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Evaluating abundance trends of iconic species using local ecological knowledge

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ABSTRACT

Abundance is commonly used to assess the status of wildlife populations and their responses to changes in management frameworks. Monitoring abundance trends often requires long-term data collection programs, which are not always carried out. One alternative to scientific surveys is to utilize the local ecological knowledge (LEK), from people in continuous interactions with the environment. We developed a semi-quantitative approach to assess shark population trends by using the LEK of non-extractive resource users. We carried out structured interviews with dive guides regarding the abundance trends of six shark species in the Galapagos Marine Reserve (GMR) across decades since the 1980s. Based on dive guides' LEK, we developed a virtual abundance change (VAC) model to assess the changes in abundance across decades. Our VAC analysis showed a 50% decline in hammerhead sharks and 30% decline in whitetip reef sharks. Silky sharks and Galapagos sharks were perceived to suffer an initial decline by 25% and 30% then stabilized. Whale shark abundance did not appear to have changed. Finally, blacktip sharks showed an apparent recovery after a decline by 25%. Furthermore, our VAC results were comparatively similar to empirical datasets from the GMR and neighboring protected areas of the Eastern Tropical Pacific. Our study highlights the value of LEK in assessing the state of marine resources in data-limited management regions. Our VAC method offers an alternative approach by which LEK can provide valuable insights into the historical trends of species abundance.

1. Introduction

The primary objective of population assessment is to collect data on population size and structure to identify trends (i.e. increasing, stable, decreasing) in plant or animal populations (Meffe and Carroll, 1997). Abundance is a predictor commonly used to assess the long-term persistence and extinction risk of a population (Sutherland, 1996), and also to assess the species response to adopted management frameworks, such as harvesting regulations or the creation of protected areas (e.g. Gillingham et al., 2015; Lubchenco et al., 2007). Unfortunately, monitoring abundance trends often requires long-term data collection programs that are not always carried out, due to adverse environmental conditions, lack of economic resources or insufficient planning (e.g. Chambers et al., 2014; Johannes, 1998). This lack of scientific data hampers the evaluation of wildlife, and consequently, the adoption of different management alternatives to deal with conservation issues (Ludwig et al., 1993; Walters, 1986).

An alternative to this issue is to explore the experience-based knowledge of people who have continuous interactions with the environment/resources (Davis and Wagner, 2003). This experience-based knowledge is generally termed local ecological knowledge (LEK), and is associated with people whose livelihood largely depends on a natural resource, either with extractive or conservation purposes (Brook and McLachlan, 2008). LEK is often criticized because perceptions can be affected by people's ability to recall past events (Schacter, 2002), their cultural beliefs (Gilchrist et al., 2005), changes in the state of resources through time (Pauly, 1995), and the economic importance of the exploited resources (Howard and Widdowson, 1996). While these

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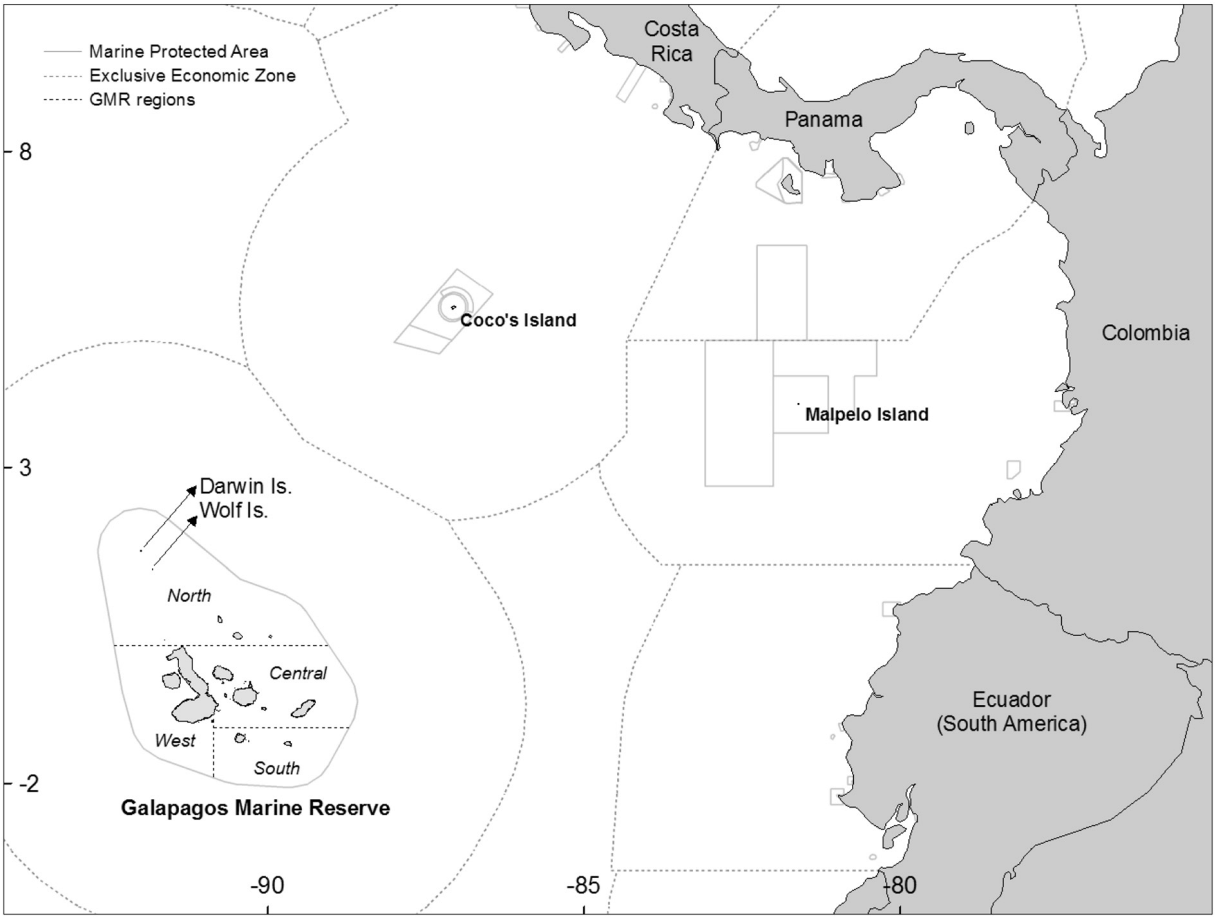

Fig. 1. Galapagos Marine Reserve, Coco's Island and Malpelo Island location in the Eastern Tropical Pacific Ocean.

factors can potentially lead to significant differences in the perception of a resource in comparison with in situ data collection methods (Daw et al., 2011; O'Donnell et al., 2012), the careful design of LEK evaluations can produce reliable information to assist the data-poor management of natural resources (Johannes, 1998; Thurstan et al., 2016). For example, LEK has been tested against empirical ecological data collection and proven to provide reliable knowledge of the population status and trends of birds (e.g. Gilchrist et al., 2005), lobsters (e.g. Eddy et al., 2010), fishes (e.g. Bender et al., 2014; Taylor et al., 2011) marine mammals (Cullen-Unsworth et al., 2017; Frans and Augé, 2016), trends in ecological processes (e.g. Poizat and Baran, 1997; Rochet et al., 2008) and fisheries dynamics (e.g. Neis et al., 1999). As such, LEK is increasingly becoming an alternative tool in assisting the evaluation of different resource management frameworks, such as fisheries community-based management (Hoggarth et al., 2006), or the establishment of marine protected areas (MPA; e.g. Friedlander et al., 2003) and their potential to preserve or rebuild fish stocks (e.g. Gerhardinger et al., 2009).

Resource development and management schemes have often been designed without significant historical information on the state of their resources (Wolff, 2009). This is especially true in marine management where the widespread lack of biodiversity baselines hampers the evaluation of the conservation state of resources and the effectiveness of adopted management frameworks. The Galapagos Marine Reserve (GMR) is a case in point. Few ongoing projects are dedicated toward monitoring the abundance and distribution of biodiversity over a sufficient time scale to test the effect of reserve creation (Danulat and Edgar, 2002). These projects have favored the long-term assessment of mostly reef fauna biodiversity with high commercial value (Schiller et al., 2014), or the use of strip transect techniques suitable for measuring abundance of marine fauna that remains close to the reef (Edgar et al., 2004b). These methods are not suited to evaluate mobile charismatic megafauna, such as sharks, although conservation issues regarding these species and their interactions with fisheries have long drawn the public attention (Camhi, 1995).

The life history traits of sharks, rays and chimaeras makes them one of the most vulnerable taxa to overfishing (Compagno et al., 2005), with one quarter of the 1041 extant species suggested to be at risk of extinction (Dulvy et al., 2014). In the GMR, the management framework adopted since 1989 has protected sharks from fishing and trading (WildAid, 2010), in response to the fishing pressure they face inside the reserve (Carr et al., 2013; Reyes and Murillo, 2007) as well as around the Eastern Tropical Pacific Ocean (ETP; Watts and Wu, 2005). While some scientists argue shark populations within the GMR may have declined despite the creation of the GMR (Schiller et al., 2014); others have suggested that the size of the reserve, coupled with the effect of El Niño Southern Oscillations (ENSO) and the adopted management framework, may have favored the recovery of some shark populations (Wolff et al., 2012). Given that shark abundance surveys within the GMR only started in 2007 (Hearn et al., 2014), the existing dataset is insufficient to establish any long term patterns.

We developed an alternative approach to conventional scientific surveys –using local ecological knowledge of non-extractive resource users to assess how shark populations have changed through time. To achieve this, we developed a semi-quantitative analysis method that evaluates population trends rather than quantifying numerical abundances. We tested our approach using the recollections of dive guides (hereafter “divers”) regarding abundance of six shark species found in the GMR. We constrained our assessment to the decades since the 1980s to coincide with the expansion of the dive tourism industry in