APPENDIX

HAZING TREATMENT DETAILS

The following Table lists the nine principal hazing treatments or treatment combinations along with additional individual hazing treatments which were tested during the hazing trials for a total of 29 unique treatments tested. For each, we describe the hazing treatment, how it was used, and provide detailed product descriptions for each hazing treatment tested. Treatments are listed in order of overall mean efficacy.

Description (abbreviation)	Treatment Use	Product Specifications
Principal hazing treatments		
Lasers *(laser)*		
Lasers are concentrated light beams used in low lighting conditions to disperse or deter birds.	Three different lasers of varying power and intensity were used during the trial, a small 5mW green penlight (las1), a large 50mW red Avian Dissuader™ (las2), and a green 50mW Aries Bird Phazer Laser® (las3). Lasers were generally used in the early morning and the evening when light levels were low. Lasers were known to be less effective during daylight hours except at close range, so limited testing of this tool during the day was undertaken.	Galileo Series 532nm 5mW Green Laser Pointer (Laserglow Technologies Ltd.); Avian Dissuader™ model BDL-650 50mW red laser (Sea Technology, Inc., Albuquerque, NM); Aries 50 Bird Phazer Laser® 532nm green laser (JWB Marketing LLC, 2308 Raven Trail, West Columbia, SC 29169)
Bird Gard Unit (amplified) *(bga)*		
Biosonics, or bioacoustics, as a hazing method, involves using animal alarm or distress calls to alter the behavior of a target species.	Bird Gard Super Pro-Amp® with 20 amplified multi-directional speakers on a tower. Each unit was pre-programmed with a combination of recorded gull distress calls and hawk, peregrine falcon, and eagle calls, and was triggered on command to flush gulls or deter them from returning.	Bird Gard Super Pro-Amp® (Bird Gard, LLC, 270 E. Sun Ranch Drive, P.O. Box 1690, Sisters, OR 97759)
Pyrotechnics plus additional treatment *(pyroplus)*		
Pyrotechnics were used in combination with other hazing treatments.	There were three main combinations tested: Bird Gard amplified followed by pyrotechnics, LRAD followed by pyrotechnics, and pyrotechnics fired from the helicopter.	See individual treatment sections for specifics
Pyrotechnics *(pyro)*		
Pyrotechnics describe a wide variety of tools that can be used to haze birds.	Pyrotechnics of seven varying types were tested. Quieter or less disturbing charges were used first when near or	Pyrotechnics used during the trial: Blank primer caps, Bird

Pyrotechnics are primarily an auditory stimulus, creating a loud bang or report, but many charges also produce bright flashes, spiraling light, and smoke.	close to pinnipeds, to minimize any unnecessary disturbance, to gauge the range of these devices and evaluate whether habituation by pinnipeds to their use was possible. Pyrotechnics were often used in conjunction with other hazing methods to disperse birds that were already in the air.	Bangers®, Screamer Sirens®, and CAPA rockets® (Reed-Joseph International Company, 800 Main Street, Greenville, MS 38701); Bird Bombs®, Bird Whistlers®, and Shell Crackers (Sutton Ag Enterprises, 746 Vertin Ave, Salinas, CA 93901)
Long Range Acoustic Device *(LRAD)*		
A powerful but portable directional speaker which can be made to play pre-recorded sounds.	Predator and distress calls were played both from the ground and later from a helicopter, to flush gulls from roost sites and deter them from resettling.	Long Range Acoustic Device (LRAD Corporation, 16990 Goldentop Road, STE A, San Diego, CA 92127)
LRAD and Helicopter *(helirad)*		
The LRAD unit was used from the helicopter to haze gulls from less accessible locations or to discourage gulls from approaching the island to roost.		
Marine Phoenix Wailer® *(wailer; wail)*		
The wailer is a large, stationary or floating multi-speaker, amplified biosonic device designed to prevent birds from alighting on the water and typically used to discourage birds from landing on oil slicks.	For the trial, the sound-emitting component of the Wailer was removed from its marine floats and placed on the ground above a gull roost. It was programmed to play pre-recorded distress and predator calls.	Marine Phoenix Wailer® (Phoenix Agritech. P.O. Box 10, Truro, Nova Scotia.B2N 5B6,Canada
Bird Gard Units *(not amplified; bg, bgm)*		
Biosonics, or bioacoustics, as a hazing method, involves using animal alarm or distress calls to alter the behavior of a target species.	Two different Bird Gard biosonic units were tested: 1) A small Bird Gard Super Pro® with four portable speakers (bg); 2) a Bird Gard Super Pro® with a 4 speaker multi-directional speaker tower (bgm); Each unit was pre-programmed with a combination of recorded gull distress calls and hawk, peregrine falcon, and eagle calls, and was triggered on command to flush gulls or deter them from returning.	Bird Gard Super Pro® (Bird Gard, LLC, 270 E. Sun Ranch Drive, P.O. Box 1690, Sisters, OR 97759)
Helicopter *(helo)*		

Helicopters present both an auditory and visual stimulus that can be used to flush roosting birds or dissuade them from landing.	A small, relatively quiet helicopter was used principally for monitoring the presence of gulls and pinnipeds on the islands, as well as to transport personnel and equipment to West End. It was also later used as a tool to dissuade gulls from returning to the island or for hazing gulls in less accessible locations (often in combination with other treatments).	Robinson 22 helicopter (Robinson Helicopter Company, 2901 Airport Drive, Torrance, CA 90505)
Additional hazing treatments not analyzed due to small sample size		
Zon cannons *(zon)*		
Propane cannons, also called gas exploders, produce a loud, directional blast similar to that emitted by a 12-gauge shotgun.	Propane cannons were tested but due to issues associated with moisture and sound levels they were only occasionally used during the trial. Cannons were triggered on command to flush gulls that were roosting or returning to roost areas.	Zon® Mark 3 cannons (Sutton Ag Enterprises, 746 Vertin Ave, Salinas, CA 93901)
Human Movement *(hum)*		
Movement of people on foot across the island	Physically walking towards gull roosts for the purpose of hazing or gulls flushed as a result of monitoring and setting up hazing equipment	
Effigies *(ef)*		
Effigies are models of animals or human forms (scarecrows) used with the intent of scaring birds.	Effigies consisting of recently scavenged dead Western Gulls were attached to 8ft poles by nylon fishing line. Approximately 15 effigies were used during the trial.	Carcasses of gulls that died of natural causes were collected locally at the Farallones
Mylar® Tape *(my)*		
Mylar® is a reflective plastic ribbon colored on one side. It is often tied to poles or suspended from overhanging lines, where its motion in the wind reflects sunlight and creates a humming or crackling sound.	Mylar® tape was deployed at a few locations to discourage gulls from roosting. The tape was secured to the top of an 8ft pole and allowed to stream out in the direction of the wind. Several poles (up to 10) were placed in a single location and were spaced approximately 10m apart.	1.25” width reflective tape, silver on one side and red on the other.
Kites *(kt)*		
Kites (traditional and inflatable) in the shape of predators or painted with	Two types of kites were deployed, a raptor shaped standard kite and a balloon kite. Both kite designs aimed to mimic aerial predators to frighten	Allsopp Helikite Ltd. helium-filled balloon kite (Unit 2, Business

predators can be used to deter birds.	and disperse birds. These were flown or positioned as close to intertidal gull roost areas as possible.	Park, Fordingbridge, UK, SP61BD).
Balloons *(bal)*		
Inflatable Mylar® balloons are highly reflective and typically mimic a predator's eye. They are often tied to poles or suspended from overhanging lines where they can move in the wind and reflect sunlight.	Balloons were used infrequently at a few roost locations to try to discourage gulls from roosting.	"big-eye"/"scare eye" balloons (Bird-X Inc. 300 N Oakley Blvd. Chicago, IL 60612)
Owl decoy *(owl)*		
Plastic owl predator decoy	Decoy deployed on a pole in a gull roost location.	Dalen "Natural Enemy Scarecrow" (Dalen Products, Inc. 700 Dalen Ln, Knoxville, TN)
Laser and helicopter *(helolas)*		
Lasers were used to flush roosting gulls from land. Helicopter hazing then followed to disperse gulls and dissuade them from landing again. This combination was used infrequently because the lasers were only effective in low light conditions when the helicopter could not fly.		

Observations on Other Hazing Treatments

Only 21 of 29 individual hazing treatments that were tested during the hazing trial were included in the statistical analysis in this study. Eight treatments were not analyzed due to low sample sizes; this was generally due to their ineffectiveness as determined during the first few days of the trial. However, it is worth noting some general observations on these treatments. Mylar tape, balloons, and kites, while common in some hazing applications (Seamans *et al.* 2002, Gorenzal & Salmon 2008), were among the least effective dissuasion methods tested and were not among the principal methods analyzed in this study. These tools were difficult to deploy, often broke down, and had little effect on gulls. Likewise, Zon propane cannons have been used effectively to deter birds from landfills and airports but were largely ineffective during our hazing trial and did not function well under the conditions typically expected at the South Farallon Islands (i.e., strong winds and foggy, wet conditions).

The only passive hazing treatment that was routinely effective were Western Gull effigies (dead gulls hung from a pole). These were particularly effective at dissuading gulls from returning to a roosting site after another treatment method had been used to flush them and gull numbers remained low for the duration of time the effigies were present, suggesting little habituation to their presence. Effigies are recommended as a deterrent once wildlife has been successfully dissuaded using one or more of the more effective treatments.

Although we tested a large range of hazing treatments, there were other options available that were not employed during this study. Unmanned Aerial Systems (UAS; aka drones) have potential as hazing tools for gulls (Pfeiffer *et al.* 2023) but permission from the Federal Aviation Administration was not obtained in time to include testing of this technology in the trial. UAVs could be flown at lower altitudes than the helicopter and would likely have greater efficacy as a hazing device.

Dogs and trained raptors (Marsh *et al.* 1991, Seamans & Gosser 2016) are other potential gull hazing tools that may be effective on the Farallones; however, the testing of these methods was not included because of resource limitations. Finally, lethal hazing techniques, such as removing a single individual gull to dissuade a group from returning to an area, have proven effective elsewhere (Cook *et al.* 2008), but were not included because of the desire to minimize the impacts of the trial on gull populations.