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Conflict on the Coast: Using Geographic Information Systems to Map Potential Environmental Disputes in Matagorda Bay, Texas

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ABSTRACT / The sustainable management of coastal natural resources inevitably involves identifying stakeholder conflicts and developing planning processes that prevent these conflicts from becoming intractable disputes. This study links environmental conflict to specific areas within a large ecological system. Specifically, we use Geographic Information Systems (GIS) to map potentially competing stakeholder values associated with establishing protected areas in Matagorda Bay, Texas. By overlaying multiple values associated with a range of stakeholders across space, we are able to identify hotspots of potential conflict as well as areas of opportunity for maximizing joint gains. Mapping stakeholder conflict is an approach to proactively locate potential controversy in response to a specific environmental management proposal and guide decision makers in crafting planning processes that mitigate the possibility of intractable disputes and facilitate the implementation of sustainable coastal policies. Results indicate that under different management scenarios, protected area proposals will generate more conflict in specific areas. Most notably, regulated uses would produce the greatest degree of conflict on or near shore, particularly at the mouth of the Colorado River. Additionally, of all the management scenarios evaluated, the prohibition of coastal structural development would generate the overall highest level of conflict within the Bay. Based on the results, we discuss the policy implications for environmental managers and provide guidance for future research on location-based conflict management within the coastal margin.

Increasing population growth and urban development in the coastal margin combined with a dwindling critical natural resource base is exacerbating environmental conflicts. As available natural resources become scarcer and target areas for human activity become more concentrated, various stakeholders are brought into conflict over issues relating to conservation and development. The sustainable management of coastal and marine resources inevitably involves ongoing conflict management and dispute resolution techniques. However, with expanding population in the coastal zone, untreated latent conflicts can intensify and manifest themselves as intractable disputes that are resistant to management solutions. Intractable conflicts can be costly, time-consuming, and reduce the likelihood that policies aimed at sustainable development will be implemented.

There is a great deal of research on the process of managing environmental and natural resource conflict and techniques for resolving the most stubborn disputes. However, these events are rarely considered from a spatial perspective within the context of larger ecological and human management systems. This study ties environmental conflict to specific locations by building on the concepts and methods of multiple criteria decision-making (MCDM) and spatial decision support systems (SDSS). We identify and examine environmental conflict in discrete areas located within a

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broader natural landscape. Specifically, we use Geographic Information Systems (GIS) to map potentially competing environmental values associated with establishing protected areas in Matagorda Bay, Texas. By overlaying multiple values associated with a range of stakeholders across space, we identify areas of potentially intractable environmental conflicts. This approach serves as a rapid scanning tool with which to pinpoint specific areas of opportunity for maximizing joint gains while at the same time avoiding hotspots of conflict in the future.

The following section provides a background on three interrelated literatures supporting this study: 1) environmental conflict management and dispute resolution; 2) the use of GIS and multiple criteria decision systems to resolve environmental conflicts; and 3) establishment of coastal and marine protected areas as a source of spatial environmental conflict. The next section describes the selection of the study area, the development of a conflict mapping protocol, and the GIS calculation and mapping techniques used to analyze potential conflict. Results are then reported by interpreting a series of conflict maps based on various management objectives or scenarios. Finally, based on the results, we discuss the implications for the field of environmental conflict management and provide guidance for future research on location-based conflict management within the coastal margin.

Background

Environmental Conflict Management and Dispute Resolution

Ecologically sustainable approaches to development involve dealing with human conflict as much as if not more, than managing critical natural resources (Daniels and Walker 1996). Environment conflicts among stakeholders are based on the convergence of different values related to natural resources and environmental quality (Crowfoot and Wondolleck 1990, Wondolleck and Yaffee 2000). Although some groups or individuals believe the integrity of natural systems and their components should be maintained in perpetuity, others perceive the natural environment as a place to maximize ecosystems for human use (Stanley 1995). In a comprehensive survey, Milbrath (1984) was one of the first researchers to conclude that there are two major environmental perspectives: those who believe the environmental problem is small and that there are no limits to growth, and those who believe the environmental problem is large and that there are limits to growth. There is in fact a broad spectrum of values associated with nature that drive people's perceptions, goals, and the manner in which they act upon critical natural resources.

Conflict ignites when these fundamentally different values represented by multiple stakeholders converge around a specific problem, issue, or place. This phenomenon is often called "interdependence" where parties enter into conflict because they have interlocking values, goals, or interests (Lewicki and others 2001). Once intertwined, these interests enter into a negotiation process of mutual adjustment where a decision by one party influences the outcome of another and these outcomes can, in turn, be influenced by others (Kolb 1985). One of the major goals of identifying potential conflicts and untangling the various interdependent relationships is to understand the different environmental perspectives and how they interlock to generate conflict (Susskind and Cruikshank 1987, Crowfoot and Wondolleck 1990, Susskind and others 1999, Wondolleck and Yaffee 2000). Unraveling the interplay of multiple environmental values, goals, and interests is one step in resolving a dispute and reaching an agreement that maximizes joint gains. Under an integrative bargaining scenario, which is most typical when there are multiple parties or stakeholders engaged in conflict, resolution occurs when the best possible outcome for each party is reached (Fisher and Ury 1991, Godschalk and others 1994).

As mentioned above, coastal environmental management entails an ongoing process of conflict management, particularly in areas undergoing rapid population growth. The search for sustainable solutions often involves a tug-of-war between conservation and development interests. As critical natural resources become scarcer or economic pressures intensify, latent conflicts between various stakeholders can transform into manifest or intractable disputes. These stubborn disputes can be costly, time intensive, and generate additional conflict in the future. Most importantly, intractable disputes can lead either to poor outcomes or reduce the likelihood of the implementation of an outcome (Lewicki and others 2002). Avoiding disputes that seem to defy resolution requires proactive measures to identify the source of conflict before it intensifies into an intractable situation (Wondolleck and Yaffee 2000). Scanning the landscape for instances where stakeholder interests are most likely to come into conflict and then taking actions to prevent a future dispute is one approach to mitigating environmental disputes.

Multiple Criteria Decision Making, GIS, and Spatial Decision Support Systems

Resolving environmental disputes often requires selecting from among multiple proposed scenarios and generating a solution that satisfies the criteria of multiple interests. MCDM has been used to assist decision makers in selecting the best alternative from a number of feasible choice alternatives under the presence of multiple priorities and choice criteria (Conchrane and Zelany 1973, Voogd 1983, Jankowski 1995). MCDM is, in many ways, a dispute resolution tool because the methodology involves identifying choice alternatives satisfying the goals of multiple parties in a decision-making process and then selecting the alternative most preferred by all parties. MCDM is particularly useful when it is applied to spatial conflicts or problems involving the search for the most suitable location for a particular use, ranging from power-line (Harris 1992) and pipeline (Jankowski and Richard 1994) routes to land uses on individual parcels (Berry 1992). Recently, Hamalainen and others (2001) applied MCDM techniques to finding Pareto-optimal alternatives among multiple stakeholders for water resource management in Finland. The authors present a framework for applying MCDM to a group decision-making context that is useful for developing a conceptual and methodological basis for our study. The framework begins by screening value dimensions of various interest groups, selecting decision criteria, and defining operational, measurable attributes. Next, Pareto-optimal alternatives that best meet the interests of all parties are searched for and identified. This study is just one example of a growing literature on multicriteria approaches to environmental problem solving (Hipel and others 1997, Ridgley and others 1997, Agrell and others 1998, Tecle and others 1998, Hamalainen and others 2000).

Beginning mostly in the 1990s, scholars began to recognize that conflict is associated with location and physical space. Locational conflict arises because of differences or disagreements in values and locational perspectives with respect to how resources are to be utilized (Susskind and Cruikshank 1987). To address this issue, researchers began integrating MCDM techniques with the emerging GIS technology to develop SDSS (Jankowski 1995). SDSS are defined as an information storage and manipulation system supported by spatially referenced data that are connected to specific thematic points or polygons in a problem-solving environment (Cowen 1988, Cooke 1992, Padget 1994). The approach has been suggested as an information technology aid to facilitate geographical problem understanding for groups engaged in a locational conflict (Carver 1991, Godschalk and others 1992, Armstrong 1993, Faber and others 1995, Jankowski and others 1997, Jankowski and others 1999, Malczewski 1999, Thill 1999, Jankowski and Nyerges 2001). SDSS and associated technology is considered helpful to resolving disputes because it allows decision makers to a) integrate information representing multiple perspectives and disciplines (MachEachren 2000), b) geographically represent value differences (Jankowski and Nyerges 2001), c) consider the multiple and conflicting viewpoints as they are situated in space, and d) visualize the results of a multiple criteria analysis (Jankowski 1995). These capabilities are especially important in a negotiation situation where new scenarios need to be spatially visualized to generate joint gains for multiple parties (Godschalk and others 1992). For example, Villa and others (1996) combined MCDM approaches with GIS to conduct a multiobjective evaluation of park vegetation. The authors produced conflict maps showing the agreement between priorities specified and the features of the landscape under consideration.

Coastal and Marine Protected Areas as a Source of Spatial Environmental Conflict

The establishment of coastal and marine protected areas (hereafter referred to as marine protected areas (MPAs)) offers an ideal case to examine the intersection of environmental conflict, location, and spatial decision-making. Increasingly, MPAs are being considered important tools for promoting the conservation and sustainable use of critical natural resources in the coastal margin. In the last 20 years, MPAs have become widely accepted as places to protect, study, and wisely utilize important parts of the coastal realm (Gubby 1995). MPAs are tied to a discrete area or location within the coastal and marine environment, and act as a spatially defined management tool satisfying a variety of interests. These range from small, highly protected reserves covering only a few square miles, to larger multiple-use areas in which conservation is balanced with various socioeconomic activities.

Recently established MPAs represent a decided departure from the limited marine management tools of the past and their strong links to terrestrial park planning (Agardy 1994). This new generation of protected areas is being implemented to address a wide range of coastal and marine resource management dilemmas, such as the overharvesting of commercial fish stocks or anchor damage from recreational boaters. Policy makers are discovering that as long as management strategies are based on ecological, socioeconomic, and political realities, multiple interests can be accommodated without causing adverse impacts on ecosystem function and overall biodiversity (Agardy 1997). In this respect, MPAs serve a variety of management objectives, including 1) protecting biological diversity, 2) protecting and enhancing commercially valuable fish stocks, 3) supporting marine research, 4) promoting marine education and interpretation, and 5) providing places for tourism and recreation (Jones 1994, Agardy 1997, Klee 1999, National Research Council 2001).

Because MPAs often entail prohibiting certain human uses based on a chosen set of management objectives and can affect a wide range of interests, their establishment is often a source of intense conflict (Wells and White 1995). Multiple interests use and value the same discrete areas of the coastal and marine environment for different purposes. For example, commercial harvesters tend to fish in the same areas visited by snorkellers, boaters, and other recreationists. When these areas are protected for a specific use (i.e., recreation), it can pit users against each other, particularly if there is a perceived adverse economic impact.

A MPA proposal will affect different parts of the community in different ways. Stakeholders representing the tourist and recreation industries often are in favor of establishing MPAs because they attract large numbers of divers, boaters, and recreational fishermen. However, local community members can object to an increase in the number of visitors, as was the case in the proposed Looe Key National Marine Sanctuary in the 1970s (Clark and others 1989). Commercial fishermen usually are opposed to the establishment of MPAs because they perceive an adverse economic impact on their livelihoods. Local commercial fisherman opposed the proposed La Parguera National Marine Sanctuary in Puerto Rico because they felt that a sanctuary would affect them negatively by not allowing them to fish. As a result, the protected area was never established (Fiske 1992).

The use of MCDM and SDSS techniques has shown promise for locating the least contentious areas for the establishment of MPAs impacting multiple parties. Villa and others (2001) argue that "systematic, objective approaches to site selection and design can help reconcile conflicting interests, represent stakeholder viewpoints fairly and evenly, and extend the scope of planning studies from single reserves to networks" (p. 515). The authors used spatial multiple criteria analysis to integrate objective data with the contrasting priorities of different stakeholders in the planning of a marine protected area in Italy. The results of the analysis were used to locate optimal spatial arrangements for marine protection under different scenarios. Available spatial data were aggregated into five higher-level variables representing values related to environmental, economic, and social influences in the study area. Spatial analysis of value-based variables produced stakeholder conflict maps, which formed the basis of a MPAs zoning plan. Our study builds on the analytical techniques used by Villa and others (2001) by mapping and analyzing overlapping values within a discrete geographic area, but has several important differences. First, our study is more concerned with identifying potential hotspots of stakeholder conflict, not selecting a site for a future MPA designation. Second, our study identifies conflict to guide future management decisions, not to develop a zoning map with specific design requirements. Finally, unlike Villa and others (2001), this study does not weight spatially derived values based on the opinions of select stakeholders. Instead, we leave the incorporation of subjective weights to the stakeholders using these mapping techniques in the context of an actual dispute.

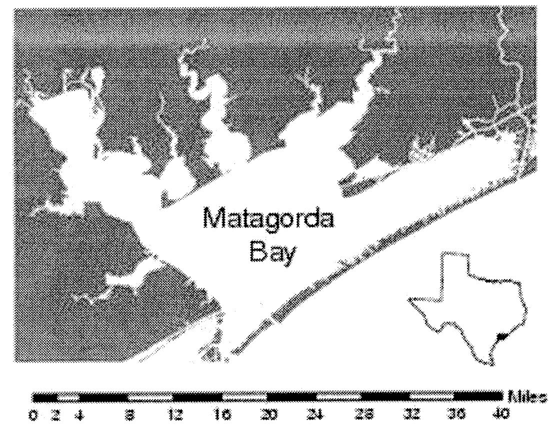

Figure 1. Location map of the study area, Matagorda Bay, Texas.

Methods

Study Area

We selected Matagorda Bay as the study area in which to proactively identify spatial environmental conflict for the following reasons: 1) the Bay is an area of high marine biodiversity and critical habitats; 2) a wide range of interests and associated stakeholders use the Bay for a variety of purposes including commercial fishing, recreational fishing and boating, tourism, transportation, research, and structural development; 3) although the Bay is relatively undeveloped and undisturbed by anthropogenic activities, it is slated for future population growth, making it an ideal place to identify latent conflict that could become manifest or intractable.

Matagorda Bay is one of seven major estuarine systems in the central region of the Texas Gulf coast (Figure 1). Its surface area is estimated at 352 square miles, second in size to Galveston Bay to the north (Texas Parks and Wildlife Department, 2003). Matagorda Bay is recognized for its high productivity of finfish and shellfish, making it an economically important commercial and recreational fishery. There are several existing protected areas in Matagorda County, including Big Boggy National Wildlife Refuge, the Matagorda Island Wildlife Management Area, the Runnels Family Mad Island Marsh, and Nature Conservancy properties.

The Matagorda Bay area experienced significant population growth between 1970 and 1980 that leveled off toward the end of the 20th century. In 2000, the U.S. census estimated that approximately 157,000 residents lived in the counties bordering the Bay. This population is expected to increase significantly over the next several decades. The economy in Matagorda Bay area is based on a combination of activities including agriculture, petrochemicals, nuclear power, plastics, oil and gas, and oilfield services. Recreational activity is also an important economic force, supported by multiple opportunities for boating, fishing, and bird watching in the Gulf of Mexico.

Selection of Stakeholder Values and Management Objectives

As done in Villa and others (2001), we aggregated spatial data to form the following seven values most likely associated with various stakeholders present in the Matagorda Bay region: 1) critical habitat; 2) economic, 3) coastal land development, 4) offshore transportation and development, 5) knowledge and education, 6) recreational enjoyment and aesthetics, and 7) commercial bioproductivity. Each value comprises multiple spatial data layers collected primarily from public agencies. The seven values and their corresponding spatial data layers are listed and described in Table 1. The environmental values and the spatial data layers are not intended to be an exhaustive list, but instead represent the potentially major values of stakeholders in Matagorda Bay as measured by the best available existing spatial data. Along these lines, our study spatially identified a range of values most likely representing the interests of those relying on the Bay's coastal and marine resources, but did not rely on the input from actual stakeholders. The focus was thus on mapping a set of commonly held values, not the positions of specific stakeholders.

Spatial data were collected from the Texas General Land Office and the Texas Natural Resource Information System. For example, habitat and biodiversity data were used to delineate areas critical to ecosystem function and health in Matagorda Bay. Recreational and coastal land development data, such as point locations of beach access, boat ramps, and marinas, were collected to assess areas for recreation and aesthetic enjoyment. Spatial data delineating shipping channels, land transportation routes, and anchorage areas were used to assess offshore transportation and development values in the study area. In some cases, the same spatial data layer was used to measure more than one value.

All spatial data were assembled into a GIS. The study area encompassing Matagorda Bay was divided into a 2,100-km^2 grid with each cell measuring 1 km^2. All data were projected and rectified to Universal Transverse Mercator, Zone 14, and North American Datum 1983. Values were measured by assigning a binary numeric field indicating the occurrence of data associated with a value layer for each cell of the grid. If spatial data associated with a value were present, the cell was coded as 1; if there was an absence of spatial data, the cell was assigned a 0. Because the number of spatial data layers comprising a value varied, we weighted the final value score by the number of spatial data layers so that different values can be compared. That is,

$$Y_i = 1/\mathrm{N}\Sigma \mathrm{Z_i}, \tag{1}$$

where Y_i is the ith of seven stakeholder values, $\mathrm{Z_i}$ are the spatial data layers, and N is the number of spatial data layers comprising a stakeholder value.

To simplify the computational process and interpretation of results, we did not weight or scale individual spatial data layers, but recorded only the presence or absence of value information for a particular cell. An alternative approach could have been to weight each spatial layer by the percentage of area it occupies within a specific cell. However, the form and scale of the data did not permit such a detailed analysis, nor was it appropriate given the broad scale of our study. We could have also weighted spatial data layers by their relative importance. However, we did not want to introduce this level of subjectivity into the analyses. Such weighting assignments should instead be conducted in a group setting with input from multiple stakeholders. In any case, the range of alternative statistical and computation techniques available for examining stakeholder values should not be ignored and may provide guidance for future studies in Matagorda Bay or other ecological systems.

Once binary numeric codes were defined for all values and corresponding cells within the study area grid, we derived four management objectives or protection scenarios with which to evaluate the response of specified values. Each objective applies to a major human use or activity that is often regulated through the establishment of MPAs. These regulated uses include 1) commercial fishing, 2) transportation and offshore industry, 3) coastal structural development, and 4) recre-

Table 1. Environmental values and corresponding spatial data layers for matagorda Bay

Values	Spatial data layer	Description
1. Critical habitat	Rookery areas	Locations of waterbird rookery sites in the coastal counties of Texas
	Audubon sanctuaries	Coastal tracts containing waterbird colonies leased to the National Audubon Society
	Priority protection habitat areas	Coastal habitat areas to be protected during oil/hazardous material spills
	Seagrass areas	Seagrass beds and areas of submerged vegetation mapped
	National wildlife refuges	Approximate boundaries of national wildlife refuge lands
	Oyster reefs	Oyster reefs mapped
	Waterways/ship channels	Dredged shipping channels in coastal waters
	Boat ramps	Locations of public boat ramps on the Texas coast
2. Economic	Anchorage areas	Offshore anchorage areas
	City Limits	Boundaries of municipalities in coastal counties
	Aquaculture facilities	Locations of aquaculture operations on the Texas coast
	Marinas	Public (and some private) marinas on the Texas coast
3. Coastal land development	Cabins	Permitted cabins in state-owned waters
	Beach access points	Public beach access points
	Marinas	Public (and some private) marinas on the Texas coast
	Boat ramps	Locations of public boat ramps on the Texas coast
	City limits	Boundaries of municipalities in coastal counties
4. Offshore Transportation & development	Dredged material Placement sites	Areas designated for placement of spoil from dredging of ship channels and the Intercoastal Waterway
	Waterways/ship channels	Dredged shipping channels in coastal waters
	Anchorage areas	Offshore anchorage areas
	Navigation districts	Boundaries of land and coastal bay areas owned by navigation districts
	Coastal leases	Locations of structures and activities on state-owned land and waters
	Offshore oil/gas platforms	Oil/gas platforms in federal waters of the Gulf of Mexico
	State parks/wildlife mgmt areas	Boundaries of state parks and wildlife management areas owned or managed by the TPWD.
5. Knowledge & Education	Rookery areas	Locations of waterbird rookery sites in the coastal counties of Texas
	Audubon sanctuaries	Coastal tracts containing waterbird colonies leased to the National Audubon Society
	National wildlife refuges	Approximate boundaries of national wildlife refuge lands
6. Recreational enjoyment and aesthetics	City and county parks	Selected city and county parks on the coast
	Beach access points	Public beach access points
	Marinas	Public (and some private) marinas on the Texas coast
	Boat ramps	Locations of public boat ramps on the Texas coast
	State parks/wildlife mgmt. areas	Boundaries of state parks and wildlife management areas
7. Commercial bioproductivty	Species/habitats	Coastal distribution of animals, plants and habitats potentially at risk from oil spill damage activities
	Oyster reefs	Oyster reefs mapped

ation and tourism. The four uses selected for this study are not intended to be inclusive of all uses taking place in the Bay area, but provide a starting point for evaluating how stakeholder values may conflict based on several protection/management scenarios.

Decision-Making Protocol for Determining Value Responses

We developed a decision-making protocol to evaluate the responses of the seven values for each manage-

Table 2. Summed spatial conflict scores (SCS) by management scenario

Management scenario	Positive count	Neutral count	Negative count	Total SCS
Commercial fishing	2857	11,468	−333	2524
Recreation and tourism	2776	11,389	−493	2283
Transportation and offshore industry	2857	10,866	−935	1922
Coastal structural development	2691	10,951	−1016	1675

ment scenario. The development of the protocol was guided by asking the question: *if a cell were closed to a particular use (management scenario), how would the corresponding values respond?* We answered this question for each of the four management scenarios defined above and evaluated stakeholder value responses in the following manner: if a value benefits or increases, then it received (+1); if a value is adversely impacted or decreases, then it received (−1); and if there is no effect on a value, then it received (0). By using if/then logic statements, we could identify an increase, decrease, or null effect for stakeholder values in response to the closure of a cell for a particular use. For example, closing a cell to commercial fishing would increase commercial bioproductivity by reducing bycatch, allowing fish stocks to naturally recover, and protecting critical fish habitats from further adverse impacts. The decision-making protocol for each management scenario is presented in Appendix A (Tables a through d).

Next, we calculated a spatial conflict score (SCS) for each cell (c_i) in the study area grid by summing across all stakeholder values (y_i) for each management scenario (x_i). That is,

$$\mathrm{SCS} = c_i \sum_{i}^{7} y_i, \tag{2}$$

where SCS is the spatial conflict score for each cell, c_i indicates whether the cell is open (0) or closed (1) for a specific management scenario, and y_i are the stakeholders values.

The SCS represents areas of maximum joint gain between competing stakeholder values. Higher scores represent cells that have the greatest potential for agreement among competing interests and low (or negative) scores represent cells with the greatest potential for intractable environmental conflict. For example, if a cell is closed to transportation uses and the sum of the seven values calculated for that cell is 3, then there is likelihood that there will be strong stakeholder agreement over the management decision in that area. Once a SCS was calculated for every cell in the study area grid, we mapped these scores for each of the four management scenarios using GIS. This phase of analysis produced a series of maps showing where in the study area conflict is most likely to occur in response to a proposed MPA. We also recorded the number of positive and negative values for each cell, which provided more information about the degree and nature of conflict. Null effects were not recorded nor reflected in map legends. In addition to calculating the SCS for each cell, we summed the scores for all cells in the study area by management scenario. This procedure allowed us to broadly measure and compare the potential level of conflict generated for the entire study area by a particular regulatory use closure.

Results

Total Conflict Scores by Management Scenario

Table 2 lists the summed SCS for all cells in the study area and provides a broad overview of the potential level of conflict generated by several management/protection scenarios. Closing Matagorda Bay to commercial fishing would cause the least amount of stakeholder conflict, primarily because so much of commercial fishing grounds are not utilized by other parties, as indicated by the high count of neutral cells (cell where the net value remains 0 in response to a proposed use closure). Regulation of recreation and tourism uses would also generate a comparatively low level of conflict. In contrast, a management scenario that prohibits coastal structural development has the lowest total SCS and the highest degree of stakeholder conflict compared to all other use closures. The large number of cells with negative value counts suggests that multiple stakeholders will be negatively affected and opposed to protecting the Bay from coastal development. Based on these initial results, focusing a coastal and marine protected areas program on prohibiting commercial fishing may generate the lowest level of stakeholder conflict in Matagorda Bay.

Conflict Scores Within Each Management Scenario

Although evaluating the sum of all cell values for a particular management scenario is useful as a broad indicator of conflict, it is more important to examine

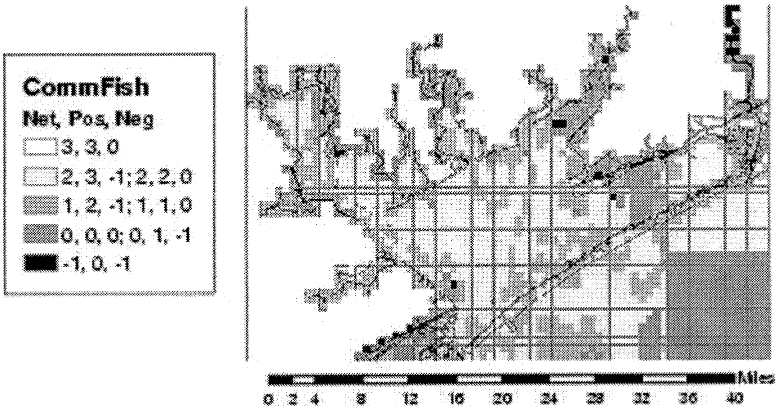

Figure 2. Maps showing the net, number of positive, and negative effects due to management by closure to commercial fishing. (Net: number of positive minus number of negative effects; Pos: number of positive effects; Neg: number of negative effects).

the degree and location of conflict within each management objective. In general, protected areas that prohibit or strictly regulate commercial fishing will create stakeholder conflict primarily in near shore areas and where tributaries feed into the Bay (Figure 2). Because the most productive commercial fishing grounds (particularly shellfish) tend to occur in more shallow areas close to shore, use closures in these areas could create the greatest conflict for commercial fishing stakeholders and economic interests relying on commercially valuable fish species. In contrast, parties valuing critical habitat, recreation, and increased scientific knowledge would benefit from MPAs prohibiting commercial fishing. Areas of the greatest stakeholder concordance, or spatial opportunities to site MPAs using this management objective tend to occur further offshore towards the center of the Bay. Presumably, these areas represent low levels of stakeholder conflict because they are least suited to coastal structural development and commercial fishing.

Of special interest is an area in the northeast portion of the study area where the Colorado River drains into the Bay. Establishing MPAs that are closed to commercial fishing would generate the most intense conflict in the upper reaches of the river but at the same time provide the greatest opportunity for joint gain in an area adjacent to the river's mouth. Spatial conflict in this instance is driven primarily by the presence and frequency of economic-oriented values, particularly shipping channels and associated marinas. Discordance may arise in this area because the negative impact to stakeholders with economic values far outweighs the marginal positive benefits to ecological values. When examining the counts of net positive and net negative values, it becomes apparent that although the level of conflict in the river is the highest in the study area, it is comparatively low compared to other management scenarios. The highest level of spatial conflict under this scenario is represented as -1, where there are no net positives and only one net negative (all other values have a null effect).

In contrast, the area adjacent to the mouth of the Colorado River has an overall net gain of 3 with no net negative counts. This area is not as important to economic values, but instead favors values associated with scientific knowledge, recreation, and commercial bioproductivity. Commercial fishing use closures in this area would provide the greatest benefit to the stakeholders who value critical habitats, recreational uses, and scientific knowledge while having a minimal negative impact on those stakeholders with economic interests. Without potentially conflicting economic interests, conflict in this adjacent area is significantly reduced.

Based on the mapped results, MPAs that prohibit marine transportation and offshore industry (i.e., oil platforms) will generate the highest level of spatial conflict in the following three areas: the Colorado River entering into the northeast part of the Bay, an inshore area in the western part of the Bay, and a coastal area at the Bay's southern mouth (Figure 3). The areas of potential stakeholder conflict coincide with locations of marinas used for commercial transportation where shipping traffic is the heaviest. Compared to spatial conflict over commercial fishing use closures, potential stakeholder conflict for marine transportation and offshore industry is more intense. The lowest total SCS in this case is -2 with three net negative values and only one net positive. Areas of concordance or opportunity to site MPAs regulating shipping lanes and oil/gas platforms occur for the most part in the center of the Bay and in an area in the far northwest part of the Bay. In these lighter shaded areas, there are no negatively impacted stakeholder values, suggesting that they are the most suitable areas for establishing MPAs that protect sensitive areas from shipping with the least amount of controversy.

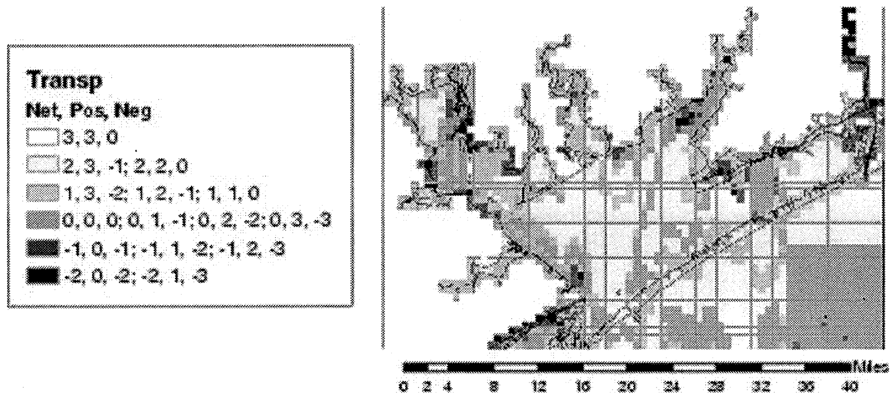

Figure 3. Maps showing the net, number of positive, and negative effects due to management by closure to transportation. (Net: number of positive minus number of negative effects; Pos: number of positive effects; Neg: number of negative effects).

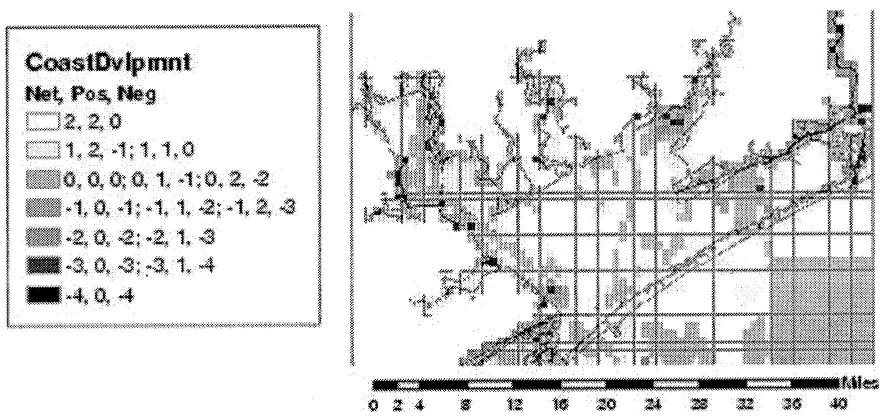

Figure 4. Maps showing the net, number of positive, and negative effects due to management by closure to coastal development. (Net: number of positive minus number of negative effects; Pos: number of positive effects; Neg: number of negative effects).

Establishing MPAs prohibiting coastal structural development will generate stakeholder conflicts primarily on the shoreline, leaving much of the Bay in concordance over this use closure (Figure 4). However, when spatial conflict does occur, it is the most intense of any management scenario evaluated in this study. Residential or commercial development often impacts critical habitats and commercial bioproductivity more negatively than other activities because of necessary site disturbance. The most intense potential conflict receives a total SCS score of -4 with no net positive stakeholder values. These hotspots of possible conflict coincide with marinas, boat ramps, and city limits where much of the development tends to take place. Areas near shore or on the coastline where there is the least amount of conflict (no net negative values) are located in the far western part of the Bay and where Garcitas Creek enters Lavaca Bay in the northwestern-most portion of the study area. This section of the study area contains values for critical habitat and commercial bioproductivity, most notably commercially important species and priority protection habitats. The closure of these cells to coastal structural development does not pose the same spatial conflict as the other near-shore hotspots for this use category because values associated with economics, coastal development, or recreation and enjoyment are not present in this area.

Finally, establishing MPAs that protect critical habitats against the adverse impacts of recreation and tourism would generate the most intense stakeholder conflict along the coast, where beach access points and boat ramps are located (Figure 5). Most of the tourism in Matagorda Bay is in the form of boating and recreational fishing. Not allowing visitors entry into the waters or prohibiting adjacent commercial development would create controversy and most likely prevent the establishment of an MPA under this management scenario. Specific potential hotspots of conflict occur at locations to the east and west of the study area (light shaded cells) where there is the heaviest concentration of boat ramps or beach access points. Once away from the shoreline, however, there are ample areas of stakeholder agreement where the presence of recreational boaters may not interfere with commercial and industrial activities.

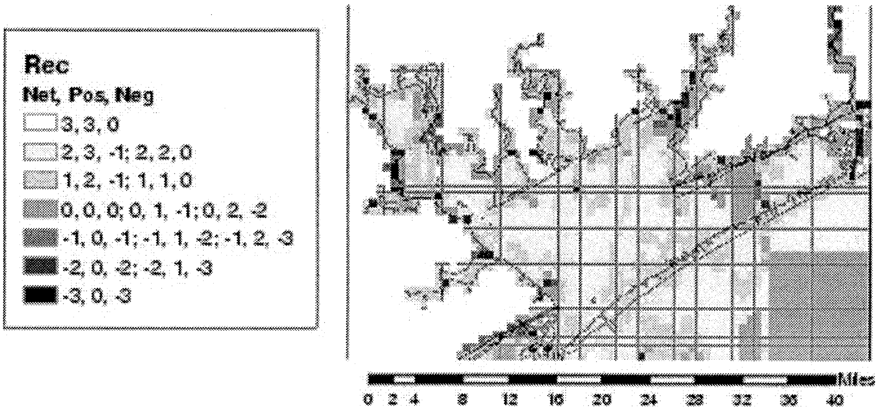

Figure 5. Maps showing the net, number of positive, and negative effects due to management by closure to recreation. (Net: number of positive minus number of negative effects; Pos: number of positive effects; Neg: number of negative effects).

Summary and Policy Implications

Mapping potential stakeholder conflict for the four management scenarios across Matagorda Bay reveals several important trends. First, as might be expected, proposing a MPA in coastal or near-shore areas would produce the greatest level of spatial conflict. Coastal areas are the focal point for a wide range of stakeholders with potentially competing goals or interests. Conflict is further exacerbated because human activities on or near land tend to generate significant adverse environmental impacts from clearing of vegetation, grading, the creation of impervious surface, and other activities that alter a natural landscape and decrease its ecological value. The coastline thus becomes a potential hotspot of conflict where, given the right conditions, there can be a collision of stakeholder values.

Second, the Colorado River entering the northeast part of the Bay is consistently an area of potentially intense conflict across all management scenarios. Underlying these spatial conflicts is the presence of one of the Bay's few dredged shipping channels and large marine transport access routes. The closure of cells in this area to various uses has the potential for economic loss due to lack of access to other areas of the bay, denial of commercial fishing opportunities in the deeper waters of the Gulf of Mexico, and recreational losses from limited public access.

Interestingly, coinciding with this shipping channel are priority protection habitats leading into the mouth of the Colorado. The intersection of multiple stakeholder values and interests in a confined geographic space thus produces a potential hotspot of conflict across multiple use closures.

Third, the middle of the Bay generally contains areas of maximum stakeholder concordance and perhaps the best opportunities to establish MPAs. Aside from shipping and offshore oil platform activities, use closures in these areas do not negatively impact stakeholder values to the same degree as on the coastline. Of course, using a lack of potential conflict as the main criteria for designating a MPA may lead to the protection of areas that need it the least. It is often the case that, for political reasons, protected areas are established in unbuildable and unwanted regions rather than in locations that contain the most important critical natural habitats from an ecological perspective. The intent of this analysis is not to suggest that stakeholder conflict should guide the establishment of MPAs, but rather to proactively use spatial conflict as a tool to understand the degree of controversy associated with a particular MPA proposal and develop planning processes accordingly.

Finally, closing areas to coastal structural development is a management scenario that incites the greatest degree of potential conflict among stakeholders. Regulating land use, particularly for residential and commercial development, has a history of stakeholder conflicts (Crowfoot and Wondolleck, 1990, Godschalk, 1992, Godschalk and others 1994, Susskind and others 1999). We believe it is the most controversial use in our study because restricting coastal development in the form of protected areas often translates into a perceived economic loss by the private sector and offends private property rights advocates. In addition, the type of use impacts a broad range of stakeholders, increasing the probability that there will be competing interests.

As indicated above, the purpose of this study is not to develop a site selection support system for establishing MPAs, but a rapid scanning technique to identify and mitigate potential stakeholder conflict within a large landscape. Using GIS to predict spatial environmental conflict and locate opportunities for maximizing joint gains may facilitate proactive planning processes, which reduce the likelihood that initial management proposals will lead to intractable disputes. Although this study focuses on Matagorda Bay, the approach to mapping conflict can be applied to other ecological systems around the world. The technique is not limited by jurisdictional or political boundaries, but by available spatial data.

Understanding exactly where hotspots of conflict are most likely to emerge in response to a protected areas proposal can alert policy makers to avoid those areas or to craft a nomination process that includes conflict management and alternative dispute resolution techniques. Developing an inclusive planning process that tempers disagreement among stakeholders should increase the probability that the protected areas nomination will be implemented once it is adopted (Gray 1989, Crowfoot and Wondolleck 1990, Godschalk and others 1994, Gilman 1997, Innes 1996). Mapping environmental conflict thus is not a substitute for collaborative planning approaches that stress the participation of key stakeholders, but a tool that can guide planners and planning participants in making informed policy decisions. Using this method in a collaborative context, where different stakeholders can understand how their own interests relate to specific locations and where they might conflict with others, may be its most effective application.

Conclusions

Using GIS to identify and map areas of potential stakeholder conflict within a large landscape can facilitate proactive planning processes that mitigate intractable disputes and enhance the implementation of sustainable policies. Applying this technique to locate possible conflict in response to MPAs designations using a variety of management scenarios provides insight for planning in Matagorda Bay and other ecological systems, particularly in the face of future population growth and development. However, no study is without limitations, and this one is no exception. First, the range of values and management scenarios are not fully representative of all possible conflicts, but a first step in testing the efficacy of the mapping technique. Second, as is usually the case, stakeholder values are not mutually exclusive, thus making interpretation of the results more difficult. Third, differences in the specificity of spatial data layers is a limiting factor in measuring values. For example, although exact locations of boat ramps are available in digital format, the same level of specificity is not available for commercial fish species. As with most exploratory GIS analysis projects, it is cost prohibitive to develop multiple data layers geared to the specific needs of the research. Fourth, combining spatial data layers with different levels of specificity and from different sources compounds spatial error. Spatial data, in all cases, are merely representations of reality and no data are free of error (Openshaw 1989). Because we were mapping broad areas of stakeholder conflict, not specific sites for locating MPAs, this limitation is less severe. Fifth, the calculation of SCSs was based on the best available data and information; analyses were limited to existing publicly available spatial data layers. Finally, the grid system in our study used a relatively coarse resolution (1 km^2). The use of finer gird cells would increase the specificity of the results. However, the quality of existing data did not support the use of smaller grid cells.

Although this study provides an initial examination of the connection between multivalue stakeholder conflict and specific locations within a natural landscape, further research is needed on the topic. Specifically, our study uses relatively simple methods for measuring the response of values and conflict vectors (increase, decrease, and null effect). More sophisticated methods for scaling and weighting spatial data that can be understood by decision makers and the public would refine the measurement of spatial conflict. Also, the series of conflict maps needs to be more thoroughly tested against the interests of actual stakeholders within the study area.

Validating the graphic results through surveys or personal interviews would add insight into the accuracy and usefulness of the mapping techniques. Most importantly, the methods described in this article need to be applied in an actual planning exercise where planners and planning participants use conflict maps to guide the planning process. Only then can the effectiveness of using GIS to identify potential conflict be fully explored.

Appendix A:

Decision-Making Protocol for Management Scenarios/Use Protection

Table a. Decision-Making Protocol of Uses: Commercial Fishing

Value	Impact	Justification
Critical habitat and	Decrease	Activities causing adverse impacts, including shrimp trawling resulting of seagrass and benthic habitats; fucling and emissions associated with vessel operations may have some effects on habitats; prop wash and prop scars damage seabeds and aquatic life; vessel wake causes erosion and destruction of coastal plant communities; bycatch reduces populations of endangered species and fish stock that are feeding sources for T/E species
Commercial bioproductivity	Increases	Bycatch reduction: increases to general fishstock; increases associated with protection of critical habitat through use closure increase bioproductivity
Economics	Decrease	Loss of commercial fishing income
Coastal development	Null	Impacts may be positive or negative depending on degree of closure throughout region
Offshore development	Null	No impact
Recreation and enjoyment	Increases	Potential of fish stocks allows for more recreational fishing opportunities; increases of critical habitats provide for ecotourism locations
Knowledge and education	Increase	Increases of fish stock and associated biodiversity allow for additional opportunities for research activities

Note: Commercial Activities–Commercial fishing defines catching and harvesting of fish, shrimp, shellfish, or other species that are sold for income. Such activities typically will utilize catch devices that can be destructive to critical habitats and are allowable only by permission and/or permits. Other activities necessary to commercial development such as dredging and waste disposal are also allowed with permission and/or permit.

Table b. Decision-making protocol of uses: recreation and tourism

Value	Impact	Justification
Critical habitat	Increase	Boating activities may result in the degradation of seagrass and benthic habitats; fueling and emissions associated with vessel operations may have negative effects on habitats; prop wash and prop scars can damage seabeds and aquatic life; vessel wake can cause erosion and destruction of coastal plant communities
Commercial bioproductivity	Increase	Reduction of disturbance from recreational activities increases fish stocks and associated bioproductivity
Economics	Decrease	Loss of income due to use restrictions
Coastal development	Decrease	Reduction of visitors due to prohibition of recreational and tourism uses
Offshore development	Null	No impact
Recreation and enjoyment	Decrease	Closure to recreation and tourism
Knowledge and education	Increase	Increase due to possible availability of research sites.

Note: Recreational Activities—Fishing, bird watching, camping, windsurfing, jet sking, swimming, waterfowl hunting, kayaking, canoeing, sailing, power boating.

Table c. Decision-making protocol of uses: transportation and offshore industry

Value	Impact	Justification
Critical habitat	Increase	Fueling and emissions associated with vessel operations may have negative effects on critical habitats; prop wash and prop scars can damage seabeds and aquatic life; vessel wake may cause erosion and destruction of coastal plant communities; adverse impacts of anchoring, invasive species, and dredging
Commercial bioproductivity	Increase	Adverse impacts of anchoring, dredging, and invasive species are reduced
Economics	Decrease	Loss of economic gains associated with transportation and energy production activities

Value	Impact	Justification
Coastal development	Decrease	Land-based development associated with affected offshore industries may decrease as a result of use closure
Offshore development	Decrease	Offshore development will decrease with closure of areas to offshore industry usage
Recreation and enjoyment	Increase	Overall, recreation and enjoyment will increase, given increased protection of critical habitat and commercial bioproductivity resulting in opportunities for ecotourism and sport fishing
Knowledge and education	Increase	Adverse impacts of anchoring, dredging, and invasive species are reduced, increasing possible availability of sites for research and education

Note: Transportation and Offshore Industry—Activities including commercial transportation and those surrounding transportation such as dredging, dredge spoil dumping, offshore oil and gas exploration and removal.

Table d. Decision-making protocol of uses: coastal structural development

Value	Impact	Justification
Critical habitat	Increase	Limitations on land-based development will increase protection of critical coastal habitats.
Commercial bioproductivity	Increase	Increases protection of critical habitats associated with coastal structural development; limits may enhance commercial bioproductivity of affected species
Economics	Decrease	Economic benefits associated with land-based commercial activities will be negatively impacted by limits to coastal structural development
Coastal development	Decrease	Coastal development will decrease with restrictions on coastal structural restrictions.
Offshore development	Null	No impact
Recreation and enjoyment	Decrease	Infrastructures associated with recreational activities (e.g., hotels, shops, restaurants) will be restricted with closure to coastal structural development use
Knowledge and education	Null	No impact

Note: Development—Commercial and residential development is distinguished into two use categories to allow certain commercial development for tourism and recreational activities. Residential development is prohibited within the buffer or general use zone, but is allowed within the zone of influence (CZM) under the appropriate authorizing party.

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