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Using eOceans diver data to describe contemporary patterns of marine animal populations: A case study of sharks in Thailand

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ABSTRACT

Many marine animals around the world are threatened by a variety of anthropogenic activities, yet there is often a paucity of data to monitor patterns in abundance and distribution or to evaluate human interventions. The new citizen science program eOceans helps to fill this gap by gathering observations of various marine animals from worldwide ocean explorers. In 2012, a dedicated Thailand-wide census of sharks, and other animals, began as a collaboration between eOceans scientists and the dive tourism industry. Using the observations from 9524 dives (9357 h underwater) logged by 169 divers on 153 sites, we describe the spatial and temporal patterns of sharks in coastal Thailand. A total of 12 shark species were encountered, most commonly (67%) as individuals, and were observed on 11% of all dives, on 59% of sites, in all months and years. The two most frequently encountered species were blacktip reef (*Carcharhinus melanopterus*) and leopard sharks (*Stegostoma fasciatum*). Many species had peak encounter rates in summer, but aggregated in various seasons in different years. Mating events and nursery sites were rarely observed, and only for blacktip reef and whitetip reef (*Triaenodon obesus*) sharks. These results could be of value to species- or region-specific biologists, ecologists and fisheries scientists, as well as to managers and policy makers that could use the findings to monitor future trends and prioritize conservation strategies. Moreover, this study highlights the value that collaborative citizen science projects could have in support of marine science, management and conservation efforts worldwide.

1. Introduction

Many marine animal populations have been, or continue to be threatened by anthropogenic impacts (Lotze et al., 2011), and sharks are among the most threatened animal groups, affected by fishing, habitat loss, and climate change (Dulvy et al., 2014; Oliver et al., 2015; Worm et al., 2013). Coastal sharks, including reef sharks, have been repeatedly shown to have declined long ago, pre-dating fishing records (Nance et al., 2011) and modern ecological assessments (Ferretti et al., 2010, 2008; Sandin et al., 2008; Ward-Paige et al., 2010b). This lack of data and protracted history of overexploitation means that historic population trends are often missing and, since fishing and other anthropogenic activities continue to affect populations, establishing rates of population change are challenging to attain and many species may be more vulnerable than previously thought (Osgood and Baum, 2015). As well, most shark research tends to occur in areas where sharks are still relatively abundant, leaving many heavily populated and overexploited coastlines undocumented by scientific observations, and therefore even contemporary baselines are not being established for monitoring into the future.

Typically, scientific population censuses of sharks are made by utilizing fisheries-dependent data, such as catch or bycatch data (e.g., Baum et al., 2003; Carlson et al., 2012; Ferretti et al., 2008) or fisheries independent data that may still involve high mortality sampling techniques, such as with gillnets (Froeschke et al., 2010; e.g., Ward-Paige et al., 2015) or trawls (Ferretti et al., 2010). Some aim to lower mortality during sampling (Hammerschlag and Sulikowski, 2011), especially where tags for mark-recapture or tracking studies are being used (Speed et al., 2011). However, in many areas where lethal sampling is illegal or unacceptable, such as on coral reefs, coastal areas near tourist sites, and marine protected areas, non-lethal sampling is often sought. In these cases, baited remote underwater visual censuses (BRUV; Brooks et al., 2013; Colton and Swearer, 2010) and underwater visual censuses (UVC) done by scientific scuba divers (Robbins et al., 2006, Ward-Paige et al., 2010a) or through trained volunteer diver programs (e.g., Reef Environmental Education Foundation (reef.org), Reef Life Survey (reeflifesurvey.org)) have been used. Similar to lethal sampling techniques, however, those focusing on sharks also typically take place

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where sharks are relatively abundant. In other areas, where sharks are rare and BRUVs or UVC are used to survey other animal groups (e.g., corals, reef fish), some sharks may be encountered, but often occur too infrequently to describe populations.

Around the world, individuals with a range of experiences, are undertaking marine tourist activities, making millions of observations on a daily basis, and reporting what they observe to personal log books, or to various science or non-profit organizations. Since the mid-2000s, many citizen science census platforms have been launched to collect these observations. Some have provided context for understanding the value and limitations of these data (Vianna et al., 2014; Ward-Paige et al., 2010a; Ward-Paige and Lotze, 2011), while others have provided important insights on shark ecology, including reproductive seasonality, fisheries interactions, and movements (Bansemer and Bennett, 2010, 2008; Whitney et al., 2011), and population status (Theberge and Dearden, 2006; Vianna et al., 2014; Ward-Paige et al., 2013, 2010b; White et al., 2015). These projects range from being species specific (e.g., whitetip reef, Triaenodon obesus, Whitney et al., 2011), which collect presence only data, to exhaustive checklists with abundance (e.g., all fish species; Reef Environmental Education Foundation (REEF.org)). Each has advantages and disadvantages. For example, species-specific projects lack non-target species and observations where no target species were observed (i.e., zeros), but can be rolled out in a target area relatively quickly and garner focused attention on the target species. Checklists that include all species, on the other hand, require extensive training and time to roll out, but get zeros, which is valuable for monitoring trends through time and space.

Because sharks are mobile and can move around and between sites there is need for high effort for detection. This is especially true for sharks that are rare, depleted, or seasonal, and may only infrequently visit sites. Correct identification to species level, however, can be a challenge for reasons ranging from encounters that are too brief to a lack of training (e.g., Brunnschweiler, 2009). However, compared to other animal groups that are regularly studied by citizen observers (e.g., eBird, Sullivan et al., 2009), the characteristics of sharks make them relatively easy to identify. Birds, for example, have checklists containing 9000–10,000 species, while there are only about 500 shark species in total (Dulvy et al., 2014), and fewer live within the depth range of divers. As well, some, especially reef-associated sharks (Osgood and Baum, 2015), have some site fidelity and are repeatedly observed and photographed by divers in-situ, which can further increase identification accuracy. Additionally, recreational divers that roam a site are better able to collect data on low density and rare fishes than many scientific divers, who use predefined transects, and they cover a bigger area and diverse habitat types (Ward-Paige and Lotze, 2011). Therefore, with appropriate caution in understanding the potential errors and biases in citizen science generated data (Bird et al., 2014; Conrad and Hilchey, 2011), using recreational divers' observations can be ideal to increase observation effort data, without the requirement of extensive training or photographs.

eOceans (www.eOceans.co) is an umbrella program that hosts various marine-focused citizen science projects (e.g., previously eShark, eManta, Global Marine Conservation Assessment). It provides an online platform where all marine explorers are invited to enter either (i) 'snapshot summaries' of past observations for hypothesis driven research questions, such as to describe the distribution and human use patterns of manta rays (Ward-Paige et al., 2013); or (ii) 'event-based reports' of each ocean experience (e.g., every dive) for ongoing, high-resolution monitoring of animal populations at specific sites (current study). The platform was developed using insights gained from years of in-depth investigations (by author CAWP) of the value and limitations of recreational divers' observations for providing shark and ray observations (Ward-Paige et al., 2014, 2010a; 2010b; Ward-Paige and Lotze, 2011). Although the primary focus was initially to collect data on sharks (and was previously called eShark), it also collects observations of rays, turtles, seahorses, jellyfish, whales, dolphins, seals, and marine debris, depending on location. These additions were found to increase participation, reporting of zeros, and the versatility of the dataset. See further details behind the development, implementation and communication strategies of eOceans in Hind-Ozan et al. (2017).

In 2012, the Thailand tourism industry, led by the local non-profit organization 'Shark Guardian' (sharkguardian.org), launched a nation-wide concentrated dive census, which was overseen by eOceans. Through this, invitations were sent out extensively to SCUBA diving companies, clubs, and individuals across the country, particularly in coastal tourist regions, to participate by submitting observations from every dive. Here, we use these reports to describe spatial and temporal patterns of surveyor effort and shark populations in Thailand. These findings demonstrate the potential of eOceans as a community-driven (i.e., bottom-up, see Roelfsema et al., 2016) marine citizen science project, for providing relatively high resolution temporal information at the site and regional scale. They may also assist species-specific or region-specific biologists and ecologists, as well as managers and policy makers to prioritize scientific investigations and conservation strategies of sharks in Thailand. As well, additional eOceans nation-wide projects (currently in Fiji, Indonesia, and South Africa) could further expand our knowledge of some coastal shark populations, and other species, which could help focus scientific investigations and conservation tactics on a regional and global scale.

2. Methods

The eOceans platform has an online form that collects event-based (i.e., every dive) information from various ocean explorers (divers, snorkelers, fishers, etc.). Data collected from scuba divers (the focus of this study) included contact email, dive experience (number of dives in life), dive location (country, area, GPS coordinates and/or site name), dive date, the use of attractant (e.g., chumming, baiting) or spearfishing, and the presence or absence of jellyfish, seahorses, turtles, mammals, and litter, as well as the number of sharks and rays by species. For each, 'unknown' is offered as an option. Observations of sharks actively involved in mating or possible nursery locations (i.e., where many small individuals were observed together), were also solicited. Since 2007, there have been two versions of the form. Version 2 (V2) replaced version 1 (V1) in November 2015. Both had similar objectives and questions, but differed slightly. V1 asked for site depth and habitat type, which was redundant for dives occurring at the same site, and were therefore included as a descriptor within the site dropdown list in V2. V1 had photos of different sharks to select from that were grouped by like species (e.g., nurse sharks with a drop-down menu for tawny nurse shark), whereas V2 had a dropdown list of the most commonly sighted species, with room to enter other species, and no photos were included.

In 2012, members of the recreational dive industry in Thailand, led by the non-profit group 'Shark Guardian' (www.sharkguardian.org), committed to submitting their daily dive observations. Dive shops typically visit 10–20 different dive sites, up to three per day, which are scheduled by the day of the week. Site schedules usually only changed according to the weather, not the presence or absence of certain species (e.g., they do not change sites to target or avoid sharks). Divers in Thailand had the option of reporting observations directly online, or by recording dives and observations into community logbooks (e.g., at a dive shop) immediately following a dive. This commenced the first-ever, nation-wide census of sharks in Thailand. Dive shops, dive guides, their clients, and other recreational divers, participated by reporting daily observations. Shark Guardian recruited members by delivering a brief (20 min) presentation to interested participants, which included reasons for the study (e.g., vulnerability of sharks), how to correctly identify shark species, and where to report observations (See presentation outline here: http://www.sharkguardian.org/the-shark-guardian-presentation/).

For the current study, only events that took place from 2012 to 2016