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Research paper

Returning information back to fishers: Graphical and numerical literacy of small-scale Indonesian tuna fishers

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ABSTRACT

Developing world fishers are often assumed unable to comprehend fisheries management information because of their poor numerical and graphical literacy. This study questions this assumption by assessing the extent to which small-scale tuna fishers in Indonesia engaged in enumeration programs are able to understand, interpret and find value in the data collected from them when presented in graphical and numerically-aggregated forms. The analysis was based on structured interviews held with twenty tuna hand-line fishers on Buru Island, Maluku, Indonesia. We found that scientific displays such as graphs, tables and maps are understandable even for semi-literate fishers. Different forms of displays have more or less relevance and value for them in reflexive way. The sequence in which scientific displays are presented also matters, indicating that displays should be presented and explained in gradations from simple to more complex forms. Overall, however, the results show that face-to-face explanation remains necessary when communicating graphical and numerical information to fishers. Further attention should be given to forms of communication with fishers that allow for more reflexive decision-making and a shift to user-centric information systems. The ongoing development of mobile technologies aimed at incentivizing fishers to engage with and contribute to data and information collection, would benefit from selecting suitable information displays, presenting these in a guided sequence, and monitoring how fishers use this information to make decisions on the water.

1. Introduction

The collection, collation and presentation of information are central to effective management of fisheries. Fishery information systems in OECD countries are based on state- and industry-sponsored data enumeration programs that record the volume and key biological attributes of the fish caught and landed, as well as the spatial allocation of fishing (Baddeley, 1986; Marchal et al., 2016; Mills et al., 2011). Data are also collected, albeit to more varying levels, on the volumes and value of fish traded into domestic and export markets (Crona et al., 2015), and increasingly from private in addition to public sources (Bush et al., 2017). Management decisions are made on, amongst others, the allocation of catch and/or levels of fishing effort to different fleets on the basis of this information (Poos et al., 2010). As argued by Verweij et al. (2010), an assumption underlying fishery information systems is that all parties involved in data collection and management, including fishers, can (1) understand the information produced, (2) recognize the consequences of their own actions in this information, and (3) see value in using the information to guide their future fishing practices.

Fisheries information systems are incomplete and contain high levels of error in developing countries, and often in small scale fisheries in OECD countries where most fishers are semi-literate (Geromont and Butterworth, 2015; Mills et al., 2011; Pilling et al., 2009; Yuniarta et al., 2017). Donor-funded programs in regions such as Southeast Asia have sought to increase the coverage and accuracy of fisheries data collection (Mills et al., 2011; Pomeroy, 2012; van Zwieten et al., 2002). However, while much attention has been given to improving data quality and availability, no comparable attention has been given to feeding back information developed from these data to fishers. This is common because while there is no lack of intention there are generally limited resources to do so in often time bounded projects, or it is assumed that fishers are unable to comprehend fisheries management information because of their generally poor literacy and 'graphicacy' (or graphical numeracy), meaning the ability to interpret visual representations of

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data (Balchin, 1972). Given the rise of transparency and citizen engagement it seems likely that the communication of scientific information will only increase − even to small scale fishers. It therefore seems inevitable that a degree of literacy will be needed to engage fishers and/or foster in adaptive forms of learning and action − where fishers reflexively integrate information in their daily decisions to iteratively change harvest strategies (e.g. Arthur and Garaway, 2004; McClanahan et al., 2016).

An improved level of numeracy and graphicacy would appear necessary if fishers are expected to be more adaptive in response to fisheries information. To date research on the capacity of fishers to interpret numerical information, in particular graphical information, has been limited to industrial fisheries in Europe. Findings from these studies show that numeracy is influenced by the extent to which fishers are involved in capturing and processing the information that underlies management decisions, and the ability of resource users to interpret and understand information presented (Densen and McCay, 2007; Verweij and van Densen, 2010). However, there is very little empirical information on the capacity of fishers to understand, interpret and position their own experiences in aggregated information on catch, effort and stock developments inferred from catch rates. There is also limited understanding of whether and how fishers make causal links between their own observations and information that represents the data collected from them in the form of structured graphical representations or tabular numerical aggregations. How these observations differ in socioeconomically different situations, extending to artisanal fisheries in countries such as Indonesia, also remain unknown.

This paper investigates the extent to which small-scale tuna fishers in Indonesia engaged in enumeration programs are able to interpret and find value in data presented to them in graphical and numerically aggregated forms. In doing so we develop an analytical framework for assessing graphicacy and numeracy based on three main attributes. First, can fishers understand the information presented to them? Second, to what degree are their own experiences represented in the information they are presented with? Third, do they see value in using the information to guide their fishing activities? Underlying these variables is the assumption that fishers need to understand scientific information presented to them to gain knowledge and reflexively use that knowledge by changing fishing practices when needed. Our results are relevant for fostering reflection among fisheries scientists and practitioners about how knowledge is shared with fishers; to provide insight into how and why fishers interpret and engage with that information; and, to make recommendations about how and why different approaches to communication between fishers and scientists might increase the relevance and usefulness of fisheries science for fishers and fishing dependent communities.

The following section outlines the concept of graphical and numerical literacy and our analytical framework applying the three attributes of understanding, representation and value. We then turn to a detailed outline of our methodology before presenting the results of the study. Finally, we return to a discussion of these results in light of their relevance for fisheries information systems.

2. Assessing graphicacy and numeracy in fisheries

Graphical literacy, or graphicacy, refers to the ability to interpret information presented in graphical forms, including an individual's ability to extract information and make inferences from different graphical formats; including diagrams, graphs, charts, maps or even photographs and sketches (Freedman and Shah, 2002; Shah and Freedman, 2011). Graphical literacy goes beyond the knowledge gained from different types of information displays, by including the visual features of a graph, as well as how the experiences and prior knowledge of an individual influences the interpretation of what is being visually presented (Freedman and Shah, 2002). In other words, if an individual has a degree of 'content familiarity', meaning their current practices are represented in some way in a given display, they are more likely to both understand and value the information being presented.

It is widely assumed that graphical information offers advantages over other information display formats. Aldrich and Sheppard (2000) argue that the advantages of graphical representations of complex information are more likely to lead to higher cognitive understanding because graphics are concise, can set a scene immediately, are memorable, and can present complex relationships between multiple variables. However, others argue that because graphical presentations most commonly demonstrate relationships and trends, instead of facts alone, a higher level of cognitive interpretation is needed by the viewer (Freedman and Shah, 2002; Moore-Russo and Shanahan, 2014). Friel et al. (2001), for example, identify three levels of interpretation: the ability to find specific information in the graph, such as the height or colour of a particular line in a line graph in relation to axes or other devices to indicate the size of values; the ability to find relationships in the data as shown on the graph, such as the difference and possible relation between two lines; and the ability to make inferences and predictions from the data, including projections into the future.

We recognize that cognitive assessment alone may limit our analysis of the graphicacy given our focus is on untrained resource users in remote coastal communities. Instead we argue that a reflexive approach is needed which goes beyond cognitive interpretation to include the degree to which a viewer sees their actions represented in the data and ultimately finds value in the data to make future projections. By taking into account representation and value we are better able to understand how the agency of fishermen ultimately helps in internalizing graphical information and adapt practices in response to the information. Conversely, the three attributes of understanding, representation and value can enable more effective design of graphical and tabular formats delivering information to fishers, such that they do not undo the goals of presenting the information in the first place (Tufte, 1997).

Graphical understanding relates to the meaning obtained from graphical or tabular information in two dimensions. First, what aspects does a target audience understand of the intended message? And second, what aspects of an information display confuse this intended understanding? Following Friel et al. (2001) we first focus on the 'dimensions' of the graph or table, including the different colours, lines, axes, titles, descriptions and formats in a display (see also Mulrow, 2002; Tufte, 1983). The complexity of these dimensions can be raised by either increasing the number of dimensions on a single display or by changing the combinations of relationships presented on a graph. Thus, it is not only the information presented that poses a challenge for accurately interpreting displays, but also the design of the display itself. While these cognitive dimensions of graphs can be learned, their interpretation will also be affected by the everyday experiences of viewers (Freedman and Shah, 2002; Shah and Freedman, 2011).

The role of wider contextual factors in influencing understanding has led to questions on the degree to which graphical information represents the practices of the individual or group presented with graphical information, and following this, whether the information holds value for improving these practices. For example, the representation of spatial or conceptual information can refer to the reader's experience of the physical environment (Okan et al., 2012). In fisheries, such experiential, 'local' or traditional ecological knowledge is often used to assess the status of a fishery in data poor environments (Beaudreau and Levin, 2014; Bundy and Davis, 2013). However, where data are available and possibilities emerge to assess the capacity of fishers to recognize spatial or seasonal patterns in a graph, then the ability to understand other properties or relationships attached to these patterns may increase (Gold, 2009; Shah et al., 2005). Others argue that a more general familiarity with the content increases the degree to which people identify, or feel represented, with a graph's message. As argued by Kragten et al. (2013), this means that if a graph and/or the topic presented (or the translation between the two) is not familiar, then interpretation becomes increasingly problematic.