Distribution and status of the Manx Shearwater (*Puffinus puffinus*) on islands near the Burin Peninsula, Newfoundland

by

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ABSTRACT

In Newfoundland, the Manx Shearwater *Puffinus puffinus* is an example of a rare extra-limital breeding seabird with imminent threat of extirpation. In Canada, shearwaters were previously known to breed regularly only on Middle Lawn Island, located within a cluster of islands of similar size, elevation, and vegetation cover close to the south coast of Newfoundland. To address an urgent need for better information about current status of the Manx Shearwater in Newfoundland, I deployed five Song Meter automated digital acoustic recording devices at Middle Lawn, Offer, Colombier (Glumby), and Green Islands near the Burin Peninsula, and Grand Colombier Island near St. Pierre during June-July 2009. Surprisingly, Manx Shearwater activity was detected at four of five islands, with only Green Island having no birds. Middle Lawn (detections on 72% of nights) and Grand Colombier (64%) islands had the most activity, followed closely by Offer Island (56%). The sex ratio of Manx Shearwater calls at Grand Colombier Island (c.50% female) differed significantly from Burin peninsula islands (c.75% female), indicating a high proportion of breeding pairs at the latter sites, as found in previous studies in Newfoundland. Also confirming previous work, my data indicated strong moonlight avoidance by Manx Shearwaters at all islands monitored. Alarmingly, multiple carcasses of sea-birds including 15 adult Manx Shearwaters, were recovered in caching sites of a carnivore, likely an American Mink (*Mustela vison*), during my burrow searches at Middle Lawn Island. As of current, there remains very little known about the status of the Newfoundland Manx Shearwater population but my results raise concerns. The occurrence of mammalian predators on islands along the Burin Peninsula and human disturbance at Green Island appear to be the major factors limiting shearwater viability.

If conservation efforts can be implemented, Middle Lawn Island may increase and also, we may see avian diversity expand on all offshore islands near the Burin Peninsula, Newfoundland. In the meantime, my study suggests the value of enhanced regular monitoring via Song Meters, on-site checks of burrows including replaced artificial nest boxes, and capture-mark-recapture effort to measure survival and Manx Shearwater population status.

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INTRODUCTION

Worldwide, small extra-limital animal populations are taking on rapidly increasing significance in some bird species' struggle for persistence in a rapidly changing environment. Seabirds, in particular, reside on remote islands and in some cases are threatened by extirpation due to human activities including the accidental or deliberate introduction of non-native predators and other alien species. Understanding the factors that contribute to continued viability of seabird populations on remote islands is therefore very important to conservation biology. In Newfoundland, the Manx Shearwater *Puffinus puffinus* is an example of an extra-limital breeding seabird species with imminent threat of extirpation. The world population of Manx Shearwater has been estimated to be approximately 300,000 breeding pairs, 94% of which breed in Britain and Ireland (Stone et al. 1994). While the centre of Manx Shearwater distribution lies in the northeast Atlantic between Iceland, the Faeroe Islands, Great Britain, Ireland, and France (Lee and Haney 1996), its peripheral distribution includes the Azores, Madeira, and the Canary Islands (Monteiro et al. 1999) and Newfoundland (Storey and Lien 1985). Manx Shearwaters are highly vagile, occurring as vagrants even as far as the Pacific Coast of North America, but breeding has only been recorded on the extreme eastern coastline of the United States and Canada. In Newfoundland, they are known to breed regularly only on Middle Lawn Island located off the Burin Peninsula (Storey and Lien 1985). They have also been recorded breeding once on Penikese Island in Massachusetts, and three times in Bermuda (Lee 1995). Small extra-limital colony sites are not conspicuous, due to the species' strictly nocturnal activity on land, so some North American colonies may

have been overlooked. Due to the importance to conservation of understanding the distribution of Manx Shearwaters in Newfoundland, I searched several suitable remote islands off the Burin Peninsula to determine whether or not new colonies have developed and to determine the status of the populations on each.

Newfoundland has few small satellite islands that are remote enough to support seabird populations; however, it is host to some spectacular seabird sanctuaries. These include the seabird-focused ecological reserves of Cape St. Mary's, Witless Bay, Baccalieu Island, Gannet Islands, Hare Bay Islands, Funk Island, and the recent Lawn Islands Provisional Ecological Reserve. Although confirmed Manx Shearwaters breeding activity has been limited to Middle Lawn Island, banded individuals have been recovered incidentally in other areas of Newfoundland including Bonivista Bay, Cape Spear, Fogo Island, Belleoram, Lord's Cove, Twillingate, Lumsden and Catalina (Storey and Lien 1985). Individuals have also been heard calling at night intermittently on Gull Island in Witless Bay since the mid-1980s, with dead adults found on or in burrows on both nearby Gull and Great Island, which are visited annually by biologists (Robertson 2002). These occurrences suggest that the distribution of Manx Shearwaters in Newfoundland could be much larger than previously thought, given the number of small islands (especially on the south coast) that have suitable breeding habitat but are rarely visited by biologists.

Manx Shearwaters are a member of the order Procellariiformes, a seabird group consisting of shearwaters, petrels, albatrosses, storm-petrels, and diving petrels (Hamer et al. 2006). The Manx Shearwater belongs to the small (335 – 687 g), 'black-and-white', pursuit-diving group of shearwaters that includes Audubon's Shearwater (*Puffinus*

Iherminieri), Little Shearwater (*P. assimilis*), Black-vented Shearwater (*P. opisthomelas*), and other species. Like other procellariiform birds, Manx Shearwaters are long-lived, delay breeding until they are several years old, have a clutch size of one egg, and the semi-precocial young remain at the breeding site for many weeks before fledging (Brooke 1990). Like many other shearwaters, Manx Shearwaters nest in self-excavated earth burrows or rock cavities on slopes of offshore islands that are free of mammalian predators. After hatching, parents brood the chick for about one week, after which parental care is reduced to periodic night-time visits for feeding only. Vocalizations in such nocturnal seabird species are very important for communication and for coordinating breeding activities (Storey 1984). Manx Shearwaters have an array of calls in their repertoire which include the soft cheeping or piping cry of chicks and a variety of distinctive calls by adults (Lee and Haney 1996). Male and female calls have pronounced differences, with male calls consisting of clear notes and female calls consisting entirely of harsher sounds (Brooke 1978; Lee and Haney 1996). Contexts of vocalization include calls as individuals fly over the colony, calls from the ground near burrows and calls in burrows; males produce most ground calls, and females produce most flyover calls (Storey 1984). Storey (1984) suggested that vocalizations are important during courtship in that they aid birds in attracting mates and forming pair bonds.

Middle Lawn Island has been known as an established breeding colony of the Manx Shearwater since 1977, and it is currently the only known active breeding colony in North America (Robertson 2002). The status of Manx Shearwater on Middle Lawn

Island prior to 1977 is not well known as no observers familiar with the species visited the island prior to that year. Thus, birds may have been coming ashore in numbers prior their discovery in 1977, possibly even for many years. However, fieldwork from 1977-1981 suggested that the colony consisted primarily of young, inexperienced adults with a low rate of breeding, despite a large number of birds (Storey and Lien 1985). The species continues to breed in small numbers on this island, and as of 2009 the population has ceased to expand and has likely declined since its discovery in 1977 (Robertson 2002, personal observations). However, Middle Lawn Island is located within a cluster of islands of similar size, shape, elevation, and vegetation cover that would appear to be suitable breeding habitat for Manx Shearwaters. The cluster includes a collection of nearly connected islets named the Columbier ('Glumby') Islands and a lone island known as Offer Island. Nest prospecting has not been previously investigated on these islands but has been confirmed on nearby Green Island and Grand Colombier Island (St. Pierre and Miquelon, France; Robertson 2002).

For most of the history of ornithology, researchers interested in documenting the presence and breeding status of rare species had to travel and camp in areas of putative habitat and make direct observations and searches. For nocturnal species and those restricted to remote islands, this meant all-night listening for distinctive calls, on many nights and at multiple locations - a daunting exercise. The recent availability to researchers of compact, battery-operated, automated digital recording devices capable of storing many hours of programmed time-stamped sound recordings has revolutionized avian survey technique – since one can now deploy devices at remote locations and pick

them up months later. One such automated digital acoustic recording device is the Song Meter from Wildlife Acoustics. Its recordings can be analyzed automatically or manually using Song Scope software to quickly locate species of interest. The Song Meter can be programmed to record automatically on a schedule set to capture expected events of interest. I used this cost-effective device to determine if Canadian Manx Shearwaters occur on neighbouring islets to the already confirmed breeding location of Middle Lawn Island.

In summary, Manx Shearwaters are a very rare breeding bird in North America but are vagile and capable of colonizing new islands suitable for breeding. Due to its precarious status as a breeding species in North America, there is an urgent need for better information about islands where it comes ashore or breeds. The objectives of my study were: (1) to determine, using automated recording devices, whether Manx Shearwaters come ashore at night on Newfoundland islands in close proximity to and with similar characteristics to Middle Lawn Island; (2) to quantify the relative amount and patterns of activity at these sites by analyzing recorded Manx Shearwater vocalizations; (3) overall, to evaluate the current breeding status of the Manx Shearwater near the Burin Peninsula of Newfoundland; and (4) to combine my results with the published literature to provide a better understanding of the species status in Newfoundland overall and to make recommendations for future research investigations which together will be used to identify appropriate conservation actions for this rare species.

METHODS

Study Area

Islands selected for this study are located near the southern tip of the Burin Peninsula, Newfoundland, Atlantic Canada, and nearby St. Pierre and Miquelon, France. Middle Lawn, Offer, Colombier (Glumby), Green, and Grand Colombier Islands (Fig. 1) were chosen because they are generally free from mammalian predators and isolated from land, characteristics necessary for burrow-nesting seabird colonies. Middle Lawn Island was selected because it is a known breeding area for the Manx Shearwater (Storey and Lien 1985). I selected the remaining islands because of their proximity to Middle Lawn Island and based on the previously reported presence of breeding Leach's Storm-petrels (Storey and Lien 1985), an indicator of ideal substrate for burrow nesting, however it is important to note that Manx Shearwaters can dig in rockier substrate than petrels (Anne Storey, personal communication).

Middle Lawn Island is located at 46.869˚ N 55.616˚ W (WGS 84) and lies 1.04 km southeast of Sand Cove Head, Burin Peninsula. This grass-covered island is approximately 300 m across with highest point 60 m asl (Storey and Lien 1985). This island has never been inhabited by humans and has no man-made structures or remains thereof, but has traditionally been used for sea duck hunting in the autumn and early winter. In some years (e.g. 2005) livestock (goats, sheep) have been placed on the island to graze. Although this island was frequently visited by humans to deliver livestock, there has been no previously documented evidence of an accidental introduction of a mammalian predator. Along with the Manx Shearwater, Middle Lawn Island is also home to a significant Leach's Storm Petrel colony (Storey and Lien 1985).

Offer Island, grass-covered and approximately 300 m in length, is located at 46.858˚ N 55.622˚ W, and situated 890 m south-south-west of Middle Lawn Island and 1.85 km south-south-east of Sand Cove Head, Burin Peninsula. With a height of 40 m asl, Offer Island is lower than Middle Lawn Island. Offer Island is not inhabited by humans but is used for sea duck hunting and livestock have been placed on the island to graze in previous years. There no evidence suggesting the introduction of alien species; however, in the winter of 2010 a local hunter claims to have seen an American mink (*Mustela vison*) on the island (Wade Roul, personal communication). Offer Island supports a large breeding colony of Herring Gull (*Larus argentatus*) and Great Black-backed Gull (*L. marinus*), and a small Arctic Tern (*Sterna paradisaea*) breeding colony.

Smallest (<100 m across, 70 m asl) of the islands near Lawn, grass-covered Colombier Island is located at 46.891˚ N 55.573˚ W, lies 3.82 km northeast of Middle Lawn Island and 1.06 km south of Ragged Head, Burin Peninsula. This island has not been inhabited by humans, however, activities such as sea duck hunting have occurred in previous years. Colombier Island supports a large breeding colony of Black-legged Kittiwakes (*Rissa tridactyla*) and small breeding colonies of Leach's Storm-petrels, Herring Gulls, and Common Murres (*Uria aalge*).

Green Island is located at 46.879˚ N 56.089˚ W, lies 7.62 km north-east of Grand Colombier Island and 8.97 km southwest of Point Crewe, Burin Peninsula and is the largest and most off shore of the islands surveyed (c.900 m across), supporting grassland, heath and scrub vegetation. This island has a light station (established in 1908), which includes a one-storey keeper's house, a helicopter pad, a supply shed, fuel tanks and a wind turbine (3 m in diameter and on a 20 m high mast guyed with numerous steel

wires). The light (focal plane 45 m elevation, white flash every 10 s) is supported on a 6 m square cylindrical aluminium skeletal tower. A fog horn (blast every 60 s) is active year-round. In addition to the keeper's house, helicopter pad and the wind turbine, evidence of human activity and disturbance occurs throughout the island. A walking trail runs along the entire diameter of the island and is heavily worn with eroded parts and passes remnants of numerous wooden structures scattered throughout the island. At present, human activity away from the light station appears to be mostly confined to this trail. Green Island supports a breeding colony of Leach's Storm-petrel's.

Grand Colombier Island (French territory) is located at 46.823˚ N - 56.167˚ W and lies 510 m north of Pointe à Henri, St. Pierre. This island is approximately 0.9 km long and has an area of about 47 Ha. Although this island has apparently never been permanently inhabited by humans, copper prospecting took place in the 1950's and 1960's. The Meadow Vole (*Microtus pennsylvanicus*), thought to have been introduced, remains on the island today (Frank Urtizberea personal communication). This island supports breeding colonies of Atlantic Puffins (*Fratercula arctica*), Razorbills (*Alca torda*), Black-legged Kittiwakes, and Great Cormorants (*Phalacrocorax carbo*). Although Manx Shearwaters have been prospecting on the island breeding has not been confirmed (Frank Urtizberea, personal communication).

Automated Acoustic Monitoring

In order to detect and quantify Manx Shearwater and other nocturnal seabird activity, five model SM-1 Song Meters (Wildlife Acoustics Inc., 970 Sudbury Road, Concord, MA 01742-0680, USA, www.wildlifeacoustics.com) were deployed at representative sites on Middle Lawn, Offer, Colombier, Green and Grand Colombier Islands. Prior to Song Meter deployment, three (Middle Lawn, Offer, and Colombier) of the five islands were visited to assess whether suitable locations for Song Meter placement, in suitable burrow-nesting seabird breeding habitat, were present. The remaining islands were not assessed due to the limited opportunities for access. Visited islands were checked for presence of Manx Shearwater nesting activity (burrows) and for suitable habitat similar to that at the known Manx Shearwater breeding colony on Middle Lawn Island. Middle Lawn Island was chosen for this study to provide a control measure of activity at a relatively well-studied active Manx Shearwater breeding colony. Each acoustic device was mounted to a 1 m tall wooden post and then secured into the ground at the desired deployment site. The habitat at each site comprised of steep slopes with low grassy vegetation that terminated in rocky cliffs with crevices, together indicating suitable breeding habitat for the burrow nesting Manx Shearwater. In addition to close proximity to suitable Manx Shearwater habitat, the location for Song Meter deployment was chosen based on the amount of exposure to the elements. Given these guidelines, Song Meters were place in areas that allowed some shelter from high winds and in areas far enough away from the shore to limit the amount of wave noise interference with the recordings. Deployment dates for each Song Meter were as follows; Middle, Offer, and Colombier Islands on June 16th 2009, Green Island on June 11th 2009, and Grand

Colombier Island on June 20th 2009. Each Song Meter was equipped with either one 32 GB or two 16 GB memory cards. With the combined total memory capacity of 32 GB and a sample rate of 16 kHZ each device could record for approximately 138.9 h, which is the equivalent of 46 nights recording at 3 hours/night. However, a device equipped with 4 standard "D" size alkaline batteries is limited to a recording time of about 32 days at 3 hours/day. This battery power, in turn, will provide 97 hours or 32 nights at 3 hours/night of acoustic recordings. Taking into consideration these limitations, the following nightly schedule was programmed for automated recordings: beginning at 22:30 h for 30 minutes, 23:30 h for 30 minutes, 00:30 h for 30 minutes, 01:30 h for 30 minutes, 02:30 h for 30 minutes, 03:30 h for 30 minutes for a total recording time of 3 hours per night. These times were chosen to encompass all times when Manx Shearwaters were thought likely to be vocalizing (Lee and Haney 1996).

Analysis

Upon retrieval of each Song Meter device from its deployment site, digital sound recording data was downloaded to an external hard drive to be analyzed using automated call-recognition software (Song Scope version 2.4, Wildlife Acoustics Inc.). Initially, analysis commenced with an attempt to build a recognizer (Wildlife Acoustics 2009). Song Scope recognizers are used to automatically compare sounds present in lengthy field recordings against a specific vocalization type of interest. Unfortunately, I quickly determined that there was too much interference from wind, wave and Leach's Storm-petrel noise to utilize a Song Scope recognizer for Manx Shearwater calls. Such a recognizer might be useful for recordings from large islands with low levels of

background noise present, but not for the small storm-petrel-inhabited islands sampled in my study. Instead, Song Scope was used to visually analyze recordings as spectrograms rapidly (6x normal speed) scrolled across my laptop computer screen, with infrequent stopping at potential Manx Shearwater calls to listen, confirm and log manually. Presence or absence and number of calls (aerial and ground calls given by male and females) were recorded for each 30-minute recording interval. Each 30-minute recording required approximately five minutes to analyze visually which amounted to 126 hours of data analysis required cumulatively for all 5 islands. To investigate the relationship of Manx Shearwater vocal activity to moonlight intensity, I derived a moon index that was a product of moon phase (estimated decimal phase, i.e., 0 = new moon, 0.5 = half moon, 1.0 = full moon) and moon reveal (0 = moon below horizon during recording period, 1 = moon above horizon; U.S. Navy (2009) complete sun and moon data web page: http://aa.usno.navy.mil/data/docs/RS_OneDay.php). To investigate the proportions of male and female calls on each island, calls of each sex were counted for five nights, ranging from June 20th – June 25th 2009, on all islands except Green Island. All statistical analyses were performed using Statview 5.1 for Macintosh (Caldarola et al. 1998).

Quantification of shearwater predation

Alien terrestrial predators have been known to cause considerable damage to native bird populations, especially in remote areas where there have traditionally been few or no mammalian predators (e.g. rats in Polynesia, Banks et al. 2008). Seabirds, such as the Manx Shearwater, reside on remote islands and in some cases are not only preyed upon by other avian species but can also become threatened by extirpation through the

accidental or deliberate introduction of non-native predators – especially terrestrial mammals including rats (*Rattus spp.*), mustelids (*Mustela spp.*), cats (*Felis domesticus*), and foxes (*Alopex* and *Vulpes spp*.; Major 2004). Therefore, it is important to understand predator - prey relations of the Manx Shearwater when considering conservation actions in Newfoundland. To look for evidence of predation I conducted an extensive ground search of Middle Lawn Island on July 21 - July 22, 2009. These searches would provide information concerning the relative amount and type of predator activity. Gulls are known predators on the eggs, chicks and adults of other colonial seabirds (Burger and Gochfeld 1984). Typically, gull predation includes the ingestion of the entire prey item followed by the regurgitation of the pellet. Another seabird predator, the American Mink (*Mustela vison*), is a semi-aquatic species that can travel to and occupy islands 2 km from the mainland (Craik 1997). American Mink is an alien species in Newfoundland, that may have been accidentally introduced via escapes from fur farms, and has the potential to seriously damage or even extirpate breeding seabirds at many Newfoundland colonies. Mink feeding activities include killing more than an individual can consume, followed by caching of the excess (Craik 1997). To determine if seabirds on Middle Lawn Island were subject to such predation by the American Mink and other seabird species, I searched for and collected Manx Shearwater remains (broken eggs, dead chicks, adult carcasses, skeletons, wings etc.) in burrows and on the surface. The collected specimens were stored in labelled bags for later identification and analysis in the lab in St. John's. Due to limited access to the remaining islands, predator checks on Offer, Colombier, Green and Grand Colombier were not completed to the same extent as on Middle Lawn Island.

RESULTS

Automated Acoustic Monitoring

The frequency of occurrence of Manx Shearwater aerial calls on Middle, Offer, Colombier (Glumby), Green, and Grand Colombier Islands varied by location (Table 1, Fig. 2) and time of night (Fig. 3). Manx Shearwater activity was detected on all islands except Green Island (Table 1, Fig. 2). Of the islands where activity was detected, the known breeding colony of Middle Lawn Island was found to have the highest shearwater activity, with the species being detected on 72% of nights monitored. Green Island had no Manx Shearwater calls detected. Among islands where shearwaters were detected, there was a significant difference in nightly frequency of calls (Kruskal-Wallis $H = 14.8$, $df = 3$, $p = 0.001$ and *post hoc* paired Wilcoxon Signed-rank $Z = 3.35$, $p = 0.0008$ for Middle Lawn versus Offer, $Z = 3.72$, $p = 0.0002$ for Middle Lawn versus Colombier, $Z = 1.31$, $p = 0.19$ for Middle Lawn versus Grand Colombier, $Z = 1.97$, $p = 0.05$ for Grand Colombier versus Offer, $Z = 3.24$, $p = 0.001$ for Grand Colombier versus Colombier , Figure 2). Discounting Green Island, the frequency of Manx Shearwater calls differed between Grand Colombier Island and all other islands except Middle Lawn and Offer islands (Fig. 2). Other than Green Island, Colombier Island was found to have the lowest call count, with detections on 40% of nights monitored. Among the remaining islands, Manx Shearwaters were detected on 64% of nights on Grand Colombier Island, and 56% of nights on Offer Island (Table 1, Fig. 2). Middle Lawn Island also had the greatest percentage of 30-minute intervals with ≥ 1 detection, while Colombier Island held the lowest percentage (Table 1). Nightly levels of Manx Shearwater activity were significantly correlated across islands, indicating strong inter-island synchrony in

behaviour (Table 2, Fig. 2).

Manx Shearwater activity (as indicated by calls detected) was inversely correlated with index of moonlight intensity (Spearman Rank Correlation Rho = -0.54, $p < 0.0001$, Fig. 4).

Among 613 Manx Shearwater calls recorded during the first five nights of monitoring, 174 (28%) were male and 439 (72%) were female (Fig. 5). The ratio of male to female calls was 21:79 (N = 261) for Middle Lawn Island, 23:77 (N = 171) for Offer Island, 12:88 (N = 26) for Colombier Island and 54:46 (N = 135) for Grand Colombier Island, with statistically significant differences in ratio ($G = 54.1$, $df = 3$, $p < 0.0001$). The sex ratio at Grand Colombier differed significantly from Middle Lawn Island ($G = 44.8$, $df = 1$, $p < 0.0001$), Offer ($G = 32.1$, $df = 1$, $p < 0.0001$), and Colombier Island ($G = 17.8$, $df = 1$, $p < 0.0001$) while there were no significant differences among Middle Lawn, Offer, and Colombier Islands.

Quantification of predation

In burrow searches carried out on Middle Lawn Island in 2009, multiple carcasses of sea birds, including 15 adult Manx Shearwaters, were recovered in caching sites, with injuries consistent with predation by a carnivorous mammal. Among the carcasses recovered were 2 untouched specimens, 6 specimens with both brain and breast meat consumed, 1 specimen with only the head remaining, and 6 specimens with only the wings remaining. During the winter of 2010 a local sea-duck hunter reported an American Mink on Offer Island. American Mink have been known to swim distances of 2 km (Craik 1997), therefore, it is possible that this species has been visiting Middle

Lawn, Offer, and Colombier Islands to prey upon burrow-nesting seabirds. A flightless juvenile Black-backed Gull was found during burrow searches on Middle Lawn island, supporting that this predatory species is nesting on the island.

Other Observations

On Middle Lawn Island, remnants of nest boxes set out in the 1970s were found, including half buried wooden material and rusted stovepipe. Goats were encountered on the island in 2005 (Gail Fraser, personal communication), but there was no evidence of grazing activity in my 2009 visit. During the overnight visit to Middle Lawn Island, 11 individuals were captured, six of which have been previously banded (Table 3). Of eleven individuals captured, ten were in burrows and two pairs were found together. A single Manx Shearwater chick was found alone in a burrow in an area of the island that contained very little shearwater activity. Human activity was noted during the visit to Green Island on June 11th 2009. Disturbances on this island included, in addition to the light, the keeper's house, helicopter pad, supply shed and fuel tanks, a fog horn (blast every 60 s) and a tower-mounted wind turbine. The 3 m wind turbine on a 20 m high mast guyed with numerous steel wires seemed notably out-of place on an important Newfoundland seabird island (Fig. 3). There was evidence of human activity throughout the island, including a walking trail (heavily worn and eroded in parts) and remnants of numerous wooden structures and other debris.

DISCUSSION

The presence of Manx Shearwaters in the north-west Atlantic is an interesting case of a seabird population that has apparently not grown since its establishment, and the question of whether the population will increase or even persist remains unanswered. My study has shown that the Manx Shearwater occurs on multiple islands along the south coast of the Burin Peninsula, suggesting that this area is important for the viability of the species in Newfoundland. Some have speculated that the Newfoundland population of Manx Shearwaters has not grown since its establishment sometime prior to 1977 (Robertson 2002), but very little known about the population, and so it is premature to make conclusions. For example, the time and location of establishment for the Manx Shearwater population near the Burin Peninsula, Newfoundland has been speculated to be about 1977 (Storey and Lien 1985). I therefore believe that Manx Shearwaters could have been present for many years or even decades prior to 1977. Well documented seabird colonizations are extremely rare (Kildaw et al. 2005), especially on an island like Middle Lawn and islands in the vicinity that were not visited prior to this year. Furthermore, in a period of rapidly changing climate and consequent ecological change, small atypical outlying populations of many species, including seabirds, may be the best hope for their persistence. Consequently, I believe that given the findings of my study coupled with the published literature, the Middle Lawn Island and other Newfoundland Manx Shearwater colonies deserve future detailed study as well as future protection and conservation.

Storey and Grimmer (1986) suggested that nocturnal seabirds like the Manx Shearwater are less numerous at breeding colonies on clear moonlit nights compared with

overcast or new moon nights. To investigate this, I derived a moon index that was a product of moon phase and moon reveal and found that on nights when moon index was high, shearwater vocal activity was low and the reverse was found on nights when the moon index was low (Fig. 4). This further indicates that Manx Shearwaters are lunar-phobic which is likely a nocturnal predator-avoidance behaviour (Storey and Grimmer 1986).

Brooke (1978) observed that female Manx Shearwaters emit most of the flyover calls whereas males emit most of the ground calls. This was investigated by determining the proportions of male and female calls on each island in the period 20 – 25 June 2009 (Fig. 5). I determined the proportions of male and female calls for each island for recordings made late in the pre-breeding season (chick-rearing period). Pairs are established throughout the breeding season when males initially colonize an island and call to attract an un-paired female mate (Storey 1984). Female calls are non-locatable and for this reason call mainly from the air while male calls, on the other hand, are very complex and locatable and therefore they call from burrows to avoid predators (Lee and Haney 1996). Female calls accounted for >75% of calls recorded (Fig. 5) on Middle Lawn, Offer and Colombier Islands indicating the presence of many paired individuals and may indicate a well-established colony. Males may be calling less frequently to avoid predation and to increase breeding success while females are continuing to emit aerial calls to maintain communication with their male partner (Brooke, personal communication). In contrast, male (53%) and female calls (47%) on Grand Colombier Island were found to be close to equally frequent (Fig. 5). This may be indicative of a colony in an earlier stage of formation with males emitting calls to attract a partner. The

relatively low amount of female calling at Grand Colombier may suggest that fewer females are present compared to islands near the Burin peninsula. Measured male and female vocal activity on Middle Lawn Island in 2009 was quite similar to patterns of activity found by Storey (1984) and indicates that behaviour has not changed in three decades.

Observations from Middle Lawn, Offer and Colombier Islands are consistent with regular catastrophic incidents of mass predation on breeding birds by visiting mammalian predators (or gulls), followed by prospecting by recruiting non-breeders. Grand Colombier is quite different from the other islands studied in overall seabird diversity and absence of mammalian predators, likely due to its isolation from the mainland. In order to know more about the breeding activity, automated acoustic monitoring should continue on Grand Colombier and burrow checks should be conducted to check for breeding pairs of Manx Shearwaters.

My results have shown that the activity of Manx Shearwaters near the south coast of Newfoundland is larger than once thought. I detected Manx Shearwater activity on Middle Lawn, Offer, Colombier, and Grand Colombier Islands, and although this was in itself an important finding, better methodology could have been implemented. There is limited information on breeding activities of the Manx Shearwater in North America, however the pre-breeding courtship activity is likely similar to the European population (Lee and Haney 1996). If this assumption holds, then courtship activity likely begins in April on Middle Lawn Island, and earlier deployment of Song Meters would have given

us vocal information concerning the relative amount of breeding activity. Recorded Manx Shearwater call frequency by time of night (Fig. 3) suggested that there was likely activity later in the morning than included in my Song Meter's recording schedule, so an additional recording interval during 0430 h to 0500 h would have made the sampling more representative of the birds' activity period. Some of the islands studied (Green and Grand Colombier) are so large size that more than one Song Meter at each site should have been deployed (e.g., at either end of these islands). On Green Island, an additional Song Meter placed near or under the wind turbine could be used to measure the frequency of bird strikes with the turbine blades and supporting guy wires. As well, intensive burrow searches should have been carried out on all studied islands and on islands with potential for supporting a seabird colony (Fig. 6).

Alien invasions are a part of the evolutionary process, but because humans have easy access to remote islands, invasions of non-indigenous mammalian predators into areas where they could not have dispersed naturally have become common (Major 2004). Predation by a mammalian predator was evident on Middle Lawn and Offer Islands. My discovery of 15 relatively fresh adult Manx Shearwater carcasses at Middle Lawn Island was very alarming and does not bode well for the future of this colony. From the observations made in 2009, the best guess appears to be that the islands were visited by an American Mink during May or June 2009. Middle Lawn, Offer, and Colombier Islands are within close proximity to the mainland Burin Peninsula, which is within easy swimming range for American Mink, Northern River Otter (*Lontra canadensis*) and even Norway Rats. Most seabirds, such as the Manx Shearwater, produce few offspring during

their lifetime. Manx Shearwater breeding begins typically when individuals are at 5-6 years old, they breed annually and have a clutch size of 1 egg and are known to have lowest hatching success in frequently disturbed burrows (Lee and Haney 1996). Because of these breeding characteristics, the invasion of mammalian predators into a seabird colony can become catastrophic (Gray et al. 2005). In some cases, when a mink gains access to a small seabird (e.g., gull) colony it is unusual for any chicks to fledge (Craik 1997). Therefore, if predation continues on my study islands the viability of these populations is open to question. However, despite Manx Shearwaters having obviously been pressured by predation on Middle Lawn Island, they continue to persist, albeit in very low numbers.

Green Island had no Manx Shearwater activity even though it is the most isolated of the five islands monitored with Song Meters in 2009. This island has a breeding colony of Leach's Storm-petrels, suggesting (along with its remote offshore location and habitat) that it is an ideal site for seabirds including Manx Shearwaters and other burrow-nesting species. However, other ubiquitous Newfoundland seabirds such as the Atlantic Puffin (*Fratercula arctica*) and Razorbill (*Alca torda*), that have colonized the nearby Grand Colombier Island, are surprisingly absent. Nearby, relatively undisturbed, Grand Colombier Island has far greater numbers and diversity of seabirds even though Green Island seems like it should be the better site due to its isolation. Green Island does however have a history of multiple human disturbances associated with the light station (founded 1908) in the form of a wind turbine, fog horn and associated human activity (Fig. 3). Domestic dogs have been frequently present on the island as pets of the light

keepers (Pierre Ryan, personal communication), and likely cause severe disturbance to the remaining burrow-nesting seabirds. The wind turbine is of significant conservation concern because of its large spinning blades and multiple steel guy wires that are likely detrimental to seabirds residing and prospecting on this island. Manx Shearwaters and Leach's Storm-petrels, that habitually circle repeatedly over their breeding habitat at night, are vulnerable to fatal collisions with such structures, and are confused by artificial light. It seems incredible that such a structure could have been erected on an important Newfoundland seabird colony site without any environmental review by, or consultation with, seabird researchers and conservation groups.

On July 20th 2009, the Lawn Islands archipelago (including Middle Lawn, Offer, and Colombier) was officially established as a Provisional Ecological Reserve. An ecological reserve, as defined by the Wilderness and Ecological Reserve (WER) Act for Newfoundland, is an area set aside that contains a representative or unique ecosystem, species or natural phenomena, (a) to provide for scientific research and educational purposes in aspects of the natural environment; (b) to preserve for scientific research and educational purposes in aspects of the natural environment; (c) to provide standards against which the effects of development of other areas be measured; (d) to provide an opportunity for study of the recovery of ecosystems from the effects of modification by human beings; (e) to preserve rare botanical, zoological, geological or geographical characteristics; (f) to preserve representatives of distinct ecosystems in the province; or (g) to preserve organisms in their natural habitat to ensure the preservation of their gene pools. Reserve establishment can be a slow process, so the WER Act allows for

"provisional reserves" to be created much like the Lawn Islands. The WER Act allows these islands to receive protection while they are being reviewed for full designation as a permanent reserve (Parks and Natural Areas Division). The avifauna of the Lawn Islands Provisional Ecological Reserve is of significant concern and when the goals for an ecological reserve stated above are applied to give these islands upon permanent reserve status, the colony of the Manx Shearwater will be a priority matter for future research and management. In the past, artificial burrows made of a wooden box and an attached stovepipe have been constructed and deployed on Middle Lawn Island (Storey 1984). It was determined that Manx Shearwaters will in fact use these artificial burrows to nest. Along with alien predator control, this method could be implemented as a Manx Shearwater recovery and enhancement management activity.

My study results lead to a number of suggestions related to seabird research and conservation. Because the goals of an ecological reserve include the preservation of rare zoological characteristics and the preservation of organisms in their natural habitat to ensure the preservation of their gene pools, more research should be carried out on the Lawn Islands Archipelago to appropriately manage the rare breeding population of Manx Shearwaters. Research should continue with the replacement of up to 30 artificial nest boxes on Middle Lawn Island and annual monitoring of the islands studied in 2009, and at additional potential seabird islands found on the south coast of the Burin Peninsula, Newfoundland (Fig. 6, Table 4). Islands of interest, due to their offshore location and habitat suitability, include Marticot, Long, Jude and Flat Islands in Placentia Bay, Isle aux Vanqueurs near St. Pierre, and St. John's and Sagona Island and islets near Brunette

Island in Fortune Bay (Table 4). Sagona Island (currently uninhabited) is included on my list because of its isolation, even though it formerly supported a fishing outport and was extensively disturbed. Similar to the islands monitored by me in 2009, the listed islands (Table 4) are not well known and may contain suitable habitat for burrow nesting seabirds, or even undiscovered populations. Acoustic monitoring should also occur on islands where, in previous years, Manx Shearwater aerial calls have been heard and where Manx Shearwater corpses have been found. These islands include Gull and Great Island located in Witless Bay (Robertson 2002). With this information, the frequency of occurrence of Manx Shearwater calls can be compared with those found on Middle Lawn Island. Acoustic monitoring could potentially detect other rare eastern Atlantic species, such as European Storm-petrel (*Hydrobates pelagicus*) that may come ashore; recordings should be carefully checked for such extra-limital occurrences. Along with acoustic monitoring, regular monitoring and control of the alien American Mink should be implemented on the islands located within the Lawn Islands Provisional Ecological Reserve. If Parks and Natural Areas Division fail to immediately implement control or eradication of the American Mink, it is possible that this important Manx Shearwater colony will not be preserved and this unusual population will be lost.

It is rare in Newfoundland to find an island that is far enough offshore and large enough to support a large diversity of seabirds, however Green Island (Fig. 6, Fig. 7) is attributed with both of these characteristics and should be considered for re-assignment as an ecological reserve, or at least as a site intensively managed by the Canadian Government for seabird conservation. Green Island is the most isolated island on the

south coast of Newfoundland with habitat and size suitable for diverse seabird colonies. However, the presence of a guyed wind turbine and domestic pets on the island are incompatible with healthy seabird colonies. In particular, the removal of the turbine is the single most urgent action indicated by this report. I hope to work closely with the Canadian Coast Guard to develop a revised management plan for the island that emphasizes seabird and other wildlife conservation, while maximizing the use of renewable energy sources. The restoration and conservation of Green Island may provide the best hope for maintaining viable seabird populations on the south coast of Newfoundland (including especially the Manx Shearwater), as nearly every other island is too small and close to the mainland. If the above recommendations are met, the Manx Shearwater population on Middle Lawn Island will have the opportunity to prosper and also, we may see avian diversity increase on all offshore islands near the Burin Peninsula, Newfoundland.

TABLES

Table 1 Comparison of Manx Shearwater activity at five Newfoundland islands during 2009, as detected by automated recording devices.

Island Name	% of nights with ≥ 1 detection	% of 30 minute intervals with ≥ 1 detection	Calls/minute for interval with greatest # of calls	Mean # of calls across all intervals sampled
Middle Lawn	72.0%	48.7%	0.97	0.15
Colombier	40.0%	13.3%	0.63	0.01
Green	-	-	-	-
Offer	56.0%	33.3%	0.07	0.07
Grand Colombier	64.0%	46.7%	0.12	0.12

Table 2 Correlations of nightly Manx Shearwater vocal activity across islands[1] near the Burin Peninsula, Newfoundland (excluding Green Island).

	Middle Lawn	Offer	Colombier	Grand Colombier
Middle Lawn	-	0.84	0.52	0.80
Offer	<0.0001	-	0.17	0.51
Colombier	0.027	0.011	-	0.54
Grand Colombier	0.0001	0.0004	0.022	-

[1] Spearman Rank Correlation, Rho above diagonal, Fisher's r to z p-value below the diagonal.

Table 3 Re-traps of previously banded Manx Shearwaters on the night of July 20-21, 2009 at Middle Lawn Island, Newfoundland.

Band number	Location[1]	Where?	Date of original banding	Location of original banding
794 60397	Area C	in burrow	July 2005	Middle Lawn
794 60527	Area C	in burrow	June 30th 2008	Middle Lawn
794 60540	Area C	on surface	July 1st 2008	Middle Lawn
794 60534	Area C	on surface	July 1st 2008	Middle Lawn
794 60324	Area B	on surface	July 5th 2003	Middle Lawn

1 As indicated on Storey and Lien's (1985) map of Middle Lawn Island.

Table 4 List of suggested offshore island locations near the Burin Peninsula, Newfoundland, for future Song Meter deployment (see also Fig. 5).

Island Location	Latitude	Longitude	# of Song Meters to be deployed	Known Seabird Colony
Middle Lawn Island	46.869º N	55.616º W	1 annually	yes
Green Island	46.879º N	56.089º W	2	yes
Sagona Island	47.370º N	55.786º W	1	no
Isle aux Vanqueurs	46.791º N	56.129º W	1	no
Marticot	47.333º N	54.583º W	1	no
Long Island	47.302º N	54.697º W	1	no
Flat Island	47.259º N	54.935º W	1	yes
Islet south of Brunette Island	47.245º N	55.955º W	1	no
Grand Colombier Island	46.823º N	56.167º W	2 annually	yes

FIGURES

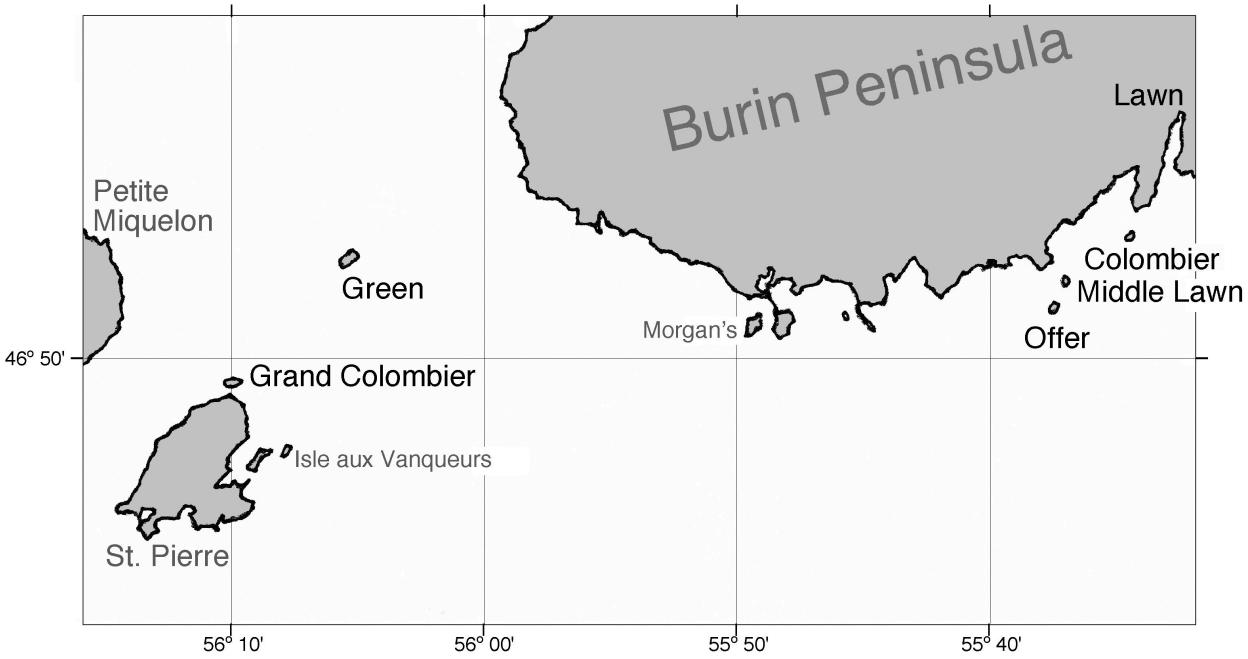

Figure 1 Location of the five Newfoundland island study sites (bold type) where Song Meter automated acoustic recording devices were deployed in June-July 2009 to detect Manx Shearwaters.

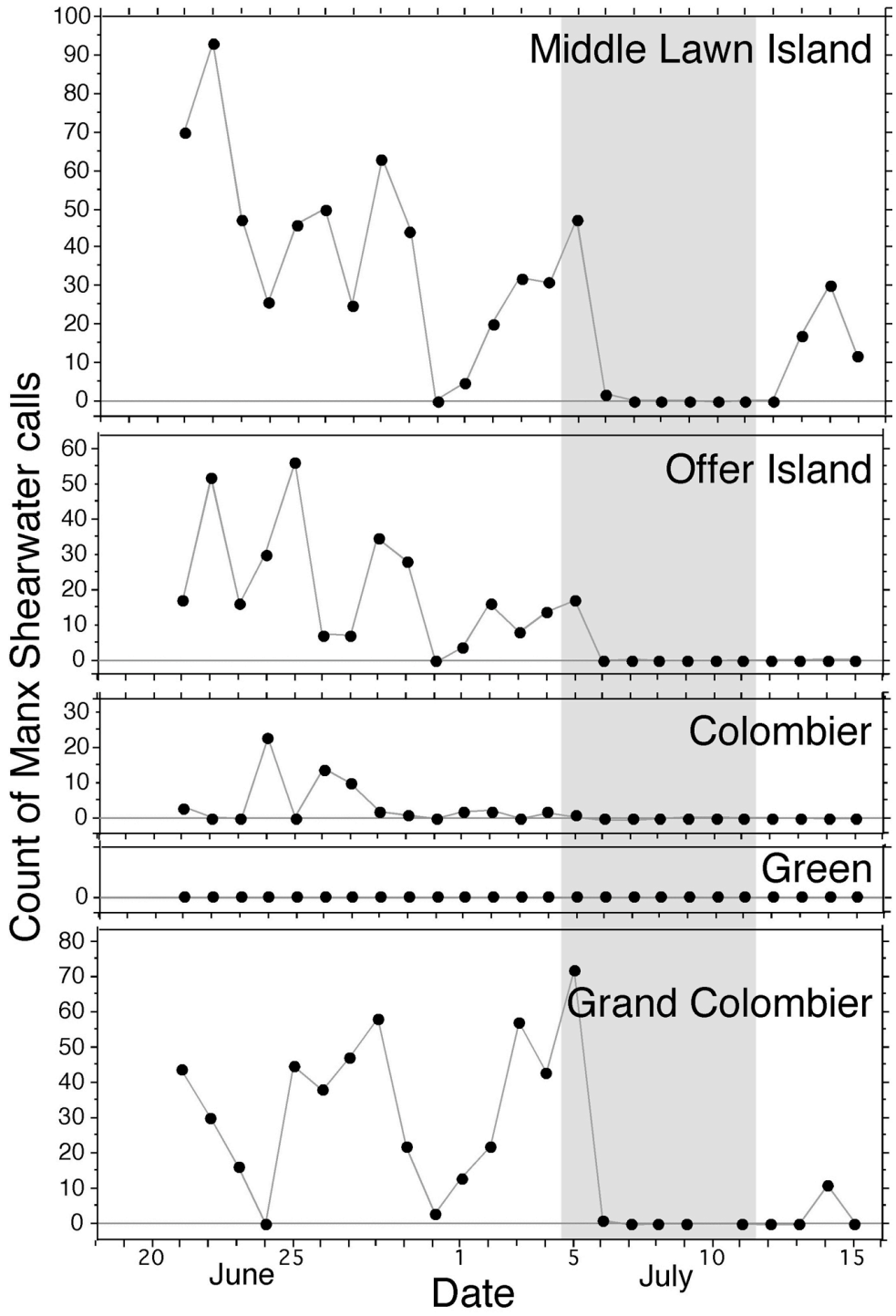

Figure 2 Frequency of Manx Shearwater calls (calls / 3 hours) detected at Middle Lawn, Offer, Colombier, Green, and Grand Columbier Islands, Newfoundland, during June and July 2009 (full moon phase as indicated by shaded area).

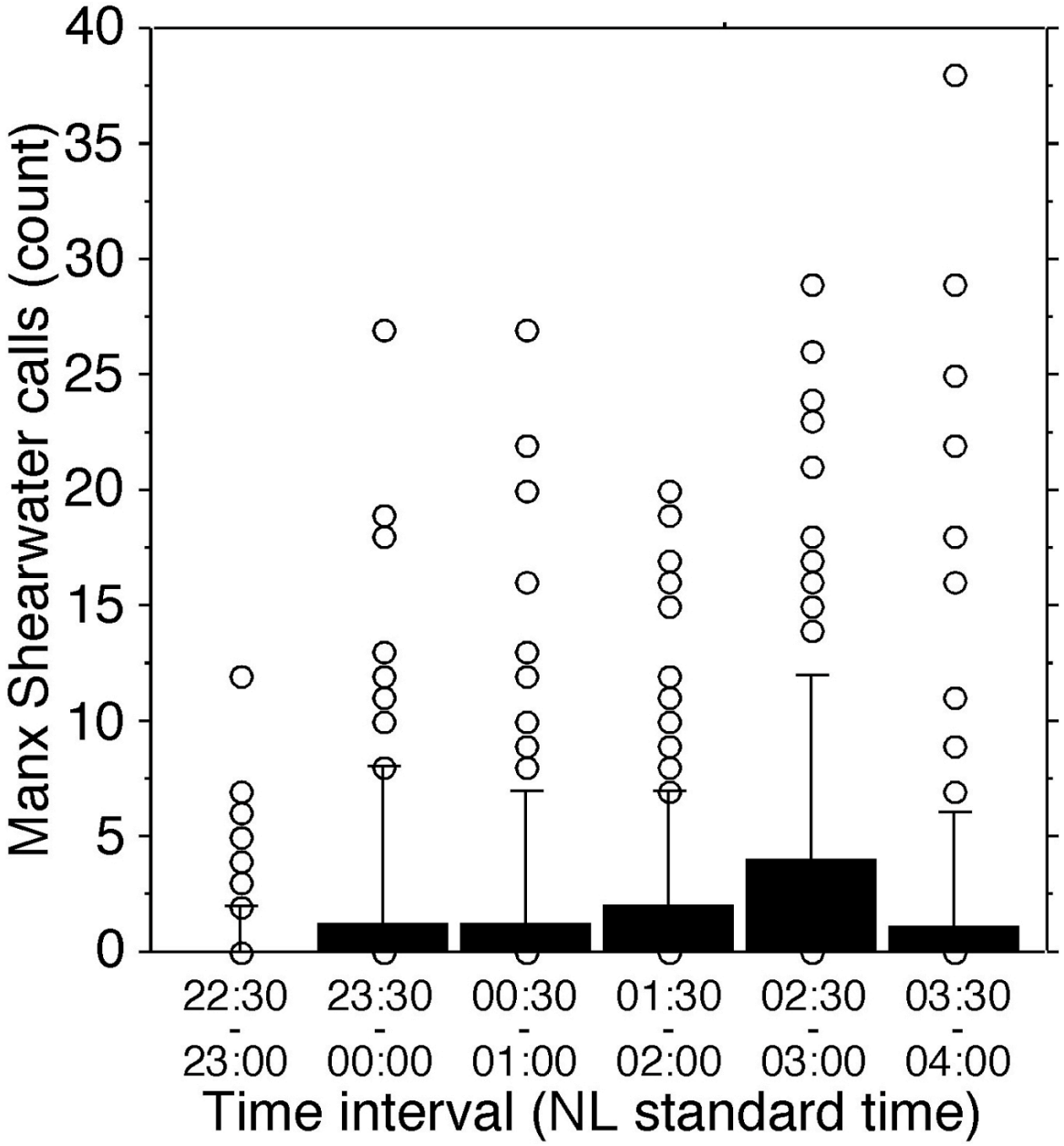

Figure 3 Box plot showing occurrence of Manx Shearwater calls according to time of night (all data combined) at Newfoundland islands monitored during June-July 2009.

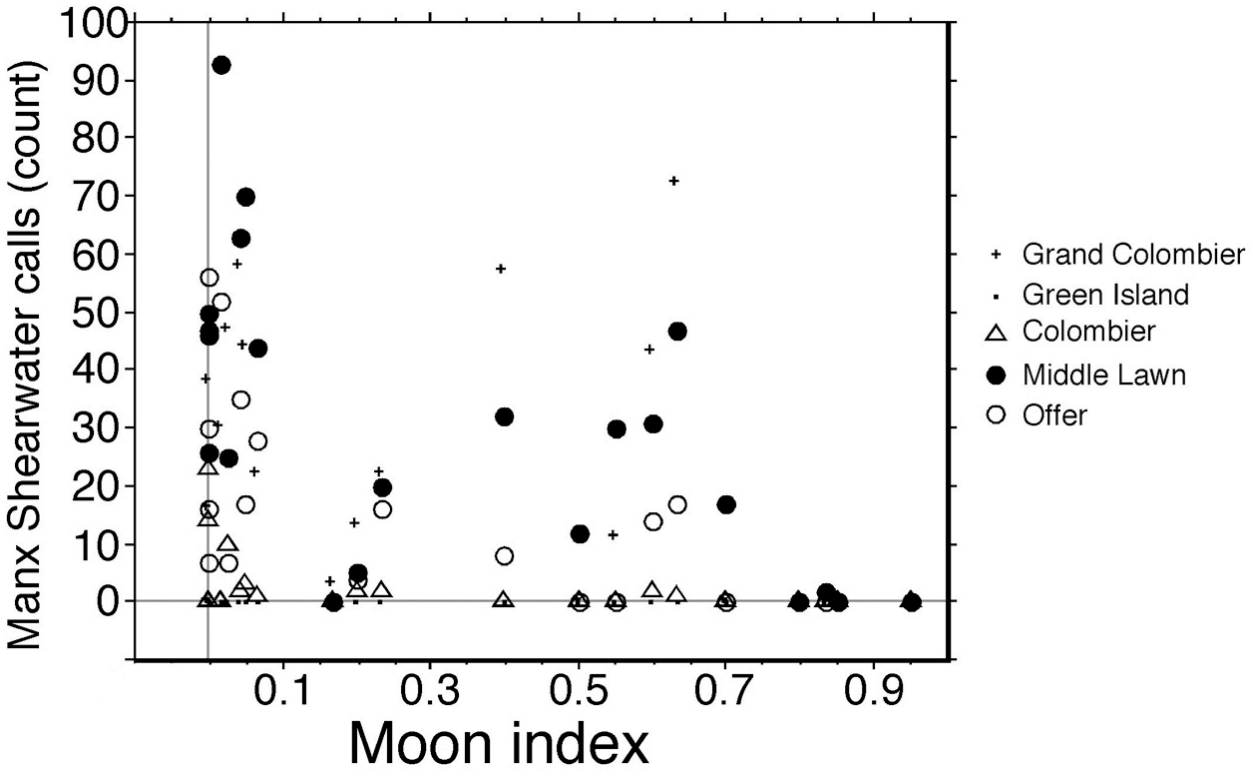

Figure 4 Relationship between occurrence of Manx Shearwater calls and moonlight intensity as indicated by moon index (0.0 is no moon, 1.0 is full moon above horizon) at Newfoundland islands monitored during June-July 2009.

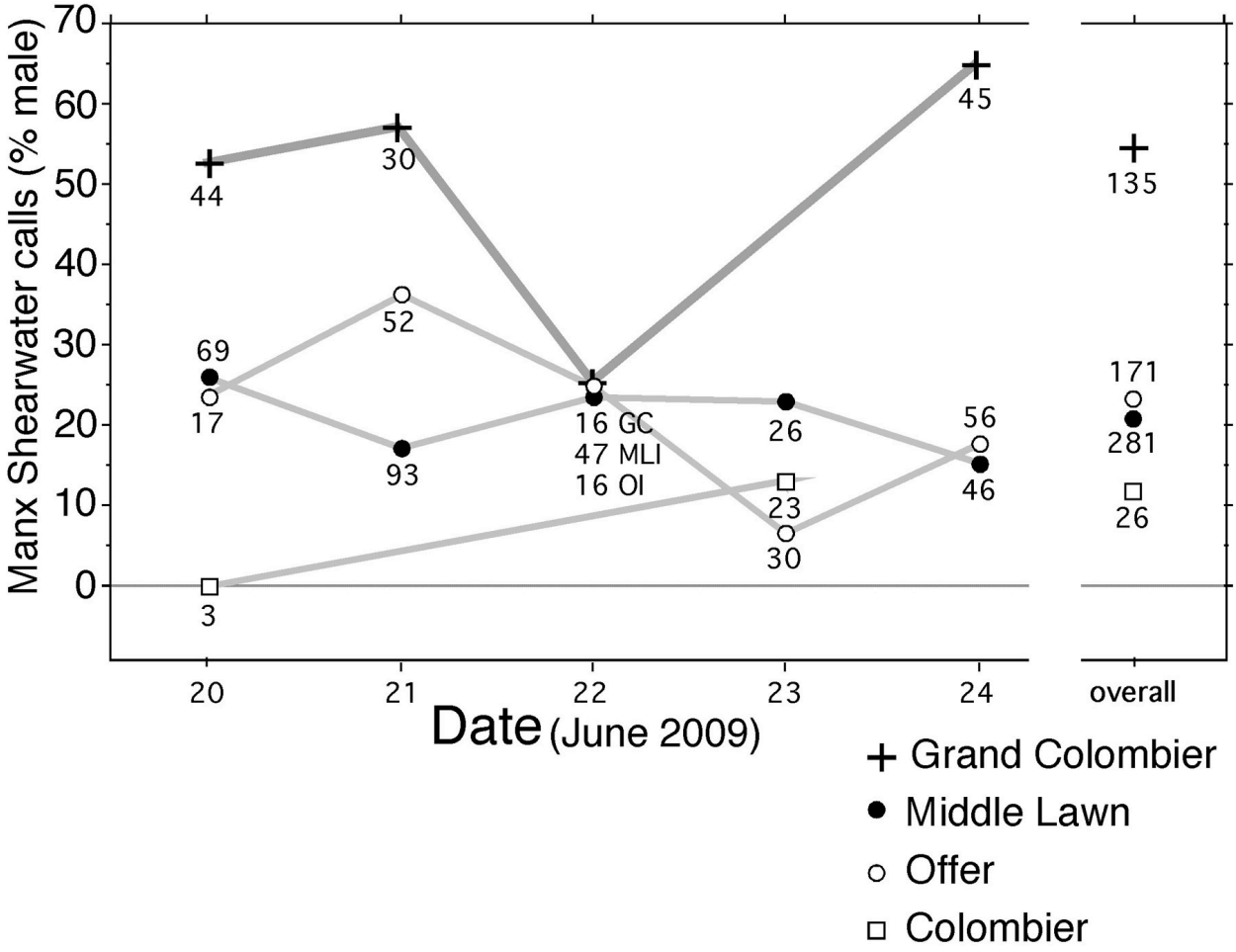

Figure 5 Proportion (%) of Manx Shearwater calls that were male calls, on five nights during June 2009 on islands near the Burin Peninsula, Newfoundland (number of total calls sampled for each night given adjacent to each point, overall ratios on right).

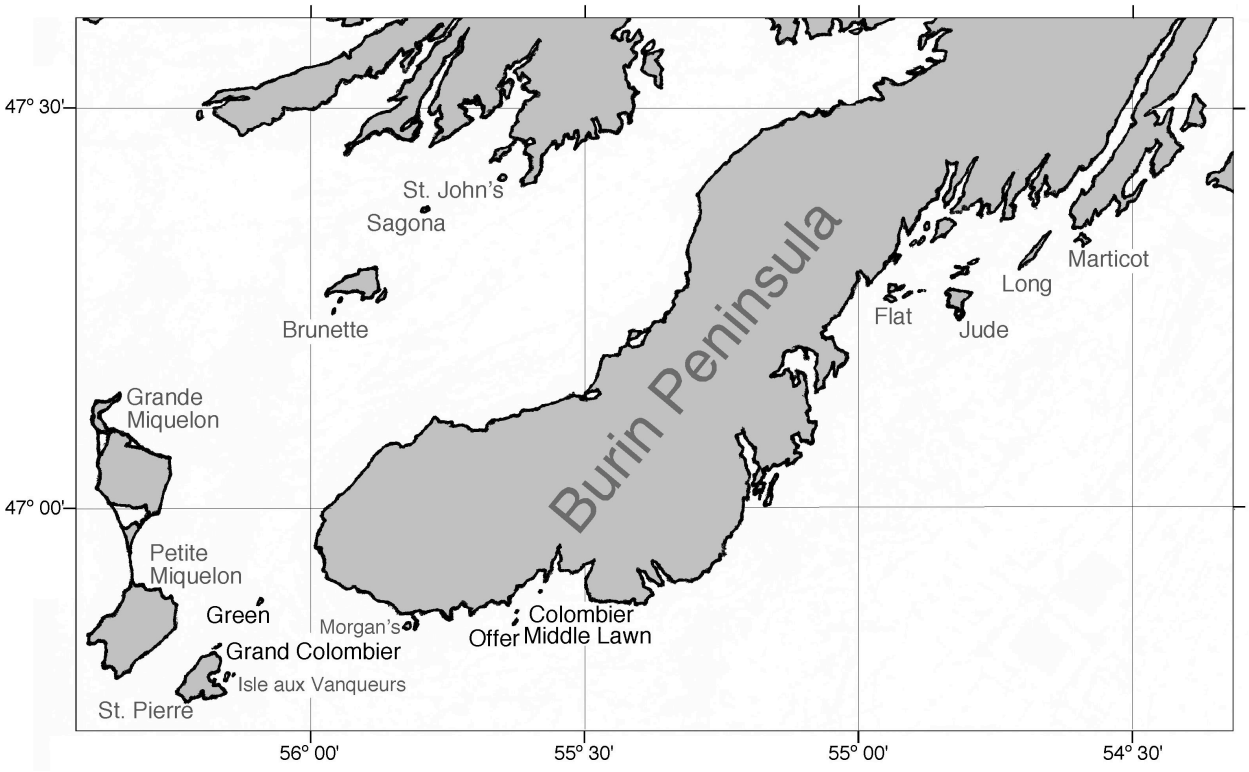

Figure 6 Location of islands near the Burin Peninsula, Newfoundland, with potential for seabird breeding colonies.

Figure 7 Green Island, Newfoundland (June 11, 2009) showing various structures that potentially impede the viability of this seabird colony site.

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