Marine Policy 75 (2017) 84–90

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Using acoustics to prioritize management decisions to protect coastal dolphins: A case study using Hawaiian spinner dolphins

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ARTICLE INFO

Keywords:
Marine mammals
Conservation
Passive acoustic monitoring
Spinner dolphins, Tourism

ABSTRACT

For more than a decade, interactions between humans and Hawaiian spinner dolphins in their resting bays have been a concern for members of the general public, managers, scientists, policymakers, and tour operators. Hawaiian spinner dolphins are the target of a large wildlife tourism industry due to their predictable daytime resting behavior and presence in coastal areas. Using results from passive acoustic monitoring between January 2011 and March 2013 on the Kona coast of Hawai'i Island, USA, the relative importance of four known Hawaiian spinner dolphin resting bays, the contribution of anthropogenic noise including vessel noise to the four bay soundscapes, and the dolphins' response to human activities were assessed. Here the findings are summarized and visualized and recommendations are provided for action to regulate directed dolphin watching and ensuing unauthorized takes under the Marine Mammal Protection Act of 1972. These findings and recommendations have implications for the federal government's ongoing efforts to implement rules that protect Hawaiian spinner dolphins in their resting bays.

1. Introduction

The areas that coastal whales, dolphins and porpoises use for critical activities like breeding, feeding and resting often overlap with areas of high human activity. One activity specifically targeting interaction with these animals is wildlife tourism, commonly referred to as whale or dolphin watching. The rapid growth of the whale watching industry [1] and the growing concern for the effects of tourism on the animals led many countries to adopt measures to protect these animals in their waters [2,3]. These measures include voluntary codes of conduct, by far the most commonly adopted measure, general laws offering protection to marine mammals, and license or permit programs for whale watching activities [3]. The ability for policymakers and managers to make informed decisions about existing measures and develop new measures to effectively protect marine mammals from these and other activities relies on having sound scientific information about habitat use and distribution, the effects of the activity on the animals and their critical habitats, and the potential response of the animals to these activities [4]. Research should therefore be conducted across an area, or multiple areas, with variation in the levels of human use, dolphin use, and the level of human-dolphin interactions to help identify issues, focus efforts, and prioritize action.

One area where management action is needed due to the rapid growth of the industry, the frequency and intensity of the human-dolphin interactions, the importance of the areas for targeted species, and the time these interactions occur is on the Kona coast of Hawai'i Island, USA. The Kona coast supports a small [5,6] and genetically distinct [7] group of spinner dolphins, *Stenella longirostris*. These spinner dolphins rest predictably during the daytime in shallow, coastal areas, necessary after hours of intense nighttime foraging [8]. This predictable behavior and the dolphins' use of these easy to access bays has resulted in a large wildlife tourism industry, including swim-with wild dolphin programs targeting spinner dolphins in their resting bays [9]. In 2008, dolphin-watching on Hawaii, Maui, Oahu, and Kauai accounted for 5.9 million US dollars in direct expenditures [1].

The frequency and intensity of the ensuing interactions between humans and spinner dolphins have been of concern to managers and policymakers in the National Oceanic and Atmospheric Administration (NOAA) and specifically the National Marine Fisheries Service (NMFS) within NOAA for more than a decade [10]. In 2005 the NMFS and

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http://dx.doi.org/10.1016/j.marpol.2016.10.015
Received 11 October 2016; Received in revised form 19 October 2016; Accepted 19 October 2016
Available online 28 October 2016
0308-597X/

NOAA announced its plan to implement new regulations to further protect spinner dolphins in Hawai'i, here referred to as Hawaiian spinner dolphins, and in 2006 suggested a network of marine protected areas, time area closures, as their proposed action with alternative options including no action, an approach rule, prohibiting certain activities, and complete closures. In August 2016, the NMFS and NOAA, instead of time area closures, proposed a no swim-with and 50-yard approach rule and is seeking public comment on this rule through October 2016 [11]. NOAA is also seeking comment on potential voluntary or mandatory closures in addition to the proposed no swim-with and 50-yard approach rule.

The NMFS is given legal authority to protect Hawaiian spinner dolphins under the Marine Mammal Protection Act of 1972, 16 U.S.C. 1361 et seq. (MMPA) [12]. The MMPA prohibits "take" of marine mammals defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill." Harassment is defined as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild; or has the potential to disturb a marine mammal... by causing disruption of behavioral patterns." Since Hawaiian spinner dolphins are not listed as threated or endangered, the MMPA is the only major piece of federal legislation involved in protecting spinner dolphins in Hawai'i. Other than the language of the MMPA, a set of posted "Dolphin Viewing Guidelines" (http://www.fpir.noaa.gov/PRD/prd_swim_with_wild_-dolphins.html) and the fact that there is no exemption to the MMPA for wildlife viewing like that for scientific research, there are no specific measures in place to manage human behavior and interactions with Hawaiian spinner dolphins within their resting bays at this time. Therefore, all activities should be conducted in a manner that does not result in unauthorized take [10]. However, neither the language of the MMPA or the posted guidelines for interacting with Hawaiian spinner dolphins, nor the notice of intent to implement time area closures have prevented the development and rapid growth of a wildlife tourism industry targeting the dolphins in their resting bays.

When NOAA suggested the time areas closures in 2006 many claimed that the effects of human-spinner dolphin interactions were not well understood and called for more research. This led to funding the Spinner Dolphin Acoustics, Population Parameters and Human Impacts Research (SAPPHIRE) Project, a joint project between Murdoch University and Duke University. This project set out to quantify the effects of human interactions on spinner dolphins across multiple sites with variation in the levels of human and dolphin use and human-dolphin interactions. The SAPPHIRE project employed multiple methodologies in four Hawaiian spinner dolphin resting bays including passive acoustic monitoring and visual surveys with the intent of providing sound scientific information to inform management action. This manuscript synthesizes and integrates the results from this multi-faceted research and provides recommendations for action to protect Hawaiian spinner dolphins in their resting bays.

2. Acoustic monitoring across multiple sites

Passive acoustic monitoring and visual surveys were conducted across four Hawaiian spinner dolphin resting bays on the Kona Coast of Hawai'i Island: Makako, Kealakekua, Honaunau and Kauhako bays here called Bay 1, 2, 3 and 4 (Fig. 1).

Acoustic loggers were deployed in each of the bays for 20 (Bay 1, 3 and 4) or 27 months (Bay 2) between January 8, 2011 and March 30, 2013, making 30-second recordings every four minutes (see [13] for more details). Concomitant vessel-based surveys were used to provide context for these recordings (see [5,6,8,14] for more details). Further information on Methods can be found in [15].

The first goal was to use the acoustic recordings to monitor the long-term presence of spinner dolphins in the four bays to understand how much the dolphins use the different sites [13]. There was great variation in the degree of presence in the four bays from less than 40% (Bay 3) to almost 90% (Bay 1) of days monitored with dolphins present (Table 1).

Using the recordings from days with overlapping visual surveys, the results were found to be comparable to those from visual surveys. Thus supporting the use of passive acoustic monitoring to reliably monitor the daily presence of Hawaiian spinner dolphins in their resting bays [13].

Having established passive acoustic monitoring as a reliable tool for Hawaiian spinner dolphins [13], the acoustic environment, or soundscape, was studied in these important resting bays (see [15] for a description of methods). Sound levels in all four bays were consistently louder at night and quieter during the day with the quietest part of the day overlapping with peak Hawaiian spinner dolphin resting time (as established in [8]). Resting during this quiet time would certainly have its benefits including aiding in communication and socialization and listening in for approaching predators. However, humans drastically altered this quiet daytime soundscape.

Many of the greatest soundscape perturbations, namely the loudest 30-second files and loudest days recorded could be attributed to human activities (see [15] for a description of methods). By quantifying the number of short, 30-second file long soundscape perturbations, here called acute soundscape perturbations and longer day-long soundscape perturbations, here called chronic soundscape perturbations, the influence of human activities on the soundscape at each site was evaluated. Humans drastically altered the daytime soundscape with sound from aquaculture, vessel sound, and military mid-frequency active sonar. Soundscape perturbations from vessel sound and mid-frequency active sonar occurred in all four bays. As an example of how much these activities can change the soundscape, during one mid-frequency active sonar event in August 2011, sound pressure levels in Bay 1 were as high as 45.8 dB re 1 uPa above median noise levels, the highest recorded perturbation in any of the bays [15].

Given the fact that vessel sound was one of the three major causes of soundscape perturbations in the bays, the recordings and the visual surveys were used to determine the effect of vessels on the spinner dolphin resting bay soundscape across the four sites [15]. Firstly, the relationship between the number of vessels present and recorded sound levels was examined. One might automatically assume that more vessels in the bay would result in more vessel sound recorded. However, for this to be true, more vessels in the bay would result in more sound and higher sound levels only if the vessels were moving. Bay 1, a bay with highly dolphin-centric activities since it is targeted by swim-with dolphin tours [9] had the strongest relationship between the number of vessels and increasing sound levels. In this bay, the vessels follow the dolphins and move to keep people close to the animals. Each vessel added in Bay 1 contributed an additional 1.3 dB re 1 uPa. Bay 2 was the busiest bay with the highest number of vessels present; however, Bay 1 had higher sound levels and a stronger relationship between increasing vessels and increasing sound levels. Vessel behavior in Bay 2 is more focused on the coral reef in the bay and the activity is not always dolphin-centric or dolphin focused like it is in Bay 1 [9]. Vessels generally enter, drop snorkelers off to snorkel the reef, wait with their engine off until they retrieve the snorkelers and then leave the bay. Each additional vessel in Bay 2 contributed only 0.5 dB re 1 uPa. There was no relationship between increasing number of vessels and increasing vessel noise in Bay 3 or Bay 4, likely due to the low number of vessels present in these two bays [15,16].

Given this knowledge of the bays, a growing understanding of important differences between the bays, and the concern for the effects of human activity on the dolphins, the last goal was to assess how dolphins acoustically respond to human activities [15,16]. Previous research on the Hawaiian spinner dolphins found that the dolphins were silent during rest and that acoustic activity matched the general behavioral state of the animals [17,18]. Therefore, higher dolphin whistle activity before and after the dolphins' peak resting time and low activity in the late morning and early afternoon to indicate rest was