The Survival of the New Zealand Fairy Tern at Mangawhai

2026 Update – Addendum to the May 2022 Discussion Paper

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Summary

Purpose

This addendum updates the May 2022 discussion paper, *The Survival of the New Zealand Fairy Tern at Mangawhai*, in light of five further breeding seasons (2021/22–2025/26) and a substantial body of new peer-reviewed research – most notably a 2026 *Notornis* special issue devoted entirely to tara iti. It also includes a reanalysis of whether local population growth can be shown to threaten breeding productivity in Mangawhai.

Principal conclusions

- Breeding performance has improved in aggregate since the earlier analysis (higher hatching success, more total fledglings) but the chance that a hatched chick survives to fledge has declined slightly. The outcomes remain highly volatile season to season, from near-total failure (2022/23, Cyclone Gabrielle) to the strongest seasons in over a decade (2023/24–2024/25) (Sections 1–2).
- Breeding-age adult numbers have been essentially flat-to-declining for two decades despite intensive management. Recent population growth is concentrated in juveniles and sub-adults, not breeders (Section 3).
- New genomic evidence confirms low genetic diversity at the same time raising the possibility that tara iti is a distinct species. This introduces risk to the 2022 report's proposed Australian egg-introduction strategy pending formal taxonomic assessment (Section 5).
- Hand-rearing and captive management have become a routine, large-scale part of the recovery programme rather than an occasional intervention (Section 4).
- The 2022 report's scepticism toward “widespread historic range” claims is now confirmed by systematic peer-reviewed evidence (Section 6).
- Satellite tracking shows preliminary evidence of much wider ranging behaviour than previously documented, though breeding remains concentrated at Mangawhai (Section 7).
- A new 34-season Mangawhai-specific analysis shows that population growth cannot be seen as a statistical threat to breeding productivity. This plausibly reflects rising conservation intervention running alongside population growth, rather than a genuinely null effect of development (Section 8).

- Most of the 2022 report's conclusions still hold, several more strongly than in 2022; two require updating in light of new evidence – the genetic-introduction recommendation (now qualified) and a newly identified male-biased sex ratio constraint (Section 9).

A note on this update

This addendum extends the May 2022 discussion paper *The Survival of the New Zealand Fairy Tern at Mangawhai* with breeding, demographic, genetic, and historical evidence published since that report. The single most important new source is a special issue of *Notornis*, the journal of the Ornithological Society of New Zealand (Vol. 73, Part 1, March 2026), devoted entirely to tara iti and comprising 22 peer-reviewed papers – including the first systematic update to the demographic analysis of Ferreira et al. (2005) that underpinned much of the original report's discussion of population viability. Other sources include Department of Conservation (DoC) season-end media releases (2023–2026), reporting from RNZ and the NZ Herald, DoC's tara iti species page, Shorebirds Trust newsletters, and a project summary on tara iti genomics prepared for the Shorebirds Trust by Professor Tammy Steeves and Dr Jana Wold (University of Canterbury).

Following the convention of the original report, indicative or unverified figures are flagged with a dagger (†). Short-term trend projections beyond the latest available estimate are separately flagged with a double dagger (‡).

1. Breeding performance, 2021/22–2024/25

Corkery, Beauchamp et al. (2026) provide the first systematic update to Ferreira et al.'s (2005) demographic analysis, using 12 seasons of data (2013/14–2024/25) directly comparable to Ferreira's own 12-year dataset (1991–2003). Table 1 reproduces their breeding statistics, extending the original report's Figures 3, 4 and 6. Figures reported here exclude eggs and chicks that entered the Auckland Zoo captive-rearing programme, which is treated separately in Section 4.

Season	Nests	Eggs laid	% eggs hatched	Wild fledglings	% hatched chicks fledged
2013–14	11	20	60%	12	100%
2014–15	17	31	39%	6	50%
2015–16	10	15	47%	4	57%
2016–17	13	23	30%	6	86%
2017–18	16	27	48%	6	46%
2018–19	10	16	25%	2	50%
2019–20	11	19	47%	8	89%
2020–21	17	23	48%	4	36%
2021–22	14	19	74%	8	57%
2022–23	15	13	31%	3	75%
2023–24	13	16	62%	9	90%
2024–25	17	20	90%	11	61%

Table 1: Tara iti wild breeding performance, 2013/14–2024/25 (source: Corkery, Beauchamp, Brunton, Cain, Greenwell, Makan, Pou, Stavert, Steeves & Wilson 2026, Notornis 73: 5–9).

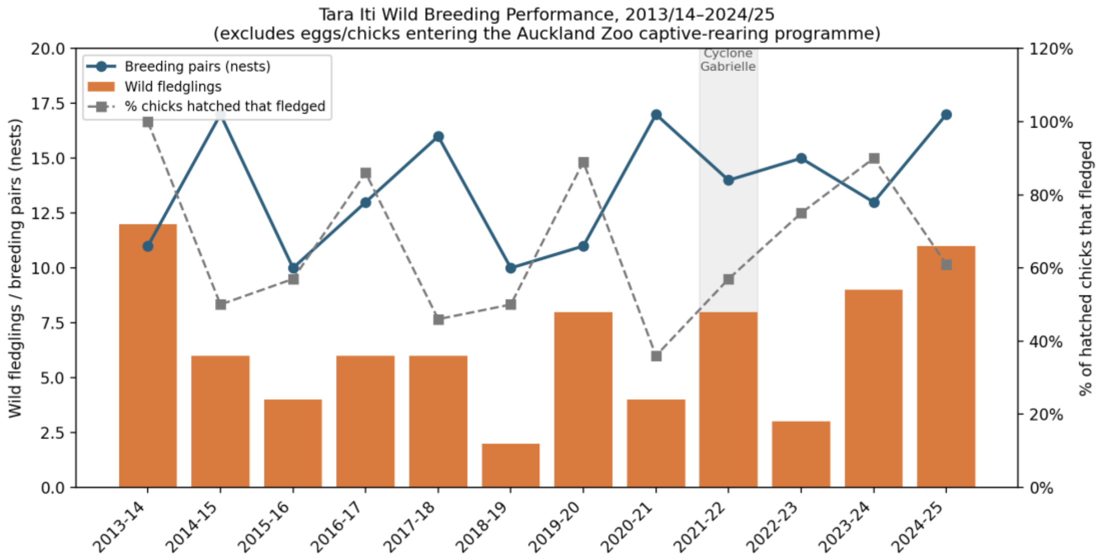

Figure U1: Wild breeding pairs, fledglings and fledging success, 2013/14–2024/25.

Two findings qualify the cautiously positive tone of recent DoC and Shorebirds Trust communications. First, mean hatching success improved significantly between periods (0.38 in 1991–2003 versus 0.50 in 2013–2025; Welch's $t = 3.71$, $p < 0.001$). This is consistent with the introduction of egg transport artificial incubation.

Second, and less encouragingly, the *wild fledging rate* – the proportion of *hatched* chicks that survive to fledge – actually declined slightly, from 0.74 (1991–2003) to 0.65 (2013–2025; Welch's $t = –2.07$, $p = 0.041$). Total fledgling output nonetheless rose 44% between the two 12-year periods (55 to 79 chicks), attributable mainly to a higher average number of breeding pairs (8.6 versus 6.5) rather than to any underlying gain in per-pair productivity. In other words, more pairs are breeding, and more eggs are hatching, but a chick that hatches is now somewhat **less** likely to survive to fledging than it was two decades ago. This finding qualifies the more optimistic framing of the original 2022 report's discussion of management gains.

The 2022/23 season was dominated by Cyclone Gabrielle, which RNZ (8 Feb 2025) reported killed five adults and “all but one chick”; Corkery et al.'s wild-fledgling count of three for that season is consistent with this. The 2023/24 season was described by DoC (media release, 21 Feb 2024) as its best in a decade at the time, with 22 eggs laid nationally and 18 chicks hatched. By late February 13 chicks had already fledged. Corkery et al.'s final wild-fledgling figure for that season is nine, lower than the in-season DoC figure of 13. This discrepancy between a mid-season progress report and the final peer-reviewed tally illustrates a recurring pattern: season-end totals reported in real time by DoC and partner organisations do not always match final analysed figures published later.

DoC's season-end media release for 2024/25 (18 June 2025) reported 19 fledglings – “a significant improvement” on nine the previous year and three the year before that, including wild and hand-reared birds. The Shorebirds Trust's Winter 2025 newsletter separately reported 17 fledglings for the same season. Corkery et al.'s peer-reviewed wild-only figure is 11. DoC's figure of 19 is treated as authoritative here as the official season-end tally; the Shorebirds Trust and Corkery et al. figures may reflect an earlier cut-off, a narrower definition of “fledged,” or simple reporting variance. The discrepancy has not been resolved.

2. The 2025/26 season: a reminder of continued fragility

The most recent complete season confirms that the population remains highly volatile from year to year despite two decades of intensifying management. RNZ (19 Mar 2026) reported 29 eggs laid nationally, of which only 11 chicks fledged. DoC's tara iti recovery programme lead, Alex Wilson, attributed the poor result primarily to predation: a rat problem at Mangawhai and losses to kāhu (Australasian harrier). Ten eggs were transferred to Auckland Zoo for artificial incubation, continuing the 2022 pattern of intensive egg-stage intervention.

3. Population size and demographic structure

Corkery et al. (2026) present the clearest population trajectory available since Ferreira et al. (2005), and it is less reassuring than recent headline figures suggest. Adult numbers (birds aged two years or older, capable of breeding) have shown virtually no net change over two decades: 27 adults in 2003/04, a peak of 37 in both 2015/16 and 2016/17, and 28 adults as at March 2025. Over the full 20-year span the population growth rate is close to zero ($r \approx 0.002\ yr^{-1}$). However, measured from the 2015–17 peak to March 2025, the trend is **negative** ($r \approx -0.031\ yr^{-1}$; $\lambda \approx 0.969$), with the last three consecutive seasons (2021/22–2024/25) each showing a net decline of two adults.

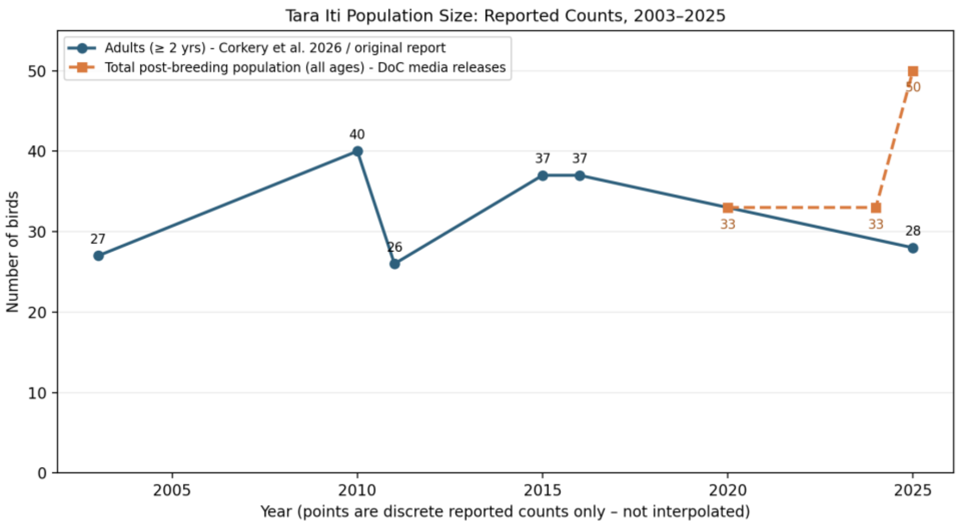

Figure U2: Reported tara iti population counts, 2003–2025 (discrete reported values only; no interpolation between years for which no count was located). Sources: original 2022 report; Corkery et al. 2026; DoC media releases.

This adult trajectory sits alongside a more encouraging statistic that DoC and the Shorebirds Trust have emphasised: the total post-breeding population including juveniles rose from 33 (2023/24 season end) to 50 (2024/25 season end, comprising 28 adults, 9 sub-adults, and 13 fledglings; DoC, 18 June 2025 release).

The two figures are not in conflict, but answer different questions. The growth evident in the “50 individuals” headline is concentrated in juveniles and sub-adults not yet contributing to breeding; the number of *breeding-age* adults has been flat-to-declining for a decade. As at July 2025, DoC's species page records fewer than 40 adult tara iti and only 10 known breeding females, a narrower bottleneck than population totals alone suggest.

A structural constraint not identified in the 2022 report has since been documented: a male-biased sex ratio that, combined with uneven survival across life stages and demographic variability, limits recruitment into the breeding population (Corkery & Pulham 2026). DoC's 2024/25 season release separately noted that DNA sexing of that season's chicks found a higher-than-normal proportion of females, offering a possible, though as yet unconfirmed, partial correction. Recent data also suggest lower annual adult survival (89%) than Ferreira et al.'s 1991–2003 estimate (95%). It is unclear whether this reflects a genuine decline, better detection, or differences in monitoring effort between the two periods. Average life expectancy remains about six years, consistent with earlier estimates, though 17 birds now exceed that threshold, including a 21-year-old male (compared with the 20-year-old cited as the oldest known bird in the 2022 report).

4. Hand-rearing and the Auckland Zoo partnership

The 2022 report anticipated – and recommended developing – more intensive captive management as part of a long-term survival strategy. This has since become a routine, formally described part of the recovery programme rather than an occasional intervention. Francescon, Grierson, Chatterton & Cornejo (2026, Notornis 73: 141–149) describe Auckland Zoo's hand-rearing techniques and the challenges overcome in developing them. Beauchamp, Ogle & Lagnaz (2026) describe a complementary in-situ supplementary feeding programme. Released juveniles are now managed through staged transition via open coastal pens with supplementary feeding stations before full independence (Corkery, Preddey, Wiles & Grierson 2026). In practical terms, roughly ten eggs per season are now routinely transferred to Auckland Zoo for artificial incubation (2024/25 and 2025/26 seasons), a scale of intervention well beyond the episodic egg transfers documented in the 2022 report (Section 4.1.3).

5. Genetic research

5.1 Species status and genomic diversity

A Shorebirds Trust–funded project led by Professor Tammy Steeves and Dr Jana Wold (University of Canterbury) generated a tara iti reference genome and whole-genome sequences from tara iti and Australian fairy tern (Western Australia) samples. Two findings stand out. First, tara iti shows low genomic diversity relative to the Australian population. This is unsurprising given the tiny population but, significantly, confirms the inbreeding risk raised in the 2022 report based on fertility and behavioural evidence alone.

Second, the two populations show strong genomic structure, indicating limited or no gene flow between them. Together, these findings suggest tara iti *may* warrant recognition as a distinct species rather than a subspecies, though the researchers are explicit that a formal taxonomic assessment – incorporating ecology, behaviour, and morphology alongside genomics, across all three fairy tern taxa – is still required before that conclusion can be drawn.

A note on mechanism: isolation versus selection, and the outbreeding depression risk

The genomic findings themselves warrant a precise reading. Low diversity within tara iti and strong structure between tara iti and the Australian population are signatures of isolation and small effective population size — genetic drift alone produces exactly this pattern once gene flow between two populations stops, regardless of whether selection is also acting. They do not, on their own, establish that the two populations have diverged *adaptively* in response to different environments. Distinguishing selection from drift would require different evidence again: locus-specific outliers against the genome-wide background, signals of selective sweeps, or a demonstrated genotype–phenotype link between specific loci and traits plausibly under selection in the New Zealand environment. None of that has yet been reported. Tara iti's smaller size relative to the Australian subspecies is consistent with adaptive divergence, but on present evidence this remains a plausible hypothesis rather than a demonstrated mechanism.

This distinction matters directly for the 2022 report's proposed strategy of introducing fertile Australian eggs to broaden the gene pool. The relevant risk is not that cross-population breeding would straightforwardly fail — hybridisation between taxa this closely related typically proceeds without difficulty at the level of fertilisation, hatching, and fledging. The risk is **outbreeding depression**, which is a different and more insidious failure mode. It can act *extrinsically*, if tara iti carries locally adaptive traits — diet, thermal tolerance, breeding phenology — that would be diluted in hybrid offspring poorly matched to the Mangawhai environment. It can also act *intrinsically* and with a delay: hybrids can appear normal in the first generation while co-adapted gene complexes break down in subsequent generations, reducing fertility or survival only once the intervention is already irreversible. Strong genomic structure and limited gene flow are precisely the conditions under which this risk rises, because the two populations have had time to accumulate independent genetic architecture that may or may not remain compatible.

This does not mean the 2022 report's original rationale was wrong. Genetic rescue — using outside genetic material to counter inbreeding depression, evidenced here by tara iti's persistently low fertility — has real precedents of success elsewhere (the Florida panther/Texas cougar introduction is the standard case), and a population this small and inbred is exactly the kind of candidate for which it is usually considered. What the new genomic evidence changes is the confidence with which genetic rescue can be assumed to be the more likely outcome rather than outbreeding depression. The formal taxonomic assessment called for by the genomics team is therefore not a routine caveat but the specific piece of evidence needed to distinguish these two outcomes before committing a genetically distinct, critically endangered population's eggs to an intervention that cannot easily be undone. Proceeding ahead of the formal taxonomic assessment that both the 2022 report and the Steeves/Wold project identify as a precondition would be unwise; this is arguably the single most consequential update to the 2022 conclusions.

5.2 Distinguishing infertility from early embryo mortality

A related but distinct question is addressed by Cubrinovska, Morland & Steeves (2026, Notornis 73: 137–139), who develop methods to distinguish eggs that are genuinely infertile from those that were fertilised but died very early in development. This refines, rather than overturns, the inbreeding-depression hypothesis raised in DoC (2005) and repeated in the 2022 report: some proportion of eggs previously classed simply as “infertile” may instead represent early embryo failure, which points toward different underlying causes (and potentially different management responses) than true infertility.

6. Historical distribution reassessed

Box 1 of the 2022 report argued that claims of tara iti being “widespread” in the 19th century rested on a combination of misrepresentation and weak and largely unverifiable evidence, much traceable to confusion with the migratory little tern. Two 2026 *Notornis* papers now substantially reinforce this conclusion with far more systematic evidence than was available in 2022. Whitelock (2026) compiled a database of 250 historical Sternula occurrences (1866–1982) from archives, journals, and museum collections, finding only 86 confirmed tara iti records against 164 little tern records over that period, and noting that formal records were “infrequent and low” (averaging 0.71 per year) before management began in 1983/84. Miskelly & Watola (2026) went further, identifying seven little tern specimens – collected in 1927, 1929 and 1940 – that had been misidentified and registered as fairy tern in New Zealand museum collections until re-identification in the 1970s, pushing the documented history of little tern/tara iti confusion back 35 years earlier than the previously accepted first record (1957/1962). Both papers concur that the last confirmed South Island breeding record was in 1905, at the Rakaia River mouth.

The practical effect is that the caution urged in the 2022 report – that historic “widespread range” claims are unreliable and should not be used to set conservation targets or baselines – is now the position taken in the peer-reviewed literature, rather than an outlying critique.

7. Movement ecology: satellite tracking

Satellite tracking of hand-reared juveniles (Hilton, Corkery, Stavert & Cain 2026, Notornis 73: 175–187; reported in the Shorebirds Trust's Winter 2025 newsletter) has revealed movements well beyond anything documented in the 2022 report, including round trips of close to 1,000 km to as far south as New Plymouth, well outside the Kaipara Harbour wintering range described. The authors are careful to note these are preliminary findings currently based only on captive-reared birds, so may not represent typical wild-fledged behaviour. If confirmed in wild birds, this extended ranging behaviour would strengthen the practical case for the translocation strategy the 2022 report recommended (Section 5.2), though as at the most recent seasons reviewed here, 8 of 10 breeding pairs in 2024/25 were still concentrated at Mangawhai, and none of the new, more remote sites identified by the 2011 Forest & Bird report or the 2022 report itself (Ruakaka, sites on the Kaipara Harbour, the Far North, Great Barrier Island) had confirmed established breeding populations.

8. Mangawhai-specific analysis: population growth, breeding performance, and the development question

8.0 Purpose of this analysis

This section reanalyses the relationship between Mangawhai's resident population and tara iti breeding performance using a new 34-season dataset (NZ Fairy Tern Charitable Trust records, 1991/92–2020/21, extended to 2025/26 using DOC ranger site reports). This enables re-testing of the 2022 report's conclusion that human presence and development have not been shown to harm the species (Section 9, below).

8.1 Principal conclusions

- Population growth **cannot be shown to be a statistical threat** to Mangawhai breeding productivity. Across the full 34-season record, fledgling output correlates **positively**, not negatively, with local resident population and this holds at one and two year lags. This is the opposite of what a disturbance-from-development hypothesis would predict.
- This is not proof that there is no effect: the positive association most plausibly reflects population growth and rising conservation intervention occurring together, so a real but modest disturbance effect could be masked (discussed further, 8.4–8.5).
- Finer-grained decade-level indicators (fertility rate, post-fertilisation survival, 2010/11–2020/21) run weakly **negative** against resident population at every lag, though not to a statistically significant degree ($p = 0.18–0.91$, $n = 9–11$) — a small effect cannot be ruled out (full figures, 8.3).
- The 2022/23 season directly illustrates intervention-dependence: Mangawhai had **zero wild-fledged chicks** that year, with every pair's eggs lost to Cyclone Gabrielle, storms, or predation – yet five Mangawhai-origin chicks survived only because they had been removed to the Auckland Zoo captive-rearing programme ahead of the losses. Left to natural outcomes alone, Mangawhai's contribution that season would have been nil.

8.2 Data and method

Two datasets were combined. Mangawhai-specific fledgling counts and resident population (“Village, Heads, Rural” – the original 2022 report's own definition, matching Stats NZ's three-Statistical-Area-2 “Greater Mangawhai” grouping) for 1991/92–2020/21 are drawn from NZ Fairy Tern Charitable Trust records. This was extended to 2025/26 using DOC ranger site reports and NZFT Trust bulletins, which allowed Mangawhai's contribution to be separated from the national total (Table 1, Section 1) in four of the five additional seasons. The 2024/25 season is flagged as indicative† throughout, since contemporaneous sources blur “chicks hatched” and “chicks fledged” at the point Mangawhai was tracking most strongly that season. Population for 2021–2025 is interpolated geometrically between the 2020/21 figure and Stats NZ census-anchored totals for 2023 and 2025, and is flagged† accordingly; the 2026/27 figure is a short-term trend projection only (flagged ‡), since no official Stats NZ estimate for 2026 yet exists. A supplementary decade-level dataset (2010/11–2020/21) with nest, egg, fertility, and hatching detail – not available for earlier or later seasons – was used to test finer-grained breeding-cycle indicators. Full source detail, construction method, and the complete dataset are given in Appendix B.

Three breeding-performance indicators were tested against the population series: fertility rate (fertile eggs ÷ eggs laid), post-fertilisation survival (fledglings ÷ fertile eggs), and fledged-per-pair, in addition to raw and 3-year-smoothed fledgling counts. Pearson correlations were calculated at lags of 0, 1, and 2 years, on the reasoning that a disturbance effect of cumulative development might not register immediately.

8.3 Results

Long-run test (1991/92–2025/26, n = 33–34):

Indicator	Lag 0	Lag 1	Lag 2
Raw fledglings	r=0.36, p=0.037	r=0.38, p=0.029	r=0.36, p=0.041
3-yr rolling average	r=0.70, p<0.001	r=0.71, p<0.001	r=0.71, p<0.001

Table U3: Population (Village, Heads, Rural) vs Mangawhai fledgling output, Pearson correlations, 1991/92–2025/26.

Sensitivity note: the raw-fledglings result depends partly on the flagged, indicative 2024/25 figure; excluding it drops the correlation to r=0.25–0.28, p=0.12–0.17 (not significant). The 3-year-smoothed result is materially more robust to this and is the more reliable of the two for drawing conclusions.

Decade-level diagnostic (2010/11–2020/21, n = 9–11): fertility rate, post-fertilisation survival, and fledged-per-pair all run weakly negative (r = −0.04 to −0.49) against population at lags 0–2, but none reach significance (p = 0.18–0.91). Full figures are given in Appendix B, Table B.2.

8.4 Development as a statistical threat: reassessed

With a much larger and now-verified sample, this reanalysis strengthens rather than weakens the 2022 report's original conclusion (8.1). This should not be read as "development is harmless" – rather, population growth **cannot be shown, on this evidence, to be a threat** to breeding productivity. The data cannot distinguish a genuinely null effect of development from an effect that has been actively offset by a rising level of intervention over the same period, and the intervention record itself (Section 8.5) favours the second reading.

8.5 Disturbance versus intervention

The available evidence favours **intervention-sustained productivity** over **disturbance-is-negligible** as the explanation for stable-to-rising fledgling numbers. Three lines of evidence support this:

- Transfers of eggs and chicks between sites and to captive care appear in most seasons of the underlying records, not as a rare emergency measure;
- The 2022/23 season shows wild breeding failing completely at Mangawhai while intervention still salvaged output (see 8.1, above);
- DOC's own reporting attributes recent productivity gains explicitly to "intensive management of wild nests and a growing hand-rearing programme," not to reduced disturbance.

The dataset does not support a clean quantitative separation of disturbance-driven mortality from intervention's offsetting effect – that would require nest-level data on cause of failure absent intervention, which is not available – but the qualitative record is consistent and one-directional.

9. Revisiting the 2022 conclusions

- **Intensive seasonal management has not broken the population ceiling:** STILL HOLDS, and more starkly than the 2022 report could demonstrate. The 20-year adult growth-rate analysis ($r \approx 0.002\ yr^{-1}$ overall; negative since 2015–17) confirms that propping up the population season by season has not translated into sustained growth in breeding-age adults.
- **Genetic diversification via Australian egg introduction:** QUALIFIED. New genomic evidence that tara iti may be a distinct species raises the risk profile of this recommendation considerably. It should not proceed without the formal taxonomic assessment that both the 2022 report and the University of Canterbury project identify as a prerequisite.
- **Historic "widespread range" claims are unreliable and should not drive strategy:** CONFIRMED, and now supported by systematic peer-reviewed evidence rather than the original report's own analysis alone.
- **Human presence and recreation have not been shown to harm the species:** RE-TESTED, and the original conclusion holds. A new 34-season Mangawhai-specific analysis (Section 8) finds population growth **cannot be shown to be a statistical threat** to breeding productivity, most plausibly because rising conservation intervention has run alongside population growth rather than because development is harmless (Section 8.4–8.5).
- **Translocation to new, more remote sites is a priority:** IN PROGRESS BUT SLOW. Breeding remains concentrated at Mangawhai (8 of 10 pairs in 2024/25); satellite tracking suggests juveniles range far more widely than assumed, which may support the case for translocation, but no new remote sites were confirmed as established in the sources reviewed.
- **The population remains highly vulnerable to storms and predation:** CONFIRMED, freshly illustrated by both Cyclone Gabrielle (2022/23) and the rat/harrier losses of 2025/26.
- **New issue, not identified in 2022:** a male-biased sex ratio is now documented as a structural constraint on recruitment, independent of the fertility and hatching-success issues the original report focused on.

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Appendix B: Mangawhai long-run dataset – sources, construction, and full series

This appendix documents the complete dataset underlying Section 8, so that every figure used in the reanalysis is traceable to a source and, where estimated or interpolated, clearly flagged as such.

B.1 Sources

- **NZ Fairy Tern Charitable Trust records** (spreadsheet compilation, provided directly): breeding-season fledgling counts by site, 1991/92–2020/21, Mangawhai resident population by breeding season, 1991/92–2020/21, and detailed nest/egg/hatch/fledge metrics for Mangawhai, 2010/11–2020/21. Underlying sources for the earliest years are Parrish & Pulham (1984–1994) and NZ Fairy Tern Charitable Trust monitoring (1995–2019).
- **Stats NZ**: Census usual-resident population counts for the Mangawhai, Mangawhai Heads, and Mangawhai Rural Statistical Area 2s (2006, 2013, 2018, 2023) and subnational population estimates (most recent release: at 30 June 2025), used to anchor the population series.
- **DOC ranger site reports**, as summarised in NZ Fairy Tern Charitable Trust bulletins (fairytern.org.nz): season-end, site-attributed breeding results for Waipu, Mangawhai, Pākiri, and Papakānui, used to extend the Mangawhai-specific fledgling series to 2021/22–2025/26.
- **DOC media releases** (doc.govt.nz): national season totals and narrative context, already cited in Sections 1–2, used here as a cross-check on the site-level figures.
- **Corkery, Beauchamp et al. (2026)**, Notornis 73 (already cited in Section 1, Table 1): national aggregate breeding data, used as a cross-check only – not merged with the Mangawhai-specific series, since the two operate at different geographic scope (see B.4).

B.2 Population series construction

The population definition (“Village, Heads, Rural”) is the original 2022 report's own, and corresponds to the combined resident population of the Mangawhai, Mangawhai Heads, and Mangawhai Rural Statistical Area 2s – what Stats NZ and Kaipara District Council documentation refers to as “Greater Mangawhai.” Table B.1 reports this split into its **Urban** (Mangawhai + Mangawhai Heads SA2s combined) and **Rural** (Mangawhai Rural SA2) components, so that urban and hinterland growth can be distinguished.

- 1992/93–2020/21: Urban and Rural taken directly from NZ Fairy Tern Charitable Trust records (Rural derived as Total minus Urban where not given explicitly; cross-checked against the Trust's own “Mangawhai Rural (109800)” series for 2001–2019 and found consistent to within 0–90 residents – a rounding-level difference between two internal compilations, not a data conflict).
- 2021/22–2025/26: Urban and Rural each interpolated geometrically between the 2020/21 figures (Urban 3,590; Rural 2,620) and Stats NZ census-anchored totals for 2023 (Urban 3,891; Rural 2,940) and 2025 (Urban 4,050; Rural 3,260). These figures are flagged † and should not be read as directly measured annual figures.

- 2026/27: **no official Stats NZ estimate yet exists** for this year – the most recent subnational population release is “At 30 June 2025”; a June 2026 estimate is not expected until around October–November 2026. The 2026/27 figures given (Urban 4,132; Rural 3,433; Total 7,565) are a short-term trend projection only, continuing the 2023–2025 growth rate, and are flagged [‡] to distinguish them from the census-anchored [†] figures. They should be treated as provisional and superseded once Stats NZ publishes the 2026 estimate.

B.3 Breeding performance series construction

- 1991/92–2020/21 fledgling counts: NZ Fairy Tern Charitable Trust records, Mangawhai column.
- 2010/11–2020/21 detailed metrics (nests, eggs, known fertile eggs, chicks hatched, chicks fledged): NZ Fairy Tern Charitable Trust site reports for Mangawhai. This is the basis for the decade-level diagnostic in Section 8.3 and Table B.2 below.
- 2021/22–2025/26: DOC ranger site reports as reported in NZFT Trust bulletins, site-differenced from national totals where a national figure only was published. Confirmed values: 2021/22 = 7 (national wild total 12); 2022/23 = 0 (national wild total 1; a further 7 chicks were captive-reared and released nationally, 5 of Mangawhai-origin eggs); 2023/24 = 7 (national wild total 9; 13 including captive-reared); 2025/26 = 3 (national wild total 11, of which Pākiri 3, Mangawhai 3, captive-reared 5).
- 2024/25 = 9[†] (indicative only). Contemporaneous sources describe Mangawhai as having “10 chicks from 6 nests, with maybe 3 to come” in mid-January 2025, but do not cleanly distinguish hatched from fledged at that point in the season; the national final total (19, wild and captive-reared combined – see Section 1) is firm, but the Mangawhai wild-only component is not separable with confidence from the sources located.

B.4 Known limitations

- The 2024/25 Mangawhai figure is indicative, not confirmed (see B.3).
- Population figures for 2021–2026 are interpolated or projected, not directly measured on an annual basis; genuine annual Stats NZ subnational estimates exist but were not extractable at the required geographic granularity within the scope of this update.
- DOC's public reporting uses at least two accounting bases for national season totals across different releases – wild-fledged only, versus wild-fledged plus captive-reared-and-released (see Section 1) – which are not always distinguished in headline figures. The site-level ranger data used in this appendix is wild-only unless explicitly noted otherwise.
- The detailed decade-level indicators (fertility rate, hatch rate, post-fertilisation survival) are only available for 2010/11–2020/21; they cannot currently be extended to the earlier or later parts of the record.
- The national aggregate dataset (Corkery, Beauchamp et al. 2026) was checked against the Mangawhai-specific series for overlapping years and found to differ substantially, confirming the two are not interchangeable and should not be merged.

B.5 Table B.1 – Full long-run series, 1991/92–2026/27

Season	Urban (Village+Heads)	Rural	Total	Mangawhai fledglings	3-yr rolling avg.
1991/92	—	—	—	4	—
1992/93	760	310	1,070	4	3.33
1993/94	810	360	1,170	2	2.00
1994/95	860	410	1,270	0	2.00
1995/96	900	470	1,370	4	2.00
1996/97	1,040	520	1,560	2	3.33
1997/98	1,050	550	1,600	4	2.67
1998/99	1,070	590	1,660	2	3.33
1999/00	1,080	620	1,700	4	3.33
2000/01	1,110	660	1,770	4	4.00
2001/02	1,120	690	1,810	4	3.33
2002/03	1,130	760	1,890	2	3.33
2003/04	1,160	830	1,990	4	2.33
2004/05	1,210	900	2,110	1	3.00
2005/06	1,270	970	2,240	4	3.33
2006/07	1,310	1,030	2,340	5	4.00
2007/08	1,380	1,120	2,500	3	3.67
2008/09	1,450	1,180	2,630	3	4.00
2009/10	1,540	1,250	2,790	6	4.00
2010/11	1,640	1,310	2,950	3	3.67
2011/12	1,750	1,410	3,160	2	2.67
2012/13	1,810	1,470	3,280	3	4.67
2013/14	1,870	1,510	3,380	9	5.67
2014/15	2,010	1,590	3,600	5	5.33
2015/16	2,200	1,690	3,890	2	3.67
2016/17	2,450	1,810	4,260	4	3.33
2017/18	2,790	1,980	4,770	4	3.33
2018/19	3,110	2,180	5,290	2	4.33
2019/20	3,320	2,420	5,740	7	4.33
2020/21	3,590	2,620	6,210	4	6.00
2021/22	3,688†	2,723†	6,411†	7	3.67
2022/23	3,788†	2,829†	6,617†	0	4.67
2023/24	3,891†	2,940†	6,831†	7	5.33
2024/25	3,970†	3,096†	7,066†	9†	6.33
2025/26	4,050†	3,260†	7,310†	3	—
2026/27	4,132‡	3,433‡	7,565‡	—	—

† = census-anchored interpolation or estimate (see B.2, B.3). ‡ = short-term trend projection with no census or official-estimate basis (2026/27 population only; no breeding-season data exists yet for 2026/27). Urban = Mangawhai + Mangawhai Heads SA2s; Rural = Mangawhai Rural SA2; Total = Urban + Rural, the "Village, Heads, Rural" (Greater Mangawhai) figure used in Section 8.

B.6 Table B.2 – Decade-level breeding detail, Mangawhai, 2010/11–2020/21

Season	Pairs	Eggs	Fertile	Hatched	Fledged	Fertility rate	Post-fert. survival	Fledged /pair
2010/11	6	15	9	4	2	60%	22%	0.33
2011/12	3	8	8	4	2	100%	25%	0.67
2012/13	3	5	4	3	3	80%	75%	1.00
2013/14	6	11	7	9	8	64%	114%	1.33
2014/15	7	18	8	7	5	44%	62%	0.71
2015/16	4	6	4	3	2	67%	50%	0.50
2016/17	3	4	3	4	5	75%	167%	1.67
2017/18	5	10	8	5	4	80%	50%	0.80
2018/19	4	9	4	2	0	44%	0%	0.00
2019/20	6	12	7	6	5	58%	71%	0.83
2020/21	6	18	16	8	2	89%	12%	0.33

Fertility rate = known fertile eggs ÷ eggs laid. Post-fertilisation survival = chicks fledged ÷ known fertile eggs. Note 2013/14's post-fertilisation survival exceeds 100%: chicks hatched (9) exceeded Mangawhai-origin fertile eggs (7) because eggs were transferred in from other sites for hatching under Mangawhai birds – itself an example of active management rather than a data error.