income populations. A geographic information system was used to model the spatial distribution of a range of OCS-related infrastructure in Lafourche Parish, Louisiana. Our results demonstrate that there are significant inequities in the distributions of support infrastructure and minority populations in Lafourche Parish. *Key Words: Outer Continental Shelf (OCS), oil and gas, environmental justice, geographic information systems (GIS), coastal Louisiana.*

Environmental justice has become an increasingly important issue in terms of industrial siting and locating hazardous facilities. On February 11, 1994, President William Clinton issued Executive Order 12898 (59 FR 7629), entitled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," which directs federal agencies to assess whether their actions have disproportionately high adverse environmental effects on people

Scott A. Hemmerling is a doctoral candidate and Craig E. Colten is a Professor in the Department of Geography and Anthropology, Louisiana State University, 227 Howe-Russell Geoscience Complex, Baton Rouge, LA 70803. E-mail: shemme1@lsu.edu and ccolten@lsu.edu.

of ethnic or racial minorities or with low incomes. The environmental effects it encompasses include human health, social, and economic consequences.

This research examines the spatial distribution of technological hazards associated with the offshore oil industry and how this distribution varies among different socioeconomic groups in coastal Louisiana. The Mineral Management Service (MMS), an agency of the United States Department of the Interior, is responsible for oversight of all Outer Continental Shelf (OCS) oil activity occurring in the Gulf of Mexico. MMS has a legal mandate under the Outer Continental Shelf Lands Act, as amended in 1978 (OCSLAA), to consider the potential impacts of oil and gas exploration on the human environment. The human environment is defined by OCSLAA as the "physical, social, and economic components, conditions, and factors which interactively determine the state, condition, and quality of living conditions, employment, and health of those affected, directly or indirectly, by activities occurring on the Outer Continental Shelf" (Luton and Cluck 2000). EO 12898 extends this mandate even further, specifically requiring the agency to consider how these potential impacts are distributed among various racial, ethnic, and socioeconomic groups.

The problem for MMS is to understand how and where the effects of the offshore oil industry will be felt. Although the oil-extraction sites are in offshore locations far from human settlement, an extensive onshore network of support facilities, ports, pipelines, and processing facilities has developed to support offshore production (Hemmerling and Colten 2003, Louis Berger Group 2004). This network of facilities is cross-sectional, making traditional environmental-justice methodologies difficult to apply.

Generally, environmental-justice methodologies have involved hazard-by-hazard analyses. Previous studies, for example, have explored the potential impacts of Toxic Release Inventory (TRI) sites (Burke 1993, Bowen *et al.* 1995, Perlin *et al.* 1995, Pollack and Vitas 1995, Pulido *et al.* 1996, Brooks and Sethi 1997, Cohen 1997, Ringquist 1997, Daniels and Friedman 1999, Mitchell *et al.* 1999), hazardous-waste treatment, storage, and disposal facilities (TSDFs) (United Church of Christ 1987, Anderton *et al.* 1994, Been and Gupta 1997, Boer *et al.* 1997, Atlas 2001), Superfund sites (Zimmerman 1993, Krieg 1995, Anderton *et al.* 1997, Stretsky and Hogan 1998), and transportation networks (Forkenbrock and Schweitzer 1999, Mills and Neuhauser 2000, Verter and Kara 2001, Jacobson *et al.* 2004). Only a few studies have incorporated multiple hazards to assess patterns of environmental justice (Cutter *et al.* 1996, Fricker and Hengartner 2001), and even fewer have modeled cumulative hazardousness of a given place (Cutter *et al.* 2000, Bolin *et al.* 2002, Dolinoy and Miranda 2004). In order to assess the potential environmental-justice impacts of the offshore oil and gas industry, it is necessary to adapt the cumulative-hazardousness model to include only facilities that are part of the onshore support network and infrastructure (Hemmerling and Colten 2003).

In Louisiana, where oil-and-gas-related industries dominate the economy, substantial attention has been paid to environmental-justice concerns along the industrial corridor of the Mississippi River (Louisiana Advisory Committee 1993; Wright *et al.* 1994; Burby 1995; Allen 2001; Colten 2001, 2002; Pine *et al.* 2002). These studies indicate that minority and low-income populations face a disproportionately greater risk than do higher income and nonminority residents due in part to public policy and its enforcement. Yet, virtually no attention has been paid to minority and low-income populations in the coastal parishes where much of the state's oil and gas is produced and brought ashore. Indeed, there has been no attempt to delimit the areas occupied by minority and low-income populations and the associated technological risks they may face in this region.

This study focuses on Lafourche Parish, a coastal Louisiana "county" that serves as the primary land-based supply center for the majority of the OCS-related oil activity occurring in the Gulf of Mexico. Lafourche Parish is uniquely affected by the industry because of its role in the extraction, transportation, and processing of OCS oil and natural gas. Using geographic information system (GIS) techniques to integrate OCS-related activities, census data, and digital transportation data, the potential geographic and demographic impacts of OCS-related hazards on minority and low-income populations have been identified. Based on this information, a hazards-of-place model was created to compare various OCS-related hazards and identify high-risk areas. It is the purpose of this study to determine whether these impacts are unevenly distributed across the parish, and whether or not certain minority and/or low-income populations within the parish bear a disproportionate burden.

The analysis presented in this study applies only to those activities linked to OCS-related oil activities within Lafourche Parish. Many other environmental hazards exist in Lafourche that fall outside of the scope of this study, such as those related to paper milling and sugar refining. In fact, in terms of overall hazardousness, these other industries present a potentially greater risk to the people of Lafourche Parish than do those OCS-related activities examined here. Similarly, many OCS-related environmental hazards, such as platform fabrication and pipeline coating, are found in many Louisiana coastal parishes besides Lafourche. The findings presented here are thus not generalizable beyond this case study.

Lafourche Parish, Louisiana

Lafourche Parish is located in southeastern Louisiana, south–southwest of New Orleans (Figure 1). The parish is accessible from the east and west via U.S. Highway 90. Louisiana Highways 1 and Highway 308 provide the only major north–south motor routes. Bayou Lafourche provides north–south waterway transportation to the Gulf of Mexico, while the Intracoastal Waterway serves Lafourche Parish as an east–west waterway and is accessible from Bayou Lafourche. The largest amount of shipping traffic occurs in the portion of Bayou Lafourche between the Gulf of Mexico and the Intracoastal Waterway in Larose. Principal tonnage items include shells, sulfur, water, drilling mud, crude oil, cement, and steel. Shrimp and oyster tonnage is smaller but of a higher value.

Lafourche Parish's population is highly concentrated along the parish's central axis and provides a suitable diversity for an examination of environmental justice. It is home to nearly 86,000 residents, including sizable Native American (2.3 percent) and African-American populations (12.6 percent), as well as a small Asian-American population (0.7 percent). In total, nearly 15 percent of the parish population is minority. Furthermore, for the parish as a whole, 14.7 percent of the population is below the U.S. Census Bureau's definition of poverty, and 19.7

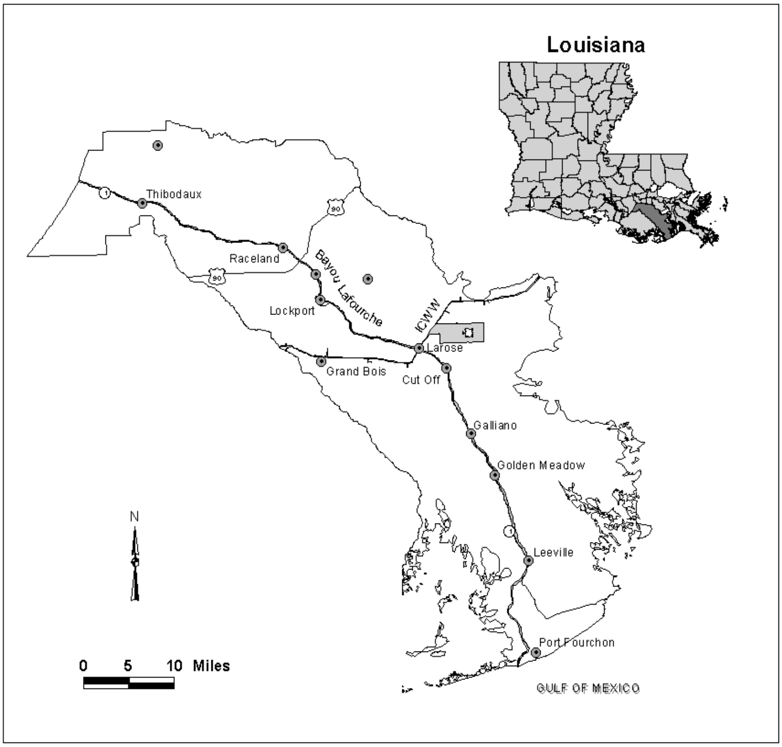

Figure 1. Lafourche Parish, Louisiana.

percent of the children in the parish live below the poverty level. While these figures are below state averages, they are significant nonetheless.

Southeast Louisiana's natural features have helped to shape the settlement patterns and development throughout Lafourche Parish. These features range from marshland, waterways, and bayous in the coastal areas to flat agricultural lands in the north (Wallace *et al.* 2001). Natural levees, islands, *coteaus* (isolated high ground), and hammocks provided elevated sites suitable for permanent communities. A number of communities sprang up along the banks of Bayou Lafourche in the 1930s. These communities have since grown and coalesced to the point where the boundaries between communities are ill-defined. This has led some to refer to urbanization along Bayou Lafourche as "the longest main street in the World." There are three incorporated towns located in Lafourche Parish: Thibodaux, Lockport, and Golden Meadow. Thibodaux is Lafourche Parish's largest town as well as the parish seat. Other communities within the study area include the unincorporated towns of Raceland, Larose, Cut Off, and Galliano. Port Fourchon, a deep-draft port at the mouth of Bayou Lafourche on the Gulf of Mexico, is a major onshore staging area for Outer Continental Shelf (OCS) oil and gas activities in the central and western Gulf of Mexico and the landfall for the Louisiana Offshore Oil Port (LOOP). Some thirteen percent of the crude oil that comes into Louisiana is piped from the LOOP, at a rate of approximately one thousand barrels of crude per minute (Hallowell 2001).

The economy of Lafourche Parish has historically revolved around natural-resource extraction. Prior to World War II, renewable resources such as cypress trees, fur-bearing animals, Spanish moss, and shrimp were taken from the wetlands and sold elsewhere (Austin *et al.* 2002). Beginning in the 1950s, however, oil and gas development came to dominate the economy of the parish. As development spread from the swamps and marshes out into the Gulf of Mexico, onshore support industries developed to provide logistical support to the offshore industry. The linear strip of high ground along Bayou Lafourche that long supplied farmers, trappers, and fishermen with most of the essentials for their economic existence ultimately established the regional pattern of settlement for the petroleum industry's logistic support (Davis and Place 1983). So, although most of the oil and gas extraction in the region takes place offshore, it is highly dependent on land-based infrastructure.

OCS-Related Activities

The activities examined here are those that are directly related to offshore oil production and processing. This includes but is not limited to those facilities listed on the Toxic Release Inventory. While the offshore oil industry may have other secondary impacts on the environment, due in part to increases in population, it is those activities that are directly related to the extraction and processing of offshore oil and gas that are most clearly overseen by MMS.

In short, the methodology used in this study involves identifying and mapping out the locations of OCS-related activities and the potential threats posed by these activities. OCS-related activities can be classified into two major categories: (1) those areas of infrastructure that support oil and gas activities, and (2) those areas that are supported by oil and gas activities (Louis Berger Group 2004). Infrastructure that supports the OCS industry includes those activities that lead up to the extraction of the product from the well. This includes the platform fabrication, shipbuilding, and pipe-coating industries. Furthermore, bases that provide supplies for the rigs and maintenance yards that repair the ships and rigs are included in this category.

Infrastructure supported by the OCS industry includes those activities that follow the extraction of product from the offshore wells. This includes gas-processing plants, refineries, and petrochemical plants, as well as the pipelines that transport the various products to and from each of these facilities. This category also includes gas and oil bulk-storage facilities, where the product is stored following extraction. Lastly, this category includes any waste-management facilities that handle waste streams generated by oil and gas exploration and production activities. This may include generic waste-management facilities, special-purpose oilfield waste-management facilities, and transfer facilities at ports, where the waste is transferred from supply boats to either barge or truck for transport to a final point of disposition (Louis Berger Group 2004).

Two infrastructure categories are important to each category: port facilities and transportation corridors. Port facilities play a vital role as the point of departure to offshore regions. The offshore oil industry relies heavily on specialized port infrastructure that specifically serves the needs of the industry. Such activities as repair and maintenance of supply vessels, fabrication yards, and supply bases are all generally located in ports nearest to offshore drilling operations (Louis Berger Group 2004). Finally, transportation infrastructure is vital for activities supporting and supported by the OCS industry. Roadways, railways, and waterways all provide access to and from the ports that supply the offshore rigs.

Most supplies needed on the offshore rigs must be transported to the port. Likewise, any waste generated offshore is generally brought onshore and transferred to barge or truck and transported away from the port.

Methods

This study utilizes a number of methodologies that draw from and contribute to U.S. Environmental Protection Agency (USEPA) guidelines for conducting environmental-justice research. The study methods included a community-mapping exercise using demographic data obtained from the 2000 Census. Wherever possible, we used census block-level data, the finest level of detail available. According to USEPA, the geographic area of analysis should not artificially dilute or inflate the affected minority population (USEPA 1999). The first stage involved compiling data on present-day social and OCS-related activity in Lafourche Parish. The approach taken was to combine minority, low-income, and environmental-burden factors in order to examine the spatial distribution and overall hazard vulnerability of these populations (Hemmerling and Colten 2004). The first step was to identify what we have termed potential areas of environmental-justice concern. These are study areas that contain a significant minority and/or low-income population, regardless of whether or not there exist any disproportionate environmental effects on these populations (USEPA 1998).

Next, we compiled and mapped out the locations of OCS-related activity in Lafourche Parish. In conducting our equity analysis, the approach we have taken here is largely proximity-based, although modified to include some risk-based aspects. Previous studies have shown that the results of equity analyses are sensitive to the methods used to delineate the impact areas (Sheppard *et al.* 1999). Most equity analyses are either risk-based or proximity-based. Risk-based analyses refer strictly to the health- and safety-related factors associated with particular facilities. They often involve complex modeling of hazardous releases and include such environmental factors such as weather conditions and prevailing winds.

In this type of analysis, risk is based on not only the distance from a facility, but upon the "magnitude of the hazards and the size, shape, and orientation of the associated impact areas" (Glickman and Hersh 1995, 9). Plume-based buffer analyses, for example, modeled using known TRI data, have found that more minority and low-income people reside in proximity to toxic releases than found in circular buffer analyses (Chakraborty and Armstrong 1997). In examining the potential impacts of OCS-related activities in Lafourche Parish, a purely risk-based analysis would provide an incomplete view of the industry, since USEPA requires that businesses only report certain releases, and thus only a handful of facilities have documented a release of any kind. Very few studies have explored methods for characterizing and mapping releases for the types of non-TRI-reporting facilities used in this study (Dolinoy and Miranda 2004). In order to examine the industry as a whole, and because we are dealing with potential rather than actual impacts, it is necessary to turn to a proximity-based analysis.

Proximity-based equity refers to the question of whether the distance-related impacts of one or more facilities are distributed evenly among the social groups in the local population (Glickman and Hersh 1995). These impacts are not only health or safety related as in a risk-based analysis, but may also include effects that have negative impacts on the overall quality of life, including unsightliness, noise, and odor. If these impacts are strong enough, they will "diminish the collective self-esteem and reputation of a community and the property values within it" (Glickman and Hersh 1995). In conducting a proximity-based analysis, the geographical unit of analysis is a uniform circular buffer created around each facility or structure in question. These buffers are not modeled on any specific release. Therefore, weather conditions and wind direction are not included in the model, and the resulting buffers are uniform in all directions. While such simple proximity measures do not rigorously account for distance-decay and the diffusion of toxic chemicals released into the atmosphere (Sheppard *et al.* 1999), they do allow us to map a greater quantity of non-TRI-based data.

For this study, we created proximity-based buffers that are dependent on the specific potential hazard associated with each activity. In other words, the hazardousness of the industrial processes was taken into account, although environmental conditions and diffusion were not. Under the Superfund Amendments and

Reauthorization Act (SARA), companies are required to develop release scenarios that estimate the potential community impact from an accidental release. Using USEPA's Risk Management Program computer modeling software (RMP*Comp), a worst-case release scenario and offsite-consequence analysis was performed for each facility to determine the endpoint distance of a hypothetical release. U.S. Department of Transportation (USDOT) guidelines also establish default isolation zones for hazardous releases on arterial highway segments and railroads (Cutter *et al.* 2000). These distances are all used to create site-specific buffers around each facility. The fugitive emissions associated with shipbuilding and repairing, for example, are largely nonreactive and have isolation distances of one-half mile. For natural-gas processing plants, this distance is extended to one mile.

Census enumeration units lying within a buffer were aggregated in order to create a new study area, one determined by the modeled impact of any potential chemical release or industrial hazard. The next step was to compare the social variables in our study areas to those in the reference area in order to evaluate the degree of equity between them. According to USEPA guidelines, it is necessary to compare a potentially impacted minority community to the larger geographic area to aid in distinguishing potential impacts on minority communities within the affected area of a proposed action (USEPA 1999). This study examines the local impacts of the OCS oil and gas industry and uses the overall parish as the reference area. Using the parish values as relative thresholds takes into account regional differences in population distribution and thus provides a much more meaningful determination of significance. We have defined *equity* and *inequity* as follows: If the percentage of a particular social group in the study area is equal to or less than that in the reference area, there is equity with respect to the facility in question; any overrepresentation of a minority group constitutes an inequity (Glickman and Hersh 1995).

For the block-level data, nonparametric procedures were used to analyze the racial and ethnic characteristics within each buffer relative to the characteristics of the portion of the parish outside of the buffer. Odds ratios and the chi-square test of significance were used to demonstrate whether any observed differences were statistically meaningful or merely due to chance. Odds ratios allow us to make inferences about how much higher or lower are the odds of a minority individual (relative to a nonminority) living in proximity to a potentially hazardous facility (Pine *et al.* 2002). An odds ratio of 1, for example, implies that the two variables being compared are independent, and this serves as a baseline for comparison. Values of odds ratios further from 1 in a given direction imply stronger levels of association.

In Lafourche Parish, where many rural census-block groups are too large to adequately utilize spatial buffers, this contingency analysis could not be performed for economic data. According to USEPA, it is important for researchers to recognize that the aggregation of data and lack of current information on income at the block level may fail to reveal certain relevant characteristics about the population. For example, the aggregation of data to the block-group level in a particular geographic area may mask a “pocket” of low-income individuals that exists among the larger general population (USEPA 1999). Similarly, attempting to aggregate any rural block groups based on spatial buffers may lead to misleading calculation of within-buffer population character, since the population of the block group may actually be concentrated in a portion of the block group not encompassed by the buffer (Mennis 2002).

After the buffer zones were created and analyzed, they were overlaid to create a cumulative hazard density score. In all, seven different OCS-related infrastructure types were used to create the model (Figure 2). Although the facilities were not weighted, *per se*, three additional data layers were used to act as weighting surrogates. Facilities classified as Large Quantity Generators (LQGs) of toxic substances by USEPA were added to the model. In addition, facilities that have appeared on the TRI were added to the model. Both of these factors imply a higher potential for hazardousness. The TRI, for example tracks manufacturing facilities that process more than 25,000 pounds or use more than 10,000 pounds of any one of the 650 TRI chemicals and requires them to report their releases to the USEPA. These releases include emissions from routine processing and/or accidental releases (Dolinoy and Miranda 2004). The final surrogate weight applied to the

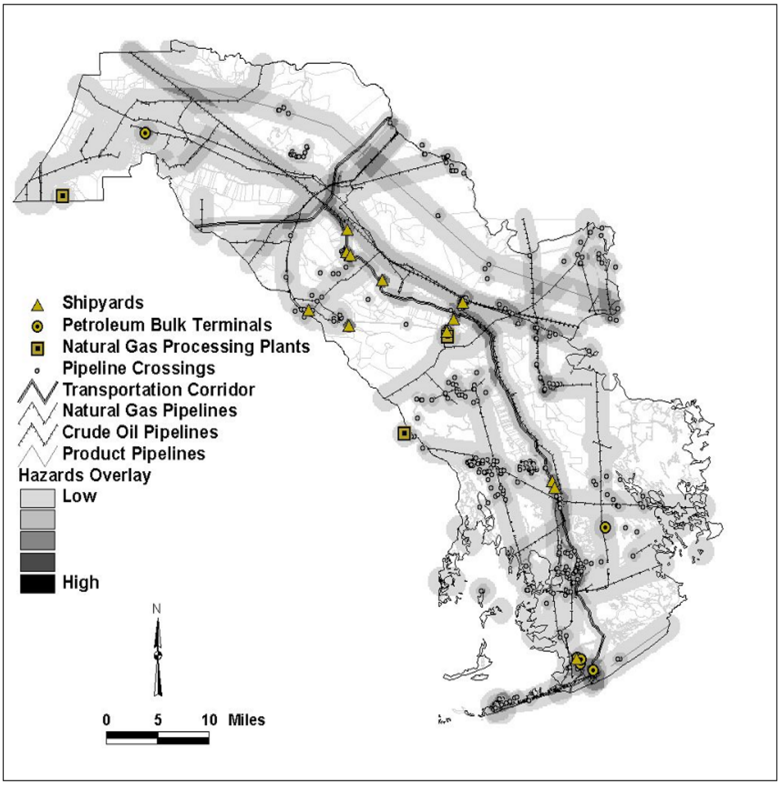

Figure 2. Areas of potential environmental-justice concern in Lafourche Parish, Louisiana.

model involved pipeline crossings. Locations where pipelines cross streams, bayous, and roadways were added to the model. In these locations, the pipelines are more exposed, thus increasing their vulnerability to accidental releases.

It is important to remember that we are considering hazards. A shipyard that is also an LQG of a toxic substance has greater hazardousness and is weighted more heavily in the analysis than a facility that is not. Furthermore, if this facility also has a history of toxic releases, either routine or accidental, it is weighted even more heavily. Similarly, the exposed pipeline sections that cross either a road or a waterway are weighted more heavily than a buried pipeline, due to the fact that exposed pipelines are much more susceptible to the elements, thus potentially increasing the risk of a pipeline failure.

In this analysis, a simple arithmetic overlay was used to produce a conceptual model of the potential hazardscape related to the onshore impact of OCS-related infrastructure in Lafourche Parish. To accomplish this, we reclassified and overlaid our maps using a process termed "sieve mapping" (Kitchin and Tate 2000, 170). Each facility, buffered out to the toxic-endpoint distance, is assigned a value of one. Additionally, TRI sites, LQG sites, and pipeline crossings were assigned values of one. All of the vector surfaces were then transformed into a number of 30-meter-resolution raster grid cells. Because raster grid cells are significantly smaller than the original vector surfaces, we are able to aggregate data to a variety of larger areal units (Mennis 2002). Using the model-building capability of ArcView 3.2, all of the rasterized facilities and buffers were combined into a single composite of intersecting grid cells. All locations in the parish were classified according to their cumulative hazard density, which was then broken down into quintiles, with one indicating the lowest hazard potential and five the highest. Those areas with no identified potential hazards were assigned a value of zero and classed separately. Finally, each census block and block group were assigned a hazards rating, based on the hazards quintile of the grid cell located at the centroid of the enumeration area. This allowed us to operationalize the model and analyze the potential environmental-justice impacts of the entire network of oil- and gas-related infrastructure in Lafourche Parish.

In attempting to operationalize our conceptual model, we have focused on the following three elements: biophysical, social, and place vulnerability (Cutter *et al.* 2000). These three outcome indicators enabled measurement of the potential hazardousness of Lafourche Parish as it relates to expanding OCS activity. The biophysical vulnerability was measured by the delineation of OCS-specific hazard zones, and social vulnerability was measured using social and demographic characteristics. The interchange of the two gives us the overall place vulnerability, the third outcome indicator.

Using the hazards rating, we were able to determine the degree of interdependence among the racial variables and the number of OCS-related facilities in each census block and block group. Initial analysis of the data reveals no obvious problems with multicollinearity and some likelihood that linear relationships exist between the hazardousness ranking and several of the predictor variables. The Pearson correlations indicate that a significant negative correlation exists between the percentage African American and the percentage Native American. Note, however, that the relationship is not strong, with a negative correlation of -0.079. There are no other significant correlations among the racial groups. When conducting parametric procedures, residual plots were examined, and any cases where the Studentized residuals exceeded two were removed from the model.

Two parametric procedures were run on the data at varying spatial scales. Discriminant analysis enabled an examination of both social and economic variables to see if they could successfully discriminate the overall hazardousness of each census block group, based upon the hazardscape model. Economic data were unavailable at the block level in the 2000 Census; consequently, our discriminant analysis was run at the much coarser block-group level. In addition to the racial variables used previously, at the block-group level we were able to employ mean household income, median house value, and median contract rent, as well as other social indicators. According to USEPA, mean house value and monthly rent can serve as proxies for income levels (USEPA 1998). This is important because, prior to the 2000 Census, house values and monthly rent were counted at the block level, whereas income was only counted at the block-group level and higher.

Finally, we attempted to simultaneously examine the impact of several independent variables on a single dependent variable, here the hazardousness-of-place rating. For this, we used multiple regression analysis of the dependent variable against race, ethnicity, age, and the various economic indicators such as household income, median house value, and median contract rent. This method allows us, specifically, to determine whether there is a positive, negative, or no correlation between the independent variables in the relationship with proximity to OCS-related facilities. Again, this analysis had to be conducted at the rather coarse census block-group level. In using regression analysis, we do not mean to imply that race, ethnicity, and income cause vulnerability. Rather, we are using regression analysis to test for the existence and strength of associations between the socioeconomic variables and vulnerability. Indeed, as Buzelli *et al.* (2003) point out, we cannot infer causality on the basis of one study alone, regardless of the modeling framework.

Hazardousness-of-Place Model

Zones of Biophysical Vulnerability

In examining the modeled hazard zones of Lafourche Parish, we see that OCS-related industry and activities are not equally distributed across the parish (see Figure 2). As expected, industry has clustered along Highway 1, particularly in South Lafourche. Two areas—Port Fourchon and Larose—stand out as being sites where industry has concentrated. The geographical location of these two areas plays a large part in the concentration of industry found there.

Port Fourchon is one of the few ports on the Gulf of Mexico equipped to handle the needs of deepwater oil and gas development. It is considered to be the most reasonable port for many OCS-related industries since it is closest to much of the deepwater development. Most of the other ports in Louisiana are located too far inland, and other ports in the Gulf of Mexico region, such as Galveston and Mobile, are considered by many to be too distant (Keithly 2001). Port Fourchon also contains the only facility in the world where deepwater supply vessels can take on fuel, water, deck cargo, barites, cements, liquid muds, and completion fluids efficiently at the same dock. This C-Port facility has cut vessel-turnaround time by more than 50 percent (Keithly 2001).

As of May of 1999, more than 100 businesses were operating out of Port Fourchon, the vast majority of which were either directly or indirectly involved in supporting OCS activity (Hughes *et al.* 2001). This includes petroleum-production firms, oilfield pipeline-laying companies, and independent drilling companies. Several shipbuilding firms are also located at Port Fourchon, including one major shipbuilding facility.

Larose is an unincorporated community located at the junction of Bayou

Lafourche and the Intracoastal Waterway, sixteen miles south of U.S. Highway 90. This community of 7,306 is home to a number of shipbuilding and repairing industries, including two major shipbuilding facilities located along the Intracoastal Waterway, both of which are identified by USEPA as LQG and TRI sites. In addition, there is a major gas-processing plant located one-half mile to the west of Larose. The Larose Gas Processing Plant is capable of storing quantities of both propane and butane onsite, while methane, condensate, and natural-gas liquid products both arrive at and are shipped from the facility via pipeline systems.

Other communities identified by our model include the incorporated towns of Lockport and Golden Meadow, as well as the small community of Grand Bois. Lockport is located where Route 1 crosses a former channel of the Intracoastal Waterway, about 5 miles south of U.S. Highway 90. Most of its 2,624 citizens find work in sugar-cane farming, paper production, oil and gas exploration, shipbuilding, and fishing. The fishing town of Golden Meadow is the southernmost town in Lafourche Parish, located at the edge of the levee system on land two feet above sea level. According to the Louisiana Department of Natural Resources, there is a small Houma Indian community on the northern shore of Catfish Lake, just to the west of Golden Meadow. This community consists of five families that hunt and trap in the area for a living.

The community of Grand Bois is unique among the sites identified by our model in that it is not located along the Highway 1 corridor. The community of Grand Bois is located along the Intracoastal Waterway near the border of Lafourche and Terrebonne parishes. Most of the approximately 300 residents alternate between growing and harvesting food and working as laborers in the shipyards or on the oil rigs (Austin 2001). In addition to an oilfield waste facility, the community is also home to a large shipyard listed as a TRI site. Grand Bois and the surrounding area are located within the Bayou Pointe-au-Chien Environmental Management Unit. The marshlands of this area are ideal for production of waterfowl food, and waterfowl game species and fur-bearing animals both thrive throughout this area. In addition, both brackish and freshwater fishing are excellent throughout the unit. Wherever OCS-related activity has the potential to affect fish, vegetation, or wildlife, that activity may also affect subsistence patterns of consumption and indicate the potential for disproportionately high and adverse human-health or environmental effects on low-income populations, minority populations, and Indian tribes (CEQ 1997).

Zones of Social Vulnerability

Our model reveals some very clear minority population clustering in Lafourche Parish (Figure 3). For the most part, the African-American population clusters in northern Lafourche, especially around Thibodaux. The Native American population is concentrated along Highway 1 in southern Lafourche, between Larose and Golden Meadow. Also, some concentrations exist along the Lafourche–Terrebonne border, in the area of Houma and Bayou Pointe-Au-Chien. Both the Asian and Hispanic populations are geographically dispersed, living along the Highway 1 corridor, and into Thibodaux.

In addition to the geographic distribution of the various minority populations, an additional environmental-justice concern may exist if there is more than one minority group present where the minority percentage meets the parish threshold values. This allows us to see areas within the parish where there are clusters of census blocks of high minority populations. What this model reveals is that there is a great deal of minority clustering occurring in and around the area of Larose extending southward toward Cutoff. There are also a number of smaller minority clusters found in and around Thibodaux.

Low-income populations tend to be dispersed across the parish, at least at the block-group level. Following USEPA guidelines, U.S. Census-defined parameters were used to measure income and poverty (USEPA 1999). The 2000 Census defines a person as poor if his or her annual income fell below $8,501 in 1999. The average poverty threshold for a family of four persons was $17,029 in 1999. In Louisiana, an estimated 15.8 percent of families and 19.6 percent of individuals have incomes below these thresholds. This is in contrast to Lafourche Parish, where only 13.2 percent of families and 16.5 percent of individuals have annual incomes below these levels.

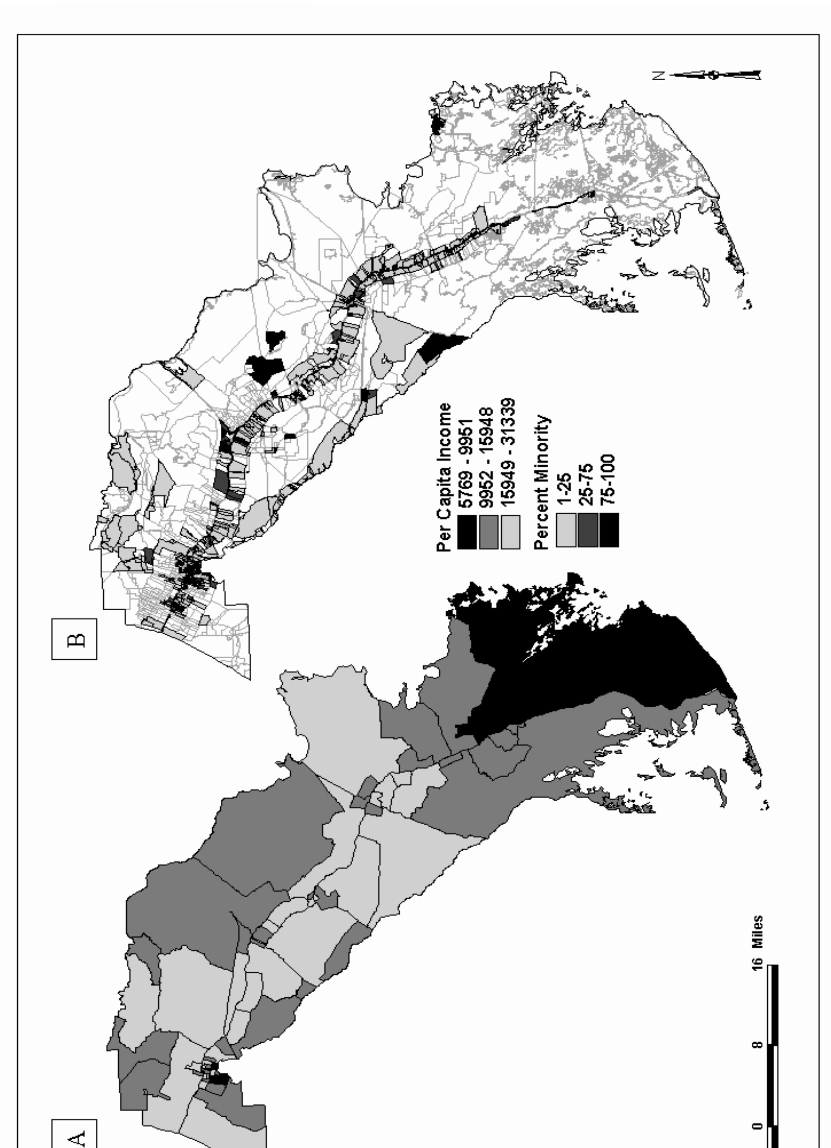

Figure 3. Two demographic variables for Lafourche Parish, Louisiana: (A) per-capita income, and (B) percent minority.

Geographically, census block groups where residents earn, on average, 20 percent or more beneath the parish average are located in the marshlands of Lafourche south of Golden Meadow, as well as in and around Thibodaux. The population along the LA 1 corridor for the most part is not low-income, although Lockport does have low-income areas. When other economic factors are examined, a similar dispersed pattern is found. Areas of low median contract rent, for example, are found in the marshlands of south Lafourche, along the LA 1 corridor and around Thibodaux. Contract rent is defined by the U.S. Bureau of Census as the monthly rent agreed to or contracted for, regardless of furnishings, utilities, fees, meals, or services that may be included. Finally, median house values have a similar pattern, although house values tend to be higher in developed areas. The marshlands below Golden Meadow and the farmland along the U.S. 90 corridor to the east of Bayou Lafourche have the lowest median house values, with other smaller clusters located in Thibodaux, Raceland, and Lockport. It is important to recognize that the block-group aggregation of data and lack of current information on income levels may fail to reveal certain relevant characteristics about the population, such as "pockets" of low-income individuals that exists among the larger general population (USEPA 1999). In order to determine whether block-group low-income patterns hold at the block level, we examined 1990 median house value data, which were available at the block level. Although the growth of the oil industry throughout the 1990s would have altered much of the economic landscape of Lafourche Parish, an examination of these data reveals a similar pattern to that found at the block-group level in 2000. The marshlands below Golden Meadow and the area to the east of Thibodaux contain a number of census blocks with low-value housing. The area around Grand Bois appears in the 1990 Census to be an area with extremely low property values.

Zones of Place Vulnerability

Place vulnerability is determined by examining areas of high hazardousness in combination with socioeconomic vulnerability and, as such, is a useful composite indicator for potential environmental injustice. We first identify any census blocks with a higher-than-average number of people indicating minority status and determine which are located in census block groups with per-capita income twenty percent or more below the parish average. This determinant of socioeconomic vulnerability is overlaid with the hazardousness-of-place model to identify areas of greatest environmental-justice concern relative to OCS-related industries.

Overall, large numbers of minority residents live in and around Thibodaux, particularly African-American, Asian, and Hispanic. In addition, our social-vulnerability model shows a large clustering of minorities around the junction of Bayou Lafourche and the Intracoastal Waterway in Larose. Our physical-hazards model revealed two areas—Port Fourchon and Larose—that are of particular concern with regard to potential environmental hazards.

Most of the land surrounding Port Fourchon is in a semi-altered natural state, while developers have drained and filled the wetlands immediately around Port Fourchon and Fourchon Island for industrial and marine support facilities. There are very few permanent habitations found around Port Fourchon, and none of these areas are home to significant minority populations. This stands in stark contrast to the demographics of the population in and around Larose. Although at or above the parish average in terms of economic conditions, Larose is home to sizable concentrations of African-American, Native American, Asian, and Hispanic populations. In terms of the overall vulnerability of place in Lafourche Parish, Larose stands out as an area of particular interest.

When economic conditions are considered along with minority population, a different pattern emerges. When census blocks with a higher-than-average proportion of minority population are examined in tandem with census block groups with incomes 20 percent or more below the parish level, the majority of the LA 1 corridor does not stand out. There are areas of concern located in and around Golden Meadow and in Lockport. Other locations are found along the Lafourche–Terrebonne border once again, and in Thibodaux. Other areas of high minority and low-income population may be masked by the usage of the coarse block-group level, such as the area around Grand Bois, which appeared as an area of concern in terms of the 1990 Census data.

The areas examined and analyzed here are important for a number of reasons. Larose, for example, is home to the largest concentration of facilities outside of Port Fourchon, and is also home to high proportions of all examined minority groups. Lockport and Golden Meadow both have multiple facilities as well, although not to the same scale as Larose. Both of these areas have a greater proportion of low-income residents than Larose, however, increasing the vulnerability of those populations residing there.

Results

This study provides a characterization of environmental justice and the potential hazards and impacts of Outer Continental Shelf oil and gas extraction in Lafourche Parish, Louisiana, a principal land-based supply center for the majority of the offshore oil and gas activity occurring in the Gulf of Mexico. Using GIS techniques to integrate OCS-related activities, census data, and TIGER files, the potential geographic and demographic impacts of OCS-related hazards on minority and low-income populations have been identified. Based on this information, a hazards-of-place model was created to compare various OCS-related hazards and identify high-risk areas.

OCS-Related Impacts

Five different classes of OCS-related activities were identified as hazardous to nearby communities. Transportation corridors, oil and natural-gas pipelines, petroleum bulk-storage facilities, shipyards, and a natural-gas processing plant are all located in Lafourche Parish. Some hazardous chemicals have low vulnerability zones and thus pose relatively less risk than other chemicals. The vulnerability zones for the facilities modeled range from one-half mile for transportation corridors and shipyards to one mile for the natural-gas processing plant and natural-gas pipelines. These distances represent the endpoint distance of a worst-case-scenario hazardous release.

Of the facilities identified in Lafourche Parish, only the natural-gas processing plant has not had a recent release or spill of any sort. Of the twenty-seven hazardous releases reported to the TRI in the last decade, twenty-five occurred in the shipbuilding and repairing industry, with the other two occurring at petroleum bulk terminals. Nineteen of the toxic releases have occurred in either Larose or Lockport, with the remainder occurring at a single shipyard located near the small community of Grand Bois. Pipeline leaks and spills along roadways are much more frequent, though not of the same magnitude as toxic releases from stationary facilities. Pipelines carry the greatest quantity of oil and natural gas and have the potential to affect the largest geographical area of all activities examined in the study. These, however, are located primarily in rural areas, thus limiting the potential impact on local populations.

The patterns of racial and ethnic distributions around these facilities all show a similar pattern (Table 1). The closer the odds-ratio value is to one, the more equitable the distribution of the population. The level of association between the minority population and the facility increases as the value of the odds ratio moves further from one (Pine *et al.* 2002). The most equitable distribution is found around the pipelines. This is most likely due to the large geographical area that the pipelines cover in Lafourche Parish. Each of the other facilities shows particular patterns of racial and ethnic inequities. These patterns are most pronounced in the case of the Houma Indian population around each facility. All of the facilities located in southern Lafourche show a statistically significant, disproportionately high Native American population around them. For example, if we look at which populations are more or less likely to live around the shipyards, we see that Native Americans are 2.27 times more likely to live in close proximity than elsewhere in the parish, and Asians are 1.96 times as likely. This stands in contrast to the white population, which is 0.61 times as likely and the African-American population, which is only 0.19 times as likely to be found living in the proximity of a shipyard. The only exception to this is the distribution of minority population around the petroleum bulk-storage facilities. Most of the bulk terminals are located in unpopulated wetlands. There is, however, one large petroleum bulk terminal located in Thibodaux. Very few Houma Indians live around this facility. In fact, this research shows that the Houma Indian population is clustered in southern

Table 1. Odds-ratio values for onshore infrastructure supporting offshore oil in Lafourche Parish, Louisiana, with census-block race variables: White, African-American, Native American, Asian, and Hispanic.

	Racial Variables									
	White		African-American		Native American		Asian		Hispanic	
Infrastructure Type	Value	Significance	Value	Significance	Value	Significance	Value	Significance	Value	Significance
Transportation corridor[1]	.464	.000***	.158	.000***	1.619	.000***	1.361	.000***	1.183	.000***
Shipyards[2]	.610	.000***	.193	.000***	2.273	.000***	1.961	.000***	.993	.926
Crude oil pipelines[3]	.767	.000***	.607	.000***	1.322	.000***	1.273	.000***	1.241	.000**
Natural gas pipelines[4]	1.035	.000***	1.074	.000***	.873	.000***	1.090	.020**	1.011	.681
Product pipelines[5]	.130	.000***	.091	.000***	.232	.000***	.317	.000***	.475	.000***
Petroleum bulk storage[6]	1.024	.671	1.218	.001***	.158	.000***	1.601	.022**	1.134	.455
Gas processing plants[7]	1.006	.952	-	-	6.713	.000***	1.795	.094*	1.467	.152

*** Statistically significant at 99% confidence level
** Statistically significant at 95% confidence level
* Statistically significant at 90% confidence level
- Population type not found in proximity

[1]Sample consists of all census blocks within 0.5 mile of primary transportation corridor ($n = 1092$)
[2]Sample consists of all census blocks within 0.5 mile of a shipbuilding and/or repairing facility ($n = 335$)
[3]Sample consists of all census blocks within 0.8 mile of a crude oil pipeline ($n = 960$)
[4]Sample consists of all census blocks within 1.0 mile of a natural gas pipeline ($n = 1816$)
[5]Sample consists of all census blocks within 1.0 mile of a refined product pipeline ($n = 130$)
[6]Sample consists of all census blocks within 0.5 mile of a petroleum bulk storage facility ($n = 122$)
[7]Sample consists of all census blocks within 1.0 mile of a natural gas processing plant ($n = 30$)

Lafourche, while the African-American population is clustered in northern Lafourche. With the majority of OCS-related infrastructure located in southern Lafourche as well, the Houma Indian population is exposed to a disproportionate number of potential impacts.

This analysis also reveals that minority population is a more important factor than income in determining the degree of environmental inequity in Lafourche Parish. Discriminant analysis and multiple regression were used to examine the significance of various racial and ethnic categories, as well as economic factors such as mean household income, median contract rent, and median house value. Percentage elderly, representing another vulnerable population, was included as a control variable. The ANOVA results (Table 2) reveal that the percentage African-American and the percentage Native American are best at discriminating the hazardousness of each block group, followed by the percentage white and percentage Asian. Percentage elderly and Hispanic, as well as median contract rent, do not help to distinguish between hazardous areas at the block-group level. Mean house-

Table 2. Significance of independent variables in discriminating the hazardousness-of-place rating for block groups in Lafourche Parish, Louisiana.[1]

Variable	Wilks' Lambda	F	Significance
Percent White	.690	4.709	.001
Percent African-American	.625	6.313	.000
Percent Native American	.637	5.994	.000
Percent Asian	.758	3.356	.006
Percent Hispanic	.896	1.223	.307
Mean Household Income	.806	2.530	.029
Median Contract Rent	.932	0.763	.602
Median House Value	.869	1.581	.167
Percent Elderly	.945	0.607	.724

[1]Sample consists of all census block groups in Lafourche Parish (n = 70). The classification results reveal that the discriminant analysis correctly classified 60.0 percent of all cases using the direct method.

hold income and median house value are intermediary, although income is the more significant of the two.

Similar results were found using stepwise multiple-regression analysis (Table 3). The percentage African-American, Native American, and Asian were included in the final regression model, reflecting the clustering of these populations around infrastructure, in the case of Native Americans and Asians, or away from them, in the case of African-Americans. Income tends to be much more dispersed throughout the parish, although rent and house values do tend to be marginally lower in potentially hazardous areas of the parish.

When economic conditions were considered in tandem with ethnic factors, a slightly different pattern emerged. The economic factors had to be examined at the much coarser block-group level, which may have masked small pockets of low-income population. Despite this, when combined with block-level racial and ethnic data, we see a shift in environmental-justice areas of concern. The economic conditions in Larose are slightly better than the parish average, and the low-income

Table 3. Results of stepwise multiple linear regression analysis for Lafourche Parish, Louisiana, with the hazardousness-of-place rating as the dependent variable.

Variable	Regression Coefficient	Student's t	Prob>t
Intercept	1.524	6.029	.000
Percent African-American	-0.024	-3.289	.002
Percent Native American	0.233	4.451	.000
Percent Asian	.428	2.356	.021
Percent Hispanic	0.063	0.653	.516
Mean Household Income	0.058	0.602	.549
Median Contract Rent	-0.181	-1.994	.050
Median House Value	-0.185	-1.803	.073
Percent Elderly	-0.081	-0.876	.384

N = 70; $R^2 = 0.454$; Adjusted $R^2 = 0.429$; F = 5.550 (0.021) areas are displaced north to Lockport and south to Golden Meadow. Both of these communities have a number of minority residents. Golden Meadow is home to a sizable Houma Indian population, while Lockport contains some of the highest concentrations of African-Americans in southern Lafourche. Both of these communities have multiple OCS-related facilities as well, though not of the same scale as Larose.

Two other areas stand out as having a high proportion of low-income residents as well as a high proportion of minorities. One of these is the city of Thibodaux and the other is the small rural community of Grand Bois. Grand Bois is a small community with a high proportion of Houma Indians. There is a major shipbuilding and repairing yard located in this community, making it an area of potential concern. Thibodaux, as the largest urban center in the parish, is also home for much of the parish's low-income population. OCS-related facilities are not ubiquitous in Thibodaux, however, although it is home to a large petroleum bulk-storage facility, and pipelines do cross the surrounding area.

Analysis of High-Risk Areas

The hazards-of-place model developed in this study identifies high-risk areas in Lafourche Parish. The four areas receiving the highest ranking were Larose, Lockport, Grand Bois, and Port Fourchon. Of these four, only Port Fourchon has not had a facility report a toxic release to the USEPA. As an intermodal port, Port Fourchon is the site of a number of hazards. In addition to transferring supplies offshore, wastes brought onshore must be transferred from ship to either barge or truck and transported out of the parish. The area around Port Fourchon is sparsely populated. So, despite the hazards associated with the port, the area does not qualify as an environmental-justice concern.

Similarly, Larose hosts the greatest number of hazardous-chemical routes, including Louisiana Highway 1, the Gulf Intracoastal Waterway, and Bayou Lafourche, and is home to two large shipyards and a gas-processing plant. Larose is relatively highly populated, and is thus the most vulnerable area in the region. Larose is also home to higher-than-average populations of Houma Indians, African-Americans, Asians, and Hispanics. For this reason, Larose represents an area of particular environmental-justice concern.

One other area identified by the hazards-of-place model is Golden Meadow, which is home to a sizable Houma Indian population. The Louisiana Department of Natural Resources has also singled out the wetland areas just to the west of Golden Meadow as important to a Houma Indian community that hunts and traps the land extensively.

Conclusion

Several important findings come out of our research. Our results demonstrate that there are significant inequities in the distributions of OCS-related infrastructure and minority populations in Lafourche Parish. Other socioeconomic factors, such as income and percentage elderly, as well as median rent and house values, were not as significant as race and ethnicity in predicting the location of OCS-related infrastructure. There are clear distributional variations found across the parish, primarily between the northern and southern portions. In terms of OCS-related infrastructure, much of the onshore support infrastructure, such as shipyards, supply bases and ports, are located in southern Lafourche, where there is easy access to water-transport systems. On the other hand, the onshore support infrastructure supported by OCS activities, such as pipelines, gas-processing plants, and petroleum-storage facilities, are much more dispersed geographically, as the extracted gas and oil is transported further inland for processing and refining and the eventual transportation to the market.

The racial distribution of the population in Lafourche Parish also varies geographically with regard to the north–south divide. Southern Lafourche, in addition to housing most of the OCS-related onshore infrastructure, is home to most of the parish's Houma Indian population. This population historically settled in southern Lafourche because of the easy access to waterways and open land for hunting, fishing, and trapping. Today, the land of southern Lafourche still provides valuable habitat for many of the animal species that hunters and trappers rely on for subsistence. These lands and waterways are also vital pathways for OCS-related industries. Conversely, northern Lafourche is much more developed and densely populated. Thibodaux, the largest urbanized center in Lafourche Parish, is home to a large portion of the parish's African-American population. This population has historically not settled in the wetlands and bayous of southern Lafourche, opting instead to locate around various agricultural regions and urban centers. Asians and Hispanics, unlike both the Native American and African-American populations tend to be much more dispersed geographically, though largely concentrated along the Highway 1 transportation corridor and in the city of Thibodaux.

These findings are important, not only because they confirm the existence of social inequities in the distribution of OCS-related infrastructure in Lafourche Parish, but also because they suggest that geography and the competition for limited space is the driving force behind these inequities. Both the greatest minority diversity and the greatest potential for environmental risk can be found at the juncture of the two primary waterways in Lafourche Parish, Bayou Lafourche and the Intracoastal Waterway. Due to the fact that minority residents have lived along the waterways and bayous of southern Lafourche long before the arrival of the oil industry, the need for water transportation may have been the genesis of many of the inequities seen today.

We conclude by stating that this research is not prescriptive, nor is it aimed at mitigating inequities. Rather, the purpose of this research was to design a model that would allow us to determine whether a proposed action occurring along the Outer Continental Shelf would adversely and disproportionately affect minority or low-income individuals living in the coastal zone and beyond. When a block of land is leased in the Gulf of Mexico, the impacts are felt onshore in myriad ways, from construction of pipelines and storage facilities to building offshore platforms and ships. All of the indirect impacts of these industries must be taken into account when determining the potential effects of any agency action. The fact that certain communities may already be disproportionately affected provides researchers and analysts with valuable knowledge when deciding between proposed actions and alternative actions.

References

Allen, B. L. 2001. Saving St. Gabriel: The Emergence of a New African-American Town. *Contemporary Justice Review* 4 (2): 145–159.

Anderton, D. L., A. Anderson, J. M. Oakes, and M. R. Fraser. 1994. Environmental Equity: TheDemographics of Dumping. *Demography* 31: 229–248.

Anderton, D. L., J. M. Oakes, and K. L. Egan. 1997. Demographics of the Discovery and Prioritization of Abandoned Toxic Sites. *Evaluation Review* 21 (1): 3–26.

Atlas, M. K. 2001. Safe and Sorry: Risk, Environmental Equity, and Hazardous Waste Management Facilities. *Risk Analysis* 21 (5): 939–954.

Austin, D. 2001. Oilfield Waste, Coastal Erosion, and Development in Louisiana. In *Exploring Environmental Values and Policy in the United States: Case Studies in Arizona and Louisiana,* D. Austin and T. McGuire (eds), pp. 129–202. Tucson: University of Arizona, Bureau of Applied Research in Anthropology.

Austin, D., K. Coelho, A. Gardner, R. Higgins, and T. McGuire. 2002. *Social and Economic Impacts of Outer Continental Shelf Activities on Individuals and Families. Volume I: Final Report*. New Orleans: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study MMS 2002-022.

Been, V., and F. Gupta. 1997. Coming to the Nuisance or Going to the Barrios? A Longitudinal Analysis of Environmental Justice Claims. *Ecology Law Quarterly* 103 (6): 1–56.

Boer, J. T., M. Pastor, J. Sadd and L. D. Snyder. 1997. Is There Environmental Racism? The Demographics of Hazardous Waste in Los Angeles County. *Social Science Quarterly* 78 (4): 793–810.

Bolin, B., A. Nelson, E. J. Hackett, K. D. Pijawka, C. S. Smith, D. Sicotte, E. K. Sadalla, E. Matranga, and M. O'Donnell. 2002. The Ecology of Technological Risk in a Sunbelt City. *Environment and Planning A* 34 (2): 317–339.

Bowen, W. M., M. J. Salling, K. E. Haynes and E. J. Cyran. 1995. Toward Environmental Justice: Spatial Equity in Ohio and Cleveland. *Annals of the Association of American Geographers* 85 (4): 641–663.

Brooks, N., and R. Sethi. 1997. The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics. *Journal of Environmental Economics and Management* 32: 233–250.

Burby, R. 1995. *Through Their Eyes: Survey Results of Lower Income Residents in the Louisiana Industrial Corridor*. New Orleans: University of New Orleans Research Center.

Burke, L. M. 1993. *Environmental Equity in Los Angeles*. Santa Barbara, Calif.: National Center for Geographic Information and Analysis. 93–6.

Buzzelli, M., M. Jerrett, R. Burnett and N. Finklestein. 2003. Spatialtemporal Perspectives on Air Pollution and Environmental Justice in Hamilton, Canada, 1985–1996. *Annals of the Association of American Geographers* 93 (3): 557–573.

Chakraborty, J., and Armstrong, M. P. 1997. Exploring the Use of Buffer Analysis for the Identification of Impacted Areas in Environmental Equity Analysis. *Cartography and Geographic Information Systems* 24 (3): 145–157.

Cohen, M. J. 1997. The Spatial Distribution of Toxic Chemical Emissions: Implications for Nonmetropolitan Areas. *Society and Natural Resources* 10: 17–41.

Colten, C. E. 2001. Environmental Justice in the Big Easy? The Agriculture Street Landfill. *Environmental Practice* 3 (1): 19–26.

———. 2002. Basin Street Blues: Drainage and Race in New Orleans. *Journal of Historical Geography* 28: 237–257.

Council on Environmental Quality (CEQ). 1997. *Environmental Justice: Guidance Under the National Environmental Policy Act*. Washington, D.C.: Executive Office of the President, Council on Environmental Quality.

Cutter, S. L., D. Holm, and L. Clark. 1996. The Role of Geographic Scale in Monitoring Environmental Justice. *Risk Analysis* 16 (4): 517–526.

Cutter, S. L., J. T. Mitchell, and M. S. Scott. 2000. Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. *Annals of the Association of American Geographers* 90 (4): 713–737.

Daniels, G., and S. Friedman. 1999. Spatial Inequality and the Distribution of Industrial Toxic Releases: Evidence from the 1990 TRI. *Social Science Quarterly* 80

(2): 244–262.

Davis, D. W., and J. L. Place. 1983. *The Oil and Gas Industry of Coastal Louisiana and Its Effect on Land Use and Socioeconomic Patterns*. Reston, Va.: U.S. Department of the Interior, Geological Survey.

Dolinoy, D. C., and M. L. Miranda. 2004. GIS Modeling of Air Toxics Releases from TRI-Reporting and Non-TRI-Reporting Facilities: Impacts for Environmental Justice. *Environmental Health Perspectives* 112 (17): 1717–1724.

Forkenbrock, D. J., and L. A. Schweitzer. 1999. Environmental Justice in Transportation Planning. *American Planning Association Journal* 65 (1): 96–111.

Fricker, R. D., and N. W. Hengartner. 2001. Environmental Equity and the Distribution of Toxic Release Inventory and Other Environmentally Undesirable Sites in Metropolitan New York City. *Environmental and Ecological Statistics* 8: 33–52.

Glickman, T. S., and R. Hersh. 1995. *Evaluating Environmental Equity: The Impacts of Industrial Hazards on Selected Social Groups in Allegheny County, Pennsylvania*. Discussion Paper 95-13. Washington, D.C.: Resources for the Future.

Hallowell, C. 2001. *Holding Back the Sea: The Struggle for America's Natural Legacy on the Gulf Coast*. New York: Harper Collins.

Hemmerling, S. A., and C. E. Colten. 2004. *Environmental Justice Considerations in Lafourche Parish, Louisiana: Final Report*. New Orleans: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study MMS 2003-038.

Hughes, D. W., J. M. Fannin, W. Keithly, W. Olatubi, and J. Guo. 2001. *Lafourche Parish and Port Fourchon, Louisiana: Effects of the Outer Continental Shelf Petroleum Industry on the Economy and Public Services, Part 2*. New Orleans: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study MMS 2001-020.

Jacobson, J. O., N. W. Hengartner, and T. A. Louis. 2004. *Inequity Measures for Evaluations of Environmental Justice: A Case Study of Close Proximity to Highways in NYC*. Working Paper 29. Baltimore, Md.: Johns Hopkins University Department of Biostatistics.

Keithly, D. C. 2001. *Lafourche Parish and Port Fourchon, Louisiana: Effects of the Outer Continental Shelf Petroleum Industry on the Economy and Public Services, Part 1*. New Orleans: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study MMS 2001-019.

Kitchin, R. M., and N. J. Tate. 2000. *Conducting Research into Human Geography: Theory, Methodology and Practice*. Harlow, U.K.: Prentice Hall.

Krieg, E. J. 1998. Methodological Considerations in the Study of Toxic Waste Hazards. *The Social Science Journal* 35 (2): 191–201.

The Louis Berger Group, Inc. 2004. *OCS-Related Infrastructure in the Gulf of Mexico Fact Book*. New Orleans: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study MMS 2004-027.

Louisiana Advisory Committee to the U.S. Commission on Civil Rights. 1993. *The Battle for Environmental Justice in Louisiana*. Baton Rouge: Louisiana Advisory Committee.

Luton, H., and R. E. Cluck. 2000. *Applied Social Science in MMS: A Framework for Decisionmaking*. Unpublished. New Orleans: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region.

Mennis, J. 2002. Using Geographic Information Systems to Create and Analyze Statistical Surfaces of Population and Risk for Environmental Justice Analysis. *Social Science Quarterly* 83 (1): 281–297.

Mills, G. S., and K. S. Neuhauser. 2000. Quantitative Methods for Environmental Justice Assessment of Transportation. *Risk Analysis* 20 (3): 377–384.

Mitchell, J. T., D. S. K. Thomas, and S. L. Cutter. 1999. Dumping in Dixie Revisited: The Evolution of Environmental Injustices in South Carolina. *Social Science Quarterly* 80 (2): 229–243.

Perlin, S. A., R. W. Setzer, J. Creason, and K. Sexton. 1995. Distribution of Industrial Air Emissions by Income and Race in the United States: An Approach Using the Toxic Release Inventory. *Environmental Science and Technology* 29 (1): 69–80.

Pine, J. C., B. D. Marx, and A. Lakshmanan. 2002. An Examination of Accidental Releases from Chemical Processing Sites: The Relation of Race to Distance. *Social Science Quarterly* 83 (1): 317–331.

Pollack, P. H., and M. E. Vittas. 1995. Who Bears the Burdens of Environmental Pollution? Race, Ethnicity, and Environmental Equity in Florida. *Social Science Quarterly* 76 (2): 294–310.

Pulido, L., S. Sidawi, and R. O. Vos. 1996. An Archaeology of Environmental Racism in Los Angeles. *Urban Geography* 17 (5): 419–439.

Ringquist, E. J. 1997. Equity and the Distribution of Environmental Risk: The Case of TRI Facilities. *Social Science Quarterly* 78 (4): 811–829.

Sheppard, E., H. Leitner, R. B. McMaster, and H. Tian. 1999. GIS-Based Measures of Environmental Equity: Exploring Their Sensitivity and Significance. *Journal of Exposure Analysis and Environmental Epidemiology* 9: 18–28.

Stretesky, P., and M. J. Hogan. 1998. Environmental Justice: An Analysis of Superfund Sites in Florida. *Social Problems* 45 (2): 268–288.

United Church of Christ Commission for Racial Justice. 1987. *Toxic Wastes and Race in the United States: A National Report on the Racial and Socioeconomic Characteristics of Communities with Hazardous Waste Sites*. New York: United Church of Christ.

U.S. Environmental Protection Agency. 1998. *National Guidance for Conducting Environmental Justice Analyses*. Washington, D.C.: U.S. Environmental Protection Agency, Office of Environmental Justice.

———. 1999. *Final Guidance for Consideration of Environmental Justice in Clean Air Act 309 Reviews*. Washington D.C.: U.S. Environmental Protection Agency, Office of Federal Activities.

Verter, V., and B. Y. Kara. 2001. A GIS-Based Framework for Hazardous Materials Transport Risk Assessment. *Risk Analysis* 21 (6): 1109–1120.

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