CONSERVATION AND EDUCATION THROUGH ECOTOURISM:
USING CITIZEN SCIENCE TO MONITOR CETACEANS IN
THE FOUR-ISLAND REGION OF MAUI, HAWAII

JENS J. CURRIE, STEPHANIE H. STACK, AND GREGORY D. KAUFMAN

Pacific Whale Foundation, Wailuku, HI, USA

Introduction

Citizen science is a growing field worldwide and involves the public in science by allowing them to collect data for scientific purposes. Some notable examples of this type of scientific collaboration are Cornell Laboratory of Ornithology’s Project FeederWatch (Trumbull, Bonney, Bascom, & Cabral, 2000) and Pacific Whale Foundation’s Great Whale Count (Tonachella, Nastasi, Kaufman, Maldini, & Rankin, 2012). Many citizen science projects are opportunistic in nature and some make use of platforms of opportunity (PoPs), such as whale-watching boats, as a way to collect data. Recent discussions by the International Whaling Commission (IWC) have called for improved and streamlined methods for PoPs to collect information on cetacean distribution and relative abundance (IWC, 2015).

There are multiple clear benefits not only for the tourism industry but also for educators, wildlife managers, and researchers to collaborate with
citizen scientists to incorporate PoP data collection. For researchers, studying cetacean populations, especially in isolated areas, can be costly, time consuming, and logistically difficult (Kiszka, Hassani, & Pezeril, 2004). As such, basic information such as abundance and distribution of some cetacean species is still poorly understood. Of the 75 species within the Balaenidae, Delphinidae, Iniidae, Physeteridae, Platanistidae, and Ziphiidae families evaluated for the International Union for the Conservation of Nature (IUCN) Redlist, 55% \((n = 41)\) were considered data deficient (IUCN, 2015). In addition to traditional systematic research surveys, alternative data collection methodologies such as PoP could be employed to aid in data collection of these poorly studied species (Moura, Sillero, & Rodrigues, 2012).

With thousands of marine tour operations worldwide, the tourism sector could make an invaluable contribution to cetacean data collection. Implementing a data collection application for citizen scientists, such as Whale and Dolphin Tracker, on various PoPs throughout the tourism sector could greatly enhance cetacean monitoring efforts and aid in quality control of such data (Carlson et al., 2016). Monitoring efforts are especially needed in areas where baseline data are lacking and limited funding is available (Kaufman et al., 2011). The focus of this article is to show the type and amount of data citizen scientists can contribute to the protection and enhanced understanding of cetacean species through data collection on PoP, and compare this to other data collection techniques. The three methods of data collection presented here were conducted over the same time period in Maui, Hawaii and the merits of each are discussed.

### Methods

#### Systematic Research Surveys

Data were collected from a dedicated research vessel from January 1, 2013 to December 31, 2015 using systematic research surveys and line transect methodologies (Buckland et al., 2004). Observations were made by three dedicated observers while a fourth staff person acted as a data recorder. Data were collected on humpback whales if the initial sighting occurred within distance criteria described in Stack et al. (2013). Odontocete encounters initiated a focal follow, where photo-ID and behavioral data were collected. The following data were additionally recorded for all species: time and location (latitude and longitude) of sighting, vessel speed, age class, distance from boat, angle to group, and direction of travel. Environmental variables were also recorded at the beginning of each transect line and as they changed throughout the surveys.

Systematic surveys are widely used and prominent in cetacean research to estimate the density and/or abundance of wild animal populations with detailed methods described by Buckland, Rexstad, Marques, and Oedekoven (2015). This rigorous sampling design usually allows for greater inferences to be made with collected data. As such, researchers often use systematic transect surveys to assess population structure, life history characteristics, habitat preferences, and home ranges for cetaceans. These data can be used to guide species-specific management techniques to provide enhanced protection for the species, but are expensive and time consuming to conduct.

#### Platforms of Opportunity

**Whale and Dolphin Tracker.** Data were collected opportunistically using the application Whale and Dolphin Tracker from January 1, 2013 to December 31, 2015 onboard ecotourism vessels conducting whale watches and snorkel trips, which followed a nonsystematic track, and the user recorded whale and dolphin activity when sighted. In depth details on the build and data collection methodologies of Whale and Dolphin Tracker have been outlined in Kaufman et al. (2011) and Davidson, Currie, Stack, Kaufman, and Martinez (2014), respectively, with updates and basic information discussed below. The WDT application consists of a mobile web-based interface that can be accessed via a username and password. The data collection process involves a user, for example an ecotour guide/naturalist, who records opportunistic cetacean sightings using the Whale and Dolphin Tracker application downloaded to a mobile device. The user starts recording the GPS track at the start of the trip, adds sightings throughout the trip, and ceases the GPS tracking at the end of the trip. In addition to the species name, the following information is recorded with
The ROB program allowed the public to observe a researcher while they collected data and provided an additional educational resource to complement the normal narrative provided by an ecotour guide. This allowed passengers an accessible way to connect with marine science, enhancing the overall ecotour experience.

Results

Survey Effort

The systematic surveys had equal coverage of the area with overall lower total survey effort; the Whale and Dolphin Tracker surveys had dense coverage within the scheduled snorkeling and whale-watching trip routes with the highest total survey effort; and the ROB surveys had dense coverage of a small area within the scheduled whale-watching routes (Fig. 1).

Data Collection

Whale and Dolphin Tracker was able to record the highest number of species, survey the most distance, and spend the longest time at sea when compared to ROB and systematic research survey datasets (Table 1). During the same time periods, Whale and Dolphin Tracker surveyed 7.9 times the distance of systematic research surveys and 16.4 times the distance of ROB while recording 11.3 times the encounters reported using systematic research surveys and 6.2 times the encounters reported using ROB (Table 1).

Discussion

An aspect of species conservation often lacking in the marine environment is consistent long-term monitoring. The use of citizen science projects using tours as platforms of opportunity provides an avenue for long-term data collection and promotes citizen science by providing opportunities for the public to contribute to species conservation and management. As demonstrated in this article, tour vessels can serve as a scalable effective means of data collection recording high effort and encounter rates. Although beyond the scope of this article, the variations in the amount of data collected using...
systematic research surveys, ROB, and Whale and Dolphin Tracker survey methods is in part due to survey specific biases such as vessel size, number of observers, and trip type. As such, it is important to note that Whale and Dolphin Tracker is not meant to replace systematic research surveys, but could be used as a means to supplement data collection and foster greater connectivity between citizen scientists, tour operators, and wildlife researchers and managers.

Both Whale and Dolphin Tracker and ROB surveys provide a similar benefit in terms of additional effort and sightings without the need for a dedicated research vessel. Collection of ROB data requires a dedicated researcher to go on trips and analyze the collected data. This method allows for the collection of specific data and has been employed for photo identification research on PoP (Allen, Carlson, & Stevick, 2011), but is difficult to scale for existing tourism operations. Given the increase in public participation of citizen science (Conrad & Hilchey, 2011), Whale and Dolphin Tracker could provide increased opportunities for individuals to engage in marine conservation-related activities and research. The utility of large-scale data collection by citizen scientists using Whale and Dolphin Tracker remains unknown, as typical biases of opportunistic and citizen science data collection apply (Isaac, Strien, August, Zeeuw, & Roy, 2014). However, the use of a standardized user-friendly method of tracking effort and recording sightings, as implemented with Whale and Dolphin Tracker, would help minimize data collection biases (Carlson et al., 2016; Vinding, Bester, Kirkman, Chivell, & Elwen, 2015). Further, the use of citizen science data as a potential source for increasing support for basic and applied science has received substantial attention in recent literature (Issac et al., 2014), and there is a clear benefit to crowdsourcing data collection in order to

| Table 1 | Comparison of Ecotour Vessel’s Opportunistic Surveys and Research Vessel’s Systematic Surveys Conducted From January 1, 2013 to December 31, 2015 Within the Four-Island Region of Maui, Hawaii |
|---------|---------------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------|
| Ecotour Vessel | Ecotour Vessel Whale and Dolphin Tracker | Research Vessel | Systematic Research |
| Distance surveyed (nm) | 7,094 | 116,683 | 14,735 |
| Number of encounters | 1,476 | 9,113 | 807 |
| Number of species encountered | 7 | 11 | 7 |
| Days on water | 281 | 1,094 | 232 |
The use of citizen scientists and PoPs have the potential of making valuable contributions to the understanding of cetacean populations by providing alternate, long-term sources of information (Kiszka et al., 2004; Moore et al., 1999; Williams, Hedley, & Hammond, 2006). Despite some biases inherent with PoP surveys and citizen scientist data collection, the information gathered can be used to provide basic metrics on cetacean ecology (Moura et al., 2012) and distribution (e.g., Felix & Botero-Acosta, 2011; Moore et al., 1999), but represent an underutilized resource (Theobald et al., 2015). These data can feed into species management and conservation plans contributing to the protection of marine resources (e.g., Constantine, 2001; Evans & Hammond, 2004; Felix & Botero-Acosta, 2011; Timmel, Courbis, Sargeant-Green, & Markowitz, 2008).

PoPs and the use of citizen scientists should not replace systematic surveys for the management of species, but should be evaluated as an option to enhance data sets, particularly in areas where the financial or personnel resources to conduct systematic studies are lacking. PoPs can provide methods of data collection during a greater window of time, providing considerable effort that is not possible with systematic surveys alone. Recent advances in analytical techniques have proven effective for data collected on PoPs; for example, species distribution models to quantify habitat use in marine ecosystems (Guisan & Thuiller, 2005; Redfern et al., 2006).

Conclusion

In 2018 Whale and Dolphin Tracker was developed into a native application (app), which is freely available for both Android and iOS devices. The goal of developing this application was to make a free and easy to use program that other researchers and citizen scientists could use to improve the global body of knowledge about cetacean populations. Data collection using Whale and Dolphin Tracker would ensure consistent data collection between individuals and be relatively
easy to implement as the only equipment required is a smartphone. Further, this would allow for the collection of data across a wide range of species and locations, providing long-term monitoring efforts and increasing sightings histories for various species. The use of Whale and Dolphin Tracker to collect cetacean sighting information presents unique challenges with inherent biases in data collection, but also great potential to advance marine and coastal conservation, particularly in areas where populations are understudied due to resource limitations.

Acknowledgments

We would like to thank the members and supporters of Pacific Whale Foundation for providing funding for this work. Additionally, we extend thanks to Blake Moore and Morgan Wittmer, all captains and naturalists of PacWhale Eco-Adventures, Researchers-on-Board, and the research interns who contributed to data collection and processing. We would also like to thank Joe Breman and IUE Tech for working with Pacific Whale Foundation on development of the Whale & Dolphin Tracker application. This article is dedicated to the memory of Gregory Kaufman, who was one of the first researchers who began using PoPs to collect monitoring data and who recognized the value of citizen science.

Biographical Notes

Jens Currie is Senior Research Analyst at Pacific Whale Foundation. His research focuses on distance sampling, modeling cetacean population dynamics, and cetacean interactions with marine debris.

Stephanie Stack is Senior Research Biologist at Pacific Whale Foundation. Her research focuses on population ecology, behavior, patterns of residency, associations between individuals, and animal health.

Gregory Kaufman died in February 2018 and this was the last manuscript he co-authored before his passing (see the In Memoriam article in this issue). He was the Founder of Pacific Whale Foundation. Through his work at Pacific Whale Foundation he committed the organization to educating the public from a scientific perspective about whales and their ocean habitat.

References


