Little Terns in New South Wales
A Six Year Review; Breeding Seasons 1998/99 to 2003/04

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1 SUMMARY

The Little Tern (Sterna albifrons subspecies sinensis) is Australia’s smallest representative of the family Laridae (gulls and terns) and is listed as an endangered species in New South Wales (NSW) on Schedule 1, Part 1, of the Threatened Species Conservation (TSC) Act (1995). Exclusively coastal in its distribution, this piscivorous species nests on ocean beaches, sand spits and sand islands within or adjacent to the estuaries of rivers, creeks and coastal lakes. This report is focused the southeast Australian breeding population within NSW, which migrates down the east coast of Australia to nest as either solitary pairs or in colonies between October and May each year.

Prior to management by the NSW National Parks and Wildlife Service (NSW NPWS)\(^1\), the Little Tern suffered a major decline in distribution and abundance across coastal NSW. This was primarily related to poor breeding success as caused by a combination of natural and human-induced threats. Rising concerns for the survival of the species in NSW triggered a number of conservation actions in the late 1970s on the north coast, which were later broadened to incorporate its statewide range. Since 1990 various funding bodies have supported the recovery of the Little Tern and a wide range of management strategies have been implemented and detailed in ‘end of season’ reports which have been produced for most sites. The purpose of this report is to collate and analyse these data for the last six breeding seasons i.e. 1998/99 to 2003/04. Specifically it provides an overview of Little Tern breeding success at a statewide, regional and site level, identifies the principal threats, defines and discusses the efficacy of applied management techniques and recommends strategies to further improve the recovery of this endangered species in NSW.


Overall, the number of breeding pairs, eggs laid and fledglings produced has steadily increased over the last six breeding seasons. The current NSW breeding population is estimated at 487 nesting pairs and during the 2003/04 season, 1685 eggs were laid and 332 chicks progressed to the fledgling stage. This contrasts auspiciously with the efforts of 251 pairs producing 739 eggs and 238 fledglings during the 1998/99 nesting season. Furthermore, all three breeding parameters almost trebled in magnitude between 1998/99 and 2003/04 when compared to the results of the previous five-year period.

As expected, considerable differences exist in the contribution of individual sites and regions to the overall breeding results. Historically recognised major sites, such as Harrington, Farquhar Inlet and Lake Wollumboola, continue to support large breeding colonies. However the broadening of the management arc to incorporate areas such as The Entrance and numerous south coast sites (e.g. South Tuross Head, Brou Lake, Bega Rivermouth) has seen additional important nesting areas emerge in recent years. There has also been a shift in terms of relative success, with Wallagoot Lake and Sawtell producing on average more fledglings per breeding pair than the other 16 sites.

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\(^1\) The NSW National Parks and Wildlife Service is a division of the NSW Department of Environment and Conservation
The size of colonies and success of individual sites and regions also varied markedly among breeding seasons. The periodic availability of suitable nesting habitat partially accounts for this with sites such as Lake Wollumboola, Brou Lake and Wallagoot Lake supporting large and successful breeding colonies when water levels were low and expanses of sand and mudflats were exposed. Many sites have also recorded higher productivity rates in recent seasons, a result which corresponds to increases in the intensity of management actions in some regions and the exploration of new management techniques.

Of the total 7730 Little Tern eggs recorded in NSW between the 1998/99 and 2003/04 breeding seasons, 40% hatched and 24% of chicks were successfully reared to the fledgling stage. The remaining 60% failed at the egg stage of development with the majority remaining unaccounted for. A variety of known threats, including stochastic natural events such as sea surges and windstorms (13%) and mammalian (11%) and avian (6%) predators, also impacted on breeding success. Physical protection of nest sites and an increase in community awareness of Little Tern conservation have corresponded to human interference occurring on only the rare occasion (3% of total eggs lost). The fate of eggs and chicks also varied markedly between Little Tern Regions and their constituent sites, and losses were generally ascribed to numerous causes.

In an effort to alleviate some of these threats, eight habitat protection and management actions were employed in NSW during the 1998/99 to 2003/04 breeding seasons. The significant threats and logistics at each site within a given season determined which actions were implemented and there was often considerable variation in the intensity and methods used. It was therefore difficult to quantitatively assess the efficacy of recovery strategies over the six-year period. Nonetheless, the results were summarised and some trends are discussed.

Breeding colonies were protected by temporary ‘people’ fences and a suite of signs, which were installed at 88% and 90% of sites with confirmed breeding activity respectively. These were generally effective in restricting access to the sites, with only several accounts of either human or domestic dog disturbance within areas. Multifaceted fox control programs, incorporating baiting, shooting, den destruction, electric fences and trapping, were thought to have significantly reduced the threat of fox depredation at most sites. In recent seasons, predator-exclusion cages have been trialed at several sites to alleviate the adverse impact by native avian predators on Little Tern eggs. Although mixed success has been reported, important discoveries about the limitations of this management strategy have been revealed by the trial. Similar results were seen with sandbagging; as some nests were not elevated high enough to combat king tides in combination with the unanticipated seas swells that frequently flood nests. At other sites, up to 94% of vulnerable eggs were effectively managed for inundation. Attempts have also been made over the past six seasons to create ideal breeding habitat for Little Terns. Whilst some sites required encroaching vegetation to be removed, additional protection for chicks in the form of branches and beach-washed debris was provided at 25% of sites with confirmed breeding. Volunteer warden programs have also been established at the majority of sites and publicity and community education campaigns have raised public awareness of the conservation status, recovery efforts, habitat importance and biology of Little Terns. Overall, the integrated and intensive management of Little Terns over the past six seasons has assisted the recovery of the NSW population and will help to ensure its continued survival in southeast Australia.
2 INTRODUCTION

The Little Tern (*Sterna albifrons* subspecies *sinensis*) is Australia’s smallest representative of the family Laridae (gulls and terns) and is listed as an endangered species in New South Wales (NSW) on Schedule 1, Part 1, of the Threatened Species Conservation (TSC) Act (1995) as it is considered to be:

- in a demonstrable state of decline which is likely to result in extinction;
- significantly prone to future threats which are likely to result in extinction; and
- very rare in terms of abundance and distribution.

This seabird species was removed from the Commonwealth Endangered Species Protection Act (1992) in 1999 as there was insufficient evidence that the relatively abundant north Australian population was genetically distinct from the southeastern population. However the Commonwealth Threatened Species Scientific Committee did state that the removal of conservation programs focusing on the southeastern population would likely result in regional declines of this species (Environment Australia 2003). For the purpose of this report the southeast breeding population will be herein referred to as Little Terns. The easily distinguished non-breeding population is not considered in this document.

In NSW, the piscivorous Little Tern is a strictly coastal species, nesting on ocean beaches and sand spits and sand islands within or adjacent to the estuaries of rivers, creeks and coastal lakes. The breeding season extends from October to May, following which the birds depart on migration to destinations which are thought to include Java, Lesser Duna Islands, Moluccas, Celebes and the Philippines (Cramp 1985; Higgins and Davies 1996). Little Terns breed as either solitary pairs or colonies and create simple scrapes on the sand within which one to three eggs are laid. Nest scrapes may be adorned with pebbles, shell fragments, small twigs and/or seaweed and are well camouflaged with their sandy surrounds. (NSW NPWS 2003.)

Major declines in both the population number and distribution of Little Terns are attributed to a combination of natural and human induced threats. The greatest threats include habitat loss through coastal development, loss of food resources, flooding of nests (by king tides, sea swells and rising river and lake levels), accidental trampling by humans and off-road vehicles and depredation by both native (e.g. Australian Raven (*Corvus coronoides*), Silver Gull (*Larus novaehollandiae*)) and introduced (e.g. Red Fox (*Vulpes vulpes*), domestic dog (*Canis familiaris*)) species (NSW NPWS 2003).

Historically, Little Terns have been recorded nesting at 70 sites along the NSW coastline. However considerable reductions in the availability of suitable nesting habitat have corresponded to declines in the utilisation of these sites. Whilst Little Terns have been observed breeding at 44 sites since 1977, only 30 of these have been active during the past 14 years. Furthermore, previously significant sites such as Bellambi Point, South Wollongong Beach and Port Kembla Harbour, which once hosted more than 20 breeding pairs, appear to have been abandoned (NSW NPWS 2003).

In terms of the number of breeding pairs, it is estimated that 340 Little Tern pairs nested within NSW during the 1950s (Morris 1979). Over the proceeding 40 years drastic reductions in the population mirrored the decline in site utilisation, with a maximum of 126 pair documented in 1977/78 (Morris, 1979) and a statewide census recording 110 pair in December 1984 (Smith, 1990).

Rising concerns over these dramatic decreases in both the number of active breeding sites and overall population size triggered a number of conservation actions including the initiation of monitoring colonies in northern NSW in the late 1970s (Clancy 1979, 1980a, 1980b, 1981, 1982, 1983, 1987) and
several statewide surveys (Martindale 1985; Morris 1985; Starks 1992; Smith 1995a). This was followed in 1990 by the preparation of a statewide Species Management Report (Smith 1990) and Species Draft Management Plan (NSW NPWS 1990) and a series of reports that focused on specific regions (Smith 1994a, b, c; 1995a, b, c, d, e, f, g). A study commissioned by the Federal Airports Corporation from 1993 to 1996 provided additional valuable insights into the ecology of Little Terns as well as the effectiveness of management techniques when the construction of the third runway required the relocation of the Botany Bay colony to Towra Spit Island (Straw and Priddel 1992; Priddel and Ross 1996).

Since 1990 various funding bodies have supported the recovery of the Little Tern in NSW including the NPWS through the Little Tern Recovery Plan and the Fox Threat Abatement Plan, Natural Heritage Trust, NSW Public Works and Services and the Federal Airports Corporation (NSW NPWS 2003). This has resulted in the implementation of a wide range of management strategies designed to increase both the population size and breeding success of this endangered species in NSW. Techniques include fencing at colonies to reduce human disturbance and multifaceted predator control stratagems. Other recovery activities include the installation of interpretive signage, establishment of volunteer warden programs and raising of nests using sandbags to alleviate the threat from inundation. Efforts have predominantly focused on major breeding locations identified in the early reports and the production of an end of season report has been undertaken at most sites since the mid 1990s. The purpose of this report is to collate and analyse these data for the last six breeding seasons, i.e. 1998/99 to 2003/04. Specifically it aims to:

- provide an overview of Little Tern breeding success at a statewide level;
- summarise changes in the breeding success of NSW Little Tern breeding colonies in a regional context;
- identify the principal threats to Little Tern breeding success;
- describe and provide an overview of the efficacy of the applied management techniques; and
- recommend strategies to further improve the recovery of this species.
3 METHODS

3.1 BREEDING SITES

The locations of the 70 historical Little Tern breeding sites are depicted in Figure 1. Eighteen have supported active nesting colonies over the last six years and are indicated by *. Also shown are the eight Little Tern Regions recognised by the Recovery Plan (NSW NPWS 2003) which are based on the current knowledge and understanding of colony dynamics.

3.2 RECOVERY ACTIONS

A wide range of management strategies has been undertaken at Little Tern colonies in NSW over the last six breeding seasons. The implementation of these actions has varied among sites and seasons. For example, since 1999 concerted efforts have been made to recover colonies located on the south coast of NSW, whereas other sites such as Botany Bay and Harrington/Manning Point have been managed for almost ten breeding seasons. Details of recovery activities utilised between the 1998/99 to 2003/04 seasons are provided below.

3.2.1 Monitoring of Sites

Little Tern nesting sites were often identified by the presence of sitting birds in breeding plumage or by brooding birds returning to the nest. When located the content of each nest was recorded and the progress of the nest site monitored for the duration of the breeding season at the majority of colonies. Both direct observations (e.g. volunteer-site-wardens documenting predator behaviour, nesting biology, bird behaviour) and indirect evidence (e.g. predator tracks at empty nests) of Little Tern biology and threats were recorded where possible. Other potential nesting sites were visited opportunistically and in response to reported sightings.

At many sites monitoring of Little Tern breeding colonies specifically involved site walkthroughs. Walkthroughs involved NPWS rangers, field officers, Shorebird Recovery Coordinators and/or trained volunteer-site-wardens walking through the site in transects, recording details of each nest and general activity within the site. The precise location of each nest was often recorded on site maps and marked in the field with either a cattle tag or a small section of tomato stake numbered with permanent ink. On subsequent visits, the contents of each nest were noted. Chick numbers were also determined during site walkthroughs and were classified as either hatchlings (chicks in nest), runners or pullis (mobile chicks). Once able to fly, young were identified as fledglings.
Figure 1: Regional distribution of Little Tern nesting sites in New South Wales. The 18 sites that supported active breeding colonies between the 1998/99 and 2003/04 seasons are indicated by *. Map modified from Little Tern Recovery Plan (NSW NPWS 2003).
3.2.2 Habitat Protection and Management

3.2.2.1 Habitat Modification

Nesting habitat, in particular on islands, was enhanced at some sites. Generally, this involved the removal of encroaching vegetation (often weeds) from affected colonies. This activity was often undertaken prior to the breeding season (i.e. August and September) to allow for optimal nesting conditions throughout the summer. Small patches of low vegetation were retained to provide shelter for chicks upon leaving the nest. Depositing sand on low-lying areas through site remediation works was another strategy used to enhance nesting habitat.

3.2.2.2 Physical Protection of Nest Sites

Temporary fences were erected around active nesting sites at the majority of locations to control the impact of human-induced threats. Such threats include accidental trampling of nests by humans and off-road vehicles, domestic dog disturbance, fox depredation and nest abandonment by excessive interference. ‘People fences’ were constructed of various materials including wooden tomato stakes and fiberglass poles connected by twine or plastic coated wire, whereas electric fences consisted of strands of electric wire joining fiberglass and/or plastics posts and were charged by a 6 or 12-volt battery connected to a pulse charger. These fences were erected at sites where foxes and/or domestic dogs were considered to pose a significant threat based on historical records and/or their presence within the area. Fences were generally positioned at a minimum distance of 10 metres, and preferably up to 50 metres, from the nearest nest to further reduce disturbance and were dismantled at the breeding season conclusion.

In recent seasons, the effectiveness of wire nest protectors (predator exclusion cages) has been trialed at several breeding sites where unexpected threats arose, such as eggs being preyed upon by Swamp Harriers (*Circus approximans*) or Gull billed Terns (*S. nilotica*), and other protective measures were ineffective. A circular cage (approximately 1 metre in diameter) was designed to allow Little Terns to walk-in from all sides (100mm x 100mm x 100mm mesh size) and fly-off the nest (the exit hole), yet not so large as to allow birds of prey to enter. Increments in the hatching success of other shorebirds have resulted from the use of similar nest cages (Melvin *et al* 1992; Dann and Baird 1997; Urquhart 2000).

3.2.2.3 Signage

Numerous signs were utilised to inform beach-users of Little Tern breeding activities. These included temporary and permanent interpretative signage, which were either generic for shorebird breeding areas or specific to Little Tern nesting sites. Signs often included photos or pictures to assist people with identification and were both attached to ‘people fences’ and positioned at major beach access points. All temporary signs were removed at the completion of the breeding season.

3.2.2.4 Fox Control

A number of fox control measures were implemented at Little Tern nesting sites that have been subject to fox depredation over the last six seasons. Fox control techniques included baiting, electric fences,
trapping, shooting and den destruction. These practices were generally carried out either directly by the NPWS or contracted out to the Rural Lands Protection Board (RLPB), however trained wardens also participated at some sites. Baiting in most areas commenced in August prior to the breeding season and was continued depending on the presence of foxes within an area. Additional sites were baited as necessary following reassessment of priority areas throughout the season. A combination of 1080 “Fox-Off” and meat baits was delivered using the mound method (i.e. buried at least 15cm below the surface) to reduce takes by non-target species. In some cases free baiting (non-toxic baits) was initially used to attract foxes to a station. Bait stations were placed at the main access points to Little Tern nesting sites where feasible. However the close proximity of some human settlements to colonies restricted the use of poisoned baits. At these locations other methods of fox control were utilised such as electric fences, soft jaw traps, cage traps and den destruction.

3.2.2.5 Managing Inundation

In an effort to control the flooding of nests by king tides, sea swells and rising lake and river levels, a number of management techniques were used at various locations. These included moving nests, creating sandbag walls, elevating individual nests on sandbags and constructing sandbag barriers and dykes around vulnerable nests. In cases where higher ground was adjacent to a vulnerable nest, eggs were moved at a rate of one to two metres per day (NSW NPWS 2003). Nests were elevated by picking up the eggs and replacing them on top of a mound constructed of sandbags and covered in loose sand.

3.2.2.6 Chick Protection

At Little Tern sites largely devoid of vegetative cover additional protection from predators and human disturbance was provided for chicks. This consisted of transferring sandbags, branches and beach washed debris to areas within close vicinity of nest sites. This practice both encouraged chicks to remain within fenced areas and provided cover from predators.

3.2.3 Community Education, Awareness and Involvement

3.2.3.1 Publicity and Community Education

Awareness of the conservation status, requirements and management of Little Terns was promoted through a number of mediums. Written information included brochures, posters, newsletters and articles in newsletters of ornithological organisations and natural history societies as well as other local publications. Brochures about Little Terns and fox baiting were distributed via letterbox drops, caravan parks and provided to site visitors, whilst posters were placed in the windows of local businesses and on NPWS information boards. Talks and Little Tern information nights were also delivered to local communities and key organisations including ornithological societies and government agencies. Incidental communication with beach users and television, radio and newspaper articles were commonly used to increase awareness of Little Tern recovery activities within the broader community.
3.2.3.2 Community Volunteers

At the commencement of the breeding season at some sites, training workshops were held to brief community volunteers on the appropriate protocol when ‘wardening’ Little Tern nesting areas. New volunteers, recruited via radio, newspapers, pamphlets and word of mouth, were informed of methods used to protect colonies and how breeding statistics, such as the number of nests, eggs, chicks and fledglings, were recorded. Green Corp volunteers also helped with fencing, signage and weed control at some sites.

Volunteers participated in the survey and monitoring of breeding Little Terns, including adult counts, nest inspections and identification of other birds utilising the sites. They also played a key role in on-site protection of nesting sites by helping to fence and raise nests and monitoring predator activity. The most important role of community volunteers was educating members of the general public on shorebird conservation and management.

3.3 Treatment of Data

For the purpose of this report a limited number of assumptions were made when assessing the data. This was only required for sites where monitoring was reduced to a few visits throughout a season or the data was unavailable or not contained within seasonal reports.

3.3.1 Site Selection

At least some data was available for the majority of sites for the past six nesting seasons. Therefore except where indicated in this report, if no data existed, it was assumed that breeding did not occur at a location during a specified season.

In accordance with the definition of a significant location provided in the Little Tern Recovery Plan (NSW NPWS 2003), in this report data is analysed for those sites that have supported colonies of at least four pairs during one of the six breeding seasons. Sites hosting less pairs during at least two seasons are also considered, as these constitute consistently used minor breeding areas.

3.3.2 Breeding Statistics

Precise data on the number of breeding pairs, nests, eggs, chicks and the fate of individual eggs was not always available within seasonal reports. A series of protocols based on current knowledge of Little Tern biology were thus applied in these cases to ensure consistency and maximise accuracy. The figures contained within this report are therefore conservative estimates based on the available data.
3.3.2.1 Breeding Pairs

Numbers of breeding pairs were estimated as ¾ of the total nest number when detailed data was unavailable for a particular breeding season. This represents a conservative estimate and accounts for a possible renesting event, which is regularly recorded for this species.

When calculating the overall figures for NSW, breeding pairs were removed from the total where known renesting events occurred.

3.3.2.2 Nests

When the total number of nests was unavailable, this breeding statistic was estimated by summing daily nest counts separated by 21 days; the average incubation period for Little Terns.

In some cases, Little Terns were discovered at either the chick or fledgling stage of development. The exact details of nesting attempts therefore remained unknown. The number of nests was thus calculated using the average number of chicks (~1) or fledglings (~0.5) per nest recorded in NSW over the last six seasons.

3.3.2.3 Eggs

In some instances total nest numbers were provided in seasonal reports but total egg counts were undetermined. The number of eggs was thus estimated at two per nest, which represents the average clutch size for nests recorded over the last six seasons in NSW.

3.3.2.4 Chicks

As described for nest counts, if the total chick number was not provided in a seasonal report, a figure was estimated by summing daily counts separated by 21 days. This represents the average fledging period for Little Tern chicks. In other cases a minimum chick number was generated based on the total number of fledglings sighted.

3.3.2.5 Fate of Eggs

Only confirmed fates are considered in this report. That is, nest failures that were attributed to presumed predators were categorised as unknown egg losses. Furthermore, when data was unavailable detailing the fate of eggs, it was presumed that all progeny not recorded as a fledgling were lost as eggs to an unknown cause.
4 BREEDING RESULTS

4.1 OVERALL BREEDING RESULTS

A total of 2351 breeding pairs laid 7730 eggs between the 1998/99 and 2003/04 nesting seasons in NSW. One thousand eight hundred and thirty seven of these progressed to the fledgling stage yielding an overall average productivity rate of 0.78 fledglings per breeding pair per season. In comparison, although a relatively similar productivity rate (0.71) resulted from the previous five-year period, breeding pair, egg and fledgling numbers have almost trebled over the last six seasons.

As discussed in the Recovery Plan, the highly variable trends in Little Tern breeding success that occurred between the 1993/94 and 1997/98 seasons corresponded to a period when intensive conservation efforts were being implemented at only four major nest sites (NSW NPWS 2003). Therefore, the catastrophic loss of eggs and/or chicks at one site dramatically affected productivity at a statewide scale. An extension of the areas covered and the exploration of new management techniques in the last six years have resulted in an incline in breeding pairs from 251 in the 1998/99 season to approximately 487 in 2003/04 (Figure 2). Similarly, the number of eggs has dramatically increased from 739 to 1685 during this period. As a consequence, the number of chicks fledged within NSW each season has also generally increased over the past six seasons from 238 to 332. The peak in fledgling numbers of 375 in the 2003/04 corresponds to the prevailing drought conditions creating ideal habitat at many breeding sites. These fledglings at least partially account for the rise in the adult population, as the overall productivity rate in each of the past six breeding seasons has exceeded the replacement rate of 0.5 fledglings per breeding pair per season which is suggested in the literature as required to maintain a stable Little Tern population (Haddon and Knight 1983; Holloway 1993; Murray 1994; Murray and Reside 1995). An influx of at least 35 breeding pairs from Victoria during the past

![Figure 2: Breeding statistics (total number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored in NSW between the 1998/99 and 2003/04 breeding seasons. The total breeding pair figure for the following seasons is adjusted to incorporate known renesting events at different sites: 2001/02 (10 – Brou to Tuross), 2003/04 (10 – Station Creek to Red Rock, 10 – Shoalhaven Heads to Lake Wollumboola and Windang, 42 – Wallaga to Bega Rivermouth).](image-url)
two breeding seasons also provides some explanation of the rise in the adult population (L. Waldegrave-Knight pers. comm.)

4.2 REGIONAL BREEDING RESULTS

Considerable differences exist in the contribution of individual sites and regions to the overall breeding results for Little Terns in NSW. For example, whilst Foster represented one of the four major breeding colonies that was intensively managed during the early to mid 1990s, this site has not been used by large numbers of terns (more than four pair) since 1995/96, and the birds appear to have relocated to the Sawtell and Manning River sites. Whilst the other three sites, Harrington/Farquhar (considered as two separate sites in this report), Botany Bay and Lake Wollumboola, continue to support major breeding colonies, the broadening of the management arc to incorporate areas such as The Entrance and numerous south coast sites has seen additional important nesting areas emerge in recent years. A total of five sites accommodated more than 200 pairs between the 1998/99 and 2003/04 seasons and more than 100 pairs established breeding colonies at a further six sites (Figure 3). More than 700 eggs have been laid over the past six seasons at the Harrington/Manning Point, Farquhar Inlet/Old Bar, Botany Bay and Lake Wollumboola sites. However, there has been a shift in terms of relative success, with sites such as Wallagoot Lake and Sawtell producing on average more fledglings per breeding pair. The Entrance, Harrington/Manning Point, Farquhar Inlet/Old Bar, Bega Rivermouth, South Tuross Head, Station Creek, Lake Wollumboola and Botany Bay sites also yielded average productivity rates that exceeded the recommended 0.5 fledglings per breeding pair per season.

![Figure 3: Total breeding statistics (total number of breeding pairs, eggs and fledglings and productivity rate) for each site monitored between the 1998/99 and 2003/04 breeding seasons.](image-url)

The size of colonies and success of individual sites also varied markedly among breeding seasons. This was particularly pronounced for colonies established on sand islands which are only periodically available as nesting habitat, such as those within Wallagoot and Brou Lakes. The intensity of management efforts have also been substantially increased within some regions and at specific sites in
recent years, and has consequently affected seasonal productivity. These patterns are apparent when the breeding statistics for each site are examined within a regional context over the six-year period.

4.2.1 Northern Rivers

The Northern Rivers Little Tern Region encompassed three breeding sites, all of which are contained within Yuraygir National Park; Lake Cakora (Figure 4), Station Creek (Figure 5) and Red Rock (Figure 6).

4.2.1.1 Lake Cakora

![Breeding statistics for Lake Cakora](image)

**Figure 4**: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Lake Cakora between the 1998/99 and 2003/04 breeding seasons. NB indicates no recorded breeding activity and NC refers to unconfirmed data.
4.2.1.2 Station Creek

Station Creek was the most important nesting site for Little Terns in the Northern Rivers Region between the 1998/99 and 2003/04 seasons. Twenty-eight pairs laid 56 eggs on the beach adjoining the mouth of the creek in 2003/04 representing the largest recorded colony for this region (Figure 5). Intensive conservation efforts by volunteers and NPWS staff over the past two seasons have contributed to the fledging of 20 and 13 chicks respectively. The 2003/04 breeding season was

4.2.1.3 Red Rock

Station Creek was the most important nesting site for Little Terns in the Northern Rivers Region between the 1998/99 and 2003/04 seasons. Twenty-eight pairs laid 56 eggs on the beach adjoining the mouth of the creek in 2003/04 representing the largest recorded colony for this region (Figure 5). Intensive conservation efforts by volunteers and NPWS staff over the past two seasons have contributed to the fledging of 20 and 13 chicks respectively. The 2003/04 breeding season was
similarly successful at Red Rock with the efforts of 11 nesting pairs yielding the only four fledglings recorded at this site over the six-year study period (Figure 6). Breeding activity was not documented at Red Rock during three of the six seasons. In comparison, Lake Cakora has consistently supported several nesting pairs (Figure 4), however a plethora of threats including trail bikes, dogs, horses, foxes and tidal inundation have resulted in the failure of all known nests (G. Hart pers. comm.).

4.2.2 Coffs Coast

During the past six seasons, Sawtell (Figure 7) and Nambucca Heads (Figure 8) have represented the two Little Tern breeding sites in the Coffs Coast Region. In terms of land tenure, the Sawtell nesting area is situated at the mouth of Bonville Creek within Bongil Bongil National Park and the Nambucca Heads site is a Nature Reserve which has been jointly managed by numerous authorities including the Department of Lands, Nambucca Shire Council and the Nambucca Aboriginal Land Council.

4.2.2.1 Sawtell

![Breeding statistics for Little Terns monitored at Sawtell between 1998/99 and 2003/04 breeding seasons.]

Figure 7: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Sawtell between the 1998/99 and 2003/04 breeding seasons.
4.2.2.2 Nambucca Heads

Prior to the late 1990s, these two sites within the Coffs Coast Region were only minor contributors to the southeastern Little Tern population (NSW NPWS 2003). However, in the 1998/99 season, 24 pairs established the largest recorded colony on the southern sand spit of Bonville Creek mouth within Bongil Bongil National Park near Sawtell (Figure 7). Thirty-seven chicks fledged and yielded an extremely high productivity rate of 1.54 fledglings per breeding pair. Numbers of breeding pairs and eggs recorded at the Sawtell site increased over the subsequent three seasons peaking at 50 and 162 respectively in the 2001/02 season. Although both parameters halved in the 2002/03 and 2003/04 seasons, fledgling success remained high. Rigorous monitoring and management actions have contributed to the consistently high productivity rates recorded for this site, which have ranged from 0.64 to 1.72 fledglings per breeding pair per season. Further south on the Coffs Coast, generally only a few pairs of Little Terns selected Nambucca Heads as nesting habitat between the 1998/99 and 2003/04 breeding seasons and no fledglings eventuated (Figure 8). Despite 16 breeding pairs, there were no successfully fledged chicks during the 20001/02 season, with high tides and predation by foxes and cats attributed to the loss of all eggs.

4.2.3 Taree

Two breeding sites occurred within the Taree Little Tern Region between 1998/99 and 2003/04 and are located at the entrances of the northern (Harrington/Manning Point – Figure 9) and southern (Farquhar Inlet/Old Bar – Figure 10) arms of the Manning River. The land tenure of these sites is Crown Land and Crowdy Bay National Park respectively.
4.2.3.1 Harrington/Manning Point

Figure 9: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Harrington/Manning Point between the 1998/99 and 2003/04 breeding seasons.

4.2.3.2 Farquhar Inlet/Old Bar

Figure 10: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Farquhar Inlet/Old Bar between the 1998/99 and 2003/04 breeding seasons.

Although the Harrington/Manning Point site has been recognised as a key NSW breeding site for almost a decade, Farquhar Inlet/Old Bar has only been actively managed since the 1989/99 season when it hosted 40 breeding pairs for the first time on record (NSW NPWS 2003). Throughout the six-year period Farquhar Inlet generally proved to be the most popular roosting and feeding area for Little
Terns prior to and after nesting. However, with the exception of the 1999/00 season, Harrington has represented the primary Little Tern breeding site within the Taree Region. Despite some fluctuations between seasons, on average 68 pairs established a colony of 215 eggs at Harrington within a season and produced 66 fledglings, whilst 43 pairs reared 38 chicks to the fledgling stage from 133 eggs at Farquhar Inlet. Productivity was also higher at Harrington than Farquhar Inlet in four of the six years, however both sites have yielded rates which supersede the recommended 0.5 fledglings per breeding pair in all seasons (Figures 9 and 10).

4.2.4 Central Coast

Little Terns have nested at one Crown Land site on the NSW Central Coast in recent years. Otherwise known as Karagi Point, The Entrance site (Figure 11) is a sand spit on the northern side of the entrance to Tuggerah Lakes.

4.2.4.1 The Entrance

![Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate)](image)

*Figure 11: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at The Entrance between the 1998/99 and 2003/04 breeding seasons. NB indicates no recorded breeding activity.*

Following a fifty-year absence, the recording of 20 breeding pairs, 54 eggs and 25 fledglings marked the reemergence of The Entrance as a major NSW nesting site in the 2000/01 season (Figure 11). The importance of this site has subsequently increased in recent years through the implementation of an intensive volunteer assisted conservation project. The efforts of an average 30 breeding pairs have resulted in at least 25 fledglings per season, with 2000/2001 representing the most successful season when 1.25 fledglings per breeding pair were produced.

4.2.5 Sydney
Botany Bay (Figure 12) was the sole Little Tern breeding site within the Sydney region between 1998/99 and 2003/04, however colonies have been established on various sub-sites including Towra Spit Island (part of Towra Point Nature and Aquatic Reserves), Molineux Point (private tenure – Sydney Ports Authority) and Penrhyn Inlet (Crown Land).

### 4.2.5.1 Botany Bay

![Breeding statistics for Little Terns monitored at Botany Bay between 1998/99 and 2003/04 breeding seasons.](image)

Figure 12: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Botany Bay between the 1998/99 and 2003/04 breeding seasons.

With the exception of Molineux Point, which was utilised during the 2001/2002 season, since its formation in 1990, Towra Spit Island has been the principal nesting site for Little Terns breeding in Botany Bay. An average of 55 pairs per season chose to nest on this sand based island, however between 28 and 78 pairs have been recorded during the past six years (Figure 12). In terms of success, Botany Bay has consistently signified an important site for Little Tern conservation in NSW. Between 24 and 43 chicks progressed to the fledgling stage in most seasons, representing an average productivity rate of 0.75 fledglings per breeding pair. Unfortunately in 2003/04, despite a record number of eggs (289), only two fledglings were confirmed. The colony endured inundation, foxes and human disturbance, however an unexplained early departure by the terns potentially meant that many fledglings remained undetected.

### 4.2.6 Shoalhaven Coast

Four breeding sites were located within the Shoalhaven Coast Little Tern Region; Windang Beach at the entrance to Lake Illawarra (Figure 13), Shoalhaven Heads adjacent to Comerong Island Nature Reserve (Figure 14), Lake Wollumboola (Figure 15) and Lake Conjola (Figure 16). The tenure of these sites is primarily Crown Land, with the exception of Lake Wollumboola, which was gazetted as part of Jervis Bay National Park in 2002.
4.2.6.1 Windang (Lake Illawarra)

Figure 13: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Windang (Lake Illawarra) between the 1998/99 and 2003/04 breeding seasons. NB indicates no recorded breeding activity.

4.2.6.2 Shoalhaven Heads (Comerong Island)

Figure 14: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Shoalhaven Heads (Comerong Island) between the 1998/99 and 2003/04 breeding seasons. NB indicates no recorded breeding activity.
4.2.6.3 Lake Wollumboola

*Figure 15: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Lake Wollumboola between the 1998/99 and 2003/04 breeding seasons.*
4.2.6.4 Lake Conjola

Lake Wollumboola represents the most significant site for Little Terns breeding in the Shoalhaven Coast region both historically (NSW NPWS 2003) and over the past six seasons. In five of the six seasons, this site accommodated the highest number of breeding pairs and eggs (Figure 15). Fledgling figures were highest at Lake Wollumboola for the seasons between 1998/99 and 2001/02 (~30), however in more recent years low productivity has been closely correlated with high fox depredation and lake levels. In the 2003/04 season, the large beach berm, which is generally favoured as nesting habitat by Little Terns, was inundated by high water levels within the lake. The majority of individuals subsequently dispersed to the alternative breeding sites of Shoalhaven Heads and Windang, which had not been utilised for seven and 41 years respectively (Figures 13 and 14). However, high levels of fox activity, large sea swells, high winds and a hailstorm limited success at these two sites. The fourth Shoalhaven site, Lake Conjola, has been a relatively consistent minor breeding site, contributing between four and seven fledglings to the NSW Little Tern population in most years (Figure 16).

4.2.7 Eurobodalla Nature Coast

South Tuross Head (Figure 17) and Brou Lake (Figure 18) are both contained within Eurobodalla National Park and have represented the two breeding sites for the Eurobodalla Nature Coast Little Tern Region in the past six seasons.
4.2.7.1  South Tuross Head

Figure 17: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at South Tuross Head between the 1998/99 and 2003/04 breeding seasons. NB indicates no recorded breeding activity.
4.2.7.2 Brou Lake

Figure 18: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Brou Lake between the 1998/99 and 2003/04 breeding seasons. NB indicates no recorded breeding activity.

A synergistic relationship existed between the two Eurobodalla Nature Coast sites during the six year period in that the birds established a large nesting colony at only one site during a specified breeding season (Figures 17 and 18). As seen for Lake Wollumboola, water level and the entrance status are significant determinants of the suitability of Brou Lake as nesting habitat. That is, 217 and 136 eggs were recorded in 2001/02 and 2003/04 when lake levels were low and either an island or expansive sand and mudflats were exposed. A total of seven eggs were laid in the other four seasons. At Tuross Heads, which is generally open to the sea, the ability of recovery activities to combat inundation by king tides and sea swells has been the primary factor affecting breeding success. An intensive management effort through artificially raising nests on sandbags has been largely responsible for the fledging of a total 129 chicks over the past six seasons, however productivity rates have ranged from 0 to 1.3 fledglings per breeding pair per season.

4.2.8 Bega Valley Sapphire Coast

The Bega Valley Sapphire Coast Little Tern Region encompassed three breeding sites between 1998/99 and 2003/04; Wallaga Lake (Figure 19) and Bega Rivermouth (Figure 20), both of which are Crown Land, and Wallagoot Lake (Figure 21) in Bournda National Park.
4.2.8.1 Wallaga Lake

Figure 19: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Wallaga Lake between the 1998/99 and 2003/04 breeding seasons.

4.2.8.2 Bega Rivermouth

Figure 20: Breeding statistics (number of breeding pairs, eggs and fledglings and productivity rate) for Little Terns monitored at Bega Rivermouth between the 1998/99 and 2003/04 breeding seasons.
4.2.8.3 Wallagoot Lake

The relative importance of the three Bega Valley Sapphire Coast sites for breeding Little Terns varied considerably between the 1998/99 and 2003/04 seasons. However, there was a general incline in the size of the Wallaga Lake and Bega Rivermouth colonies over this six-year period based on the number of recorded breeding pairs and eggs (Figure 19 and 20). In terms of fledgling numbers, whilst up to 70 have been recorded at the Bega Rivermouth site, a plethora of threats including human interference and Swamp Harriers have severely restricted the productivity of Wallaga Lake in recent seasons. The suitability of Wallagoot Lake as nesting habitat for Little Terns is determined by lake levels as seen in 2002/03 when 74 breeding pairs utilised the expansive mudflats related to the prevailing drought conditions (Figure 21). In other years, only minimal breeding activity has been documented for this site. Overall, intensive recovery efforts since 1998/99 by NPWS, Bega Valley Shire council, the South Coast RLPB and a large team of community volunteers have corresponded to at least one highly productive Little Tern colony per season in the Bega Valley Sapphire Coast Region.
5 FATE OF EGGS AND CHICKS

5.1 OVERALL FATE OF EGGS AND CHICKS

Of the total 7730 Little Tern eggs recorded in NSW between the 1998/99 and 2003/04 breeding seasons, 40% (3096) hatched and 24% (1837) of chicks were successfully reared to the fledgling stage. The remaining 60% (4634) failed at the egg stage of development (Figure 22).

The fate of Little Tern eggs and chicks was determined through both direct (e.g. observations of inundation or predators removing eggs or chicks from a nest) and indirect (e.g. recording of tracks, diggings, bodies, broken eggshells) evidence. However it was still difficult to attribute the fate of all eggs and chicks to a definitive cause largely due to the periodic nature of monitoring efforts. This was particularly evident for chicks, which are mobile within days of hatching and are difficult to detect when camouflaged amongst vegetation. For this reason, the fate of 27% and 39% of the total eggs and chicks lost respectively remained unaccounted for (Figure 22). Other major causes of egg failure included stochastic natural events such as sea surges and windstorms (13%) and mammalian (11%) and avian (6%) predators. Physical protection of nest sites and an increase in community awareness of the plight of these birds have corresponded to human interference occurring on only the rare occasion (3% of total eggs lost).

Figure 22: Overall fate of Little Tern eggs and chicks lost in NSW between the 1998/99 and 2003/04 breeding seasons.
The threats to Little Tern breeding success are further clarified when the constituents of each fate category are examined. These are discussed below in order of major to minor causes of overall nest failure.

5.1.1 Unaccounted Loss

As stated above, large numbers of chicks, and particularly eggs, were lost to unknown causes during the six breeding seasons. Overall 42% of eggs laid remained unaccounted for (Figure 22). It is possible that the magnitude of this statistic misconstrues the effect of other known threats on Little Tern breeding success. That is, some causes of loss, such as depredation, can be difficult to detect and may be underrepresented in the ‘loss to predators’ category.

![Figure 23: Unaccounted loss of Little Tern eggs and chicks in NSW between the 1998/99 and 2003/04 breeding seasons.]

Of the 3275 eggs and chicks that remained unaccounted for, 304 (9%) eggs were abandoned and/or not viable and 26 (1%) chicks were found dead (Figure 23). Adults may abandon their eggs if infertile or when excessive disturbance by predators, humans and/or adverse weather conditions prevent them from incubating the nest. Although the recording of incidents is less frequent, chicks may also die from environmental stress such as exposure to wind, extreme heat, cold and/or lack of food resources. Eggs and young may also be deserted at the end of a breeding season when the adults leave on their northbound migration (Owen 1990 in Higgins and Davies 1996).

5.1.2 Loss to Stochastic Natural Events

Stochastic natural events were the most frequently recorded cause of known nest failure in NSW between the 1998/99 and 2003/04 breeding seasons (13% (969) of all eggs recorded) (Figure 22). The majority of eggs were lost to inundation (67% - 653), as a consistent behaviour of Little Terns is to select nest locations that are subject to flooding by king tides, sea swells and rising river and lake levels (Figure 24). Brou Lake represents one such site, as 162 eggs were lost during the 2001/02 season when a combination of king tides and large sea swells caused water to swamp the small breeding island.
Adverse weather conditions such as torrential rains, strong winds and the associated shifting of large sand dunes have also buried a total of 306 (32%) eggs in the past six seasons, including 156 at Harrington in 2002/2003 (Hole and Hole 2003). A further ten eggs (1%) and numerous adults and chicks were lost during a severe hailstorm at Windang Beach during the 2003/04 season (Keating and Jarman 2004).

Figure 24: Loss of Little Tern eggs in NSW to stochastic natural events between the 1998/99 and 2003/04 breeding seasons.

5.1.3 Loss to Mammalian Predators

Despite the implementation of intensive and multifaceted fox control programs at the majority of breeding sites, foxes remain the primary predator of Little Tern eggs and chicks. This introduced predator accounted for the loss of 855 eggs between the 1998/99 and 2003/04 season, a figure which represents 11% of the overall egg loss (Figure 22) and 93% of eggs lost to mammalian predators (Figure 25). Foxes have repeatedly wrecked havoc on the Lake Wollumboola colony (Jarman 2001; Keating and Jarman 2002, 2003) and collectively caused the loss of 214 eggs at the Harrington and Farquhar Inlet sites during the 2000/01 breeding season (Hole and Hole 2001). In comparison, rats (Rattus rattus and R. norwegicus) and cats (Felis catus) represented minor predators, devouring only 1 and 48 Little Tern eggs and chicks respectively.
5.1.4 Loss to Avian Predators

Overall avian predators accounted for the loss of 6% of Little Tern eggs and chicks between the 1998/99 and 2003/04 breeding seasons (Figure 22). As stated in the Recovery Plan, the Silver Gull is the most frequently reported native predator at NSW colonies (NSW NPWS 2003) and in the past six seasons 39% of eggs lost to avian predators (194 eggs) have met this fate (Figure 26). A further 26% (129) of eggs have failed due to Corvids, such as the Australian Raven and its congener the Torresian Crow (C. orru), invading breeding colonies. Incidents of Silver Gull and corvid depredation are often attributable to a single or several rogue individuals (Ross and Jarman 2001; Parramore and Parramore 2003; pers. obs.) and control programs have reduced this threat at some sites during selected seasons (e.g. Harrington and Farquhar (Hole and Hole 2001); Botany Bay (Ross and Jarman 2001)). Based on avian tracks leading to empty nests, another 75 eggs were lost to unidentified avian predators during the six-year period. Furthermore, whilst Swamp Harriers have been implicated in the loss of 36 eggs in the past two seasons at the south coast site of Wallaga Lake (Keating and Jarman 2003, 2004), on the north coast, Gull-billed Terns depredated 62 eggs at Sawtell (M. Smith pers. comm.), Harrington and Farquhar Inlet (Hole and Hole 2003, 2004) during the same period. In 1998/99, the somewhat interesting dilemma of one endangered species preying on another arose at Harrington when a Beach Stone Curlew was witnessed devouring four Little Tern eggs (Mardell 1999).
Figure 26: Loss of Little Tern eggs and chicks in NSW to avian predators between the 1998/99 and 2003/04 breeding seasons.

5.1.5 Loss to Human Interference

Historically, human disturbance of nesting Little Terns has been identified as a major factor in poor breeding success (e.g. Morris 1979; Vincent 1983; Clancy 1987; Hill et al 1988; Smith 1990). However active management of colonies in recent years through fencing, signage and community awareness campaigns have tempered this threat. This is evidenced by only 3% of the total eggs laid between 1998/99 and 2003/04 being lost to human interference (Figure 22). Nonetheless isolated incidents do occur, and a total of 167 (79% of losses to human interference) eggs and chicks have been lost to direct human interference (Figure 27). This statistic is primarily accounted for by the disappearance of 111 eggs and chicks at Wallaga Lake coinciding with the vandalism of the temporary ‘people’ and electric fences during the 2003/04 breeding season. In terms of other ascribed losses to human interference, humans, 4WD vehicles, quad bikes and horses occasionally trampled eggs and chicks. Ample signage, fences and definitive access tracks at many north coast sites has been particularly effective in keeping 4WDs out of nesting areas.
5.1.6 Loss to Other Predators

Less than 1% (33) of the total eggs laid have been lost to predators other than mammals or birds in the past six breeding seasons. Ghost crabs have been implicated in the loss of several eggs and chicks at the Harrington, Farquhar and Botany Bay sites in most seasons and goannas were the recorded predators of at least 13 eggs at Sawtell during the 2002/03 nesting season (Parramore and Parramore 2003). However overall these have had a negligible effect on the breeding success of Little Terns in NSW.
5.2 **REGIONAL FATE OF EGGS AND CHICKS**

As expected, the fate of eggs and chicks varied markedly between Little Tern Regions and their constituent sites and losses were generally attributed to a number of causes (Figure 29). At each site, prevailing circumstances such as weather conditions and habitat suitability, in addition to implemented management actions were the main determinants of nest fates.

**Figure 29: Overall fate of Little Tern eggs for each site monitored between the 1998/99 and 2003/04 breeding seasons.**
The majority of eggs at half of the 18 sites remained unaccounted for. This trend was particularly evident at Botany Bay, where 65% of all eggs laid between the 1998/99 and 2003/04 breeding seasons were lost at the egg or chick stage to an unknown cause. Although the fate of 46% of Wallaga Lake eggs and chicks was also unidentified, a combination of Swamp Harriers and human interference have caused the failure of 39% of eggs laid on the sand spit during the past six seasons. In recent seasons, fox depredation has dominated the fate of eggs and chicks at the Lake Wollumboola and Lake Conjola colonies, where this introduced predator has wrecked havoc on 43% and 38% of the total eggs laid respectively. It is highly likely that foxes have consumed more eggs and chicks than are reported here, however it is often difficult to confirm fox depredation particularly for mobile chicks and when wind and rain distort tracks in the sand. Natural stochastic events, such as inundation or the burying of eggs by wind-blown sand, were the most frequently recorded causes of nest failure at the Station Creek, Nambucca, Shoalhaven Heads and Brou Lake site. At all four sites, a single event accounted for this. For example, a combination of king tides and storm surges flooded 162 eggs on the Brou Lake nesting island during the 2001/02 breeding season (Keating and Jarman 2002).

At least one chick has fledged from 16 of the 18 breeding sites during the past six nesting seasons. However, the majority of eggs and chicks were lost prior to their anticipated fledging date to a range of causes. At Sawtell, Harrington and Bega Rivermouth, more eggs hatched and progressed to the fledgling stage than were lost to any other single cause.
6 RECOVERY ACTIONS

In an effort to alleviate some of the threats encountered by nesting Little Terns, eight habitat protection and management actions were utilised in NSW during the 1998/99 to 2003/04 breeding seasons. The significant threats and logistics at each breeding site within a given season determined which actions were implemented (Table 1). Community awareness of Little Tern conservation was also raised at many sites through publicity and active community participation in recovery efforts. The methods and intensity utilised to implement these recovery actions also varied among sites and seasons making it difficult to quantitatively assess their efficacy over the six-year period. Nonetheless a summary table is provided below and some trends are discussed.

6.1 HABITAT PROTECTION AND MANAGEMENT

6.1.1 Habitat Modification

Little Terns favour sandy substrates covered in shell-grit or shingle as nesting habitat (Higgins and Davies 1996). Sites may therefore be gradually rendered unsuitable through the natural process of vegetation encroachment and may require clearing prior to the breeding season (NSW NPWS 2003). Potential nesting habitat was cleared of vegetation at the Sawtell site during the 2000/01 to 2002/03 seasons and in five of the six seasons on Towra Spit Island, Botany Bay. Minor remediation works through the creation of levees with an excavator to increase the island’s height has also been implemented at Botany Bay (e.g. Ross and Jarman 2001; Ross et al 2003). The importance of these recovery actions was evidenced in the 2001/02 season when Towra Spit Island remained low-lying and uncleared and the birds relocated to Molineux Point, on the opposite side of the bay (Ross pers. comm.).

6.1.2 Physical Protection of Nest Sites

‘People’ fences were erected around Little Tern colonies at 88% of sites with confirmed breeding activity. These protective fences were generally effective in restricting access to the sites, with only several accounts of either human or domestic dog disturbance within areas. One exception is the 2003/04 Wallaga Lake event wherein sections of both the ‘people’ and electric fences were destroyed and coincided with the disappearance of 52 Little Tern eggs and 39 chicks (Keating and Jarman 2004). Although isolated, similar incidents involving the removal of fencing materials have been documented at Nambucca Heads (Wallace 2002) and Lake Wollumboola (Keating and Jarman 2004) in the past. Nonetheless, fences have almost eliminated the threat posed to nesting Little Terns by trampling of eggs. This threat accounted for only the loss of only 0.5% of all eggs laid between the 1998/99 and 2003/04 breeding seasons. Furthermore fences are important habitat protectors and provide secure roosting and breeding areas for a suite of shorebird species other than Little Terns.

Electric fences were additionally installed at the commencement of most breeding seasons at the Lake Wollumboola and Bega Rivermouth sites and during 2003/04 at Wallaga Lake. Whilst these fences effectively reduced the impact of foxes at the Bega Rivermouth and Wallaga Lake sites, Little Tern eggs and chicks were still lost to this introduced predator at the Lake Wollumboola site in 2001/02 and
2003/04. This was due to foxes becoming accustomed to the 12-volt shock delivered by the fence and entering the enclosure on several occasions during 2003/04. In the previous year, foxes depredated many chicks when they ventured from the confines of the electric fence to nearby sand dunes.

As depicted in Figure 22, 60% of all Little Tern eggs laid in NSW during the past six breeding seasons did not hatch. One recovery action targeting the egg stage is predator-exclusion cages, which have been trialed at several NSW Little Tern breeding colonies in the past two seasons. Principally designed to combat native aerial predators such as Swamp Harriers and Gull-billed Terns, mixed success has been reported. Important discoveries about the limitations of this management strategy have also been revealed by the trial. For example, Hole and Hole (2004) found that Little Terns abandoned caged single-egg nests at the Harrington/Manning Point site. Whilst 26% of caged Little Tern eggs at the Brou Lake colony were also abandoned, up to 74% hatched, the majority of which were contained in two and three-egg nests. Furthermore, nest cages proved successful at Wallaga Lake during 2002/03 against Swamp Harriers (Keating and Jarman 2003).

6.1.3 Signage

A variety of both temporary and permanent interpretative signs were utilised at 90% of Little Tern nesting sites with confirmed breeding activity between the 1998/99 and 2003/04 seasons. The type of utilised signage varied with site and included generic shorebird breeding signs, information on Little Tern breeding, and wildlife protection signs preventing dogs and 4WD vehicles from disturbing nesting areas. In most cases all were effective in minimising disturbance and educating both general beach-users and those in 4wds and exercising dogs. Signs have not been erected at The Entrance colony over the last three seasons due to volunteer concerns relating to the attraction of unwanted attention to the site. They are however being considered for the 2004/05 breeding season to compare the incidence of human disturbance with and without signs (A. Morris pers. comm.).

6.1.4 Fox Control

Although fox depredation represents one of the key threats to the survival of breeding shorebirds (e.g. NSW NPWS 2003), the severity of this threat is reduced when effective management strategies are implemented. A number of fox control measures were employed at 81% of NSW Little Tern sites with confirmed breeding activity between 1998/99 and 2003/04. Fox control principally involved 1080 baiting, however shooting, den destruction, electric fences and soft jaw traps were also utilised. The latter methods were specifically employed at sites that were located within 500 metres of a settlement or when baiting was ineffective. Shooting was only utilised to augment the baiting program at Sawtell during the 2002/03 breeding season.

It is extremely difficult to quantify the effectiveness of the fox control programs implemented at individual colonies and to accurately compare their efficacy across sites. However, this introduced predator was known to vary its impact among sites and seasons and accounted for the overall known loss of 11% of Little Tern eggs. Although the cause of many egg and chick losses remained unknown, these could also be attributable to foxes. Nonetheless many seasonal reports noted that the fox control campaigns were successful and well warranted (e.g. Keating and Jarman 2002, 2003, 2004; Parramore and Parramore 2000, 2001, 2002), and at least minimised their adverse impact on Little Tern breeding success.
There are several critical factors which maximise the effectiveness of a fox baiting program including the scale at which baiting is conducted, the continuum of baiting and timing of control. As expected continuous and large scale baiting programs tend to be the most effective. In most cases, continuous baiting was not practical, and targeted control was instead conducted either prior to and/or during the breeding season. Fox depredation was generally recorded less frequently at sites where baiting was conducted in either the prior winter or early spring (e.g. Keating and Jarman 2003, 2004).

6.1.5 Managing Inundation

As stated above, Little Terns are known to select nest locations that are subject to flooding by king tides, sea swells and rising river and lake levels. In an effort to combat this behaviour, a variety of sandbagging strategies were employed at seven flood-prone sites (Sawtell, Botany Bay, Shoalhaven Heads, South Tuross Head, Brou Lake, Wallaga Lake and Bega Rivermouth) during 25% of the confirmed breeding seasons. Mixed success of sandbagging efforts has been reported. On one hand, although nests were often protected to endure king tides, unanticipated storm surges and high winds still caused the inundation of nests. For example, during the 2001/02 breeding season, 50 and 162 eggs were flooded when adverse weather conditions afflicted the Sawtell (Parramore and Parramore 2002) and Brou Lake (Keating and Jarman 2002) colonies respectively. Both the elevation of individual nests and construction of sandbag walls at the Botany Bay site have yielded similarly unsuccessful results in the past (e.g. Ross and Jarman 2001). Contrastingly, enormous sandbag mounds created at South Tuross Heads in 2002/03 secured 82 nests and contributed to the fledging of 65 chicks, the best result on record for this site (Keating and Jarman 2003). Furthermore, during 2003/04, 47 of the 50 Little Tern eggs elevated at south coast sites remained protected from the effects of both tidal inundation and large sea swells (Keating and Jarman 2004).

6.1.6 Chick Protection

Additional protection of chicks and runners against predators and human disturbance was provided at 25% of sites with confirmed breeding in the past six seasons. The majority of sites, particularly on the north coast of NSW, were sufficiently vegetated so that this recovery action was not required. However, anecdotal evidence from sites where this strategy was used, suggests that the creation of cover, through the transferral of sandbags and beach washed debris (predominantly large logs and branches), was a successful strategy.

6.2 COMMUNITY EDUCATION, AWARENESS AND INVOLVEMENT

6.2.1 Publicity and Community Education
Community interest in Little Tern conservation was generated through publicity and/or community education at the 78% of sites with confirmed breeding activity between 1998/99 and 2003/04. Promotional media included site specific and general ‘Little Tern breeding’ pamphlets and brochures, posters, newsletters and articles, public talks, workshops and training sessions, scientific papers, newspaper articles, radio interviews, television features and internet information. The efficacy of these media in educating the community on the plight of the Little Tern is difficult to assess, however general trends in beach usage have changed (e.g. less people walk their dogs and drive their 4wd vehicles in the close vicinity of breeding colonies) and an increase in community awareness has been reported from the majority of sites.

### 6.2.2 Community Volunteers

Community volunteers continue to play a vital and significant role in the monitoring and protection of Little Terns in NSW. Volunteers assisted at 92% of sites with confirmed breeding pairs between 1998/99 and 2003/04. Key responsibilities of volunteers included the collection of survey and monitoring data on breeding colonies such as adult counts, nest and chick activity, evidence of predators, other birds utilising the area and general colony behaviour. On-site management was also provided by volunteers who elevated vulnerable nests on sandbags, erected protective fencing and performed fox baiting at some sites. The volunteer wardening program has also been essential in educating both local residents and visitors to shorebird breeding sites and has consequently reduced human disturbance in these areas. Overall, the efforts of often small groups of people and/or individual volunteers have been quintessential in protecting Little Tern colonies in NSW.
Table 1: Recovery actions implemented (+) and not utilised (-) at Little Tern nesting sites in NSW during the 1998/99 to 2003/04 breeding seasons. NB = no breeding recorded. NC = breeding and/or recovery actions unconfirmed.

<table>
<thead>
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<th>Electric Fence</th>
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### Table 1 (continued): Recovery actions implemented (+) and not utilised (-) at Little Tern nesting sites in NSW during the 1998/99 to 2003/04 breeding seasons. NB = no breeding recorded. NC = breeding and/or recovery actions unconfirmed.

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Overall, the NSW Little Tern population is recovering due to the integrated and intensive management actions that have been implemented across the state. This strategy may be refined through the following recommendations:

7.1 SURVEYS, MONITORING AND RESEARCH

- Aim to achieve more consistency in data collection methods and reporting across sites. An example of a standardised end-of-season data sheet, which was used by some Little Tern researchers during the 2003/04 breeding season, is provided in Appendix 1.
- Develop a field manual to advise on ‘best practice’ field-based methodologies (detailed in NSW NPWS 2003). This would further assist in providing a management continuum across breeding sites.
- Continue conducting coordinated statewide Little Tern surveys in conjunction with Victorian researchers to establish an overview of the south-eastern population, however include one early (early November), mid (mid-December) and late (early February) in the breeding season. This would also enable more accurate estimates of total breeding pairs to be made, as it does not rely on knowledge of renesting events at different sites.
- Reinstate debriefing sessions on a biennial basis (pre and post breeding season), for all individuals involved in Little Tern management in NSW and potentially in other states. Also maintain more regular contact between Little Tern researchers throughout the breeding season, possibly via an e-mail group.
- Liaise with universities and establish research projects to rigorously assess the efficacy of management techniques. Examples of projects include investigations of nest-site selection in relation to physical beach characteristics and video surveillance of nests to determine fates and examine shorebird behaviour in response to a range of disturbances.

7.2 HABITAT PROTECTION AND MANAGEMENT

- Commence fox control programs in the winter and/or spring prior to the breeding season at sites where this is not yet occurring (i.e. at least in August to coincide with the peak fox breeding season).
- Investigate management options to alleviate the impact of avian predators such as Silver Gulls and Australian Ravens in effected areas.
- Continue discretionary use of wire nest protectors for Little Tern nests; however incorporate an external skirt of mesh footing to prevent predators from tunnelling underneath. Also only utilise cages for two and three egg nests.
- Anti-perching wire devices could be fitted to fence posts to reduce predation by birds of prey if required.
- Continue early habitat enhancement of shorebird breeding sites by removing encroaching vegetation at some sites or placing ample branches and beach washed material within fences at other sites to provide additional protection for chicks.
7.3 Community Education, Awareness and Involvement

- Attach ‘breeding in progress’ boards to pedestal signs or permanent interpretive signs at the entrance to Little Tern colonies to inform beach users of the progress of the nesting season at a site.
- Approach local councils early in the season to outline areas of the Little Tern Recovery Program where they can contribute.
- Regular policing of sites by NPWS and council rangers.
- Raise awareness of disturbance by recreational vehicles near breeding sites (i.e. hovercraft, kite surfing, 4WD vehicles)
8 REFERENCES


Little Terns in New South Wales - A Six Year Review; Breeding Seasons 1998/99 to 2003/04


Little Terns in New South Wales - A Six Year Review; Breeding Seasons 1998/99 to 2003/04


NSW NPWS. 2003. Little Tern (*Sterna albifrons*) Recovery Plan. NSW NPWS, Hurstville, NSW.


9 APPENDICES

9.1 APPENDIX 1: STANDARDISED END-OF-SEASON SHOREBIRD SUMMARY SHEET

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