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Field trials of an acoustic decoy to attract sperm whales away from commercial longline fishing vessels in western Gulf of Alaska

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ABSTRACT

In the Gulf of Alaska, sperm whales (*Physeter macrocephalus*) are known to remove sablefish (*Anoplopoma fimbria*) from commercial longline fishing gear. This removal, called depredation, is economically costly to fishermen, presents risk of injury or mortality to whales, and could lead to unknown removals during the federal sablefish longline survey that contributes to estimation of the annual fishing quota. In 2013 the Southeast Alaska Sperm Whale Avoidance Project (SEASWAP) evaluated the efficacy of an acoustic decoy in reducing encounters between sperm whales and longline fishing gear. The aim of the acoustic decoy was to use fishing vessel sounds to attract whales to an area away from the true fishing haul in order to reduce interactions between commercial fishing vessels and whales. A custom playback device that could be remotely activated via a radio modem was incorporated into an anchored buoy system that could be deployed by the vessel during a two-month trip between June and July 2013. Once activated, the decoy broadcasted vessel-hauling noises known to attract whales, while the vessel performed several true hauls at various ranges from the device. Passive acoustic recorders at both the decoy and true set locations were also deployed to evaluate whale presence. Twenty-six hauls were conducted while a decoy was deployed, yielding fourteen sets with whales present while the decoy was functional. A significant relationship was found between the number of whales present at the true fishing haul and the distance of the haul from the decoy (1–14 km range), with the decoy being most effective at ranges greater than 9 km ($t = -2.06$, $df = 12$, $p = 0.04$). The results suggest that acoustic decoys may be a cost-effective means for reducing longlining depredation from sperm and possibly killer whales under certain circumstances.

1. Introduction

Removal of hooked or netted fish from fishing gear by marine mammals is a worldwide phenomenon known as depredation. Rarely are these interactions positive, often resulting in economic costs for fishers, and risk of bycatch or entanglement for animals (Gilman et al., 2006; Read, 2008; Read et al., 2006). Odontocetes (toothed whales) are particularly attracted to longline fisheries as fish are easily accessible on the lines. In the Hawaiian, Australian, and Fijian pelagic longine fisheries, false killer whales (*Pseudorca crassidens*) routinely remove fish, and may become hooked themselves (Gilman et al., 2006; Hamer et al., 2015; Mooney et al., 2009). Similar occurrences are reported with false killer whales off the coast of Brazil and the Azores archipelago in the Atlantic Ocean (Hernandez-Milian et al., 2008). Sperm and killer whales routinely depredate demersal longline vessels in the Patagonian toothfish fisheries off the Crozet Islands (Guinet et al., 2015; Roche et al., 2007; Tixier et al., 2010), Chile (Moreno et al., 2008), and South Georgia (Purves et al., 2004). The Norwegian demersal longline fleet targeting Greenland halibut, Patagonian toothfish, Atlantic halibut and cod have been experiencing depredation from sperm whales since the mid 1990′s (Dyb, 2006).

Techniques to prevent marine mammals from interacting with fishing operations are known as "deterrents", which are defined as aversive, harmful, fearful, or noxious stimuli that elicit defensive or avoidance responses in animals (Götz and Janik, 2010). These stimuli can be painful, disruptive, threatening, or distracting, and delivered through acoustic, chemosensory, visual, or tactile means (Schakner and Blumstein, 2013). The goal of a deterrent is for the animal's perceived cost of continuing the behavior (e.g. exposure to loud noise) to outweigh the gain from this action (food resource/caloric intake).

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A variety of gear modifications have been tested to reduce depredation effects in longline fisheries (Gilman et al., 2006; Hamer et al., 2012). Wire nets, chains, streamer devices, and net sleeves have been tested on pelagic longline gear as modifications to protect fish as they are hauled to the surface, with some preliminary success (Hamer et al., 2015, 2012; Moreno et al., 2008; Rabearisoa et al., 2015). A primary concern with many of these gear modifications for fishers is often the impracticality of adapting the additional gear to their fishing operation, cost of doing so, and minimal buy-in when depredation persists.

Acoustic deterrents, commonly known as Acoustic Deterrent Devices (ADDs) for marine mammals are designed to emit sounds particularly distracting or annoying to the target animal, such that an aversion to the area is created (Jefferson and Curry, 1996). ADDs designed specifically to disrupt depredation behavior include acoustic playback devices, a specific type of acoustic deterrent that are designed to play pre-recorded sounds from underwater speakers to animals for deterrence purposes. Playback experiments have targeted both cetaceans and pinnipeds, and include a variety of signals such as tonal sounds, frequency modulated sweeps, and windowed pulses (Cummings and Thompson, 1971; Deecke, 2006; Fish and Vania, 1971; Gilman et al., 2006; Kastelein et al., 2006a,b; Mooney et al., 2009; Nowacek et al., 2004; Shaughnessy et al., 1981; Tixier et al., 2014b; Tyack, 2009). Most marine mammal species have been observed to exhibit avoidance and anti-predatory responses to transient killer whales, which has prompted some playback experiments to assess behavioral responses (Cummings and Thompson, 1971; Deecke et al., 2002; Fish and Vania, 1971; Shaughnessy et al., 1981). Testing of playback devices has found that while they show some short-term success, their efficacy vanishes after a few days as animals habituate to the sound and ignore it, suggesting long-term success is likely low (Arangio, 2012; Mooney et al., 2009; Tixier et al., 2014a). In general ADDs can be difficult to design, face regulatory concerns about noise exposure and animal injury, and are vulnerable to animal habituation (Arangio, 2012; Jefferson and Curry, 1996; Mooney et al., 2009; Schakner and Blumstein, 2013; Tixier et al., 2014b; Tyack, 2009).

In Alaska demersal longline fishermen have been experiencing removal of sablefish (*Anoplopoma fimbria*) by sperm whales (*Physeter macrocephalus*) and killer whales (*Orcinus orca*) since the 1970s (Dahlheim, 1988; Hill et al., 1999; Peterson et al., 2013; Sigler et al., 2008; Straley et al., 2015; Yano and Dahlheim, 1995). Reports of depredation have increased in Alaskan waters after implementation of the catch-share program in the mid-1990s (Hanselman et al., 2014; Hill et al., 1999). In addition to increased reports, documentation of depredation on the federal longline sablefish survey has experienced an accelerative pattern of increase over time, and fits predictions of social transmission of this behavior (Schakner et al., 2014).

Since 1995 the sablefish fishery in Alaska has been managed under an Individual Fishing Quota (IFQ) program by the National Marine Fisheries Service (NMFS) with a season of roughly 8 months, from mid-March to mid-November. In 2012 there were 838 individuals that fished quota shares for sablefish in Alaska, from just over 600 vessels (NOAA Fisheries Service, 2013). Vessels are classed into size categories of A (freezer vessel any length), B (> 60 ft), and C (≤60 ft), with median vessel length increasing from 49 ft in 1995–56 ft in 2012 (NOAA Fisheries Service, 2013). The total fishery value for 2016 was estimated to be over $189 million (NOAA, 2017). While pot gear and demersal longline gear have both been legal in the Bering Sea region since the IFQ program began, the Gulf of Alaska (GOA) has restricted the gear to demersal longline gear from 1989 to 2017, when pots were first allowed again in the GOA (NOAA, 2017). The GOA has four management areas (Western Gulf, Central Gulf, West Yakutat, and Southeast), in addition to the Bering Sea (BS) and Aleutian Islands (AI) regions.

In 2003, as a response to economic costs of depredation and entanglement risks to whales, the Southeast Alaska Sperm Whale Avoidance Project (SEASWAP, www.seaswap.info) was formed. SEASWAP is a collaborative effort between fishermen, scientists, and fisheries managers, working cooperatively towards the common goal of investigating and documenting the occurrence of sperm whales in association with longline fishing to develop strategies to minimize this interaction. Within the SEASWAP project in the GOA, a variety of deterrence strategies have been tested including changing fishing practices, gear modifications, and acoustic playbacks of frequency modulated upsweeps, white noise, and transient killer whale vocalizations (O'Connell et al., 2015; Thode et al., 2010, 2009). However, none of these strategies has provided a significant reduction in depredation rates (O'Connell et al., 2015; Straley et al., 2015; Thode et al., 2010, 2009).

One of the first major findings from SEASWAP gave insight into how sperm whales were able to detect and locate longline fishing activity in the vast offshore habitat of the GOA. SEASWAP found that fishing vessels make a distinct sound as fishermen engage and disengage the engine to stay on top of their gear as they haul their long lines to the surface. This sound, arising from propeller cavitation, creates a distinctive pattern that can be measured at distances of 4–8 km (Thode et al., 2007). Anecdotal evidence has revealed that whales were observed abruptly changing direction and making a beeline for a fishing vessel that began hauling gear 18.5 km from a tagging vessel (Straley pers. comm.). Whales have learned that this 'acoustic cue' is a signal that longline hauling is occurring (Thode et al., 2007).

During the first few years of acoustic SEASWAP studies (Thode et al., 2009, 2006), fishing vessels would often drop extra buoylines that contained passive acoustic instruments, in addition to their actual groundline deployments. Sperm whales would often loiter around the instrumented buoylines as the vessel departed the area, and would be present when the vessel returned to haul both the true and instrumented gear. A review of sperm whale sounds on the acoustic instruments demonstrated that the animals remained in the vicinity of the instrumented gear all night (Thode et al., 2006), revealing that animals were willing to wait near an anchored buoyline that contained no real fishing gear. Anchored buoylines appear to act as a decoy, distracting whales from the true fishing set.

The discovery of acoustic cues that alert and attract sperm whales suggested that acoustic playbacks could be combined with the passive decoy strategy to create an "acoustic decoy" (Thode et al., 2015). Here the "passive decoy" represents a buoy deployment, not attached to true fishing gear, that is used to delay and/or distract marine mammals from true fishing activity, but does not generate any sound. The acoustic playback component adds a device emitting vessel hauling sounds, the attractant for sperm whales to detect fishing activity, to this anchored buoyline. The idea of using acoustic playbacks to attract animals *away* from a region is not nearly as common in the scientific literature as the use of playbacks to drive animals out of a region (Gilman et al., 2006; O'Connell-Rodwell et al., 2011; Schakner and Blumstein, 2013).

An initial engineering trial of the decoy concept was performed off Sitka in August 2011, during which pre-recorded sounds of a fishing vessel hauling longline gear were played back from an underwater speaker. Both visual and acoustic observations suggested that animals did converge to the decoy, delaying their response to an actual fishing haul (Thode et al., 2015). Based on that trial, this study was designed to test the efficacy of an acoustic decoy device in attracting sperm whales away from fishing activity and reducing the effects of depredation on longline fishermen in Alaska. The basic premise of the acoustic decoy device was to deploy it away from the vicinity of the true fishing gear, where it would play recordings of vessels hauling gear, thereby attracting whales away from the fishing gear. Thus the fishers could haul their fishing gear without whales present, with fewer numbers of whales present, or with increased time delay for whales to leave the decoy and travel to their gear.

The goal of this experiment was to determine how the distance between the decoy and the true fishing haul affected depredation and whale interactions with fishing operations. The distance variable was