BREEDING POPULATION TRENDS AND MANAGEMENT OF SILVER GULL *LARUS NOVAEHOLLANDIAE* IN SOUTHEAST TASMANIA, 1975–2023

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ABSTRACT

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The control and management efforts directed towards Silver Gulls *Larus novaehollandiae* on the causeways in the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex in southeast Tasmania, Australia, have been episodic and largely short-term in nature between 1975 and 2023, inclusive. These efforts have comprised primary (culling) and secondary (habitat modification) measures at different intensities, durations, and areas/extents of application. The primary measures resulted in short-term, immediate responses to the culling, from which the population recovered within two or three years of the cessations of efforts. Permanent alteration to nesting habitat reduced the area available for nesting, but overall, the breeding population within the complex is unchanged after 47 years. Control measures that aimed to reduce the areas available for nesting (secondary measures) had a greater influence than did the primary control measures (population culling). Habitat modification to prevent nesting and provision of alternative nesting sites with some active (non-lethal) deterrence from the causeways is likely to provide the greatest potential for success in terms of future management of Silver Gulls in the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex in southeast Tasmania.

Key words: Laridae, long-term monitoring, colony management, culling, habitat restoration, invasive plants

INTRODUCTION

Globally, many gull populations, especially those close to urban, agricultural, and industrial areas, have increased to numbers often described as overabundant or superabundant. Adapting to human-modified landscapes and habitats, gulls have become synanthropic species—undomesticated animals that benefit by living in association with humans. Managing gull species that can adapt to, and in many cases readily exploit, human-altered landscapes presents a broad spectrum of management options and challenges. Often, the ability of gulls to exploit human-altered habitats has led to conflict situations ranging from nuisance to significant safety threats (e.g., Belant, 1997; Mallory et al., 2024; Pais de Faria et al., 2021; Smith, 1992).

In Tasmania, Australia, Silver Gulls *Larus novaehollandiae* (*Chroicocephalus novaehollandiae* in other taxonomic treatments) breed extensively around the coastline, with numerous colonies on islands around the state's coast (Brothers et al., 2001). Silver Gulls typically lay three eggs per clutch (range = 1–6) and commence breeding at 3–4 years of age (Higgins & Davies, 1996; Wheeler & Watson, 1963). In southeast Tasmania, the current (2025) Silver Gull population is approximately 60% greater than in the early 1980s (Woehler, 2024a, 2024b).

A Silver Gull colony is located on the Sorell Causeway between Midway Point (42.804°S, 147.534°E) and Sorell, approximately 20 km east of Hobart. A second causeway between Pittwater Bluff and Midway Point (previously known as the "Golfcourse" or Pitt Water Causeway) is located to the southwest (Fig. 1; Figs. A1 and A2 in Appendix, available on the website), and both are situated within the Pitt Water–Orielton Lagoon Ramsar Site and Nature Reserve. The Pitt Water and Sorell Causeways were opened for traffic in the 1870s and are approximately 1.6 and 1.4 km in length, respectively. Early observations of Silver Gulls breeding on islands in the Pitt Water area were made in the 1960s and 1970s. The Sorell Causeway colony established in October 1975, with early accounts of the breeding effort and management responses detailed in Skira and Wapstra (1990). Over the last 50 years, colonies have established and ended due to natural processes and management efforts on both causeways.

Intermittent surveys and monitoring of the breeding population on the causeways were undertaken during the 1980s to early 2000s (e.g., Horner, 1997a, 1998, 1999; D. Horner, unpublished data; W. C. Wakefield & M. J. Wakefield, unpublished data). Detailed and intensive monitoring of the annual breeding population and annual breeding phenology commenced in 2011/12 (Woehler, 2013) and continued until the 2022/23 breeding season (Woehler, 2019, 2020, 2021, 2022).

Control measures throughout the 1980s were primarily directed to reducing the breeding population of Silver Gulls on the Sorell Causeway and were variable in their efficacy (Skira & Wapstra, 1990), matching results elsewhere in Australia (e.g., Hope et al., 2025; Smith, 1995; Smith & Carlile, 1993; van Tets, 1969) and overseas (e.g., Blackwell et al., 2000; Burger, 1983; Lewis & Malecki, 1984). These early control measures were in response to rapid population increases that resulted in road and aircraft hazards, amongst other management issues (Skira & Wapstra, 1990).

Primary control measures involving oiling eggs *in situ* in nests, intended to result in breeding failure, were initiated on the Sorell Causeway in 2007/08 and continued until the end of the 2017/18 breeding season (M. Foale, Department of State Growth, personal



Fig. 1. The Pitt Water/Midway Point (lower left) and Sorell (upper right) Causeways. Inset shows the location of the study area relative to Tasmania and the rest of Australia.

communication, November 2025). Other primary control measures involving eggs being addled, oiled, or injected with formalin were undertaken in the late 1990s (Horner, 1998, 1999). As with mainland Australian studies (Smith & Carlile, 1993), these efforts had little influence on gull numbers beyond the period of implementation. Secondary efforts at Sorell were directed towards preventing nesting using bitumen or small gravel to coat and cover nesting ledges, respectively; fencing was used concurrently at times to reduce access to the road surface to reduce interactions with vehicular traffic.

The objectives of the present study were to (1) collate the available data on the breeding population of Silver Gulls on the Midway Point (Pitt Water) and Sorell Causeways since 1975 and assess the observed population trends within the context of regional (southeast Tasmania) trends for the species, (2) examine the efficacy of the various control measures used in that period as manifested in the breeding population since 1975, and (3) provide a context for suggested future management strategies following the construction of duplicate causeways to begin in 2026 or 2027.

METHODS

The following terminology was used to describe the age classes of the gulls in this study: a chick is a flightless individual gull hatched in the current breeding season (typically August–March in southeast Tasmania), a juvenile is a young gull capable of flight after fledging (leaving the nest), and an adult is a gull of breeding age. For this study, culling refers to efforts undertaken to remove eggs, chicks, and adults from the wild population, using direct methods such as egg removal or injecting eggs with formalin.

Pre-1975 Census Data

Pre-1975 observations for both causeways and colony survey data from the adjacent Barren Island and Susie Islet, both of which supported nesting colonies of Silver Gulls, were collated. Visits to both islands were made in 1960–1961, 1964–1967, and 1970–1971 to record population data on Silver Gull breeding colonies (L. E. Wall & D. G. Thomas, unpublished data). Early occasional records from the 1960s of Silver Gulls present on the Sorell Causeway were presumed to be roosting birds, given that breeding on the causeway established in October 1975 (Skira & Wapstra, 1990).

Contemporary Breeding Population Data, 1975 to Present

Colony census data (nest, egg, and chick) for the causeways, Barren Island, and Susie Islet were obtained from published peer-reviewed and technical reports (Horner, 1997a, 1997b, 1998, 1999; Skira & Wapstra, 1990; Woehler, 2013, 2019, 2020, 2021, 2022) and unpublished field notes (W. C. & M. J. Wakefield, C. Wolff, E. J.

Woehler, unpublished observations). Details for the population survey methods used before 2008/09 are not described in their respective reports, but on the basis of the data collected, they were deemed to be compatible with contemporary surveys (see below). Further, the author was involved in earlier surveys, which allowed for survey protocols to be adopted for contemporary efforts.

The surveys to assess annual breeding populations from 2011/12 to 2022/23 collected data on the number of nests present (under construction and with eggs present) and the numbers of Silver Gull adults in attendance at the Sorell Causeway colony (Woehler, 2013). All field surveys were undertaken by the author at or just after sunrise on Sunday mornings to minimise the potential for disturbed adult gulls to be struck by vehicular traffic. Weather permitting, the Sorell Causeway colony was visited on a weekly basis each season from mid-August, and visitation ceased on the second visit that chicks were observed in or around nests (mean: 12 visits/season, range: 8–23; E. J. Woehler, unpublished data). Cessation of visits to the colony was to prevent disturbance to adults brooding chicks and to prevent chick losses due to intra-specific aggression.

As Silver Gulls within a colony are asynchronous in their breeding schedules and can re-lay following a successful breeding effort (Smith & Carlile, 1992, 1993), the population estimates reported for the 2011/12 to 2022/23 breeding seasons must be considered conservative, representing the absolute minimum estimates for breeding population (nests) and breeding effort (eggs) per season. Identical survey and monitoring methods were used over the study period to ensure consistency in the data set to allow inter-annual comparisons to be made and long-term trends to be investigated.

Control Measures, 1980/81 to 2017/18

A wide range of control measures was used in efforts to reduce the Silver Gull breeding population on the Sorell Causeway from 1980/81 to 2017/18, inclusive. Skira and Wapstra (1990) detail the removal of just under 14,000 eggs from nests on the Sorell Causeway in nine breeding seasons (1980/81 to 1988/89, inclusive). Concurrent measures to reduce the availability of nesting sites on the Sorell Causeway comprised the use of wire and nylon netting and pouring hot bitumen at selected sites to cover nesting habitat along the causeway. Each measure had limitations that reduced its efficacy (Skira & Wapstra, 1990).

Eggs were addled, oiled, or injected with formalin in 1997/98 (Horner, 1998), and more than 1,000 eggs were either addled or collected and removed from nests in the 1998/99 breeding season (Horner, 1999). An extended program to reduce breeding success of Silver Gulls on the Sorell Causeway was initiated in 2007/08. Eggs were sprayed with a light oil at approximately fortnightly intervals each season during 11 breeding seasons from 2007/08 to 2018/19, inclusive. Chicken wire fencing was installed along parts of the Sorell Causeway sometime after the 1999/00 breeding season, but the fencing had deteriorated to a decrepit state with extensive gaps by 2011/12 (E. J. Woehler, unpublished observations).

Mortalities, 2018/19 to 2021/22

Monitoring and GPS mapping of mortalities on the Sorell Causeway were undertaken in four breeding seasons 2018/19 to 2021/22, inclusive, (Woehler, 2019, 2020, 2021, 2022) to assess the efficacy of new fencing installed in winter 2020 (see below). These mortality surveys were concurrent with, and subsequent to, visits undertaking breeding population (nests and eggs) censuses.

All gull carcasses were removed from the roadsides and thrown into Orielton Lagoon or Pitt Water where possible and safe to do so, to prevent double counting. Where possible and when safe, fresh carcasses from the road surface were removed. However, road surface carcasses typically comprised "smears" of feathers and tissues and could not be easily removed. The carcasses and smears were aged as adult if red legs or a red bill was evident, and otherwise the bird was deemed to be a juvenile; brown wing coverts were often seen in the smears, confirming the age as juvenile.

Analyses of mapping data showed that smears typically persisted on the road surface for well over a month (E. J. Woehler, unpublished data), so weekly increments were used to estimate the number of "new" carcasses between consecutive surveys. Occasionally there were fewer carcasses on subsequent surveys, and these decreases were attributed to scavenging of the carcasses. Scavenging of carcasses on the roadside and road surface by Silver Gulls, common brushtail possums *Trichosurus vulpecula*, and rakali/water rat *Hydromys chrysogaster* was observed on multiple occasions during surveys (E. J. Woehler, personal observations). The estimates of the numbers of gulls killed were derived solely from the total number of roadside carcasses observed and removed, and from the weekly accumulation of "smears" on the road surface.

RESULTS

Silver Gull Breeding Population Size and Trends

Pitt Water/Midway Point and Sorell Causeways, 1976 to 2023

Over the 47 years from 1975/76 to 2022/23, the estimated breeding population of Silver Gulls on the Pitt Water/Midway Point and Sorell Causeways ranged from two pairs in 2000/01, following control measures, to more than 600 pairs in 2013/14 (Fig. 2, lower graph). The overall population trend for 1975 to 2023 is stable, with no change in the estimated annual mean number of breeding pairs (320 ± 160 pairs; derived from the numbers of nests each breeding season) over the 47-year period.

When these data are examined at finer temporal scales in relation to control measures, population trends are evident in the numbers of nests present (Fig. 3, lower graph). Rapid decreases in annual numbers were recorded in the 1980s, coinciding with the large-scale removal of eggs (Skira & Wapstra, 1990). The population recovered during the 1990s, leading to the implementation of a subsequent program in the late 1990s when eggs were addled, oiled, injected with formalin, or removed (Horner, 1998, 1999). The decrease in nest numbers recorded during the control program in the 2010s is statistically significant (Fig. 3, lower graph).

Similar results were obtained for analyses examining egg production per season for the 47 years from 1975/76 to 2022/23. The numbers of eggs recorded ranged from four in 2000/01, following control measures, to more than 1,100 in 2012/13 (Fig. 4, lower graph). The overall trend is not statistically significant, indicating no change in the estimated annual numbers of eggs laid each breeding season over this 47-year period. When the egg data are examined in relation to control measures (1980 to 1998/99 and 2007 to 2018), both trends are statistically significant (Fig. 5, lower graph). This

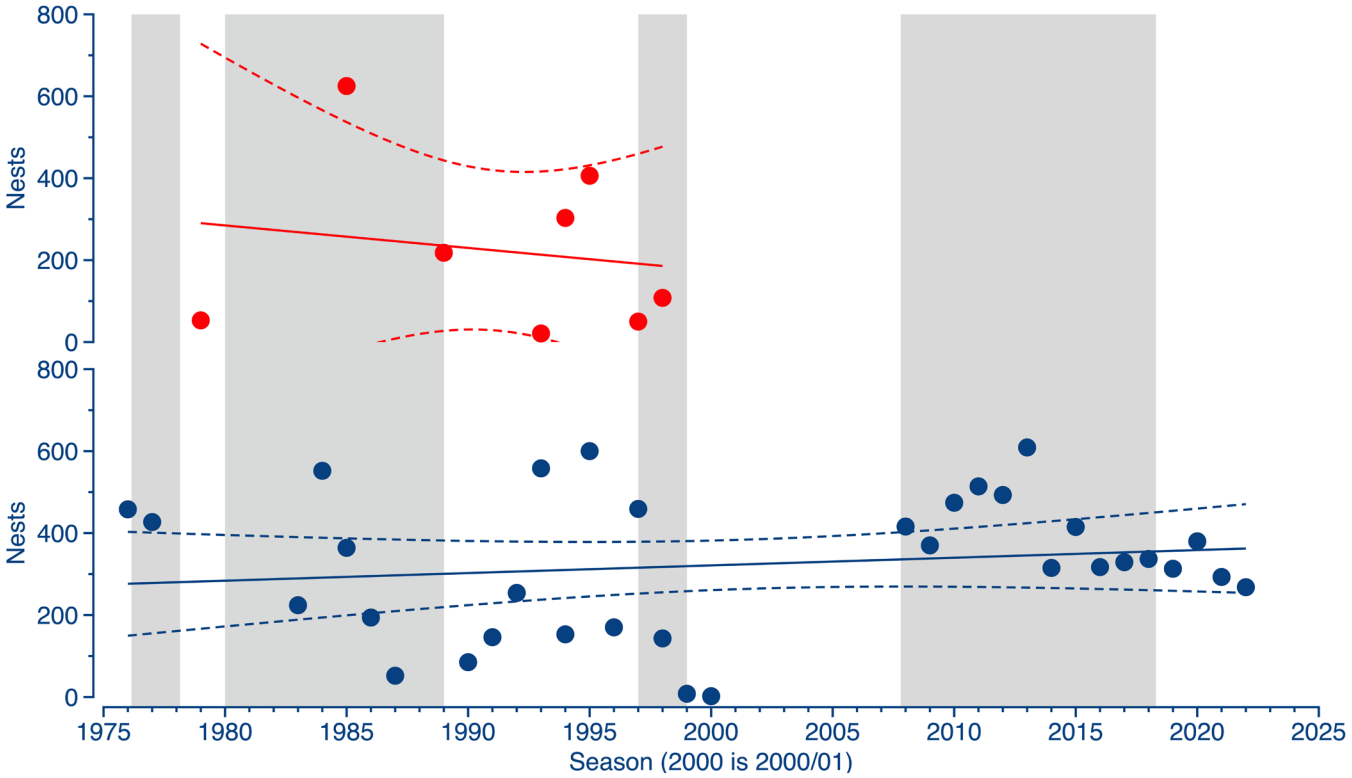

Fig. 2. Annual estimated Silver Gull *Larus novaehollandiae* nest data for Sorell and Pitt Water (Midway Point) Causeways (lower graph, blue symbols) and Barren Island (upper graph, red symbols), in Tasmania, Australia, 1976/77 to 2022/23. The grey shading indicates seasons when control measures were undertaken. Correlations with 95% confidence limits are shown for all Barren Island data (1979/80 to 1998/99) and for the causeways 1976/77 to 2022/23. Neither trend is statistically significant.

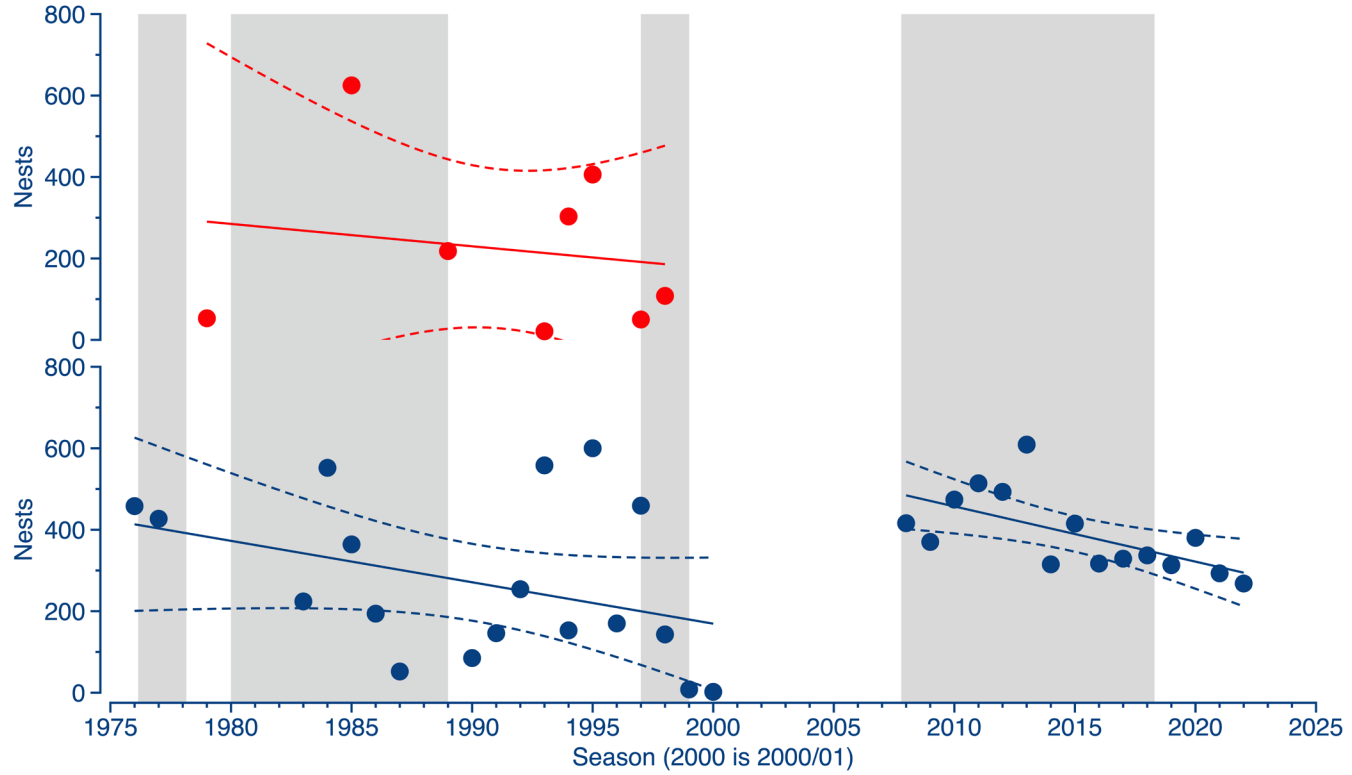

Fig. 3. For relationships shown in Fig. 2 for Silver Gull *Larus novaehollandiae* nest data (in Tasmania, Australia), correlations with 95% confidence limits for Barren Island census data (1979/80 to 1998/99) in the upper graph, and for the causeways (1976/77 to 2000/01 and 2008/09 to 2022/23) in the lower graph. Only the causeway nest data for the period 2008/09 to 2022/23 (lower right) show a statistically significant trend ($.05 > p > .01$). See text for details of control measures and data sources.

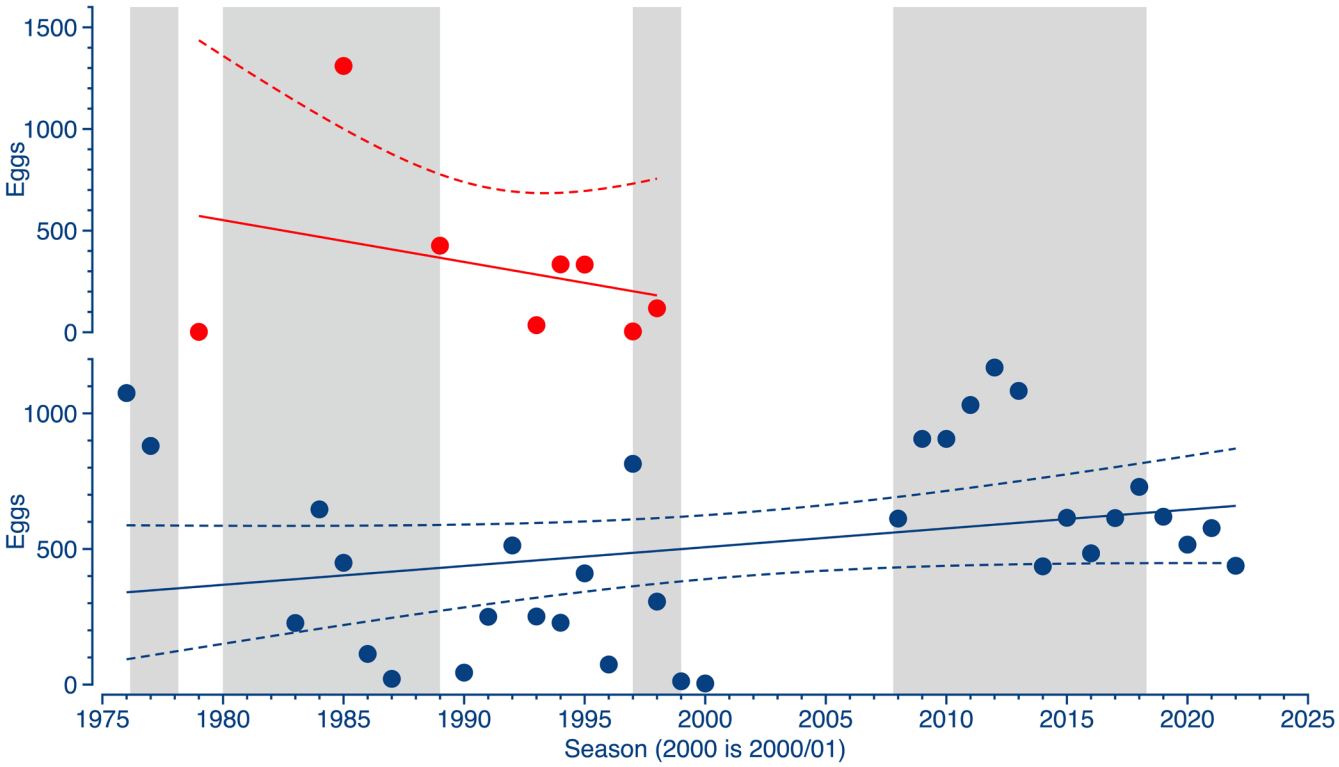

Fig. 4. Annual estimated Silver Gull *Larus novaehollandiae* egg data for Sorell and Pitt Water (Midway Point) Causeways (lower graph, blue symbols) and Barren Island (upper graph, red symbols), in Tasmania, Australia, 1976/77 to 2022/23. The grey shading indicates seasons when control measures were undertaken. Correlations with 95% confidence limits are shown for all Barren Island data (1979/80 to 1998/99) and for the causeways (1976/77 to 2000/01 and 2008/09 to 2022/23). Neither trend is statistically significant.

result is due to the control measures implemented in these periods directed solely towards removing, oiling, or injecting eggs. The high numbers of eggs recorded in 2011/12 to 2013/14, when egg numbers exceeded 1,000 in all three seasons, are believed to be from replacement laying (E. J. Woehler, unpublished observations).

Barren Island (1970/71 to 1998/99) and Susie Islet (1964/65 to 1992/93)

During the 1980s, Barren Island supported more than 600 nests (maximum in 1985/86), a breeding effort greater than that recorded on the Sorell Causeway for the period 2008/09 to 2022/23 (E. J. Woehler, unpublished data; Fig. 2). By the mid-1990s, the colony had decreased by *ca*. 35%, but there were more than 400 nests recorded in 1995/96 (W. C. & M. J. Wakefield, unpublished data).

This decrease was attributed by Horner (1998, 1999) to the expansion of African boxthorn *Lycium ferocissimum* and pines *Pinus* spp. on the island, which reduced the available nesting habitat. Following limited rehabilitation efforts on Barren Island in 1998/99, numbers of breeding Silver Gulls on Barren Island increased (Horner, 1999). The last recorded breeding by Silver Gulls on Barren Island was in 1998/99, with no further breeding recorded in subsequent surveys (W. C. & M. J. Wakefield, unpublished data).

Susie Islet supported *ca*. 400 nests in 1965/66 (L. E. Wall, unpublished data). The islet is now overgrown with African boxthorn and is unsuitable for nesting by Silver Gulls, except perhaps within a narrow ribbon of unvegetated foreshore around the periphery of the islet. The last recorded breeding effort by Silver Gulls on Susie Islet was in 1991/92 (W. C. & M. J. Wakefield, unpublished data).

Regional Gull Population Trends, 1983 to 2025

Winter Kelp Gull *Larus dominicanus* and Pacific Gull *L. pacificus* counts (Winter Gull Counts, WGCs) commenced in 1980 in southeast Tasmania, and Silver Gulls were incorporated in WGCs in 1983. No WGCs were conducted in 1991 to 1994, inclusive, and the 2025 WGC was the 42nd WGC for southeast Tasmania. Based on the 2025 WGC, the current regional population of Silver Gulls is more than 16,000 birds, or approximately 60% higher than in 1983. In contrast, the breeding population of Silver Gulls on the Pitt Water and Sorell Causeways over the 1976/77 to 2022/23 period has not changed (Fig. 2, lower graph). The regional populations of all three gull species are currently substantially greater than their respective initial counts in the 1980s (Woehler, 2024a; Woehler et al., 2014).

Efficacy of Control Measures, 1975 to 2023: Culling

Primary control measures throughout the 1980s were directed to reducing the breeding population of Silver Gulls on the Sorell Causeway (i.e., culling), with additional efforts attempting to prevent nesting by reducing habitat availability and suitability on the causeways. At various times, and with variable effort and duration of control measures, culling involved eggs being removed from nests, addled by vigorous shaking and returned to nests, oiled *in situ* with a light machine oil spray, or injected with formalin.

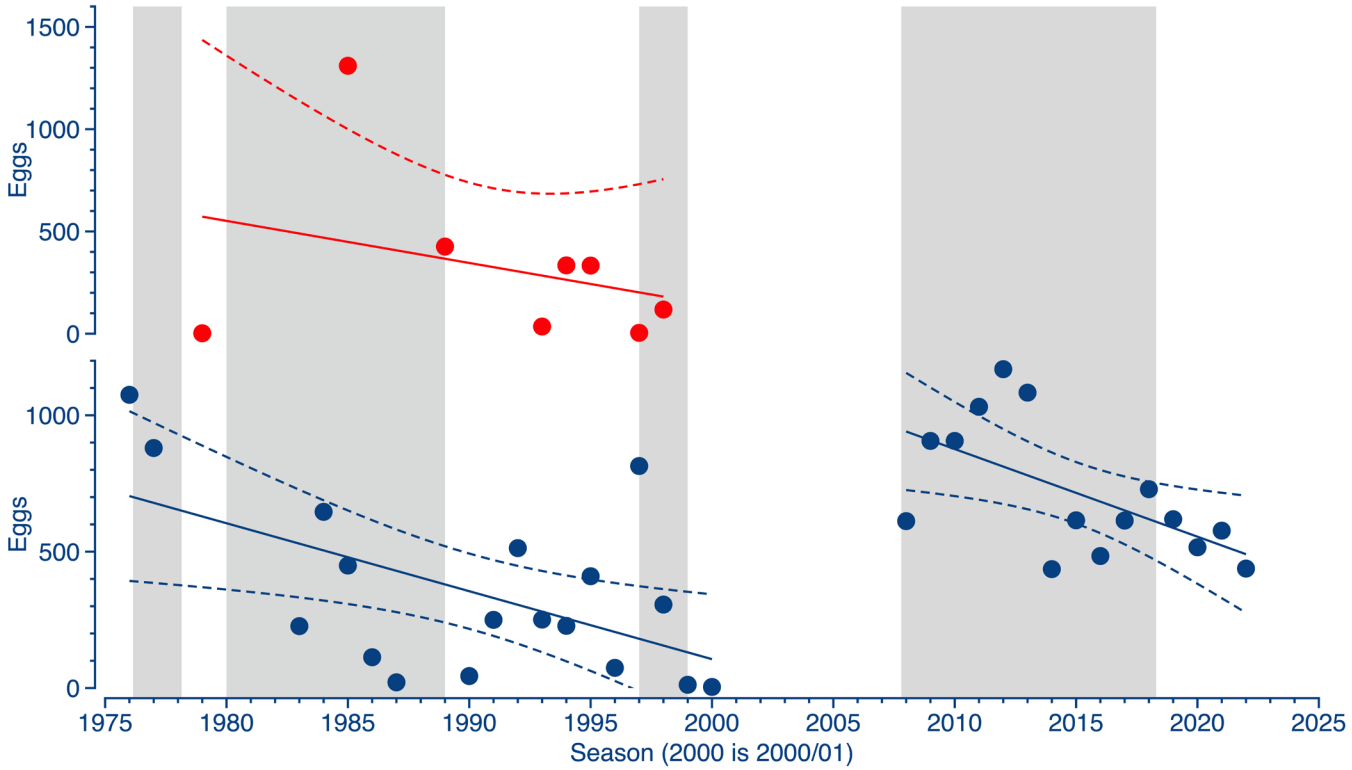

Fig. 5. For relationships shown in Fig. 4 for Silver Gull *Larus novaehollandiae* egg data (in Tasmania, Australia), correlations with 95% confidence limits for Barren Island census data (1979/80 to 1998/99) in the upper graph, and for the causeways (1976/77 to 2000/01 and 2008/09 to 2022/23) in the lower graph. Causeway egg data for both 1976/77 to 2000/01 (lower left) and 2008/09 to 2022/23 (lower right) show statistically significant trends ($.05 > p > .01$). See text for details of control measures and data sources.

In some cases, the measures were undertaken as trials and were in effect for as little as one breeding season (Horner, 1998, 1999). Longer periods of control measures to cull the breeding population involved egg removal for nine breeding seasons in the 1980s (Skira & Wapstra, 1990) and spraying eggs in nests with light machine oil in 12 breeding seasons until 2017/18 (Figs. 2–5).

Efficacy of Control Measures, 1975 to 2023: Secondary Measures

Secondary control measures were directed towards reducing the suitability of the causeways as nesting habitat and reducing the accessibility of the road surface for nesting birds to reduce interactions with vehicular traffic. Skira and Wapstra (1990) noted the methods to discourage breeding had "varied success". Wire and nylon netting were installed over an area used for nesting; this was effective but was not appropriate for large colonies. The netting collapsed after a brief period, allowing gulls to nest on the substrate, despite the presence of the netting.

Hot bitumen was poured over a small area of the causeway to create a smooth surface that was immediately unsuitable for nesting in the late 1970s; as with netting, this was effective but was not appropriate for large colonies (Skira & Wapstra, 1990). The Orielton Lagoon (northern) embankment of the Sorell Causeway supported nesting Silver Gulls until mid-December 1997 (Horner, 1998). The addition of loose fill to bury nesting ledges and niches among the boulders in December 1997 removed suitable nesting sites, and the area was immediately abandoned (Horner, 1998) and has not been used since (E. J. Woehler, unpublished data).

Other secondary measures comprised wire fencing approximately 0.8 m high that was installed between February 1976 and February 1978 to discourage gulls from breeding on the Sorell Causeway. The 80-cm-high fencing extended for approximately 120 m (of the 1.4-km causeway) and was intended to keep chicks off the road surface. The fencing was largely ineffective, as it failed to prevent recently fledged chicks accessing the road on early flights and also prevented wandering chicks that strayed onto the road from returning to their nests until they reached either end of the fence line (Skira & Wapstra, 1990). Horner (1998) reported substantial chick mortality in the 1997/98 season and estimated an entire season's mortality of chicks on both causeways at 20%–25%. Based on these estimates, he subsequently recommended a 1.0- to 1.5-m fence for the entire length of the causeway to prevent gulls accessing the road.

Additional fencing was installed on the Sorell Causeway after 1978, but no details are currently available as to when or for what extent of the causeway. By the mid-2010s, the remnant fencing was decrepit, with extensive gaps present and vegetation growing through and over the collapsed fencing. All remaining fencing was removed in mid-2020 and immediately replaced with a wire fence *ca*. 1 m high along the entire length of the Sorell Causeway, on the southern flank adjacent to the extant Silver Gull colony.

The fencing resulted in an immediate decrease in the numbers of adults and juveniles killed by vehicles on the Sorell Causeway (Table 1; Fig. 6). The minimum breeding populations in 2020/21 and 2021/22 following the installation of the fence were 10%–40% greater than in the two breeding seasons 2018/19 and 2019/20.

TABLE 1
Summary statistics for four breeding seasons 2018/19–2021/22 for the Sorell Causeway Silver Gull *Larus novaehollandiae* colony[a]

Season	Minimum breeding population (pairs)	Adults killed	Juveniles killed	Total mortalities	Mortalities per day	Mortality per breeding pair
2018/19	340	10	51	61	1.02	18
2019/20	320	5	64	69	1.15	22
2020/21	450	4	31	35	0.40	8
2021/22	350	6	34	40	0.27	11

[a] The horizontal line indicates the timing of the installation of new fencing along the Sorell Causeway in winter 2020 (see Fig. 6). All data from Woehler (2019, 2020, 2021, and 2022).

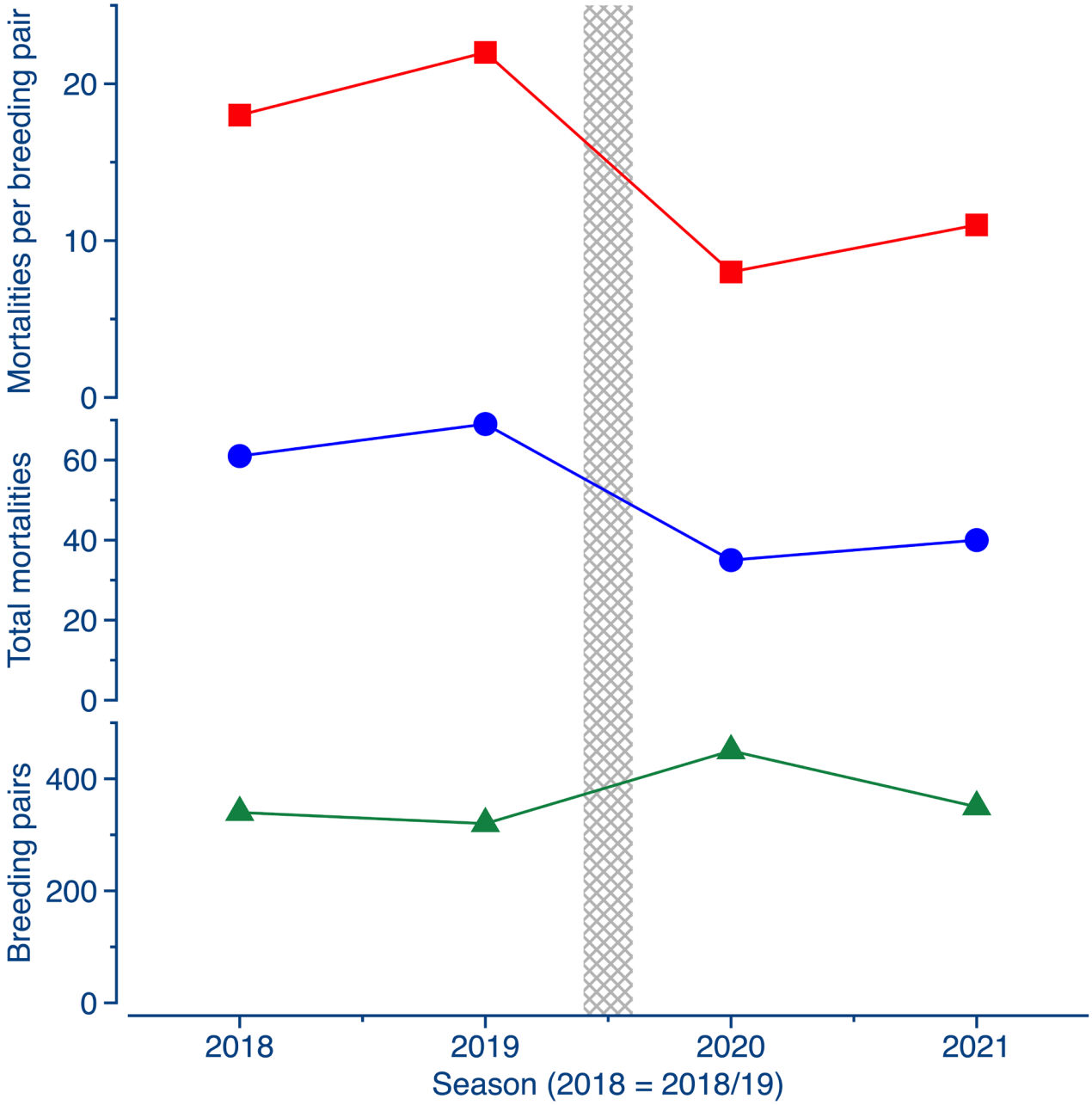

Fig. 6. Estimated minimum numbers of breeding pairs of Silver Gulls *Larus novaehollandiae* in Tasmania, Australia, on the Sorell Causeway in 2018/19 to 2021/22 (green triangles, lower graph), total mortalities per season (blue circles, central graph) and mortalities per seasonal breeding pairs (red squares, upper graph); see Table 1. The vertical cross-hatching indicates the approximate timing of the installation of the fence along the Sorell Causeway in winter 2020 (modified from Woehler, 2022).

Despite the increase in breeding effort, the numbers of juvenile gulls killed by vehicles almost halved, both in absolute numbers and in the numbers of juveniles killed per breeding pair. These data indicate that the installation of the fence resulted in lower mortality of juveniles in the colony in the two breeding seasons. The small data set (two seasons before/after the fence installation) prevents more rigorous analyses, but the limited data available illustrate the efficacy of the fencing.

DISCUSSION

Study Limitations

The census data collated herein were obtained over a 47-year period from 1976 to 2023, inclusive. Over that time, the survey effort was intermittent in timing, variable in effort, and involved a number of researchers, government contractors, and skilled members of the community. Despite these limitations, the survey and reporting protocols were sufficiently similar and robust among the studies to allow for the data from the disparate sources to be collated to establish the basis for the analyses undertaken.

The census data represent the minimum annual counts for nests, eggs, and chicks for the seasons in which data were collected. The data must be considered conservative—there can be no fewer nests, eggs, and chicks than recorded, and there will be additional unsurveyed nests each season, depending on survey effort, extent, and timing. The onset of breeding and the timing of peak numbers of nests and eggs on the Sorell Causeway varied by more than four weeks over the 2011/12 to 2022/23 period, with poor weather conditions often resulting in abandonment of early nesting efforts (E. J. Woehler, unpublished data). The variability in the onset of breeding was reflected in the variability in the duration and conclusion of laying among seasons. Variation in the timing of the onset of annual breeding and the peak numbers of breeding adults at the colony does not influence the overall trend over the period 1975 to 2023.

Silver Gulls are asynchronous breeders that can lay multiple clutches when eggs or chicks are lost, and lay second clutches when conditions allow (Nicholls, 1974; Wooller & Dunlop, 1979). Many early counts from the mid-1970s to the late 1990s were centred on October visits, possibly based on observations of "peak" breeding in October in three seasons (1975 to 1977, inclusive; Skira & Wapstra, 1990), likely contributing to the timing of subsequent colony surveys. It is believed that this was a deliberate effort to ensure a "standardised" survey effort/protocol; the majority of these early counts were undertaken in a voluntary capacity. Fixed snapshot counts are appropriate for synchronous species but less useful for asynchronous colonial species, and they cannot capture the full extent of inter-annual variations in breeding season phenologies (E. J. Woehler, unpublished data).

The most detailed survey and monitoring program was undertaken from 2011/12 to 2022/23 inclusive, in which survey and/or mapping data were collected on 149 visits to the Sorell Causeway during the 12 breeding seasons (mean = 12.4 visits/season: E. J. Woehler, unpublished data; Woehler, 2013, 2019, 2020, 2021, 2022). The 2011/12 to 2022/23 surveys ended following egg hatch to minimise disturbance to nesting birds and chicks. Nest construction and laying were observed to continue after the end of annual surveys, but the rates of both new nest construction and egg laying were very low relative to the rates earlier in each season, and thus the contribution from later nesting is relatively low and would not alter the results or interpretation of the data (E. J. Woehler, unpublished data).

Silver Gull Breeding Population Size and Trends, 1976 to 2023

This is the first synthesis of Silver Gull breeding population data for the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex, and it complements the 45-year population data set for regional southeast Tasmania (Woehler, 2024a, 2024b). From a management perspective, it is appropriate to consider the breeding population of Silver Gulls within the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex as a single population that moves among nesting sites in the complex, both within and between breeding seasons, depending on habitat availability and suitability. Episodic management and control measures in some seasons (Figs. 2–5) further influence the distribution of annual breeding efforts.

Long term (decadal-scale) data sets are critical for assessing population trends of long-lived species such as Silver Gulls, which can live to 30 years (e.g., the Australian Bird and Bat Banding Scheme, https://www.environment.gov.au/cgi-bin/biodiversity/abbbs/abbbs-search.pl). In the absence of national-scale population data, regional-scale data sets such as that for southeast Tasmania (1983 to present; Woehler, 2024a, 2024b) provide the context for site-specific studies. The survey and monitoring data for the Silver Gull population in the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex extends from 1976/77 to 2022/23, which overlaps with the regional data from 1983 to present, providing a long-term context for regional trends underlying short-term colony trends in response to management and control efforts.

There are insufficient data to assess the relationships among the annual breeding efforts on the causeways, Barren Island, and Susie Islet over the last 50 years in terms of total breeding efforts. Detailed data are available for the causeways, but there are few census data for Barren Island between 1969/70 and 1998/99 (n = 8, Figs. 2 and 4). Even fewer data are available for the breeding effort on Susie Islet, with data for just five breeding seasons between 1964/65 and 1989/90, inclusive.

Early observations showed an inter-annual dynamic in the relative numbers of Silver Gulls nesting on the two causeways (R. Cooper, L. E. Wall, D. G. Thomas, W. C. Wakefield, unpublished data; M. J. Wakefield & E. J. Woehler, unpublished data). It is possible that earlier breeding attempts on either or both causeways were not detected. Skira and Wapstra (1990) refer to breeding on the "causeways" in their paper but provide no details as to the location(s) of the colonies under investigation; their Figure 2 shows nesting Silver Gulls on the south embankment of the Sorell Causeway.

Reports of Silver Gulls roosting on the causeways and breeding on the small islands within the complex are available from the early 1960s, but it was not until October 1975 that the first record of Silver Gulls breeding on the causeways was reported (Skira & Wapstra, 1990). The first records of Silver Gulls nesting on the Pitt Water Causeway were in October 1983, and this colony persisted until the late 1990s. Early records report nesting on both the north and south aspects of the Pitt Water Causeway (*cf*. Horner, 1997a, 1998) and that the breeding colony on the Pitt Water Causeway was

larger than that on the Sorell Causeway in some years. The small colony on the north side of the Sorell Causeway was first reported in October 1984 and persisted until December 1997, when the nesting area was covered in gravel fill (Horner, 1998, 1999).

The overall trend in the number of Silver Gull breeding pairs on the causeways 1976/77 to 2022/23 is stable (Fig. 2, lower graphs). This trend is inconsistent with the long term (1983–2025) regional increase of *ca*. 60% in the Silver Gull population in southeast Tasmania (Woehler, 2024a, 2024b). Within the context of a regional increase, the stable population on the causeways over 47 years suggests suitable nesting habitat is limited, rather than that the population is responding to intermittent control measures (see below for further discussion). The low levels of disturbance to nesting birds associated with colony monitoring of nests from 2011/12 to 2022/23 are not believed to influence colony trends, as these surveys cease once eggs hatched, and time within the colony was minimised to the greatest extent possible.

The highest estimates for nests were in 1995/96 and 2013/14 (when *ca*. 600 nests were recorded). These maxima occurred before and during control measures, respectively (Fig. 2). By 2013/14, Silver Gulls were nesting only on the south embankment of the Sorell Causeway, yet the total breeding population was equal to or higher than when the north and south embankments of both causeways had been used previously for breeding (Horner, 1997a, 1998). This suggests that the past control measures that aimed to reduce the areas available for nesting (secondary measures) had a greater influence than did the primary control measures (population culling). Populations are known to be more vulnerable to habitat manipulations than they are to direct (primary) population control (Burger, 1983; Smith, 1992).

Efficacy of Control Measures, 1975 to 2023

A range of control measures has been used in efforts to control the Silver Gull breeding population on the causeways since the establishment of breeding in the mid-1970s. The control measures were directed to reducing the breeding population by culling, while complementary habitat-specific measures attempted to prevent or reduce the breeding population by limiting habitat availability and suitability.

The roles of control and management efforts on the abandonment of the Pitt Water Causeway Silver Gull colony in the mid- to late-1990s is unclear. The filling of the colony area on the Orielton Lagoon embankment of the Sorell Causeway in December 1997 coincided with the abandonment of the Pitt Water Causeway colony. It is possible that disparate efforts over several years contributed to the breeding gulls shifting from the colonies. The displaced birds from these two colonies are inferred to have shifted to the adjacent colony on the south embankment of the Sorell Causeway, resulting in a colony supporting the same or higher numbers of nests post-2000.

The population responses to culling measures (e.g., addling, oiling, formalin, and removal of eggs) were immediate. The responses were typically confined to the operational period of the measures and persisted until the following breeding season, but thereafter the breeding population entered a rapid recovery phase in which the breeding population returned to or exceeded pre-control numbers (Figs. 2–5; Skira & Wapstra, 1990), a condition known as overshoot. The culling of breeding adults creates nesting opportunities for adult birds from the colony or from adjacent colonies (Smith & Carlile, 1993). In conjunction with the existing food resources subsequently available to fewer birds post-cull, a typical response is a population exceeding pre-cull numbers, resulting in an overshoot in the colony population for a variable, albeit temporary, period. The rapid recovery in the breeding population following the cessation of culling efforts was further enabled by Silver Gulls' ability to re-lay if eggs or chicks are lost (Smith & Carlile, 1993). In addition, Silver Gulls can lay a second clutch in a season when conditions are favourable (Nicholls, 1974; Wooller & Dunlop, 1979).

Wire and nylon netting, hot bitumen, and gravel fill were used to prevent Silver Gulls nesting on various areas of the causeways between the mid-1970s and late 1990s. Of these, bitumen and gravel fill permanently altered the profile and structure of the embankments, removing nest sites and preventing further nesting by gulls. The wire and nylon netting were draped over the embankments but allowed nesting where either was in contact with the substrate. Both deteriorated rapidly and thus had no further influence in nesting by Silver Gulls (Skira & Wapstra, 1990).

Wire fencing was installed for approximately 120 m of the 1.4-km Sorell Causeway sometime in the late 1970s or early 1980s but proved ineffective in preventing chicks accessing the road surface (Skira & Wapstra, 1990). Additional wire fencing was installed along parts of the Sorell Causeway sometime in the early 1990s and had deteriorated to a decrepit state with extensive gaps by 2011/12 (E. J. Woehler, unpublished observations). The remaining fencing was removed in 2018 and replaced with wire fencing along the entire length of the Sorell Causeway in 2020 (Woehler, 2019, 2022). The fencing resulted in halving the juvenile gulls killed by vehicles (Fig. 6), both in absolute numbers and in juveniles killed per breeding pair, for the two breeding seasons for which data were collected.

Indirect measures to reduce the breeding population of Silver Gulls on the causeways were made by removing weeds and trees in 1998/99 from an area of Barren Island that used to support nesting gulls (Horner, 1999). Barren Island and Susie Islet both supported breeding Silver Gulls until the 1990s, but the expansion of introduced plants led to the islands being abandoned as breeding localities, and a resultant shift by breeding Silver Gulls to the Sorell Causeway. The removal of the vegetation resulted in the return of Silver Gulls to Barren Island for one breeding season until the vegetation returned.

The other island that supported breeding by Silver Gulls is Little Spectacle Island, approximately 9 km as the gull flies southeast from the Sorell Causeway. Approximately 500 pairs were reported from the late 1980s (Brothers et al., 2001) and approximately 600 pairs in 2010 (Woehler, 2010). Visits during the 1990s recorded annual breeding efforts approaching 1,000 nests (E. J. Woehler & W. C. Wakefield, unpublished data). Silver Gulls ceased breeding on Little Spectacle Island in the late-1990s due to the encroachment of vegetation over the colony area (E. J. Woehler, unpublished observations).

Future Management Strategies

The control and management efforts directed towards Silver Gulls on the causeways have comprised primary (culling) and secondary (habitat modification) measures at different intensities, durations,

and areas of application over the last 50 years. Egg culling resulted in short-term responses from which the population recovered within a few years. The loss of nesting habitat, arising either from invasive vegetation encroachment on the adjacent islands or from the deliberate modification to nesting habitats, has been more successful than culling, as the breeding biology of the gulls cannot recover from the permanent reduction or loss of nesting habitat (*cf*. egg culling).

Suitable nesting habitat for Silver Gulls appears to be the limiting factor in determining their breeding distribution and abundance in southeast Tasmania, particularly in the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex, including the Sorell Causeway. Despite a broad range of efforts to control their population over 47 years, the measures that restricted the availability of nesting habitat or improved gulls' access to suitable nesting habitat had the greatest influence on gull numbers over the longest time periods.

The proposed construction of two additional causeways paralleling the existing causeways may potentially result in the creation of additional breeding habitat for Silver Gulls, removing the limiting factor that has maintained a stable population in the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex over 47 years. A strategic approach to reduce or manage the potential for nesting by Silver Gulls on the existing and new causeways is required.

This strategic approach would involve the restoration and ongoing management of Barren Island, Susie Islet, and Little Spectacle Island to facilitate nesting colonies of Silver Gulls by removing invasive weed species. Combined, these three sites previously supported higher numbers of nesting gulls than the current breeding population on the Sorell Causeway.

Attempts by Silver Gulls to nest on the Sorell Causeway in future, and potentially on the new causeways while under construction, would require active, non-lethal suppression and deterrence. The use of decoys on the islands could be trialled to determine if they enhance the shift to the previously restored islands. Vegetation on the Sorell Causeway is currently used both for nesting sites and for nesting material on the rocky embankment. Several of the adult Silver Gulls struck by vehicles in recent years were killed as a result of the birds collecting nesting material from the roadsides (E. J. Woehler, unpublished observations).

Recommendations for Future Management Strategies and Options

The following strategies are recommended for future management of Silver Gulls in the Pitt Water–Orielton Lagoon Ramsar and Nature Reserve complex. These strategies are based on the results presented and synthesised above and would also apply to Kelp Gull and Pacific Gull populations:

1. Removal of invasive plants, restoration of native vegetation, and ongoing management of invasive plants on Barren Island, Susie Islet, and Little Spectacle Island to facilitate nesting by Silver Gulls;
2. Removal of all vegetation from the existing and proposed causeways to prevent its use as nesting sites and/or nesting material;
3. Identification of construction materials and concomitant causeway design that prevents or discourages nesting by gulls on the causeway embankments; and
4. Maintenance of all wire fencing adjacent to road surfaces (only required if nesting on the causeway/s persists).

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