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Information systems for marine protected areas: How do users interpret desirable data attributes?

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ABSTRACT

The purpose of this paper is to provide empirical evidence on how various user groups related to Marine Protected Areas (MPAs) interpret desirable data attributes, whether their interpretations differ and to what extent. Moreover, this study aims to make a methodological contribution to the interpretive information systems (IS) literature by showing the potential of Spradley's (1979) ethnographic methods for understanding the human context in IS research and practice. Semi-structured interviews of MPA managers, academics, government officials, and environmentalists were analysed in four steps. Our findings show that each of the five data attributes studied encompassed more than one and often partly overlapping meanings. Commonalities and differences in interpretations between groups were observed. Users' organisational background helped to explain these differences; cross-cutting themes that seemed to guide users' interpretations and actions were perceived legitimacy and accountability of practices along the data value chain. Systematic use of ethnographically-informed methods allowed the detection of subtle differences in how users constructed meaning. As these different interpretations may lead to misunderstandings during requirements engineering, Spradley's approach could prove useful as a tool not only to elicit and analyse requirements, but also to facilitate unambiguous communication to reach mutual understanding among participants. This may help to improve IS development and thus enhance IS use for participatory governance and management in MPAs.

1. Introduction

Worldwide, participatory approaches for managing the marine environment have been promoted in the last two decades, with sustainability as overarching goal (Pomeroy and Douvere, 2008; UNCED, 1992). To realise this vision of a participatory management, adequate information provision that supports decision-making in complex socio-natural systems is required (McIntosh et al., 2011; Szaro et al., 1998). Significant investments to develop marine information systems (IS) and e-infrastructure that seek to integrate fragmented data and cater to various users at different scales have been undertaken recently in several parts of the world (Canessa et al., 2007; Eleveld et al., 2003; Masalu, 2008; Meiner, 2010; Tolvanen and Kalliola, 2008; Wheeler and Peterson, 2010). Despite high expectations of the potential benefits of IS for participatory governance and management of the marine environment, concerns have been raised regarding failed adoption of such systems by their intended users (Diez and McIntosh, 2011; McIntosh et al., 2011, 2008; Quinn, 2010). There are multiple explanations for the lack of adoption and use of IS in managing and governing the marine environment, but we focus on one particular – but far from marginal – cause.

Poor determination of IS requirements is recognised as a major source of adoption failure (Nuseibeh and Easterbrook, 2000; van Lamsweerde, 2000). This failure often results from inadequate involvement of future users in information system development (ISD) and/or from communication problems between participants in the requirements engineering (RE) process (Al-Rawas and Easterbrook, 1996; Anwar et al., 2011; Byrd et al., 1992; Diez and McIntosh, 2009; Fuentes-Fernández et al., 2010; Gallivan and Keil, 2003; Lyytinen, 1988; McAllister, 2006). It is acknowledged that not only technical and functional aspects but also the 'human context' (be it cognitive, organisational, political or cultural) is of vital relevance in and for the RE process and misunderstanding or ignoring that hampers IS adoption (Bergman et al., 2002; Checkland, 2000; Vidgen, 1997; Viller and Sommerville, 1999). Valusek and Fryback (1985) identified three main types of obstacles that hinder an effective elicitation process in ISD: obstacles within

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individual users or developers, obstacles among users, and obstacles between users and developers. Obstacles within individuals are related to cognitive constraints (Browne and Ramesh, 2002; Valusek and Fryback, 1985), whereas obstacles among users, and between users and developers, are mainly related to divergent interpretations of similar concepts that lead to miscommunication of requirements and thus to IS that fail to meet users' needs (Byrd et al., 1992; Fuentes-Fernández et al., 2010; Hughes and Wood-Harper, 1999; McAllister, 2006; Valusek and Fryback, 1985).

This paper analyses potential communication obstacles among users of prospective IS for marine environmental governance and management. We examine how different user groups associated with marine protected areas (MPAs) differ in defining and conceptualising data and information attributes, and as such may prevent development and adoption of adequate IS. Our focus is on five data attributes that are considered generally desirable in IS: data/information availability, accessibility, quality, consistency and security (Panian, 2009).

MPAs are an interesting study area for marine ISD, given the current global momentum in establishing MPAs and MPA networks (Belfiore et al., 2004; UNEP-WCMC, 2008; Wood et al., 2008), the conflict around managing and governing these MPAs (Jentoft et al., 2007), and the calls to develop IS on protected areas that satisfy a variety of user requirements (Bertzky and Stoll-Kleemann, 2009; Corrigan and Kershaw, 2008; UNCED, 1992; UNEP-WCMC, 2008). In analysing how users of existing IS interpret and define data attributes, the focus should not only be on individual interpretation schemes, but also on how the 'human context' influences data attribute meanings; both should be included in designing future IS. To the best of our knowledge, no work has focused on this aspect of ISD for MPAs.

Hence, the goal of the paper is two-fold. First, we provide empirical evidence on how and to what extent various user groups interpret desirable data attributes differently. Second, this study aims to make a methodological contribution to the so-called interpretive IS literature (Klein and Myers, 1999; Walsham, 2006). By systematically and in a transparent way applying ethnographic techniques that focus on semantic analysis we show that data analysis in interpretive studies need not be "...a rather subjective and unplanned process..." (Walsham, 2006: 325).

The next section provides further background on MPAs and describes how we approach IS user requirements. The third section introduces the ethnographic techniques applied, and presents our conceptual framework for semantic analysis, to be followed by the methods used for data collection and analysis. The fifth and six sections present and discuss the results, respectively. The paper closes with substantive and methodological conclusions.

2. Marine protected areas and requirements of information systems users

2.1. Marine protected areas

The most commonly used definition of a Marine Protected Area (MPA) is "any area of intertidal or sub-tidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (Kelleher, 1999). More than 5000 MPAs have been established worldwide, ranging from 0.4 up to 41,050,000 ha and with a wide spectrum of management goals and strategies (Wood, 2007; Wood et al., 2008). Management strategies range from full protection in no-take areas, where extractive activities (i.e. fishing, oil/gas winning, mining) are severely restricted or prohibited, to multiple-use areas where regulation aims at sustainable resource use. Similarly, governance arrangements vary widely, including governance by indigenous or local communities, by government(s), by private actors and all kinds of shared governance modes (Dudley, 2008).

A key aspect to effectively manage MPAs is to follow an adaptive management approach, which requires continuous monitoring, evaluation and adjustment of management decisions in a learning cycle that builds on information of results (AIDEnvironment, 2004; Day, 2008). Hence, effective MPA management relies on a continuous flux of different types of information on bio-physical, socio-economic and legal/institutional indicators and parameters (Agardy, 2000; Pomeroy et al., 2005). Financial constraints of most MPAs (Balmford et al., 2004), and significant costs of data collection and handling, encourage strategic and coordinated efforts to effectively meet information needs (de Freitas et al., 2009; UNCED, 1992; UNEP-WCMC, 2008).

In marine environments data production and handling activities are highly fragmented, owing to the large numbers and heterogeneity of individuals and organisations involved, each with their own needs and objectives (Corrigan and Kershaw, 2008; Dyer and Millard, 2002; Eleveld et al., 2003; Stojanovic et al., 2010). The data processing chain conceptualises the flow of the various types of generated data into information (Dyer and Millard, 2002; Hansen and Wang, 1991), and consists of three stages: data production, data handling and data consumption.[1] Best practices during the production and handling stages ensure that desirable data attributes are met, such as availability, accessibility, quality, consistency and security. And such data attributes facilitate – or even precondition – data use to meet the goals of individuals and organisations involved in MPA management, governance and use.

2.2. Approaching information systems, users and requirements

Within the IS discipline no agreement exists on how to define key concepts such as "information system" (Alter, 2008), "requirements" (Hickey and Davis, 2004) or "user" (Millerand and Baker, 2010). For instance, Alter (2008) shows the great variety of IS definitions proposed in the literature, ranging from a simple data table or software directed information technologies to complex human-technology systems. The definition used by a researcher delineates the boundaries of the inquiry and underpins the selection of conceptual and methodological frameworks. This section explicates the main assumptions underlying this research and clarifies the way these three key concepts are used.

As a starting notion IS are seen "as all components that together provide the necessary information. The components are: the hardware and the software, the people and the procedures with which they work, and the data that are processed by the system" (Renkema and Berghout, 1997:2). As found in the scientific literature, existing IS are being used by various individuals and organisations to facilitate policy and management decisions in MPAs and improved/new IS are being developed to meet information needs (Bertzky and Stoll-Kleemann, 2009; de Freitas et al., 2009; UNEP-WCMC, 2008; Wood, 2007). Various sorts of IS are distinguished, including "integrated assessment models, geographic information systems and decision support systems [which] are well suited to informing environmental management and policy processes" (Diez and McIntosh, 2009:588) as well as the more ubiquitous environmental information management systems (Quinn, 2010).

[1] The term *data* is used throughout the paper for consistency purposes, although the terms *information* and *knowledge* may be more appropriate to refer to the second and third stages of the data processing chain, respectively (Canessa et al., 2007; Stojanovic et al., 2010).