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Piloting participatory smartphone mapping of intertidal fishing grounds and resources in northern Mozambique: Opportunities and future directions

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ABSTRACT

The participation of local communities in marine resource management can contribute to the sustainability and longevity of marine resources across diverse coastal settings. In contexts where there are low levels of formal education and high levels of illiteracy, and where marine resource management is governed predominantly by customary management systems, the introduction of formal marine resource management can be challenging. Maps are often required as the basis for spatial marine management measures, effective spatially-explicit fisheries monitoring, and for formal support from fisheries authorities. Our research with local women reef gleaners of Cabo Delgado, in northern Mozambique, pilots the potential uses of smartphones and digital mapping as a tool to allow fishers to map these understudied intertidal fishing grounds, and to understand the ecological dynamics as well as social uses of the intertidal resources. Even though women are key food and income providers through intertidal resource gleaning in this area of Mozambique, they have limited roles in fisheries management decision making. Therefore, we developed a participatory approach to mapping that could act as an entry point for their involvement in the design of a spatial fisheries management plan and associated community monitoring. Fisherwomen were trained to use smartphones with CyberTracker software for mapping intertidal fishing grounds in their village, and the locations of intertidal resources most important to their livelihoods, including octopus, pen shells and oysters. Interviews and focus groups were conducted throughout the mapping process to ascertain women's use and interest in the technology. We conclude that community-based mapping through simple tools as developed in this research can help connect local community groups, bridge traditional and formal governance systems and provide a positive example of co-management in practice.

1. Introduction

The overexploitation of coastal marine resources remains a major threat to the food security and overall quality of life for many subsistence coastal communities who are dependent upon these resources (Wong et al., 2014). The accelerating pace and scale of extraction is rapidly reducing the overall ecological integrity and biodiversity of these resources, which normally would provide a variety of ecosystem services from fisheries to coastal protection (Jackson et al., 2001). Worldwide, as finfish stocks are overexploited and catch declines, fishermen and fisherwomen increasingly rely on accessible intertidal marine invertebrates for food and income (Anderson et al., 2011).

Sustainable management of intertidal stocks has been compromised from limited incorporation of local knowledge on ecological processes, together with social and economic benefits often not flowing to the communities who own or live adjacent to the resource source areas (Basurto et al., 2013). This situation is particularly poignant in remote coastal communities throughout much of the developing world, where intertidal resources are governed and managed predominantly by customary *de facto* management systems, and for which there is little integration with more formal, science-based, government-led *de jure* management (Mackinson and Nøttestad, 1998; Béné and Neiland, 2006). It is now

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broadly recognized that the participation of local fishers and their representing institutions is a prerequisite to connecting formal science-based marine management measures, with community knowledge and engagement, as seen with the expansion of Locally Managed Marine Areas (LMMAs) in the West Indian Ocean (WIO) (Rocliffe et al., 2014). Developing suitable tools and approaches that allow for the integration of local ecological knowledge and scientific knowledge is critical for communities and scientists working together to develop effective marine management measures. We directly examine this nexus through the lens of participatory mapping of the intertidal fishing areas in Mozambique.

1.1. Sustainability and livelihood importance of intertidal harvesting

For decades, invertebrates were considered to be more resilient to fishing and harvesting pressure than other fish stocks due to the large geographic ranges they occupied and their relatively short life cycles (Jamieson, 1993; Carlton, 1993). Evidence from recent studies suggests, however, that invertebrate populations are quite heavily affected (Basurto et al., 2013), on top of other pressures such as climate change and pollution (Harley et al., 2006). A recent study in Tanzania showed significant and quantifiable decreases in invertebrate abundance from overharvesting, with gastropod and bivalve abundances decreasing by over 60% during the five year study period seemingly due to harvesting pressures (Fröcklin et al., 2014). As most invertebrate species are sessile, relatively immobile or territorial, overharvesting can easily become a major challenge in either areas with large human populations, such as the Philippines, and in areas with lower densities, but where the local communities are highly dependent upon local harvesting (Richmond, 2011).

Despite the combination of declining finfish resources and increasing economic value of invertebrate fisheries, formal management of intertidal areas is rare, and where present remains largely unregulated and unmonitored (Anderson et al., 2011). The lack of formal management regimes for invertebrate species may be connected to historically low valuation of these resources, as it was often presumed that artisanal subsistence fisheries have limited ecological impact and did not contribute significantly to national economies (Barnes-Mauthe et al., 2013).

Many coastal communities across the WIO rely on marine resources for subsistence and income, with seafood providing the principal source of protein (Jiddawi and Öhman, 2002). Marine invertebrates, such as octopus and oysters, are essential intertidal resource and are primarily hand-gleaned by women, children, and elderly, particularly during low spring tides (Richmond, 2011). Men also dive for invertebrates such as oysters and octopus in deeper sub-tidal areas adjacent to the intertidal. For women, gleaning enables direct acquisition of both protein or cash income in communities where agricultural production is only sufficient for subsistence purposes (Rosendo et al., 2011). In Mozambique, where 60% of rural households incomes are spent on food, additional sources of cash income are essential, particularly to female-headed households without additional income sources (Republic of Mozambique, 2008). Additionally, these resources can provide a safety net in times of food scarcity, as reef gleaning is generally less risky and more predictable than fisheries further offshore or than agriculture (Tucker et al., 2013).

In coastal areas where invertebrate resource extraction is increasing, local communities, and particularly women, are reliant upon effective sustainable management of these resources. Co-management legislation introduced in Mozambique in 1990 (Blythe et al., 2013) provides a management mechanism, allowing community fishing councils (Conselhos Comunitários de Pesca – CCPs) to take on responsibility for management of marine resources in collaboration with the government (ADNAP, 2012). The CCPs are responsible for areas between two points along the shoreline, and three nautical miles out to sea (Garnier et al., 2008).

1.2. The role of participatory fishing ground mapping in intertidal resource management

A precursor to formal marine monitoring and management measures is the need for basic information on species status, combined with accessible and repeatable forms of mapping and assessments of invertebrate status to initiate, and continue, essential monitoring protocols and management regimes. A map of a community fishing ground, and the principle intertidal resources found within this area, is essential to establish locally meaningful spatial units for management. It is also important for long term monitoring of ecological change to ensure that data collection is spatially explicit to accurately understand trends in catch and Catch Per Unit Effort (CPUE) data (Ling and Milner-Gulland, 2006). In addition to these practical requirements for maps, legislation can often require a map as the basis of a formal management plan. In Mozambique, while there is no specific requirement in fisheries legislation for CCPs to have maps, the recent conservation legislation requires a management plan and a zoning plan, with a classification of the area and geographical limits (Lei de conservação, 2014). Communities wishing to formally register an LMMA as a community conservation area, will need maps with a specific zoning plan.

Fishermen and fisherwomen in coastal communities rarely document this type of spatial knowledge in written format, but have excellent spatial knowledge of the fishing grounds, the names, and resource type and status within these areas (Daw et al., 2011). Participatory Rural Appraisal (PRA) techniques, such as participatory resource mapping, were developed in the 1980s specifically to capture and integrate this knowledge into environmental and development plans, and prevent outside groups misinterpreting local realities (Chambers, 1994a, 1994b, 1997). Despite the existence of PRA techniques for mapping, in Mozambique maps are rarely accessible to fishers but mostly available and common for government, NGOs and the private sector.

For these reasons, community-led mapping and monitoring, as well as citizen science, has become popular as a tool to bridge gaps between local knowledge and more formal systems of resource management (Spellerberg, 2005). Such processes can also provide other contributions, e.g. the mapping can build the capacity and interest of local people, educate, promote awareness of environmental change, and empower communities to be at the centre of the process rather than rely on outside experts (Chambers, 1997; Spellerberg, 2005; Lawrence, 2006; Conrad and Hilchey, 2011). Local people often have a deeper understanding, trust and reliance on their own data more than expert data (Danielsen et al., 2005). This said, participatory map creation and community-based monitoring is not without its critics, where there can be concerns over scientific rigor and accuracy of approaches (Spellerberg, 2005). Consequently, while there might be a "trade-off between community involvement and scientific rigor" (Aswani and Weiant, 2004, p.309), the long-term merits of the local participatory learning can result in more sustained monitoring, buy-in to management measures based on locally-produced data, and scope to incorporate and validate local ecological knowledge.

1.3. Use of smartphone technology for participatory fishing ground mapping

Our research aimed to put these ideas into practice using an