



Evaluating monitoring methods for cetaceans



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ARTICLE INFO

Article history:

Received 28 November 2015

Received in revised form 14 July 2016

Accepted 19 July 2016

Available online xxxx

Keywords:

Power analysis

Sampling effort

Hawaii spinner dolphins

Stenella longirostris

Human pressures

Individual identification

ABSTRACT

With increasing human pressures on wildlife comes a responsibility to monitor them effectively, particularly in an environment of declining research funds. Scarce funding resources compromise the level and efficacy of monitoring possible to detect trends in abundance, highlighting the priority for developing cost-effective programs. A systematic and rigorous sampling regime was developed to estimate abundance of a small, genetically isolated spinner dolphin (*Stenella longirostris*) population exposed to high levels of human activities. Five monitoring scenarios to detect trends in abundance were evaluated by varying sampling effort, precision, power, and sampling interval. Scenario 1 consisted of monthly surveys, each of 12 days, used to obtain the initial two consecutive annual abundance estimates. Scenarios 2, 3, and 4 consisted of a reduced effort, while Scenario 5 doubled the effort of Scenario 1. Scenarios with the greatest effort (1 and 5) produced the most precise abundance estimates ($CV = 0.09$). Using a $CV = 0.09$ and power of 80%, it would take 9 years to detect a 5% annual change in abundance compared with 12 years at a power of 95%. Under this best-case monitoring scenario, if the trend was a decline, the population would have decreased by 37% and 46%, respectively, prior to detection of a significant decline. With the potential of a large decline in a small population prior to detection, the lower power level should be used to trigger a management intervention. The approach presented here is applicable across taxa for which individuals can be identified, including terrestrial and aquatic mammals, birds, and reptiles.

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1. Introduction

With the ever-increasing human pressure on wildlife, we have a responsibility to monitor and manage wildlife populations effectively (Geffroy et al., 2015; Tablado and Jenni, 2015). Management decisions for the conservation of wildlife should be based on sound scientific investigations and rigorous monitoring regimes, particularly for those populations whose viability is threatened (Jaramillo-Legorreta et al., 2007; Turvey et al., 2007). These requirements, however, conflict with the perennial problem of scarce funding resources in conservation biology (Williams and Thomas, 2009; Williams et al., 2011). The challenge that management agencies face is the effective allocation of scarce funding resources to conservation research and management, while still being able to fulfill their statutory obligations. Consequently, managers often cut the costs of research to estimate wildlife abundance (Williams and Thomas, 2009; Williams et al., 2011). The trade-off for reduced funding for abundance estimation is a reduction in the precision of those estimates (Thomas et al., 2010), which has important

implications for the power of detecting trends in abundance. Power analysis determines the ability of a study to detect an effect of a given size with a degree of confidence and should be an integral part of any study that is investigating the demographic parameters of wildlife populations. Detecting changes in populations is critical for managing populations with low abundance.

Taylor et al. (2007) reviewed decades of monitoring data for marine mammal stocks under United States (U.S.) jurisdiction and found that agencies had almost no statistical power to detect even catastrophic declines in many stocks, especially oceanic dolphins. For example, a study of the Atlantic spotted dolphin (*Stenella frontalis*) in the Western North Atlantic had only 11% power to detect a 50% decline in 15 years (Taylor et al., 2007). In the waters of the U.S., marine mammals are data-rich by global standards, as exemplified by the fact that 75% of the world's ocean has never been surveyed to estimate cetacean density (Kaschner et al., 2012). In the face of such uncertainty, two broad approaches have been suggested as precautionary ways to conserve marine mammal populations when statistical power is low or data are scarce. One approach is to lower the burden of proof that a population is in decline before triggering a mitigation approach (e.g., Taylor et al., 2000). The other is to set allowable harm limits on an annual basis, so

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that populations should never decline below some predefined threshold, as long as those annual limits are not exceeded (e.g., Wade, 1998). Although these harm limits are usually thought of in terms of lethal removals from a population (e.g., through incidental catch in fisheries or ship strikes), decision rules could be articulated equally well in terms of the number of sub-lethal takes that policy makers are willing to allow animals to withstand (e.g., Higham et al., 2016).

Notwithstanding the difficulty in detecting declines in long-lived, slowly reproducing mammals, managers often require proof that a population falls within either the classification of “small population” or “declining population” (Caughley, 1994) before they act. Population monitoring programs designed to detect change and determine management strategies that hinge on proof of declines to trigger management intervention require precise and unbiased estimates of population parameters (Taylor and Gerrodette, 1993; Taylor et al., 2007). To do this, these programs must be designed to satisfy the assumptions of the estimation methods to ensure that the estimates are unbiased and have sufficient sampling effort to produce precise abundance estimates (Wilson et al., 1999; Thompson et al., 2000).

The power to detect trends in abundance depends on the relationship between the rate of change in the abundance, the precision of the abundance estimate (e.g., the coefficient of variation), and the acceptable levels of making errors to detect change (Type I (α) and Type II (β) errors). Variations in these parameters can then determine the efficacy of proposed monitoring programs to detect trends in abundance and provide a scientific basis for the level of precaution required to address management issues.

The U.S. National Oceanic and Atmospheric Administration (NOAA) has the mandate under the *Marine Mammal Protection Act* 1972 (MMPA) to protect all cetaceans, seals, and sea lions in U.S. waters and the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service have the responsibility for assessing the stocks of cetaceans and pinnipeds. The frequency of stock assessments depends on the classification of the stock: strategic stocks require annual reviews, while non-strategic stocks require reviews every 3 years or when new information becomes available (Carretta et al., 2014). A strategic stock is defined under the MMPA as a marine mammal stock “... (A) for which the level of direct human-caused mortality exceeds the potential biological removal level; (B) which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the Endangered Species Act (ESA) within the foreseeable future; or (C) which is listed as threatened or endangered under the ESA, or is designated as depleted under the MMPA.” Currently, Hawaiian spinner dolphins (*Stenella longirostris*) are not listed as threatened, endangered, or depleted. Furthermore, the levels of serious injury and mortality due to anthropogenic causes do not exceed the estimated potential biological removal (PBR) level for the stock (Carretta et al., 2014). Therefore, they are classified as a non-strategic stock.

In Hawaii, spinner dolphins live in small (Tyne et al., 2014), isolated stocks with restricted ranges (Andrews et al., 2010) and have evolved a specialized behavioral ecology (Norris and Dohl, 1980). They forage cooperatively offshore at night and return to sheltered bays to socialize and rest during the day (Norris and Dohl, 1980; Norris et al., 1994; Benoit-Bird and Au, 2009; Tyne et al., 2015), during which time the bays are also used extensively by people for tourism, recreational, and subsistence purposes (Heenehan et al., 2015). Some of these activities, in particular nature-based tourism, engage in repeated, close-up encounters with dolphins on a daily basis (Heenehan et al., 2015). These close-up encounters may have negative consequences for spinner dolphins, which is a major concern for managing the population. However, currently no data are available on the trends in abundance for any spinner dolphin stock in the Hawaiian archipelago (Carretta et al., 2014), which hampers the evaluation of potential impacts on Hawaiian spinner dolphins.

Here, data from a rigorous photo-identification study designed to estimate abundance were used to provide a second consecutive annual

abundance estimate for the Hawaii Island spinner dolphin stock (see Tyne et al., 2014, for the first estimate) and evaluate the power of different sampling strategies to detect change in abundance. Five scenarios with different levels of sampling effort, based on the systematic approach employed in Tyne et al. (2014), were evaluated in terms of their efficacy to detect trends in abundance by varying sampling effort, rate of change in abundance, precision, power, and interval between annual abundance estimates. The results from this research provide management with guidelines for evaluating sampling programs of different intensity to detect a trend in abundance and to guide where limited funding resources may be directed. This approach is applicable across taxa for which individuals can be identified, including terrestrial and aquatic mammals (e.g., Pennycuik and Rudnai, 1970; Parra et al., 2006), birds (Buckland et al., 2008; Williams and Thomson, 2015), and reptiles (Sacchi et al., 2010). The results also provide fundamental information for the development of monitoring programs that evaluate the efficacy of management interventions (e.g., time-area closures) designed to reduce the number and intensity of human–wildlife interactions.

2. Materials and methods

2.1. Fieldwork

Hawaii Island is the largest, youngest, and most southerly of the main Hawaiian Islands. On the leeward (west) side of the island is the Kona Coast, where four important dolphin resting bays are located: Makako Bay, Kealakekua Bay, Honaunau Bay, and Kauhako Bay (Fig. 1); (Norris et al., 1994; Thorne et al., 2012; Tyne et al., 2014, 2015).

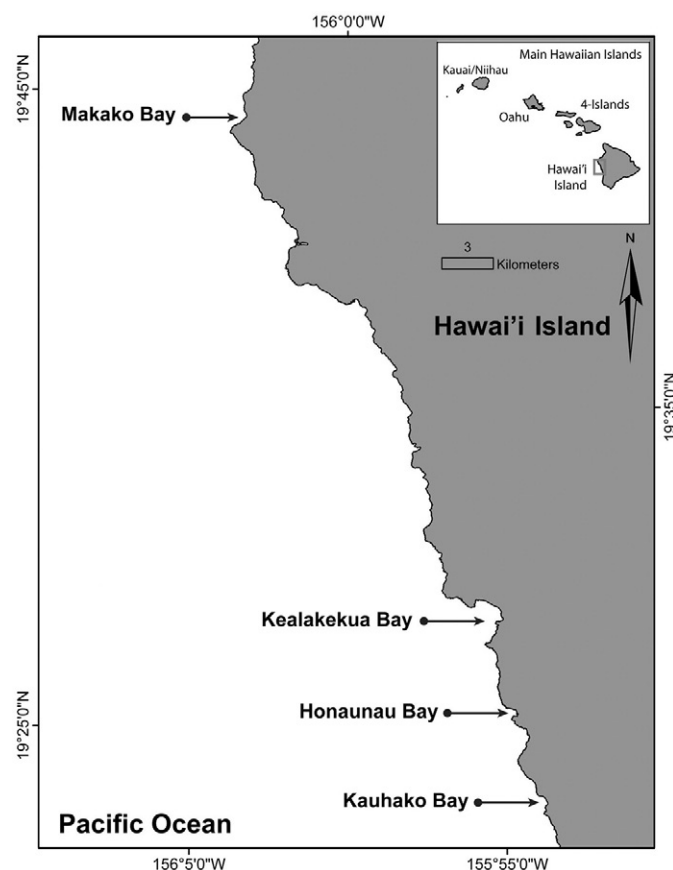


Fig. 1. Map of the study area illustrating the four spinner dolphin resting bays, Makako Bay, Kealakekua Bay, Honaunau Bay, and Kauhako Bay, along the Kona Coast of Hawaii Island.

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