EVALUATING VESSEL SPEED RESTICTIONS TO MITIGATE IMPACTS TO MARINE MAMMALS IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY

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BACKGROUND

Stellwagen Bank National Marine Sanctuary (SBNMS), located off the coast of Massachusetts, is recognized as one of the primary feeding grounds of the humpback whale and seasonal habitat for the endangered northern right whale. However, the Sanctuary is also used for fishing, boating, marine transportation, and whale watching, each of which has the potential to negatively impact marine mammals. Specific objectives and strategies relative to such conflicting uses are outlined within each sanctuary's management plan, a long-term, detailed operational plan that integrates current science and management policies.

The National Oceanic and Atmospheric Administration's (NOAA) Office of National Marine Sanctuaries (ONMS) is required by law to review these management plans periodically to ensure that individual sites continue to protect and enhance their living and cultural resources and that any potential changes in science, management priorities, and resource issues are incorporated. This is a participatory, community-based process in which ONMS relies heavily on its local constituents to generate an initial list of concerns.

In 1999, SBNMS initiated the formal review of its plan and, as a result, collected thousands of comments. One recurring theme relates to the impacts of human activities on marine mammals (SBNMS 2002). This has been a concern for sanctuary staff as well, since many cetaceans within the local population exhibit propeller scars or gashes indicative of a ship strike. In addition, studies have shown that the northern right whale exhibits the highest incidence of mortality from vessel collisions – possibly a result of behavioral patterns that render these animals vulnerable and/or unresponsive to approaching vessels.

ADDRESSING THE ISSUE

Sanctuary staff and advisory councils are responsible for creating management objectives that address priority issues raised during the comment periods (e.g., marine mammals) and to evaluate potential changes in policy or regulatory guidance that could serve to mitigate impacts. In order to reduce the probability and severity of vessel collisions, SBNMS began to investigate the implementation of speed restriction zones. Existing literature suggests that "the most severe and lethal injuries [to marine mammals] caused by ship strikes appear to be caused by vessels traveling at 14 knots or above" (Laist *et al.* 2001). For this reason, it was proposed that limiting high speed traffic through regions of high whale density could have the dual benefit of less total strikes (given the additional time to react) and a lower probability that a given strike would be fatal. Still, staff must

balance the interests of disparate user groups and attempt to mitigate the economic impact imposed by potential speed zoning.

SBNMS partnered with the NOAA Coastal Services Center (Center) to design and automate spatial analyses that allow for the evaluation of a suite of zoning alternatives based on the potential of each to reduce the risk of injury and mortality to cetaceans, while minimizing economic impact to the user community. Designed for use by the sanctuary advisory committee, the tool allows speed zones to be tested against any number of vessel routes, speeds, and operating costs. It returns relative economic impact values that will, in turn, help the group design the most effective speed zone scheme with limited economic impact.

WHALE DENSITY DISTRIBUTION

Two non-governmental organizations in the Northeast were able to provide conditional access to 20 years of whale sightings data within the sanctuary. Correction factors were applied to normalize the data for effort and address concerns relative to the opportunistic nature of these sightings. In addition, two years of scientific transect data were collected within the sanctuary that could be used not only to validate the 20-year database but also to provide a data resource that would be able to support more scientific analyses.

A density grid was created for each database to highlight areas within the sanctuary toward which management measures should be focused. However, the data contained within this density grid are not used in subsequent economic impact analyses. Rather, the grid is provided as a visual reference to determine specific regions within the Sanctuary in which the implementation of speed zones would be most effective to mitigate vessel collisions. Using ArcGIS® 8.2, a geographic information system (GIS) software package created by Environmental Systems Research Institute, the density of points within each $1nm^2$ grid cell was calculated and assigned a value. Although a much smaller grid cell size could have been applied for a more visually pleasing output, the data were more accurately represented at the coarser scale. For migratory species, while a sighting is noted at a particular latitude and longitude, the animal is actually moving throughout that area so the more conservative representation is sometimes preferred.

Within the ArcGIS Spatial Analyst extension, a variety of statistical options are available to perform density calculations; however, due to the predictive nature of some of these other options (e.g., kriging and spline), the standard density calculation was preferred to represent the transect data. Because a whale sighting is not a static or stationary event, the validity of projections or interpolations based on these observations would be questionable. To calculate the density of whale sightings, all points contained within a pre-defined search radius were summed and divided by the area of the circle in area units. In this way, no assumptions are made relative to locations in which non-observed whales may exist based on apparent patterns in the data. Rather, the density grid represents the observed “hot spots” in which whales are known to congregate.

ECONOMIC ANALYSES

With the density grid completed, Center staff began to develop an analysis tool that could be used to design and evaluate potential zoning options. The tool automates certain functionality contained within the ArcGIS Spatial Analyst extension to manipulate a series of grids and execute the economic analysis based on a few predefined parameters. The basic principle on which the analysis is based is simply the fact that additional travel time resulting from a reduced transit speed will translate into an increased operating cost per trip.

A base speed grid was created to evaluate the speed at which a vessel travels through the sanctuary and to calculate the total distance traveled. The grid was produced with a known cell size of 0.1nm; therefore, the program can very simply monitor path and distance traveled as cells are selected. To account for variability in "normal" or average speeds based on vessel type, the user is required to designate an initial travel speed in knots. Each cell within the entire speed grid is then assigned this value so that, wherever the user travels throughout the study area, this speed will be applied unless a restricted zone is encountered. The grid now contains information regarding distance and speed – two key parameters in the final calculation.

In order to create speed restriction zones, the user selects from a range of available speed restrictions and draws the outer boundary of the zone on-screen, encompassing the area of interest (most likely, a high-density region). The tool then recalculates the speed value for all grid cells within the boundary of this zone from the initial travel speed to the restricted speed. Users are permitted to define as many zones as necessary to complete a particular scenario.

In order to design an analysis that is as realistic as possible and to accommodate differences among the various user groups within the sanctuary, it was necessary to allow the user to interact with the tool and draw a transit path through the sanctuary that best represents an actual trip taken (Figure 1.). As the ship track is drawn on-screen, each cell through which the user traveled is selected and its speed value is extracted. With the speed, distance, and path defined, the final parameter required to complete the economic impact analysis is vessel operating cost. If the user chooses not to enter an individual operating cost, a default value is assigned that is the result of economic data collected from whale watching vessels in another part of the county.

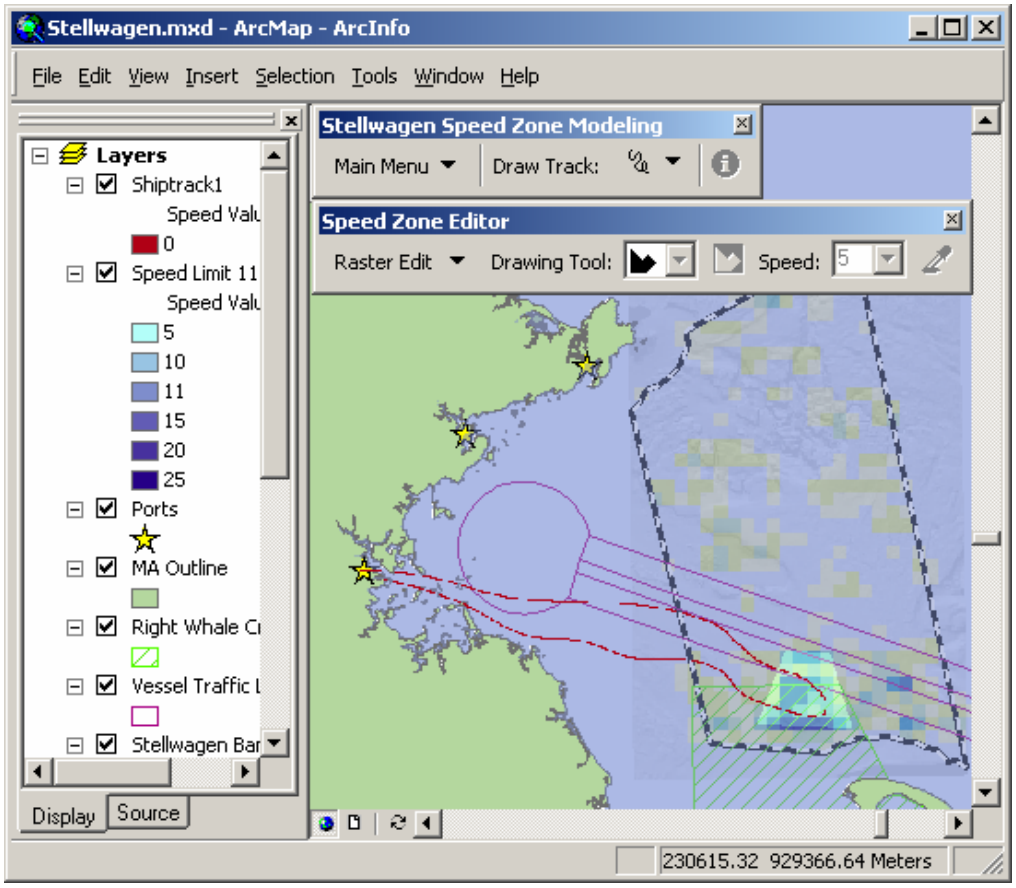

Figure 1: The Stellwagen Bank Speed Zone Analysis Tool provides the ability to design speed zones and create ship tracks through the region to determine potential economic impact imposed by the zoning measure.

An output document is then produced that includes a graphic of the completed zoning option and path, as well as the results of the economic impact analysis (Fig. 2). Data and output documents may be saved for future use or discussion; however, it is anticipated that zoning design and analysis will be an iterative process in which a number of options relative to size, orientation, and speed of the zone will be evaluated against a variety of potential ship tracks to move toward an acceptable option for all groups involved.

Speed (Knots)		Travel Time (Hours)			Cost of Trip (Dollars)		
Initial	Restricted	Initial	Restricted	*Change*	Initial	Restricted	*Change*
11	5	8.52	9.39	0.87	$ 170.19*	$ 187.55*	$ 17.36*

Figure 2: The output table generated from the economic impact analysis includes an estimation of the additional time and cost associated with a particular zoning option, based on the parameters enetered. In the above example, a round-trip ship track is initiated in Boston and passes through a 5knot speed zone that was implemented in the southern portion of the sanctuary. The result in an additional cost of $17.36.

CONCLUSION

Stakeholder involvement and community input has a large role in the management plan review processes currently underway within the ONMS. However, it is often a challenge to continue that level of participation beyond initial scoping stages or to determine an effective means to incorporate feedback. This analysis tool is meant to enhance the participatory aspects of this process by providing stakeholders and decision makers with a mechanism to communicate and evaluate a suite of potential zoning schemes. By including diverse user groups in the evaluation process, sanctuary staff can ensure that the resulting management strategy addresses conservation objectives with limited economic impact to the local community. This is a difficult process that, in order to be effective, requires the input of all stakeholder groups. For this reason, it was necessary for the tool to be flexible in terms of values and inputs, allowing each group to have a voice in the process and to feel that their particular concerns are being addressed.

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