Review

Visualization for planning and management of oceans and coasts

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ABSTRACT

This paper reviews visualization tools available to environmental planners and managers working on ocean and coastal environments. The practice of visualization involves making and manipulating images that convey novel phenomena and ideas. First I describe visualization within the context of visual environmental communication, an emerging and rapidly evolving discipline. A review of the literature on visualization is provided and a typology of cartographic visualization and scene simulation is proposed. Ways to make visualizations relevant for work with the public and policy makers is discussed. While significant progress has been made in the area of visualization for climate change with much of it focusing on coastal impacts, little attention has been given to visualizing the marine environment within the framework of visualization studies. More technical work on integrating maps and scenes is needed for planning and management of ocean and coasts, including research on advanced GIS methods for decision-making and virtual reality.

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1. Introduction

Rachel Carson, a founder of the modern environmental movement, wrote three books about oceans — all best sellers — before writing her most famous book: *Silent Spring*. Few may remember these ocean primers. The second of these books, *The Sea Around Us* (1952), was adapted to film following its publication. Beyond the business angle, is the idea that a book, using written words to inform about the sea world, was not enough. Director Irwin Allen (later coined the "Master of Disaster" for films like *The Poseidon Adventure* and *Towering Inferno*) turned Carson's book into an entertaining look at a world unknown to most of the viewing public. This adaptation went on to win the Academy Award for Best Documentary Feature in 1953.

Over half a century later, reams of information exist about oceans going far beyond what Carson likely dreamed possible. Much of today's data documents the ongoing degradation of oceans and coasts and the implications for the rest of our planet. This information is essential for planners and various other professionals increasingly involved in efforts of marine spatial planning (Collie et al., 2013; Eastern Research Group, 2010; Ehler and Douvere, 2009). How can professionals get the word out about the oceans' predicament so that this information can best be used for decision-

making in a marine planning context? What tools are at their disposal? Visualization is clearly one of them. A case in point is the pivotal role visual simulation played in the approval of the array of 130 wind turbines for energy production off the coast of Cape Cod in 2010. Much of the debate concerning the impact of the offshore wind farm hinged on the accuracy of simulated seascapes (Phadke, 2010).

Marine and coastal environments engender special communication challenges. Visualization techniques such as maps, graphical displays and virtual reality, are particularly important as environments being impacted by development are farther from shore. In these locations which are often purposefully far from population clusters, environments are unfamiliar to the general public and policy makers. They are hard, if not impossible, for much of the public to access. Dramatic changes are taking place in oceans due to climate change that require both 3D (depth) and 4D (time) representation capabilities. While there has been some work on visualizing climate change both through simulation maps and scenes along coastlines (see Shaw et al., 2009), communicating about climate change effects in the deep sea lags far behind.

Environmental planners often obtain information about the physical world and use it to improve foresight. They also need to make it easier for stakeholders to examine their own medium-term and long-term futures, to envision what is virtually inaccessible or to envision what doesn't *yet* exist. This article reviews current progress on visualization techniques for planning and management

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of oceans and coasts from a general technical perspective. It discusses communication tools for two target audiences: the public and policy makers.

I draw on work in the area of visual environmental communication and visual representation. I begin by placing the topic of visualization for oceans and coasts into the wider trajectory of research on visual representations of the environment as a form of communication. Maps and visual scenes are discussed. Scenes in this context refer to a full range of imagery including photos, movies, video, imaginaries and more. These types of scenic images are well-known mechanism for planning and management, often used to facilitate public participation and as a basis for decision-making about terrestrial environments. This article serves as a review of current progress on researching these mechanisms with insights highlighting new directions and further research needs for seascape visualization.

2. Visual communication

The idea that "seeing *is* knowing" is well entrenched in Western society (Jenks, 1995). Therefore, research on how images are perceived and how visuals influence the viewer is important. To answer these question researchers have drawn on psychology, neuroscience, cognitive science and communications (Hasson et al., 2008) which has led to a significant body of knowledge sought by media professionals and just about anyone who has an agenda to promote. The practice of visualization involves making and manipulating images that convey novel phenomena and ideas and therefore both the informative and the ideological come into play. Tufte (1990) describes visualization as a medium for clarifying certain complex data and it has great advantages over the written word or the voice alone. The visual sense is by far the most dominant component of human sensory perception (Bruce et al., 1996).

Recent work on visualization promotes expanding the sense of the visual, incorporating political economy of all types of representation — television, film, photographs, across different fields, and including the broadest range of representations possible — from maps, to photos, to visual representation of data in graphs and tables (Hansen and Machin, 2013; Valiela, 2009). Environmental visualizations could be 2D, 3D or 4D maps, graphical representations of data or real, imagined and/or manipulated scenes such as photo images shown in a virtual reality setting.

Visualization has been studied in recent years within the context of environmental communication[1] (Hansen and Machin, 2013). Environmental communication is a relatively new discipline but one gaining in interest, especially as tools such as crowdsourcing and social media monopolize channels of everyday interactions and local activism takes on global challenges, such as changing behaviors to mitigate climate change (Sheppard, 2012). The discipline emerged as a field of research in its own right for two main reasons. First, researching all aspects of communication on environmental issues —including those doing the communicating, their positions, historical-political affiliations and means of communication —is necessary to fully understand the scope, scale and content of socio-environmental problems. The second reason is that in the face of the major environmental crises of our time, communication influences public opinion and it can promote sustainable behaviors (Katz-Kimchi, 2013). The discipline has

developed such that it considers myriad modes of communication from discourse and rhetoric to conservation and environmental protection as themes in popular media (see Cox, 2013).

Images have a major role in popular media and therefore an emphasis of environmental communication deals with the visual. Within the framework of environmental communication, scholarly work analyzes how different modes of representation influence the viewer; such analyses have focused on a broad range of environmental advocacy media campaigns, such as those dealing with wildlife conservation (Milstein, 2008), climate change (Sheppard, 2012) and pollution protection (Schwarz, 2013). In regards to general environmental advocacy, researchers have found that television and other media increasingly use decontextualized global, symbolic and iconic images to reach a more universal audience, disconnected from a particular geographic/historical place and time or a particular social/cultural milieu (Hansen and Machin, 2008). But beyond the "aspatial" (non-spatial) nature of environmental representation in the popular media that largely ignores geographic location, landscape assessment research deals with connecting images to place and vice versa (Lange, 2011; Orland, 1992). For example, as local activism takes on global challenges, such as changing behaviors to mitigate climate change or for conservation planning, more research on visualization is place-based. In the case of sea-level rise, the focus has been on visualizing the land and sea interface where communities may be most impacted in order to mobilize viewers to take action or make decisions.

3. Visual representations of the environment

Hansen and Machin (2013) claim that the public vocabulary on the environment is to a large extent a visual one. Scholars such as Chias and Abad (2013) and Lange (2011) have brought the study of visualization into the realm of environmental planning. The role of planning has evolved over the years to frequently be a communication between planners and communities, where planners guide the communities to decisions (Cinderby, 2010; Kingston, 2007). However, these decisions by communities may be incorporated, or not, by decision-makers (Arnstein, 1969; Randolph, 2011). Opposite the public, or community members, are the decision-makers who usually determine policy. The planner may be somewhere in the middle, bridging the science-policy gap while infusing opinion, knowledge and preferences of the public into the decision making process.

Communication of knowledge between the scientific and management communities can be a difficult process complicated by the distinctive nature of the career goals of practitioners, scientists and decision-makers. Planning practitioners are often working to implement the goals of their clients, scientists are busy researching topics that are "hot", current and fundable, whereas decision-makers are at the mercy of elected officials and their appointees. In the latter case, goals are short-term — i.e., something needs to get done during the incumbent's term —and for academic scientists, time is needed to conduct experiments, write about them and ensure continued funding. Therefore, the use of visual representations by environmental planners for interfacing between science and policy has become important, especially when timeframes are short and data is complex (Gill et al., 2013). Visuals that often take the form of maps in a planning context (Smith and Brennan, 2012) can reduce or convey complexity of situations that call for timely decisions.

Visual researchers point out that we are increasingly surrounded by an immense proliferation of visual images such that the traditional division between maps and other image types has become blurred (Smith and Brennon, 2012; McKinnon, 2011).

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[1] Article 2 of the National Communication Association's charter for the Environmental Communication Commission declares "The purpose of the Commission is to promote scholarship, research, dialogue, teaching, consulting, service and awareness in the area of environmental communication" (1998, para. 2).