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Adapting strategies to maintain efficiency during a cull of yellow-legged gulls

Sugoto Roy, National Wildlife Management Centre, Animal and Plant Health Agency, Sand Hutton Campus, York, United Kingdom, YO41 1LZ *sugotoroy@gmail.com*
Ray Ridley, National Wildlife Management Centre, Animal and Plant Health Agency, Sand Hutton Campus, York, United Kingdom, YO41 1LZ
Jeff Sandon, National Wildlife Management Centre, Animal and Plant Health Agency, Sand Hutton Campus, York, United Kingdom, YO41 1LZ
John R. Allan, National Wildlife Management Centre, Animal and Plant Health Agency, Sand Hutton Campus, York, United Kingdom, YO41 1LZ
Peter A. Robertson[1], National Wildlife Management Centre, Animal and Plant Health Agency, Sand Hutton Campus, York, United Kingdom, YO41 1LZ
Andrew Baxter, Birdstrike Management Ltd., Applied Innovation Campus, Sand Hutton, York, United Kingdom, YO41 1LZ

Abstract: Increasing populations of yellow-legged gulls (*Larus michahellis)* in the Mediterranean have created conflicts with seabird conservation, migrating raptors, and humans. As a mitigation measure, gulls are routinely culled in the region. Previous studies of extended culls show that catch per unit effort declines over time through a combination of population reductions and avoidance behaviors developing within the remaining population. We countered these problems during a 4-year cull of yellow-legged gulls in Gibraltar by matching the type and mode of deployment of firearms in response to changes in gull distribution and behavior. We found that shotguns were effective when gulls mobbed operators near nesting areas, while rifles were more effective as gulls became wary and retreated farther from the operators. Changing the type of firearm enabled us to counter the expected rate of decline in culling efficiency throughout the project. We were most efficient in the first year of the project, killing gulls at a mean rate of 8.35 birds per man-hour. Although this declined to 4.83 by the third year, the adjustments that we made to the way firearms were deployed raised it to 6.4 in the fourth year despite a 79% decline in the observed total gull population over this period. We modelled the population data collected using a Leslie Matrix to evaluate the impact of management at the end of the culling period. The population declined at a greater rate than explained by the numbers actually culled, suggesting that the cull resulted in an additional disturbance, which triggered emigration at a rate of 35%, over and above the numbers culled.

Key words: control methods, cull, disturbance effect, emigration, firearms, Gibraltar, gulls, *Larus michahellis,* population decline, yellow-legged gull

Yellow-legged gulls (*Larus michahellis*), hereafter referred to as gulls, are common throughout the Mediterranean region with a total population size estimated between 310,000 and 580,000 pairs (Birdlife International 2009). Populations have increased over the last few decades (Vidal et al. 1998) due to the increased availability of anthropogenic food sources, such as refuse and discarded fish (Duhem et al. 2003), and have resulted in yellow-legged gulls increasingly coming into conflict with human populations (Ramos et al. 2009).

High densities of gulls have a range of impacts, including bird strike risk to aircraft, and concentrated deposition of feces, which can soil buildings and vehicles while increasing the potential transmission of pathogens such as Salmonella, *E. coli*, and avian botulism (Ortiz and Smith 1994). Breeding gulls can also be aggressive to people. These gulls are kleptoparasites of populations of the near-threatened Audouin's gull (*Larus audouinii*) and

[1]Alternate address: Centre for Wildlife Management, Newcastle University, Newcastle, United Kingdom, NE1 7RU

storm petrel (*Hydrobates pelagicus*; Oro et al. 2005, Paracuellos and Nevado 2010). Gulls can also disrupt the annual migration of a number of raptor species between Africa and Europe (Mosquera 2008).

To reduce conflicts, the species is routinely culled in the Mediterranean region (Bosch et al. 2000, Sanz-Aguilar et al. 2009, Paracuellos and Nevado 2010). Though effective in reducing numbers in the short term, culling may cause birds to disperse, transferring the conflict to other areas. Also, populations may show compensatory population responses, with increases in reproduction or juvenile survival reducing the effectiveness of culling operations (Bosch et al. 2000). Most recent studies on the culling of gulls focus on the benefits on other species (Sanz-Aguilar et al. 2009, Paracuellos and Nevado 2010) or compared lethal and non-lethal control methods (Cook et al. 2008, Thiériot et al. 2012). Most of the limited studies carried out on the effectiveness of culling techniques suggest that the efficiency of firearms (i.e., birds shot per man-hour) decreases as population density is reduced and remaining individuals display increased avoidance behaviors. Many gull species retreat to increasing distances from firearm operatives as they learn to associate them with danger (Thomas 1972, Dolbeer et al. 2003, Donehower et al. 2007). A possible strategy to overcome this may be to vary firearm type during a culling operation to sustain efficiency over time.

Gibraltar experiences many of the problems typically associated with high densities of yellow-legged gulls. Gull populations on Gibraltar are difficult to determine accurately because of the terrain. There is a large 4-km section of sandy slopes and boulder scree on the eastern side that is difficult to access, while gulls also nest on both the rock face and urban rooftops on the populated western side. Population estimates from 2000–2004 vary between 7,000 and 8,000 breeding pairs (Cortez et al. 2005). To limit the gull population, the Gibraltar Ornithological and Natural History Society carried out a historic culling program annually. This group prioritized resources and efforts in the areas of greatest conflict (i.e., the populated urban areas of western Gibraltar) while leaving the eastern slopes relatively undisturbed. In 2009, we initiated a 4-year culling program targeting the eastern slopes. We planned a 4-year cull period, as gulls reach sexual maturity in their fourth year (Bosch et al. 2000) and an annual cull over an equivalent time frame would ensure the disruption of 1 complete breeding cycle. We used a combination of different firearms and culling strategies to respond and adapt to anticipated changes in the behavior of gulls over time. During the culls, we collected data for a gull population model, which evaluated the impacts of the culling program. In this paper, we present the results of the culling program, with particular focus on how methods were adapted over time to maintain efficiency in response to changing gull behavior. We also describe the wider impacts of control on disturbance and emigration from the local population.

Study area

Gibraltar is located on the southern tip of the Iberian Peninsula, with a total area of 6.7 km^2. It consists of a limestone and shale ridge (the Rock), which rises steeply to 421 m. The Rock slopes down to the sea at the southern tip of the peninsula. Gibraltar's eastern coastline consists of steep slopes and cliffs. The more gradually sloping western side is a densely populated urban area of about 30,000 people. We carried out all shooting on the uninhabited eastern slopes, secluded from the public.

Methods

Monitoring populations and data recording

We culled gulls for an 8-week period between May and July during the 4 years of the project (2009–2012). To monitor the gull population, we carried out a census on the eastern side of Gibraltar prior and subsequent to the cull. The post-cull estimate for each year included the addition of that year's young to the population as well as the reduction caused by the cull. We used digital photography, combined with customized image analysis software, to count birds both on the ground and in the air. This was carried out by taking high-definition photos of the slopes and the sky, ensuring that every section of the eastern slope was covered. We counted the gulls using software that was originally created to count spot and rust fungi on leaves and calibrated it to recognize gulls in

Table 1. Parameters of yellow-legged gull (L. michahellis) population dynamics from which population models were developed and used to compare expected and observed changes in populations during a 4-year culling operation in eastern Gibraltar (2009–2012).

Parameter	Estimate (best estimate with range)	Source data
Chick survival	0.75 (0.04–0.9)	Snow and Perrins (1998)
Adult survival	0.85 (0.7–0.9)	Snow and Perrins (1998)
Proportion females breeding	0.67 (0.5–0.8)	Snow and Perrins (1998)
Chicks/nest	2.3 (2–3)	Snow and Perrins (1998)
Emigration	0.5 (0.3–0.7)	Snow and Perrins (1998)
Immigration	0.08 (0.01–0.2)	Snow and Perrins (1998)
Starting population	8,089 (8,000–8,200)	Gibraltar culling operations
Proportion culled/year on eastern slopes	0.5 (0.35–0.65)	Gibraltar culling operations
Proportion of chick/eggs removed	0.4 (0.1–0.6)	Gibraltar culling operations

the photos. In addition to these photographic methods, 2 independent observers counted the birds visually, and these counts were compared to the photographic counts to ensure comparability. During the cull, we recorded the number of gulls killed using each different type of firearm, and the number of man-hours spent in the field during each culling session. We converted all final totals to numbers of gulls killed per man-hour to allow comparison between weapon types and years.

Firearm techniques and strategies

During the course of the program, we used 4 different types of weapons:

- Air rifles: .22-caliber air rifles firing Air Arms Diablo Field pellets (lead, round nose)
- .17 rifle: Brno CZ .17 caliber firing 17-grain Remington Accutip ammunition (lead core with copper jacket and polymer tip)
- .22 rimfire rifles: Brno CZ .22-caliber rifles firing 40-grain Winchester (subsonic hollow point ammunition)
- Shotguns: Benelli semi-automatic 12-gauge shotguns firing steel (36 grams, No. 5 shot)

While the air rifles and .22 rimfire rifles were almost silent, shotguns and .17-caliber rifles were loud, creating a disturbance. The strategy that we developed over time was to use the air rifles and .22 rimfire rifles to quietly snipe sedentary gulls, and to use shotguns to create a disturbance that resulted in mobbing behavior, making it easier to shoot birds as they started mobbing shotgun handlers.

The shooting strategy followed a seasonal pattern. Early in the season we focussed on the use of air rifles and .22 rimfire rifles to target prospecting and therefore relatively sedentary birds. Our use of all rifles, however, was constrained by the need for a backstop to prevent stray bullets travelling long distances, and the need to avoid their use in areas with the risk of ricochet. As birds began to nest and lay eggs, they became more likely to mob intruders on the open slopes, diving at potential predators to scare them away. Mobbing is a well-known response of colonial birds to potential predators at nesting sites (Kruuk 1976, Conover 1987, Stenhouse et al. 2005, Kazama and Watanuki 2010). During mobbing, gulls often fly close to carcasses of deceased birds (Kruuk 1976). We exploited these behaviors by shooting in the open with shotguns while walking across nesting sites and using gull carcasses as lures. We resumed the use of air rifles and .22 rimfire rifles during evening periods when low light levels meant that the birds were unaware of the presence of riflemen. We avoided shooting within 150 m of raptor nests to avoid disturbance until after the raptor chicks had fledged.

We recorded the distance from the operator to a sample of shot gulls annually. We measured this in meters with a Bushnell rangefinder (Model 202342). We compared the distance between gulls and shooters over time using an analysis of variance. We then performed a post-hoc Tukey test to assess differences between paired groups of years.

Although control at nests was not a focus of this project, we also pricked eggs and culled chicks by cervical dislocation; both methods were recommended for humane despatch (Humane Slaughter Association 2014).

Modeling

In 2011, after 3 years of data collection, we developed a Leslie matrix population model (Leslie 1945, Crouse et al. 1987) using population parameters drawn from Snow and Perrins (1998) and from the data collected in this study (Table 1). This used Crystal Ball (<http://www.oracle.com/us/crystalball/>), an extension of Microsoft Excel. This produced estimates the annual population broken down by age and sex. We ran 10,000 iterations for an initial 10-year period to assess variation within set limits and incorporate the uncertainty around the parameter values. We then added the observed levels of culling as an extra mortality factor of the adult population to assess the impacts of culling and compare the observed and expected changes in the population. This additional mortality was distributed evenly between the sex and age classes of the population.

Results

Mortality and culling efficiency

Pre-cull and post-cull estimates of total gull numbers declined annually over the period of the cull. The pre-cull population decreased by 79% from 8,099 during 2009 to 1,700 during 2012, and the post-cull population decreased by 85% from 5,570 during 2009 to 812 during 2012 (Figure 1). Over the 4 years, the overall culling rate (number of birds shot per man-hour using all weapons) decreased by 23%. The culling rate fluctuated among years, being highest in 2009 (8.3 birds per man-hour) lowest in 2010 (4.8 birds per man-hour), and increasing again in 2012 to 6.4 birds per man-hour (Figure 1).

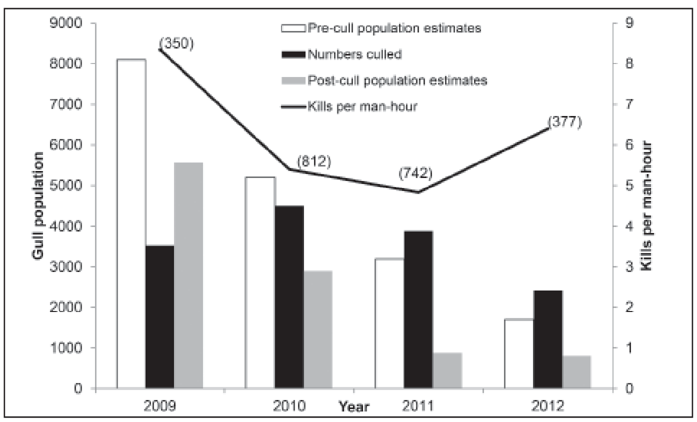

Figure 1. Annual population estimates of *L. michahellis* on the eastern slopes of Gibraltar from 2009–2012 before and after culling operations, together with numbers killed and kills per man-hour. The total number of man-hours expended per year is presented in brackets.

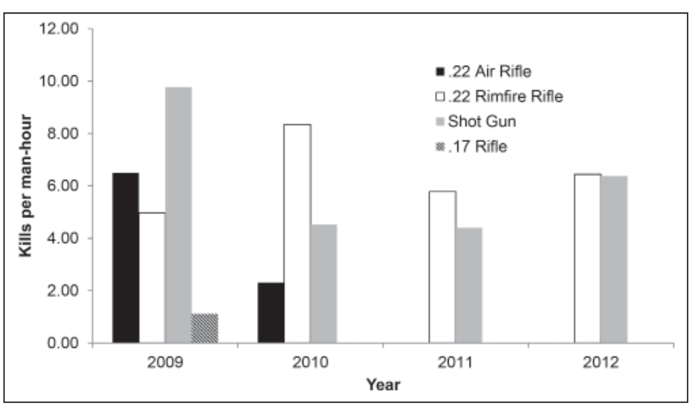

Figure 2. Number of *L. michahellis* killed per man-hour by different weapon types on eastern Gibraltar from 2009–2012.

Comparisons of different firearms

In 2009, shotguns were responsible for the most kills per man-hour (9.77), while during 2010 the .22 rimfire rifle had the most kills per man-hour (8.34; Figure 2). Through adjustment and response to changes in gull behavior, the 2 weapons had almost identical efficacy (6.38 and 6.44, respectively) by the end of the project in 2012. The .17 rifle had a low kill rate in the first year (1.12 kills per man-hour) and its use was discontinued, while the air rifle was discontinued after 2 years of use after its kill rate fell dramatically between the first and second year (6.2 to 2.0 kills per man-hour). The distance at which firearms operatives shot gulls increased as the cull progressed (Figure 3). In 2009,

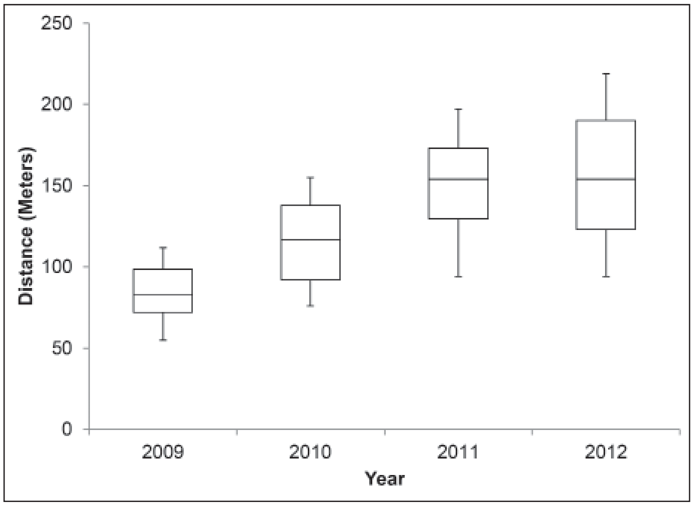

Figure 3. Distances in meters that gulls retreated from firearm operatives during a cull on eastern Gibraltar from 2009–2012.

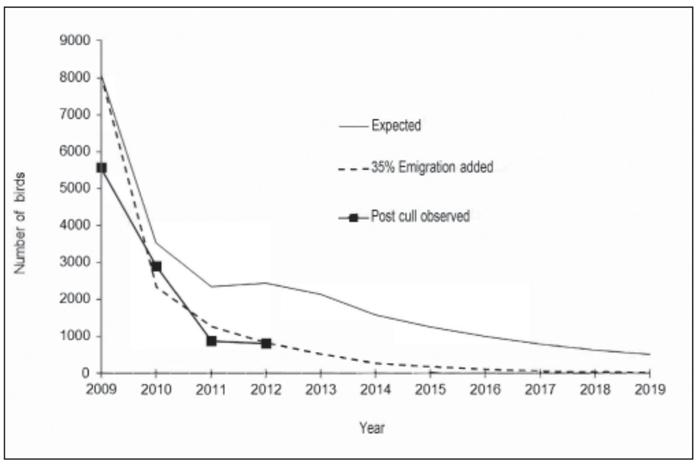

Figure 4. Expected and observed declines in post-cull yellow-legged gull population on eastern Gibraltar from 2009–2012 with expected trend to 2019.

the mean distance at which birds were killed was 85 m (SE 12.0 m, n = 218), with the range varying between 55 m and 112 m. By 2012, the distance had increased to a mean of 155 m ± 3 m, n = 133), with a range between 9 m and 219 m. The difference between years was significant (df = 3, F = 287, P < 0.001). A post-hoc Tukey test showed a significant difference between all years, except 2011 and 2012 (P = 0.21).

The observed population declined between years at a faster rate than was predicted by the model based on the numbers shot. To match the observed declines, an additional mortality factor needed to be added to the model; this was equivalent to net emigration of 35% per annum (Figure 4).

Discussion

This study demonstrates that with the flexible deployment of different weapons and approaches in the field, it is possible to carry out a firearm-based cull of gulls over several years while maintaining efficiency of kills per man-hour. A decline of 23% in the rate of kills per man-hour over a 4-year period compares favorably to other projects such as a culling program of laughing gulls (*Leucophaeus atricilla*) that showed a decline in kills per man-hour of 72% after a year of shooting using only shotguns at an airport (Dolbeer et al. 2003). Roy et al. (2008) suggests that information on the efficiency of different culling methods is often the key data required to model operations, though this is rarely reported.

During 2009, after an initial period of shooting sedentary birds with rifles as they prospected for nest sites, gulls began mobbing firearm operatives as they walked across the nesting sites. To capitalize on this behavior, shotguns were deployed and were particularly effective (9.77 kills per man-hour). This study also found that a dead gull placed outside a hide as a lure brought gulls closer and initiated mobbing, confirming Kruuk's (1976) observation.

During 2010 and 2011, mobbing behavior lessened, possibly due to birds becoming wary. Not all birds have equally strong urges to mob, and the more aggressive birds had potentially been removed during the earlier shooting operations (Kazama and Watanuki 2010). Shotguns were no longer the most effective weapon, and rifles shooting at long range or during periods of low light became more effective. This study confirmed that gulls increased the minimum distance they approached firearm operators as a cull progressed (Thomas 1972, Dolbeer et al. 2003, Donehower et al. 2007), suggesting that they were responding to the firearm operators as if they were predators (Kruuk 1976).

The .17 rifle and the air rifle were the least effective weapons. The former created disturbance due to a resulting sonic retort and could only be used on static targets. Its use meant that birds rose into the air and took several minutes to resettle, preventing this weapon from being used again in rapid succession. In comparison, the almost silent .22 rimfire rifle did not disturb static birds during culls. The air rifle had too small a range to be effective once the birds began to retreat from firearm operators.

During 2012, the rate of kills per man-hour increased to 6.4, compared to 4.83 in 2011. This was despite a greatly reduced population. By this stage, retreat distance had plateaued, and by continuously adjusting the use of the 2 weapon types we maintained, kills per man-hour, which was similar between the 2 main weapon types.

Management implications

This project illustrates how an understanding of gull behavior can help determine choice of culling method and strategy, helping long-term culling operations to maintain efficiency. In this study, a variety of culling options allowed a flexible response to changing behavior. Surprisingly, the magnitude of the disturbance impact on the population caused disproportionately high emigration from the area. Every gull culled functionally resulted in approximately 1.3 to 1.5 fewer birds when counted the following year (Figure 4). This has important implications in the management of other species, where a combination of culling and disturbance could reduce impacts of a species on a local resource, such as the impacts of piscivorous birds on fisheries (Bishop et al. 2003). In this study, it was not possible to determine the movements of displaced birds or the wider impacts on the regional population, though this would be useful to understand how local mitigation affected the scale and distribution of wider conflicts. For the ongoing management of gull conflicts on Gibraltar, we recommend that a combination of culling and disturbance related measures, such as the use of loud shotguns, is continued to maintain the pressure on the population and keep the numbers within acceptable limits. It is also important to monitor the gull population and estimate the population age structure and size, as culling is known to result in birds breeding at a younger age, probably because many nesting territories become vacant (Coulson et al. 1982, Bosch et al. 2000).

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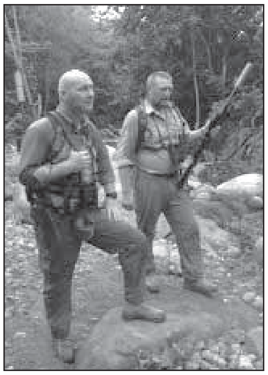
SUGOTO ROY is the coordinator of the Integrated Tiger Habitats Conservation Programme at IUCN.

Prior to this, he was a vertebrate ecologist at the National Wildlife Management Centre at the UK Government's Animal and Plant Health Agency for 12 years. His experience lies in the restoration of endangered species, the management and eradication of overabundant and invasive species, and the management of human–wildlife conflicts.



RAY RIDLEY (right) is a firearms specialist for at the National Wildlife Management Centre at the UK Government's Animal and Plant Health Agency. Over the last 8 years, he has been developing techniques and strategies for culling wild, feral and non-native animals in the UK and Overseas Territories. He has been working on the North American Ruddy Duck eradication project in the UK, culling of feral cattle in the Caribbean Overseas Territories, and culling of gulls in Gibraltar. He is also a certified firearms trainer and professional deer stalker.

JEFF SANDON (left) is a firearms specialist for the National Wildlife Management Centre at the UK Government's Animal and Plant Health Agency. He has been involved in formulating and implementing native and non-native animal control projects both in the UK and abroad, including the provision of localized firearms training. Projects include the North American Ruddy Duck eradication project in the UK, culling of feral cattle in the Caribbean Overseas Territories, and culling of gulls in Gibraltar.

JOHN ALLAN is head of the National Wildlife Management Centre at the UK Government's Animal and Plant Health Agency. His main interest is the management of bird populations, particularly in relation to the management of birds as hazards to aircraft. John was Chairman of the International Birdstrike Committee for 7 years and has provided advice to national and international aviation regulators, airports, and military aviation around the world on bird management issues.

PETE ROBERTSON (photo not available) has a shared role between the National Wildlife Management Centre at the UK Government's Animal and Plant Health Agency, and the Centre for Wildlife Management at Newcastle University. His research interests include the management of human–wildlife conflicts and the risks posed by invasive alien species.

ANDY BAXTER runs Birdstrike Management Ltd., a specialist company developed to help the aviation industry control wildlife hazards using sound science and effective management. Andy specializes in evaluating and delivering innovative practical solutions to reduce birdstrike risk from species such as gulls, geese, raptors, and pigeons. Prior to this, he has been working for the National Wildlife Management Centre's bird management unit for 18 years, more recently as manager of the wildlife management team.