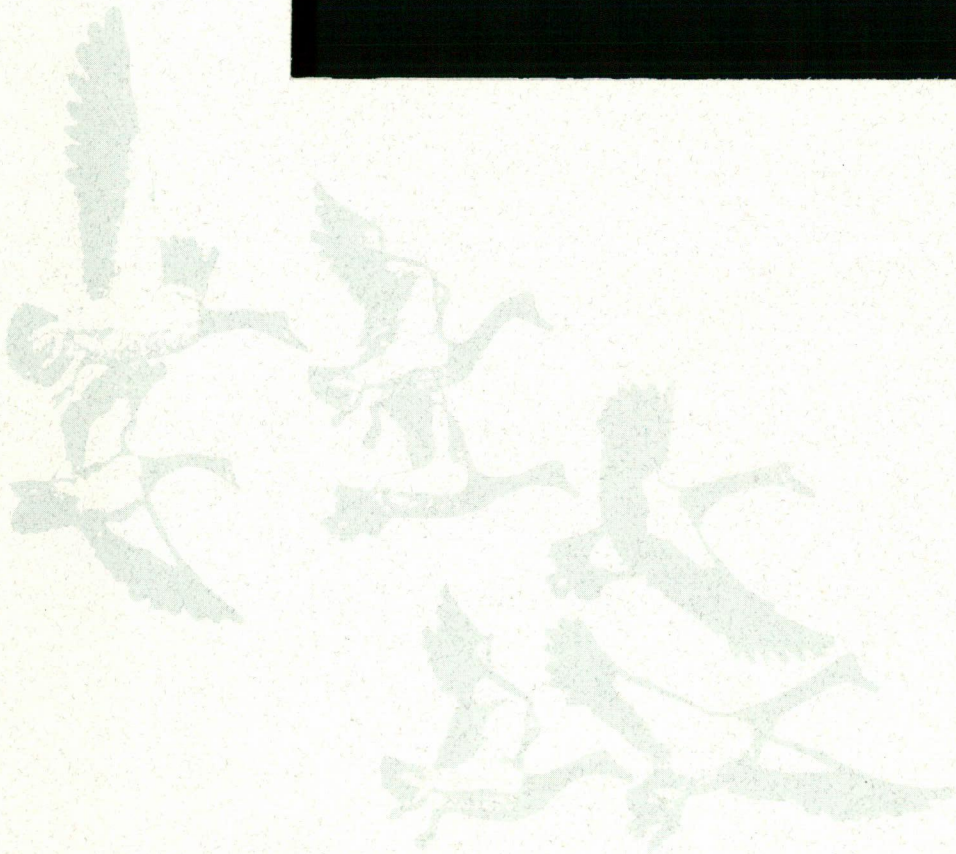
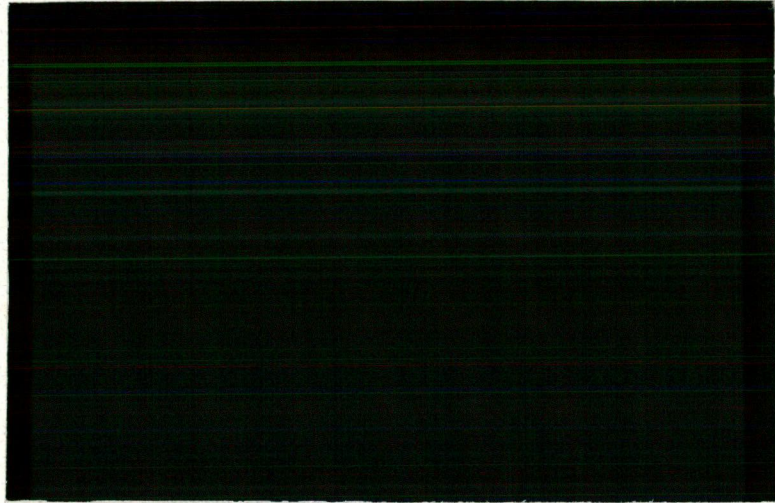


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the
**Wetlands
Centre**

FINAL REPORT
NSW ENVIRONMENTAL RESEARCH TRUST GRANT 1991
SEPTEMBER 1994
Revised May 1995

**BREEDING ECOLOGY AND
MIGRATION OF WETLAND BIRDS**

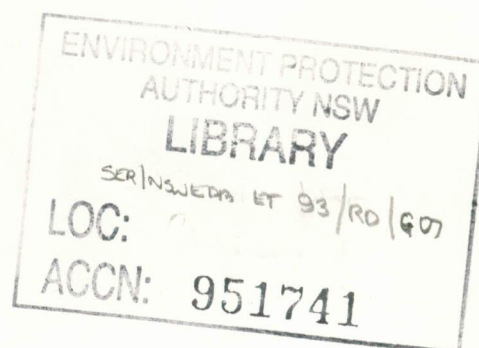
PROJECT G/RE 54

Shortland Wetlands Centre Ltd.

ACN 002 975 144

Chief Investigator: DR M. Maddock

Associate Investigator: Mr D.J. Geering



PROJECT SUMMARY

Achievements directly attributable to the assistance provided by the Environmental Trust Grant are:

- major progress has been made in defining the patterns of Cattle Egret migration and habitat used by the birds during the breeding season and on migration;
- significant progress has been made towards solving the problem of defining migration of Great, Intermediate and Little Egrets;
- results of breeding success and relationships to rainfall for Cattle Egrets have been extended to a 13 year period and confirm earlier findings that Cattle Egrets can breed as successfully in dry seasons, even severe drought periods, as in wet seasons;
- a start has been made on comparing the behaviour of egrets breeding in inland colonies with that of birds in coastal colonies - this work will be of particular importance because of the pressure of the drought cycle and competition for water with irrigation requirements on the inland colonies;
- fourteen publications have been published in scientific journals, a further two have been accepted for publication, four others are in preparation, a paper was presented to the Southern African Ornithological Society thematic symposium on Migration, Dispersal and Nomadism at Langebaan, South Africa in September 1993 and three posters presented at the International Ornithological Congress in Vienna in August 1994;
- a serious decline in the number of breeding pairs of Great, Intermediate and Little Egrets in coastal breeding colonies has been identified since 1989 and it is imperative that the research be continued to identify whether this trend is due to the climatic cycle or is an indication of serious environmental problems;
- a paper on the migration of Cattle Egrets presented to the Southern African Ornithological Society thematic symposium on Migration, Dispersal and Nomadism at Langebaan, South Africa in September 1993 received high acclaim from an international audience;
- the Chief Investigator was chosen by the International Waterfowl Research Bureau's Heron Specialist Group to prepare the chapter on the herons of Australasia as a member of a 19 person international team preparing a new definitive manual on world-wide research on the conservation and status of herons.
- continual interaction between the egret research and the Wetlands Centre's education programs has occurred throughout the study. Educational resource material developed include a schools newsletter, handbook and bulletins, an egret kit and an interactive computer program. Extensive community feedback has been achieved through a newsletter and use of the media.

INTRODUCTION

The Grant was for a three year period September 1991 - September 1994 and was used to finance research coordinated by the Shortland Wetlands Centre into the breeding biology, ecology and migration of waterbirds with emphasis on egrets. The main aim of the project was to identify ecological factors affecting long term survival of the species to provide a data base for management and conservation decisions concerning habitat and species. A subsidiary aim was to use the outcomes to develop educational materials for schools and the general community.

The main focus of the work has been at the breeding colonies of Shortland and Seaham in the Hunter Valley. Other colonies in coastal NSW, inland NSW, Queensland and Victoria have been involved with the assistance of a team of banders and volunteer assistants. It was planned to extend the work on pelicans during the life of the project, but unfortunately the breeding of pelicans at Wallis Lake was seriously disrupted by factors external to the project and the pelican project has been held in abeyance pending resumption of breeding.

The Shortland Wetlands Centre extends its sincere thanks to the Environmental Trust for its support. Without the assistance provided by the grant the significant achievements made by the project during the three years would not have been possible.

The fundamental work achieved under the grant assistance also provided the foundations for two complementary studies funded by the ARGC Small Grant Scheme - the relationship between Cattle Egret migration and meteorological conditions and a satellite tracking project.

OBJECTIVES

The Project is an investigation of the breeding biology, ecology and migration of egrets. The results are disseminated through publications in the ornithological literature and by being fed into the Shortland Wetlands Centre's formal, non formal and informal mechanisms for community education.

The Project has gradually expanded to also include herons, ibis and spoonbills nesting in association with egrets. An extensive data set has been obtained for birds from breeding colonies in coastal northern NSW and southern Queensland. With an expansion to breeding colonies at the Macquarie Marshes, by collaborator G. Cam in 1993/94, data is being gathered to compare the coastal data with that obtained from inland breeding colonies.

Cattle Egrets provide the bulk of the data obtained to date. Over 20 000 sightings of patagial tagged have been reported from the breeding colonies, the foraging sites surrounding these colonies and wintering sites. This has enabled a clear picture to be obtained of the pattern of migration of this species. Details of the breeding biology has also been obtained from observations of individually marked birds. In the case of tagged individuals nesting attempts can to be identified once a nest site is selected and thus provide much finer detail on breeding ecology.

METHODS

Patagial tagging of egrets took place at 12 breeding colonies by five banders in 1993-94: Shortland and Seaham, near Newcastle, by M.N. Maddock; Boambee, near Coffs Harbour, by S.G. Lane; Junction Hill and Lawrence, near Grafton, by D.J. Geering; Ballina and Murwillumbah by J. Willows; Skyring Creek, near Gympie, by D.J. Geering; Ten Mile Lane and Bullyard, near Bundaberg, by D.J. Geering; as well as Bora Channel and Wilgara/Sandy Camp, in the Macquarie Marshes, by G. Cam and C. Ireland.

In 1989-90 and 1990-91 Cattle Egrets were also tagged at Bracken Ridge by R. Sonnenburg and Great Egrets were tagged from 1990-91 to 1992-93 at Dowds Morrass, in Victoria's Gippsland, by J. Reside and P. Lawrence.

The tags are made of flag pennant cloth, which is both light weight and tough. Egrets at four breeding colonies are marked with tags comprising two colours while the remaining eight colonies utilise a single colour. Different species are allocated different colours to enable sightings from non-expert observers to be interpreted. Where two colours are used the upper colour identifies the colony while the bottom colour indicates the species. The tags also carry coding that further identifies the colony, year of tagging and the individual bird. Care has been taken to devise a system that minimises confusion between colonies and seasons, for example the placement of the year code in different positions readily separates tagged birds from other similarly marked colonies.

Banding and colour marking is almost exclusively of nestlings, ideally of three to five weeks of age but occasionally birds up to the point of fledging are caught by hand for tagging. Records of tag sightings are maintained for tagged nestlings within the colony and, later, juveniles and adults by the principal researchers and a network of approximately 200 volunteer observers throughout south-eastern Australia and New Zealand. Observations of tagged egrets are also received from members of the broader community each autumn and winter, often as a direct result of appeals through local radio and newspapers in areas in which egrets winter. Primary schools at Lawrence, Boambee, and Seaham in NSW and Elliminyt in Victoria have also been involved in the Project, monitoring breeding colonies or the number of egrets in their district as well as reporting tagged birds.

Breeding biology has been studied by detailed observations at least twice per week of nests of tagged and non-tagged birds at the Seaham breeding colony to determine fledging success. Nest contents were counted until fledging was complete.

EDUCATION

There has been continuous interaction between the formal scientific research program and the education program of the Shortland Wetlands Centre throughout the grant period. School pupils and their parents and university students, as well as other members of the community have acted as volunteers in the tagging process, as well as in the field observations. All have received continuous feedback as part of the educational process. In addition, feedback has been

provided to the community at large through a number of avenues.

A Project Egret Watch Activity Group was formed at Seaham Public School. The group assisted with tagging, recorded presence of tagged birds in the district and met regularly at lunch times. The Chief Investigator and Project Officer made regular visits to the school to service the group. Similar groups were formed at Lawrence Public School near Grafton and Boambee Public School near Coffs Harbour. Students at these schools assisted with tagging and reporting tagged birds but were not able to be personally serviced to the same extent as Seaham Public School. Ellimynit Public School near Colac, Victoria was also involved in recording the number of egrets wintering in their area. All schools were involved in an "Adopt an Egret" project. Students were provided with all sightings of their particular tagged Cattle Egret and so were able to monitor individual migrations. All students involved in the project received a regular newsletter directly relating to the school egret project.

The Hunter Wetlands Trust newsletter *The Wetlander*, published quarterly included a report on the project each issue during the period of the grant (examples attached). Three Newcastle Herald articles and a number of press items in country newspapers (examples attached), several interviews on rural and urban radio programs (eg. ABC rural programs, Australia Allover, ABC Sunday Show) and TV interviews on NBN3, NRTV and Prime Television have provided informal feedback to the general community.

Educational materials resulting from the project:

- a newsletter for participating schools;
- an "Egret Kit" for schools;
- activity sheets for Seaham Public School developed by the staff of the school;
- a model of Seaham Swamp Nature Reserve and its egret colony developed by pupils of the Seaham school;
- an interactive computer software package (Windows on Wetlands), developed by Chris Prietto, Greg Preston, Keith Davey and Max Maddock, which included sections and videoclips from the egret research (now in wide use by schools);
- a revised handbook for field participants which was also used to service requests for information on the project from students and the general public;
- a summary information bulletin which is given to all volunteers and is used as a handout in response to the many requests by school and university students doing projects on the egret research.

Slide sets developed have been used in invited lectures on the research methodology outcomes given to the Bachelor of Applied Science (Environmental Assessment and Management) courses at the University of Newcastle, plus numerous presentations to bird clubs and service clubs.

ADMINISTRATION

The overall administration of the Project was the responsibility of the Chief Investigator. Upon receipt of the Grant in September 1991 the position of Project Officer was advertised and the position was filled in early January 1992. The Project Officer has been responsible for the day to day administration of the project. This included the recruitment and co-ordination of the network of over 200 volunteer observers as well as the team of banders. Consolidation of the volunteer observer network has greatly increased the quality of data obtained from sites that could not be adequately covered otherwise. The number of breeding colonies where nestlings are being wing tagged has been gradually increased to 12 in 1993-94, broadening the base of the study.

Administrative support was provided by Shortland Wetlands Centre while an IBM database for the Projects banding data and tag sightings, of which almost 25 000 have been reported, has been developed by Mr Richard Dear of the University of Newcastle's Geography Department.

At the due date of completion of the grant period a total of \$13631.64 will be unexpended. This is due to the Project Officer being placed on temporary secondment to another project administered by the Royal Australasian Ornithologists Union. Upon completion of that project the Project Officer will resume duties on the waterbird project. This has several advantages, the primary one to the waterbird project being that the project life will be extended into another winter migration period thus further consolidating the data collected to date.

RESULTS/DISCUSSION

As indicated above the basic aims of providing baseline data on breeding behaviour, nesting success, habitat usage and movement patterns have been achieved. Much of this information has been published in various refereed journals (see publication list).

CATTLE EGRET

Breeding colonies

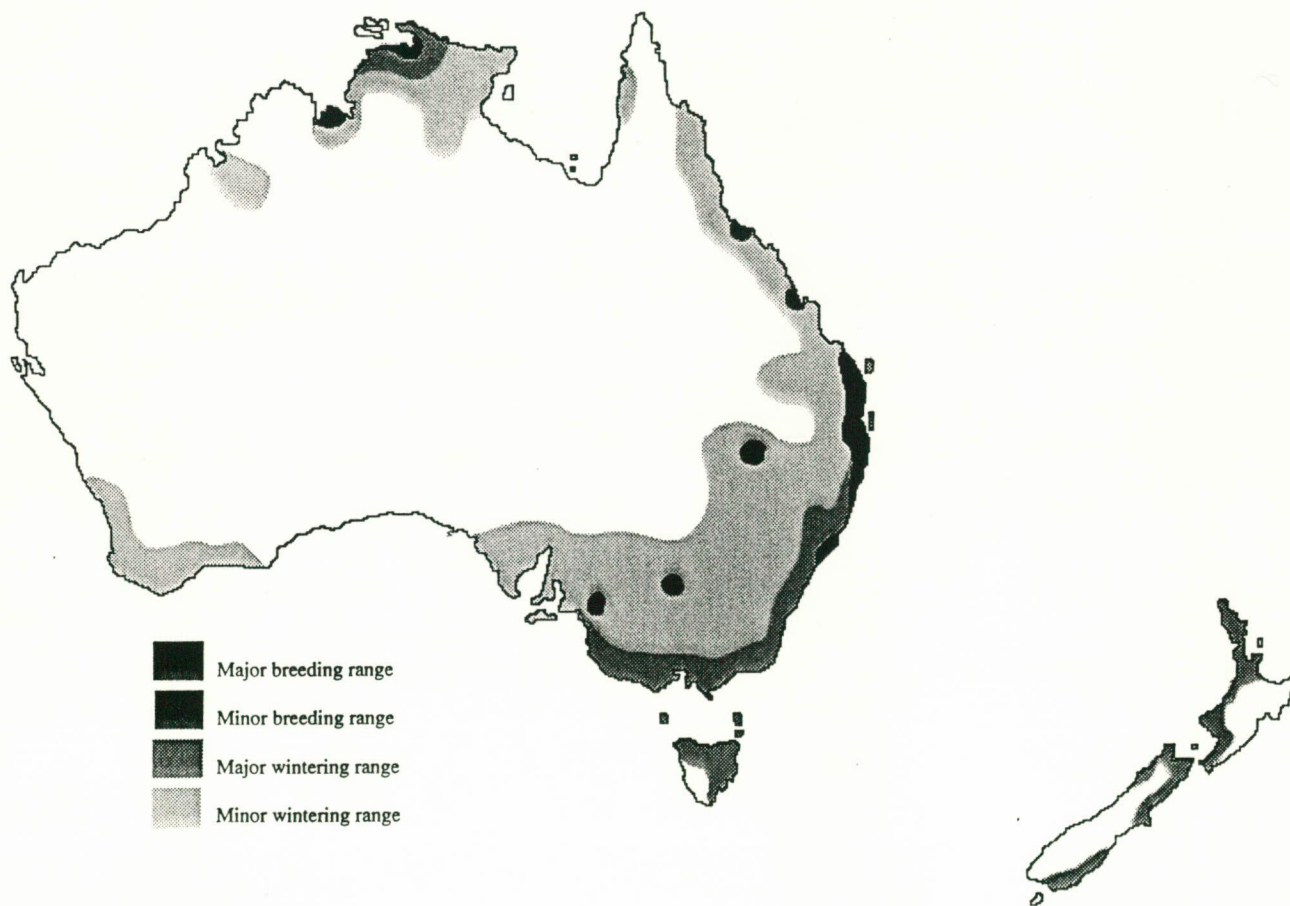
At present Cattle Egret breeding colonies essentially occur in two major areas in Australia (Figure 1). In northern Australia colonies are found in the Top End of the Northern Territory east of Darwin and in the Wyndham-Kununurra area of the eastern Kimberly region of Western Australia. In eastern Australia a series of colonies occur from Bundaberg, Queensland to the New South Wales central coast with one or two colonies on most of the major coastal floodplains. Isolated, minor colonies also occur elsewhere in coastal central Queensland and in the inland of New South Wales, principally in the Macquarie Marshes, the Lachlan and Murrumbidgee confluence wetlands and the Murray River. Nesting has also been reported in South Australia's Lakes Albert-Alexandria. These inland colonies usually consist of only a few pairs nesting with other egret species.

Due to the remoteness of the north Australian colonies little is known of these other than what has been ascertained from aerial surveys during other studies (R. Chatto pers. comm.). In contrast the east coast colonies are well known with most colonies being visited regularly at

some stage, generally for the purpose of banding nestlings. Greg Baxter visited and described all known egret colonies on the New South Wales coast during work on a Ph D. thesis (Baxter 1992). At present seven of the 13 New South Wales coastal colonies containing Cattle Egrets are visited to patagial tag nestlings while the remaining colonies are regularly monitored. During the 1992-93 breeding season approximately 14 750 pairs of Cattle Egrets nested in the New South Wales coastal breeding colonies.

At least a further ten colonies, supporting an estimated 20 000 pairs, occur in southern Queensland. Nestlings in three of these colonies are being patagial tagged. Patagial tagging and/or colour banding also took place at a further six colonies during the early to mid 1980s.

FIGURE 1: Breeding range and distribution of the Cattle Egret in Australia and New Zealand



Post-nesting dispersal

This study found that, as for other bird species, Cattle Egrets of all ages undertake considerable movement from the birth site soon after fledging. Immediately following fledging many adult and juveniles dispersed throughout the feeding areas surrounding the breeding colony forming night roosts and establishing foraging home ranges at sites that are generally re-used each year in a post-nesting local dispersive migration.

Some moved around these feeding areas in an apparently random manner, being seen in a number night roosts over a relatively short period. However, tag sightings indicate that some Cattle Egrets, including juveniles, disperse far more widely, undertaking post-nesting extended migration soon after fledging.

Timing of migration

The breeding season in the study area usually lasts from late October to mid February. Some tagged adults and some juveniles depart the colony area very soon after fledging and travel long distances before nesting has finished. In the 1990-91 breeding season nesting finished at Shortland in the second week of February, but many birds had left the colony area well before that. The following examples illustrate these early movements:

- Seaham 394 fledged on 3 February 1991, was found dead near Taree (115 km north) in late February;
- Seaham 352 fledged on 21 January 1991, was not found in the Hunter after that date, but was seen alive near Kempsey (215 km north) on 26 February;
- Seaham 418 fledged on 16 February 1991, was killed by a vehicle near Kempsey (215 km north) on 13 March;
- Junction Hill 205 was seen alive at Raymond Terrace (370 km south) on 11 February 1991 some 2 - 3 weeks after its estimated time of fledging;
- Lawrence 361, fledged on or about 25 January 1990, was at Seaham (374 km south) on 2 March.

A number of birds remain, however, using roosts near the natal colony for some time before undertaking any extended migration. Table 1 shows the number of tagged adult and juvenile Cattle Egrets sighted around the Hunter Valley colonies once nesting was completed in 1993.

The timing of this post-nesting extended migration not only varied between birds but also between years. For example, in 1990 and 1991, first year birds from the northern New South Wales breeding colonies began arriving in the Hunter region in mid February, whereas in 1989 and 1992, the first arrivals were in late March-early April. The same pattern was evident for the movement of young birds from the Seaham and Shortland colonies. Annual variation in these movement dates was also evident in individual birds.

Early in the 1991 autumn migration a chronological progression of first sightings of Cattle Egrets was evident up to 9 March at which time the birds arrived at Coolart, Victoria. After this date the birds began to appear throughout Victoria, in South Australia, Tasmania and New

TABLE 1: Number of tagged Cattle Egrets sighted in the Hunter Valley after completion of nesting, 1993

Month	No. Adults	No. Juveniles
March	17	59
April	16	29
May	8	3
June	2	3

Zealand at about the same time. A similar trend was also evident for the arrival dates of tagged birds in the wintering, or staging, areas and has been duplicated in subsequent autumn migrations. The picture is confused somewhat by the arrival of small numbers of birds undertaking migratory movements very soon after nesting is completed and before the major movement of birds from the breeding areas. Cattle Egrets appear to arrive at some, distant, locations earlier than sites closer to the breeding areas suggesting that the migration consists of a series of moderate, rather than short, distance stages.

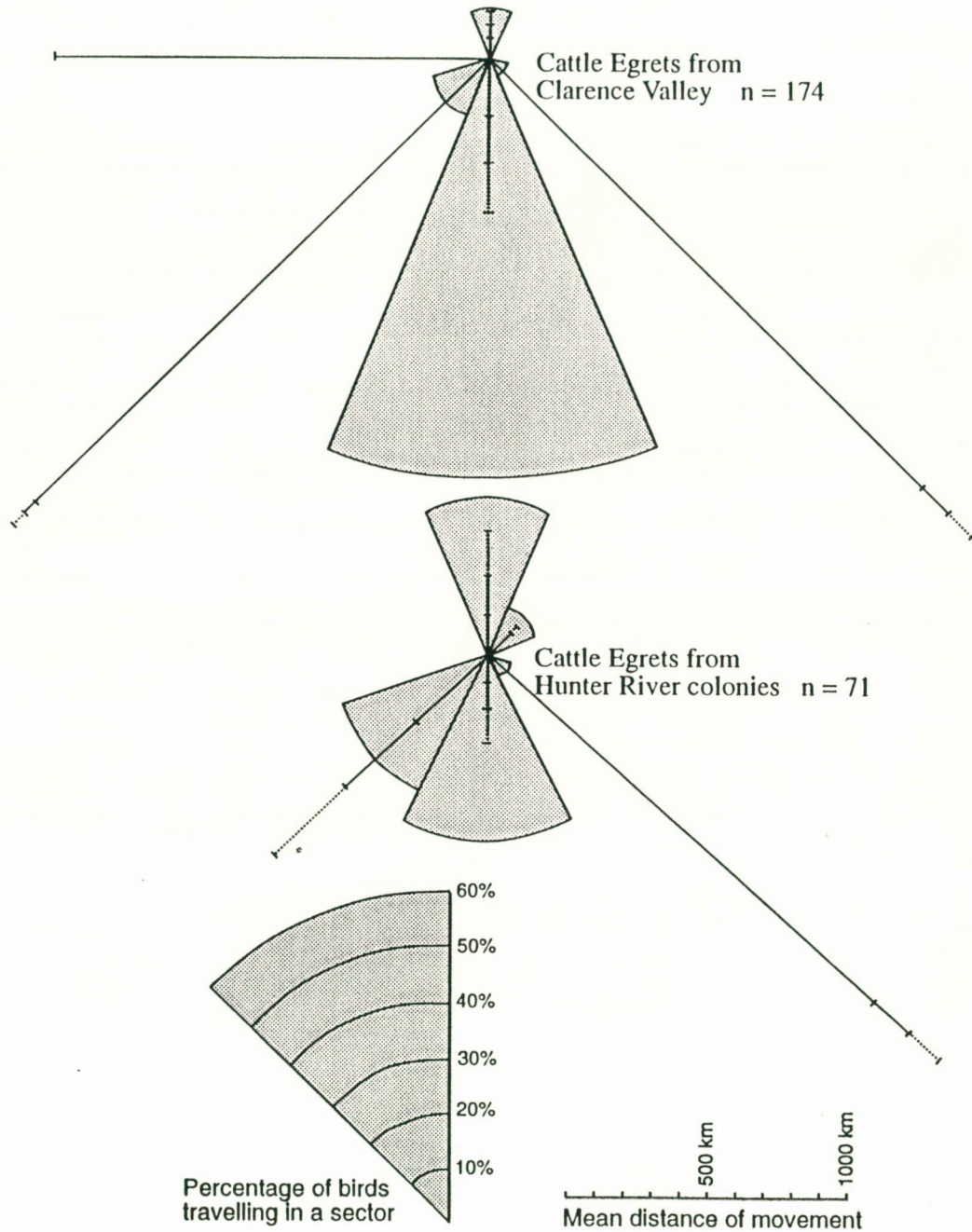
Wintering range and migration

During the autumn, winter and spring months Cattle Egrets may be found throughout the known breeding areas, as well as in the south-west of Western Australia and in south-eastern Australia including the south coast of New South Wales, Victoria, south-west South Australia, Tasmania and New Zealand (Figure 1). Although considered vagrants they are also reported annually from Lord Howe and Norfolk Islands.

Reports of metal banded, colour banded and patagial tagged birds have enabled the construction of a clear picture of the migration of Cattle Egrets in south-eastern Australia. Birds originating from the southern Queensland/northern New South Wales breeding colonies are generally involved in a strong southerly movement during the autumn to all areas of south-eastern Australia and New Zealand.

Figure 2 shows the percentage of birds moving in each 45 degree sector for birds undertaking post-nesting extended migration from the Hunter and Clarence Valley colonies along with the mean distance travelled in that direction. The pattern of this type of migration from the two Clarence Valley colonies, constructed from the movements of 174 birds, shows a distinct southward movement. This form of migration from the Hunter Valley colonies, compiled from the movements of 72 birds, differs somewhat from the pattern of the northern colonies with 36% of birds involved in northward (includes north-east) movements compared with 9% northward movements for the Clarence birds. The mean distance of southward (includes south-

FIGURE 2: Direction ratio of post nesting extended migration of Cattle Egrets from Clarence Valley and Hunter Valley breeding colonies, and mean and SD moved in each sector: radius indicates % of birds with destination within this compass range; length of the line indicates mean distance, and SD, from colony to point of destination.



east, south-west and west) movement, 540 km for Hunter birds and 554 km for Clarence birds, was greater than for birds moving north, 248 km for Hunter birds and 123 km for Clarence birds. The distance represents a translocation measured in a straight line from the natal colony to the last reported sighting on the outward migration and gives no indication of the distance or track of the actual flight path undertaken.

As relatively few of these marked birds were determined to be actually at their ultimate wintering site these distances must be considered as under-estimates of the translocation, as they may have been at a staging point. The distances reported here are considerably less than those reported by Maddock & Geering (1993) for 109 birds from the Clarence colonies, 615 km south and 137 north, and 48 Hunter birds, 629 km south and 256 km north. This has been largely due to an increase in reported sightings of staging birds at locations, such as the New South Wales mid-north coast, only several hundred kilometres from the colony sites.

Just as there are variations in the the direction of movement, individual birds showed striking differences in the distance of such migrations (Table 2). Marked birds have been recorded undertaking a local migration to a permanent winter roost of only 0.75 km up to extended movements in excess of 2 500 km.

No marked bird in the study has undertaken zero migration by continuing to use its natal colony site as a home range base during its entire lifetime. The closest to zero migration occurred in the case of two Shortland birds which used a permanent winter roost 0.75 km east of the colony site for two years and foraged in the same local feeding sites used by birds at the colony during the nesting season. This roost was also used by fluctuating numbers of visiting migrants from northern colonies, identified by patagial tags and colour bands.

The number of tagged birds located in the vicinity of the colonies drops significantly soon after the end of the breeding season and by June, very few are left. In the years 1990 - 1993, only 4% (N 128), 1% (N 171), 2% (N 143) and 3% (N 156) of all tagged birds (newly tagged fledglings and adults) known to be present at Seaham at the end of the breeding season were present at winter roosts within 10 km of the Seaham colony.

With the exception of an occasional small flock at several scattered inland locations such as Canberra (ACT), Cooma, Goulburn, Dubbo, Tamworth and Glen Innes (New South Wales), almost all reports of Cattle Egrets on migration or wintering were on the coastal plain. The presence of a patagial tagged bird of uncertain origin at Bungendore, near Canberra, and the recovery near Wodonga (Victoria) in July 1993 of a bird tagged at Shortland the previous February suggests that these birds may originate largely from coastal breeding colonies rather than the small inland colonies that are occasionally set up in conjunction with other egret species.

Staging

Repeated sightings of tagged birds and the pattern of arrival and departures indicate that flocks

TABLE 2: Examples illustrating range of distances to wintering sites

Tag	Wintering Site	Distance from Natal Colony	Winters at Site
Post-nesting local dispersive migration			
Shortland 036	Shortland	0.75 km east	1st, 2nd
Junction Hill 087	near Grafton	4 km south-east	1st, 2nd, 3rd, 4th
Seaham 104	near Maitland	10 km south-west	3rd, 4th
Shortland 198	near Maitland	15 km north-west	1st, 2nd, 3rd, 4th, 5th
Post-nesting extended migration			
Seaham 250	Gloucester	70 km north	1st, 2nd, 3rd, 4th
Seaham 216	Ourimbah	85 km south	1st, 2nd, 3rd, 4th
Lawrence 224	near Kempsey	175 km south	2nd, 5th
Junction Hill 191	near Maitland	370 km south	1st, 2nd
Lawrence 490	Wyong	450 km south	1st, 2nd, 3rd
Lawrence 006	Windsor	525 km south	2nd, 3rd,
Shortland 027	Sale, Vic.	720 km south	1st, 3rd
Lawrence 142	Bairnsdale, Vic.	1056 km south-west	1st, 2nd, 3rd, 4th
Shortland 080	Lake Elesmere, N.Z.	2180 south-east	1st, 2nd

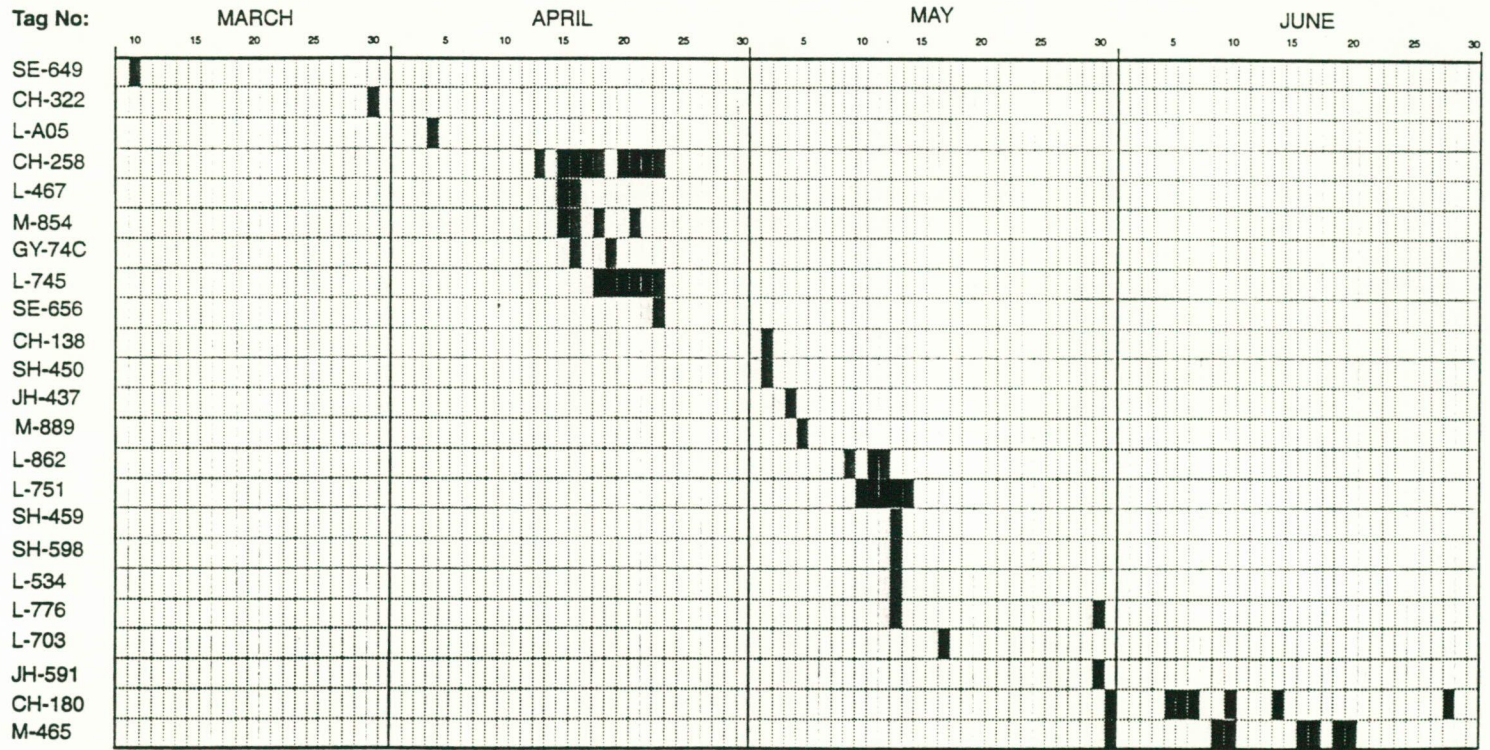
of Cattle Egrets moving south along the east coast in the autumn outward migration do so in stages. A distinct pattern of Cattle Egrets flocks appearing and subsequently disappearing has been identified along a regular road transect in the Lower Hunter Valley. These flocks have been identified, by the presence of patagial tagged birds, as originating from more northern breeding colonies. The regular increase and decline in numbers observed indicate that the birds comprising these flocks stage for relatively short periods.

A particularly intensive effort to locate tagged birds by observers in the Shoalhaven River Valley, on the New South Wales south coast, meant that the arrival and duration of stay of patagial tagged birds in this region was able to be closely monitored during the autumn migration of 1993. The first tagged bird was sighted on 10 March and from this day until 31 June 23 tagged birds were reported (Figure 3). However, only three birds were to winter in the area, the remaining 20 birds staging before moving on. Thirteen of these were reported on one day only, six for two to seven days and one bird for eleven days. From 13 to 23 April migration appeared to be halted with tagged birds being reported for longer periods. On 12 and 13 April the prevailing north-westerly winds around the back-side of a high pressure system would have assisted the arrival of migrating flocks, including those containing patagial tagged birds, in the area. On 14 April the passage of a cold front apparently halted migration and this was not resumed until 23 April when winds were again northerly on the back-side of a high pressure system. The domination of a high pressure system, with only light variable winds, over the area may not have provided sufficient stimuli, or assistance, for migration to

FIGURE 3: Pattern of sightings of patagial tagged Cattle Egrets in the Shoalhaven Valley, autumn 1993.

KEY:

- SH = Shortland
- SE = Seaham
- CH = Boambee
- L = Lawrence
- GY = Gympie
- JH = Junction Hill
- M = Murwillumbah



recommence prior to 23 April.

Tagged birds were first reported in the Shoalhaven on 10 March, the day after the first flock of Cattle Egrets were sighted in the valley. The peak of the migration, based on sightings of new tagged birds was from mid April to mid May with no new tagged bird sighted after 30 May. The two birds that were repeatedly sighted from this time were wintering in the area rather than staging. A similar pattern involving 100 sightings of 48 individuals was recorded in the Shoalhaven during the autumn of 1994.

In the lower Hunter Valley many tagged birds from the Clarence Valley colonies were seen only once or for a week at most. Of 38 birds seen during the general southward migration 27 were seen for less than a week, 7 for less than a month and 4 for 1 - 2 months. As some of these birds were subsequently located back at their natal colonies in the next breeding season it is assumed that they were staging before moving further south.

Staging has been further confirmed by repeated sightings of tagged birds along migration routes:

- In 1990 Lawrence 036 was seen near Maitland (380 km south) on 6 April and at Wyong (63 km further south), where it spent the previous winter, the next day. It remained at this location until 4 May;
- Seaham 215, was at Lawrence (375 km north) on 29 January 1990 and at Mullumbimby (100 km further north) on 6 June;
- Junction Hill 205 was seen at Raymond Terrace (370 km south) on 11 February 1990 and again at Nowra (250 km further south) on 22 March;
- Ballina 674 was seen at Raymond Terrace (460 km south-west) on 13 March 1990 and at Nowra (250 km further south) on 2 April;
- Ballina 691 was seen at Nowra (710 km south-west) on 27 April 1990 and then at Scottsdale, Tasmania (750 km further south-west) on 17 November;
- Seaham 656 was seen at Wauchope (180 km north) on 15 March 1993 and then at Nowra (435 km south-west of there) on 23 April. This bird was reported at Nowra on only one day before again moving on.

Staging has also been identified on the return migration. 18 tagged birds from more northern colonies have been reported at breeding colonies in the Hunter Valley en route to their natal colonies during the return migration. Three examples of staging on the spring migration are:

- Junction Hill 011 was at Shoalhaven Heads on 10 November 1991, at the Seaham breeding colony (260 km north) on 13 November and finally at its natal colony (360 km further north) on 3 December;
- Junction Hill 226 was at Nowra on 30 November 1991, at the Seaham breeding colony (260 km north) on 13 December and then near its natal colony (365 km further north) on 13 January;
- Lawrence 006 wintered near Windsor, was at the Seaham breeding colony (135 km north-east) on 11 November 1991 and then seen at its nest at Junction Hill (360 km

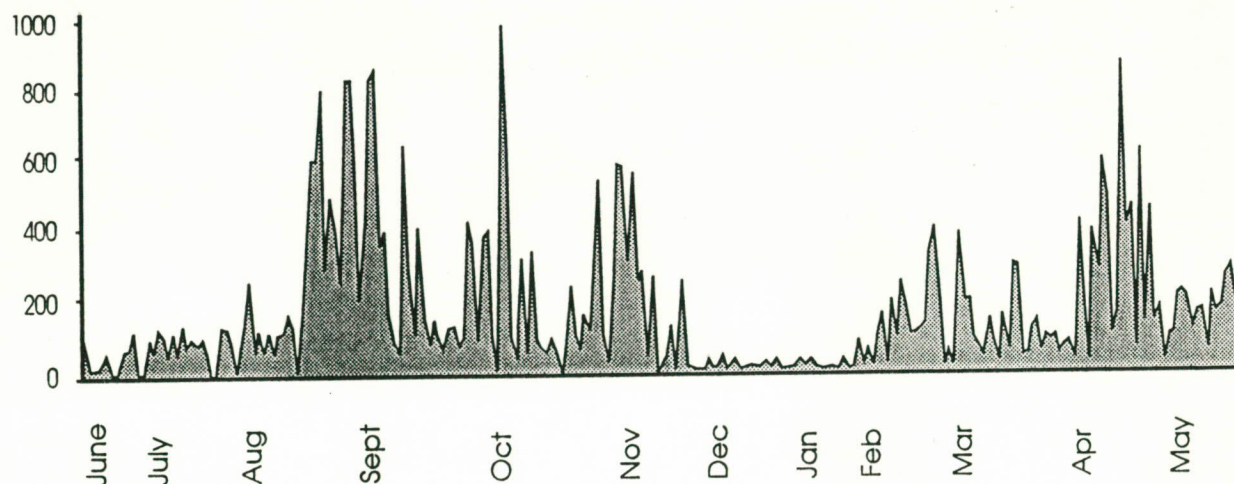
further north and 30 km south-west of its natal colony) on 23 November.

When Lawrence 006 was located at the breeding colony it had already acquired a mate and passed through its magenta courtship phase. The mean time for which this magenta is held is 15 days. It had, therefore, taken considerably less than the ten days between these sightings to travel the 360 km of the last leg of its journey. Certainly, Junction Hill 011 took two days, or less, to travel 250 km.

Travelling flocks

Cattle Egret migration typically occurs in flocks although single travelling birds have been identified. Travelling flocks numbering up to about 700 birds have regularly been identified at closely monitored observation centres. For example, Figure 4 clearly shows the pattern of arrival and disappearance of such flocks in the lower Hunter Valley determined previously. The origin and composition of such flocks can only be determined by the presence of marked birds. During the total duration of this study it was not unusual to find several tagged birds from different colonies within the same migrating flock (Figure 3 provides several examples) indicating that mixing of populations occurs on migration. Feeding flocks at winter foraging sites have also contained birds from two to four colonies.

FIGURE 4: Number of Cattle Egrets counted along the Glenoak-Raymond Terrace road transect between the end of May 1987 and the end of May 1988 (after Maddock 1990).



The evidence to date suggests that flocking is unrelated to sibling relationship. Of 33 cases of patagial tagged birds with known siblings, no sibling was located in the same foraging area, either within the local dispersal area or at distant locations. In another eleven cases, two siblings were located at foraging areas on different migration routes. In the most extreme of these Seaham 215 spent its first year at Jamberoo (250 km south) and its second at Murwillumbah (500 km north-east), while its sibling Seaham 216 spent three winters in a row at Ourimbah (85 km south).

Out-and-return migration

There have been 61 recorded cases of marked birds making at least one out-and-return extended movement between the breeding colony area and a known wintering place well beyond the natal colony area and 14 cases of similar local migration. Of these 36 are known to have returned to the same wintering place for two or more years (see Table 2 for examples).

Two birds have been reported returning from different locations in each of two years:

- Seaham 215 was reported from Jamberoo (250 km south) in 1989 and at Mullumbimby (500 km north-east) in 1990;
- Lawrence 167 was at Edithvale, Victoria (1 200 km south-west) in 1989 and Portland, Victoria (1 445 km south-west) in 1990.

It is possible that the latter bird may have moved on to Portland in 1989 although no sighting was reported nor was it seen at Edithvale in 1990.

Migration to New Zealand

Cattle Egrets generally arrive in New Zealand in April-May and depart October-November with a few remaining over the summer although they do not breed there. The number of birds wintering in New Zealand steadily increased from their first appearance in 1963 to 1980. Since 1980 numbers wintering each year have varied, at times substantially. There is circumstantial evidence that such fluctuations are linked with autumn weather patterns over the Tasman Sea. Weather patterns have been demonstrated to influence migration within Australia.

To date 11 Cattle Egrets banded or patagial tagged in New South Wales and southern Queensland colonies have been recovered or sighted in New Zealand. As yet no marked egrets seen in New Zealand have been seen back in Australia although the presence of only very small numbers during summer strongly suggest a return to Australia.

Cattle Egrets overshooting New Zealand and Tasmania have also been reported from subantarctic islands including Macquarie Island.

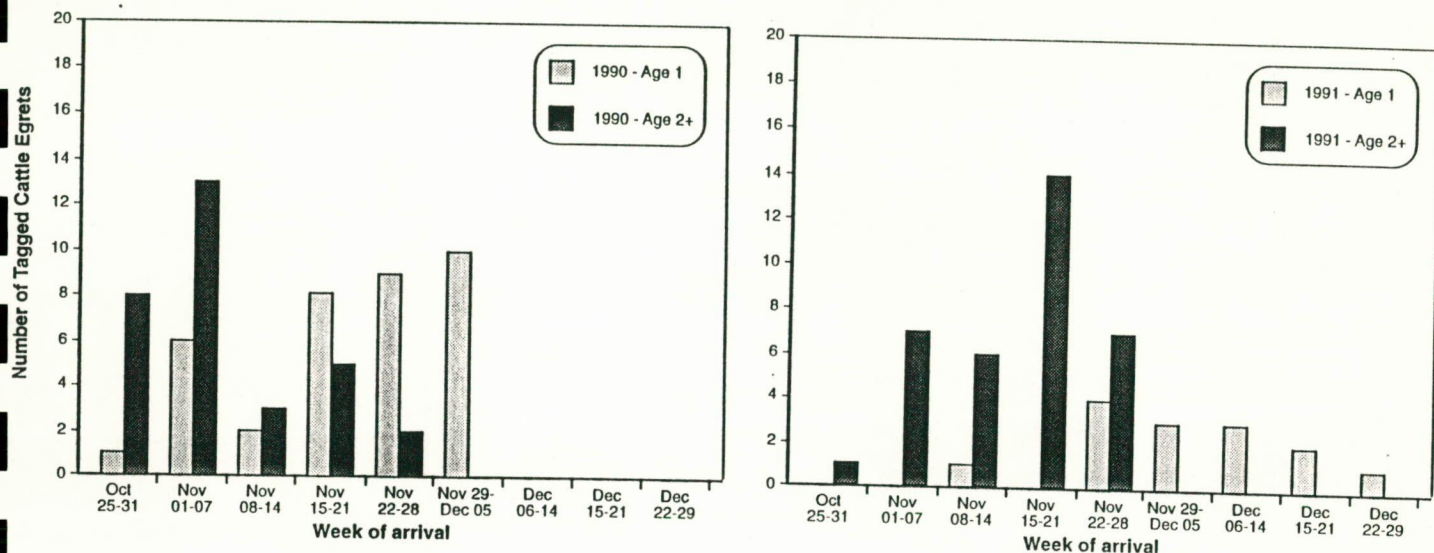
Return (spring) migration

Most Cattle Egrets in this study arrive back at the breeding colony during November, but significant variation occurs between individual birds. One local dispersal case from Seaham remained away from the natal colony site for only 108, 103, 59 and 103 days in its first to fourth year respectively, returning on 13 August, 11 July, 18 May and 6 June. In the 1991-92

breeding season the first tagged bird arrived back at Seaham on 29 October, the day before nesting commenced. Thereafter, birds arrived at intervals of a few days until 10 December. Similar patterns were recorded in previous and subsequent years (Figure 5).

First year birds generally arrive at the breeding colony later than older birds. In 1990 and 1991, for example, 75% and 93% respectively of year 1 birds arrived back at Seaham after 14 November, compared with 23% and 60% for older birds.

FIGURE 5: Return of patagial tagged Cattle Egrets to the Seaham breeding colony, 1990 and 1991.



Meteorological conditions aiding migration

Weather factors have been linked to timing, flight time and flight behaviour for migrating birds. For birds which move long distances, wind is a key factor. It influences energy expenditure, the ability to settle in a perceived destination and probably also survival. Three potential weather related pathways for outward southward migration in autumn have been identified (Figure 6):

1. using a northwest airflow ahead of a front, providing a direct following wind for egrets migrating to Victoria and Tasmania;
2. travelling around the northern boundary of a weakening low pressure system to New Zealand;
3. travelling to New Zealand via Tasmania utilising a similar weather system to No. 1 above to reach Tasmania and then moving onwards across the Tasman, probably after resting.

Two return pathways from wintering locations to the colonies in spring have also been identified (Figure 7):

1. utilising a southerly airflow ahead of an advancing high, or behind a cold front to travel from Tasmania and Victoria;
2. travelling westward along the northern edge of a high pressure system centred over New Zealand to return from that country.

FIGURE 6: Cattle Egret autumn migration pathways and meteorological conditions
a - to New Zealand from the breeding colonies around the northern boundary of a weakening low pressure system
b - from the breeding colonies to Tasmania around a high pressure system with some moving on to New Zealand, probably after resting

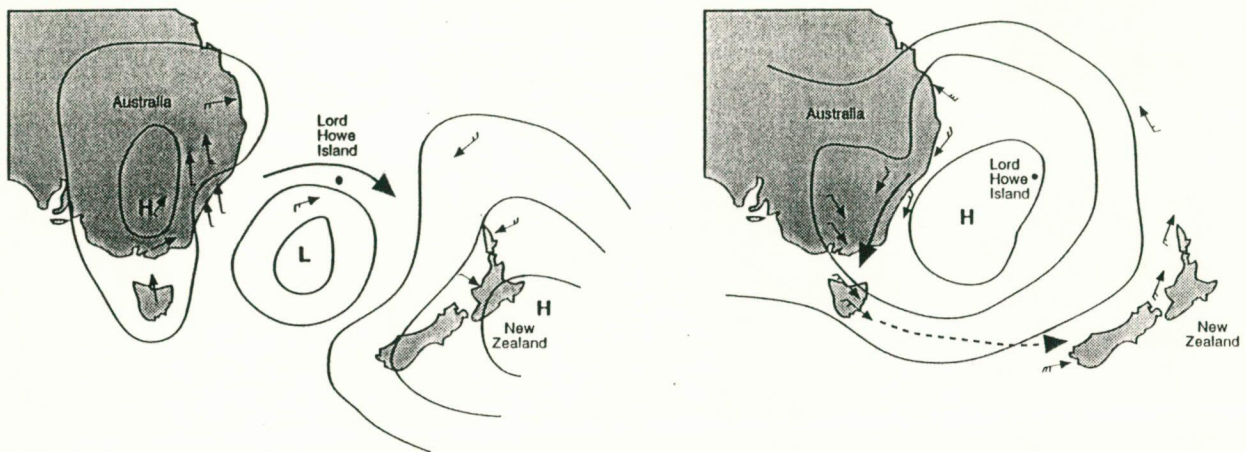
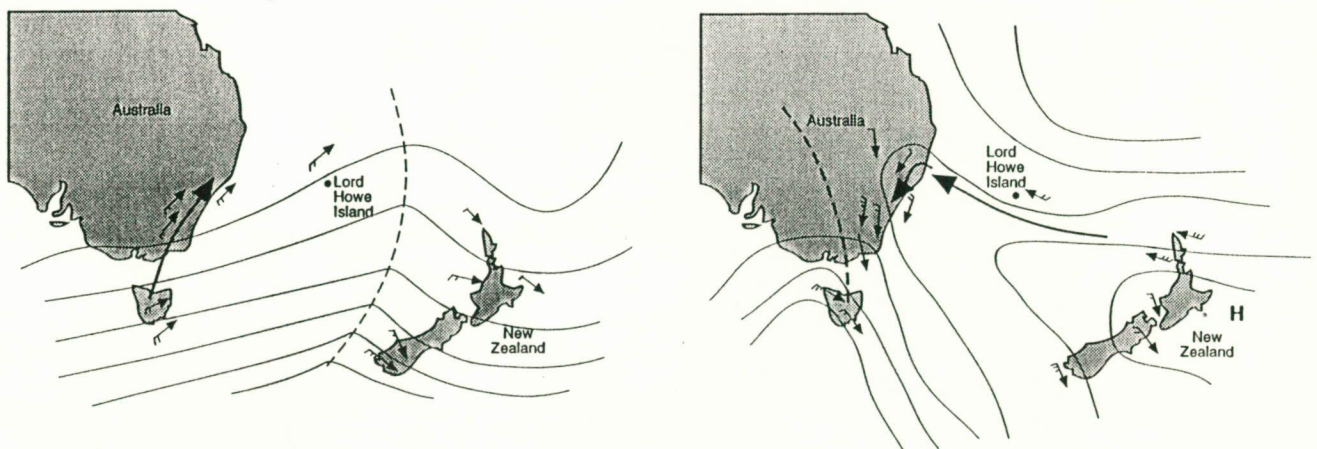


FIGURE 7: Cattle Egret spring migration pathways and meteorological conditions
a - to the breeding colonies from Tasmania in the southerly airflow ahead of an advancing high pressure system
b - to the breeding colonies from New Zealand along the northern edge of a high pressure system



Relationships between breeding colonies

The majority of tagged Cattle Egrets return to, and breed at, their natal colony although a few have been recorded nesting at a nearby colony, particularly should breeding not occur at the natal colony for some reason. Six tagged birds have, however, been reported breeding at distant colonies (Table 3).

Tagged egrets are commonly seen visiting colonies other than their own natal breeding colony on both the autumn and spring migration.

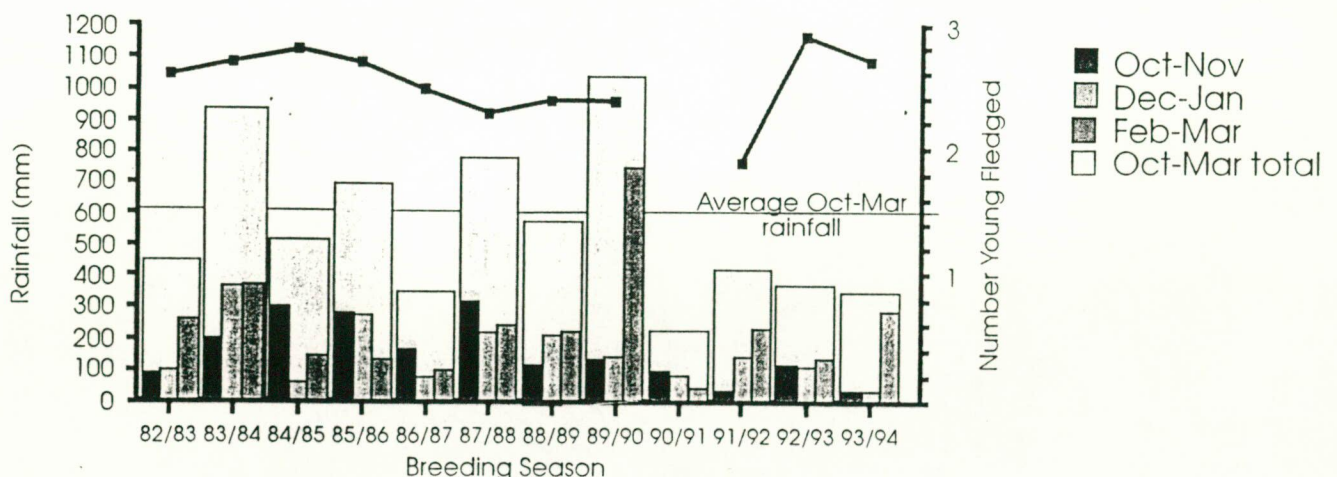
TABLE 3: Cattle Egrets recorded breeding at other than natal, or neighbouring, colony

Tag No.	Year Hatched	Colony where Nested	Year of Nesting	Distance from Natal Colony
Seaham 163	1987-88	Lawrence	1989-90	375 km N
Lawrence 036	1988-89	Shortland	1990-91	400 km S
Lawrence 055	1988-89	Shortland	1990-91	400 km S
Shortland 192	1988-89	Junction Hill	1991-92	375 km N
Lawrence 009	1988-89	Seaham	1991-92	375 km S
Lawrence 156	1988-89	Murwillumbah	1991-92	135 km N

Breeding Biology

Annual observations at Seaham on fledging success of Cattle Egrets (except for 1990-91 when the result sheet was lost in the field) has confirmed the findings of Maddock and Baxter (1991) that success in fledging young in Cattle Egrets is not dependent on breeding season rainfall (Figure 8) (non significant correlation -0.12). High breeding success occurred in dry seasons and the second lowest occurred in a wet season.

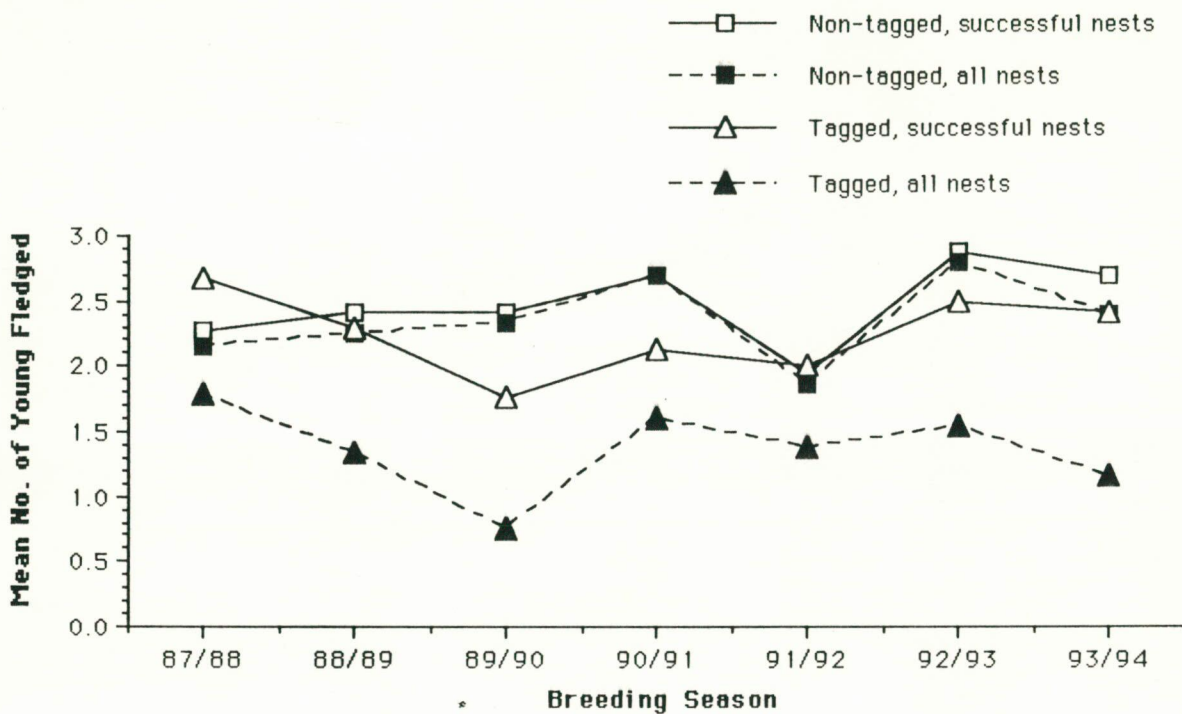
FIGURE 8: Cattle Egret breeding success and breeding season (Oct-Mar) rainfall 1982 - 1994



The ability of the species to breed successfully in both wet and dry seasons may in part account for the increase in the population since the beginning of its colonisation of Australia.

There was no significant difference in fledging success of untagged and tagged birds when only successful nests are taken into account. However, when all nesting attempts (defined as an attempt by a pair which results in nest building) are taken into account, success is significantly lower than figures obtained from both tagged and untagged birds for successful nests (Figure 9).

FIGURE 9: Comparison of tagged and non-tagged Cattle Egret breeding success for all attempts and successful nests only



These results have implications for determining the productivity of individual birds and of colonies over time. Tagging of individuals enables much more accurate data on nesting attempts than observations of unmarked birds. When unmarked birds are being studied, determination of success of all attempts is unreliable because nest sites are often taken over by new pairs before the end of the day in which a nest has been abandoned.

Colony output can be determined from the output of successful nests, the percentage of successful nests from all attempts, determined from studies of tagged birds, and the number of nests in the colony. The data is still to be analysed to estimate colony output at Seaham over time since tagging started in 1985.

Analysis of records of individual birds nesting at Seaham over their lifetime to determine productivity of individual birds is still to be completed.

Implications for Conservation Management

The results gathered by this project, linked with an analysis of the literature on the species in Australia indicates that the Cattle Egret is in a strong position, with an expanding population. The number of breeding pairs in coastal NSW colonies grew by 140% between 1989 and 1993. Although some foraging sites on the migration routes have been lost, there is currently no threat of significant loss of either roosting or foraging habitat.

Major sites for winter roosts and locations of staging habitat along the migration routes have been identified, with a sound data base on usage for action should any threats arise.

The situation in the breeding colonies is less clear. A member of the Project Egret Watch team, Baxter (1992) studied habitat requirements for colony use and concluded that nutrients from colonies and tree destruction are threats to long-term colony viability. The Lawrence and Junction Hill colonies have been active for 24 years, the Seaham colony for 16 years and the Shortland colony for 14 years. Baxter (1992) suggested that most the the NSW colonies had a future life expectancy of less than 10 years and recommended management strategies.

There have been problems in the Lawrence and Shortland colonies, with much reduced breeding in the very dry recent years. No breeding occurred at Lawrence in 1992-93 and it is uncertain whether this can be attributed to lack of water due to drought or to deterioration of environmental conditions favourable to breeding caused by as yet unidentifiable causes. Extensive breeding, however, occurred in 1993-94 during similar drought conditions while only limited breeding took place in 1994-95 during yet another drought summer. Management strategies are being developed at Shortland, including additional plantings of the favoured nest tree in the colony, *Melaleuca quinquenervia*.

Because breeding colonies are shared with the Great, Intermediate and Little Egrets, there are implications for the conservation status of these three species.

GREAT, INTERMEDIATE AND LITTLE EGRETS

Population and Breeding Colonies

The literature on population and breeding of these species in Australia is fragmentary. The Marchant and Higgins (1990) review of this literature suggests that the conservation status of these three species is strong, although the population of the Little Egret is small. A more detailed review of recent literature, linked with results from Project Egret Watch and information obtained from reliable informants on as yet unpublished data, indicates that the breeding populations of the species outside of the tropical north is not large (Maddock 1994) and that the most important of the colonies with the largest number of breeding pairs are in inland NSW, especially the Lachlan-Murrumbidgee and the Macquarie Marshes areas (Table 4).

There has been no nesting of egrets in the Gwydir colony since 1984 (J. Southeron pers. comm.) and the breeding habitat in both the Lachlan-Murrumbidgee (MacGrath 1992) and the

TABLE 4: Location and Size of Intermediate Egret Breeding Colonies in Victoria and New South Wales

No Breeding Pairs	Vic.	Inland NSW 1,2,3	Coastal NSW 4	Total	Percent of Colonies
1-10	0	2	5	7	23
11-50	0	2	1	3	10
51-100	0	2	1	3	10
101-1000	1	9	2	12	40
> 1000	0	5	0	5	17

1 Johnson (1994, pers. comm.)

2 Morris (1994, pers. comm.)

3 Magrath (1992)

4 Baxter (1982) and Project Egret Watch unpublished data

Macquarie Marshes has been deteriorating because of reduction of natural flooding due to water regulation (Kingsford and Thomas 1994, Johnson pers. comm.). The Macquarie Marshes are the only important breeding area for colonial waterbirds remaining in the Darling section of the Murray Darling system (Fullagar and Davey 1983).

Declines in the breeding populations of the Great, Intermediate and Little egrets since 1989 have been identified for the coastal NSW colonies. The situation in the Macquarie Marshes, listed as a Ramsar site under the Convention for Protection of Wetlands of National Importance, is critical, with a decline in Intermediates over much the same time period and no breeding at all in 1991-92 and 1992-93.

Post-nesting dispersal and timing of migration

Recovery data (Table 5) indicates that the movement of juveniles from the natal colony can occur very soon after fledging. This is particularly highlighted by the recovery of a Little Egret at Newlands, New Zealand, 2 months 11 days after banding at Red Bank Weir in NSW, a distance of 2440 km; Intermediate Egrets at Kurnell, NSW, 1 month 11 days after banding at Shortland, NSW, a distance of 133 km; at Belmore River, NSW, and Landsborough, Qld., both 2 months 3 days after banding at Lawrence, NSW, distances of 177 km and 300 km respectively and near Townsville, Qld, 3 months 1 day after banding in the Macquarie Marshes, NSW, a distance of 1262 km; and a Great Egret at Port Germain, SA, 2 months 1 day after banding at Narrung, SA, a distance of 297 km. This is similar to the rapid dispersal of Cattle Egrets reported above.

Limited data obtained from patagial tagged Great, Intermediate and Little Egrets tagged at the Shortland, Lawrence and Junction Hill breeding colonies indicate that many juveniles exhibit similar behaviour to Cattle Egrets, moving from the natal colony to forage and establish night roosts on the floodplain surrounding the natal colony. Tagged juveniles have been located in

Table 5: Long distance movements of Great, Intermediate and Little Egrets banded in Australia

Banding location	Band date	Finding location	Find date	Distance	Time elapsed	Source
Great Egret						
Gunbower Island (Vic)	19-01-61	Kiunga Oktedia R. (PNG)	05-10-62	3333 km N	1yr 8mth 16day	ABBBS
Narrung (SA)	29-01-63	Port Germein (SA)	30-03-63	304 km N	2mth 1day	ABBBS
Bool Lagoon (SA)	20-12-64	Menindee Lake (NSW)	00-09-71	553 km N	7yr 8mth	ABBBS
Bool Lagoon (SA)	20-12-64	Blanchetown (SA)	23-05-65	322 km NW	5mth 3day	ABBBS
Bool Lagoon (SA)	20-12-64	Gazette Penhurst (Vic)	30-06-65	158 km E	6mth 10day	ABBBS
Bool Lagoon (SA)	08-01-65	near Geelong (Vic)	10-04-65	337 km E	3mth 2day	ABBBS
Narrung (SA)	30-12-67	Mile End South (SA)	19-08-68	87 km W	7mth 20day	ABBBS
Dowds Morass (Vic)	1988/89	Mount Marthavic (Vic)	21-05-89	192 km W	6mths	ABBBS
Lawrence (NSW)	1988/89	near Casino (NSW)		63 km N		PEW
Shortland (NSW)	30-11-89	Gympie (Qld)	21-10-90	747 km N	10mth 21day	PEW
Lawrence (NSW)	20-12-89	Shorncliffe (Qld)	24-04-90	243 km N	4mth 4day	PEW
Lawrence (NSW)	26-12-89	Wards River (NSW)	12-05-90	320 km S	4mth 17day	PEW
		Seaham (NSW)	05-11-90	374 km S	10mth 10day	PEW
Ballajura Lakes (WA)	09-01-90	near Cuballingwa (WA)	20-04-90	158 km SE	3mth 11day	ABBBS
Junction Hill (NSW)	15-01-91	Innesplain (Qld)	00-07-91	163 km N	6mth	PEW
Shortland (NSW)	09-02-93	Wards River (NSW)	26-03-93	77 km N	1mth 14day	PEW
Shortland (NSW)	09-02-93	Armidale (NSW)	01-06-93	265 km N	3mth 23day	PEW
Shortland (NSW)	18-02-93	Merriwa (NSW)	22-06-93	150 km NW	4mth 4day	PEW
Shortland (NSW)	18-02-93	Berry (NSW)	19-05-93	230 km S	3mth 1day	PEW
Intermediate Egret						
Campbells Island (NSW)	04-01-75	Desa Mapur (IJ)	?	3990 km N	?	ABBBS
Booby Island (Qld)	28-03-88	Lake Murray (PNG)	02-11-89	401 km N	1yr 7mth 5day	ABBBS
Shortland (NSW)	28-11-88	Kurnell (NSW)	09-01-89	133 km S	1mth 11day	PEW
Lawrence (NSW)	03-02-89	Raymond Terrace (NSW)	05-03-90	382 km S	1yr 1mth 2day	PEW
		Shortland (NSW)	31-10-90	399 km S	1yr 8mth 28day	PEW
Lawrence (NSW)	20-02-89	14 km S Casino (NSW)	12-12-90	63 km N	9mth 8day	PEW
Shortland (NSW)	05-03-92	Muswellbrook (NSW)	18-04-92	78 km W	1mth 13day	PEW
Lawrence (NSW)	1991/92	Seaham (NSW)	16-04-92	374 km S	?	PEW
Lawrence (NSW)	26-02-92	South Rockhampton (Qld)	14-01-95	727 km NW	2yr 10mth 19day	PEW
Lawrence (NSW)	07-03-92	Dyers Crossing (NSW)	04-06-92	297 km S	2mth 28day	PEW
Lawrence (NSW)	07-03-92	Upper Belmore (NSW)	10-05-92	179 km S	2mth 3day	PEW
Lawrence (NSW)	07-03-92	near Sarina (Qld)	07-08-94	975 km NW	2yr 5mth	PEW
Lawrence (NSW)	07-03-92	Landsborough (Qld)	10-05-92	300 km N	2mth 3day	PEW
Lawrence (NSW)	07-03-92	Landsborough (Qld)	05-07-92	300 km N	3mth 28day	PEW
Lawrence (NSW)	10-03-92	near Mackay (Qld)	08-11-94		2yr 7mth 29day	PEW
Shortland (NSW)	?	Toorbul (Qld)	20-02-94	695 km N	?	PEW
Shortland (NSW)	11-02-93	Alice Springs (NT)	23-05-93	2015 km NW	3mth 12day	PEW
Macquarie Marshes (NSW)	08-01-94	Lightning Ridge (NSW)	17-02-94	168 km N	1mth 9day	PEW
Macquarie Marshes (NSW)	08-01-94	Laloki, PNG	27-05-94	2400 km N	4mth 19day	PEW
Macquarie Marshes (NSW)	09-01-94	Lake Daviambu (PNG)	08-05-94	2671 km N	3mth 30day	PEW
Macquarie Marshes (NSW)	22-01-94	near Mackay (Qld)	16-08-94	1082 km N	6mth 25day	PEW
Macquarie Marshes (NSW)	22-01-94	Yepoon (Qld)	22-09-94	914 km N	8mth	PEW
Macquarie Marshes (NSW)	22-01-94	Thargomindah (Qld)	09-10-94		8mth 17day	PEW
Macquarie Marshes (NSW)	23-01-94	near Townsville (Qld)	24-04-94	1262 km N	3mth 1day	PEW
Macquarie Marshes (NSW)	23-01-94	Tinaroo Dam (Qld)	21-05-94	1545 km N	3mth 29day	PEW
Macquarie Marshes (NSW)	1993/94	Dalby (Qld)	27-03-94	521 km NE	3mth	PEW
Macquarie Marshes (NSW)	1993/94	Georgetown (Qld)	02-04-94	1468 km N	3mth	PEW
Little Egret						
Red Bank Weir (NSW)	02-01-60	Kulipi (PNG)	19-06-60	2923 km N	5mth 17day	ABBBS
Red Bank Weir (NSW)	15-12-62	near Oamaru (NZ)	09-05-63	2597 km SW	4mth 25day	ABBBS
Red Bank Weir (NSW)	15-12-62	Talasea (PNG)	06-06-63	3291 km N	5mth 22day	ABBBS
Red Bank Weir (NSW)	14-12-63	Boset Village (PNG)	13-12-64	3028 km N	11mth 29day	ABBBS
Red Bank Weir (NSW)	14-12-63	Wairavanua (PNG)	02-09-64	2805 km N	8mth 18day	ABBBS
Red Bank Weir (NSW)	14-12-63	Newlands (NZ)	25-02-64	2620 km SE	2mth 11day	ABBBS
Bool Lagoon (SA)	13-12-64	Cessnock (NSW)	17-05-65	1081 km NE	5mth 4day	ABBBS
Shortland (NSW)	23-11-88	Numbaa (NSW)	12-10-89	240 km S	10mth 19day	PEW
Shortland (NSW)	28-11-88	Forster (NSW)	23-02-89	108 km NE	2mth 25day	PEW
Shortland (NSW)	28-11-88	Hawks Nest (NSW)	15-01-91	52 km NE	2yr 1mth 18day	PEW
Shortland (NSW)	28-11-88	Joskeleigh (Qld)	31-07-89	1056 km N	8mth 3day	PEW
Shortland (NSW)	22-12-89	Chittaway Point (NSW)	17-03-91	56 km S	1yr 2mth 23day	PEW
Shortland (NSW)	?	Warnambool (Vic)	13-04-87	1045 km SW	?	PEW

such areas within the Hunter Valley up to three months after banding.

Unlike the Cattle Egret, no Great, Intermediate or Little Egret has yet been found to spend the entire winter in the region around the nesting colony. This suggests that a subsequent post-nesting extended migration has occurred. However, the lack of over-wintering birds in the local floodplain may be an artefact of the small sample size.

Migration

The recovery data, although limited, suggests that all three species of egret may undertake long distance movements in any direction from the natal colony. This appears to be particularly so when the mean distance, in a straight line, of the recovery site from the natal colony is examined. This is further supported when taking into account the location of the natal colony in relation to the recovery site. Seven recoveries of Great Egrets banded in the Murray area (Gunbower Island, Vic., Bool Lagoon and Narrung, S.A.) show an apparent northward bias, while eight birds wing tagged on the NSW coast (Shortland, Junction Hill and Lawrence) were recovered, or seen alive, to the north and south. A similar pattern exists for Intermediate Egrets. Seven Little Egrets banded in the Murray area (Red Bank Weir, NSW and Bool Lagoon, S.A.) undertook movements, all in excess of 1000 km, to the north and south-east while six tagged at Shortland, NSW, were sighted to the north and south-west.

Differences between movement patterns of birds originating from the Murray and/or Macquarie Marshes and coastal NSW colonies are also reflected in the mean distance of movements undertaken. This may reflect less extreme climatic variation and a more predictable coastal environment. Egrets originating from less stable inland wetlands, where longer, more severe droughts have a greater impact on wetlands, may be more likely to initiate more extensive movements. It is, however, difficult to draw any firm conclusions given the small number of recoveries.

Migration to New Zealand and Papua New Guinea

One Great, three Intermediate and four Little Egrets banded in southern Australia have been reported in Papua New Guinea while two Little Egrets have been reported in New Zealand.

Large numbers of Intermediate and Great Egrets have been reported as migrating across Torres Strait at Booby Island (A. Taplin pers. comm.) with both diurnal and nocturnal movements being recorded. An Intermediate Egret banded on Booby Island was later recovered 401 km north at Lake Murray, Papua New Guinea.

Out and return (spring) migration

The circumstantial evidence from unmarked birds linked with a limited number of recoveries of birds returning to their natal colonies for the breeding season suggest that a migratory pattern may be in operation, at least for some birds, but many more repeated sightings of tagged individuals is needed to confirm this conclusion.

Relationships between breeding colonies

To date relatively few wing tagged Great, Intermediate or Little Egrets have been found breeding (Table 6) and these have involved birds returning to the natal, or a nearby, colony. Only one Great Egret has been reported from a breeding colony outside the floodplain area of the natal colony and breeding was not confirmed for this bird. This pattern is similar to that of Cattle Egrets, the birds generally returning to the natal colony to breed with some nesting occurring at nearby colonies and only a few reported breeding at more distant colonies.

While relatively large numbers of Intermediate and Great Egrets have been tagged in the Macquarie Marshes during the breeding season of 1993-94 none have been reported at their natal, or any other, breeding colony. However, it appears that Intermediate and Great Egrets breed only after their second year so it is unlikely any would have attempted to breed to date. Because of the, generally, ephemeral nature of many inland breeding colonies it is possible that some egrets from these colonies may breed at coastal sites should conditions there be suitable.

TABLE 6: Breeding Activity of Individually Marked Great, Intermediate and Little Egrets

Individual	Year Tagged	Colony	Year	Activity
Great Egret				
Lawrence 003	1988/89	Junction Hill*	1992/93	Courting flush
Lawrence 004	1988/89	Junction Hill*	1990/91	Incubating - failed
Lawrence 009	1988/89	Lawrence	1989/90	Carrying sticks
		Junction Hill*	1990/91	Present only
		Lawrence	1991/92	Raised young
Lawrence 037	1989/90	Lawrence	1991/92	Courting flush
Shortland ??? #	?	Shortland	1993/94	Raised young
Intermediate Egret				
Lawrence 049	1988/89	Shortland**	1990/91	Present only
Lawrence 056	1988/89	Junction Hill*	1990/91	Incubating
Lawrence 065	1988/89	Lawrence	1993/94	Courting flush
Shortland 140	1988/89	Shortland	1989/90	Present only
Shortland 141	1988/89	Shortland	1990/91	Raised young
Shortland 154	1988/89	Shortland	1989/90	Present only
Little Egret				
Shortland 025	1988/89	Shortland	1990/91	Raised young
Shortland 027	1988/89	Shortland	1990/91	Present only

* ~ 30 km from natal colon

** ~ 375 km from natal colony

Tag number not able to be read

Activity listed is that confirmed by observation, birds present or in courting flush may not have successfully established nests.

Implications for Conservation Management

The co-occurrence of the declines in breeding populations identified at the coastal colonies and in the Macquarie Marshes are of sufficient magnitude to be a cause for concern. It is difficult to determine within the time scale of the study to date whether they are natural fluctuations due to the prevailing drought and will reverse if the climate cycle returns to a wetter period or are due to a general decline in environmental conditions affecting breeding.

The artificial drought conditions in the Macquarie Marshes brought about by water regulation are an obvious artefact of human activity. Unless the Macquarie Marshes Management Plan allows for an adequate water supply to support the regular breeding of colonial waterbirds, the decline could reach dimensions which have a serious effect on the conservation status of the species. Two years with no breeding has resulted in a significant loss of recruitment to the population in these years. The data on migration obtained so far suggests that the inland colonies are also of importance for Papua New Guinea.

Insufficient data has yet been obtained to determine whether staging is a characteristic of Great, Intermediate and Little Egret migration as it is for Cattle Egrets. Staging has so far been identified in the case of only one Great, one Intermediate and one Little Egret. Some evidence has been obtained in the coastal colonies that suggests that the birds return to their natal colonies to breed. It seems logical to assume that they do move in stages, and if so water conditions along migration routes would be a critical factor. Continued intensive monitoring on a much longer time scale is essential to identify important staging points.

The three species have proved much more difficult to study than Cattle Egrets. Great Egrets nests are extremely difficult to access in the coastal colonies. All three species occur in much smaller numbers than the Cattle Egret and tagging sufficient numbers to obtain sufficient recoveries is much more difficult. Access to the inland colonies is difficult because of the remoteness of the locations both from centres of operation and within the wetlands.

Cattle Egrets live and move in substantial flocks and colonies and movements occur in populated areas where it has been easy to recruit observers and observation is relatively simple. The other species are more likely to be found as individuals or in very small groups in remote wetlands on private property, particularly in the inland. Availability and recruitment of observers in these areas is much more limited.

The problem of the survival of the coastal breeding colonies has already been referred to in the section on the Cattle Egret. The Project Officer represented Project Egret Watch at a workshop on the Macquarie Marshes early in 1994 and submissions are to be made in the process of revision of the Macquarie Marshes Management Plan.

FACTORS AFFECTING THE RESULTS OF THE PROJECT

Like any biological study, this project has been subject to a number of factors outside its control.

Besides the cessation of breeding by pelicans which resulted in the stalling of Project Pelican few problems were encountered. Of greatest concern was the small number of Great, Intermediate and Little Egrets that were able to be tagged at the coastal breeding colonies due to a series of dry breeding seasons during the period of assistance. As a consequence, only a small number of tag sightings were reported. The reliance on rainfall for effective nesting of Great, Intermediate and Little Egrets means that it is often difficult to mark sufficient birds to obtain a reasonable rate of tag sightings. For this reason the Project expanded to include colonies in the Macquarie Marsh in 1993-94, the first time these colonies had been active since 1990.

Large numbers of Great and Intermediate Egrets, in particular, were tagged at colonies in the Macquarie Marshes during 1993-94. To date eleven Intermediate Egrets from the Macquarie Marshes have been reported away from these natal colonies, four in north Queensland and two in Papua New Guinea. This initial result indicates the potential of tagging at these inland colonies. In the future the Project will be targeting other inland breeding colonies to further capitalise on this erratic, but potentially very productive, inland breeding.

The development of a strong volunteer network has enabled the Project to gather data about usage of particular areas by egrets as well as ensuring reports of tagged birds. Within the Shoalhaven Valley, for example, an excellent data set has been obtained over a two year period of the pattern of usage of habitat types and movement patterns of many tagged, and non-tagged, Cattle Egrets. However, these strengths may well have introduced a degree of bias when interpreting movement distances.

Movements of Cattle Egrets has been well documented with numerous reports of tagged birds well away from the breeding colonies. Table 7 provides the recovery rates of Cattle Egrets greater than 50 kilometres from the breeding colony and the relative distances.

The most northerly and southerly colonies have lower reporting rates of Cattle Egrets greater than 50 kilometres from the natal colony. This could reflect differing survival rates of nestlings or juveniles from different colonies, however the pattern of distribution of the established observer network probably plays a much more important role in determining reporting rates. At present, the observer network has several areas of particularly high observer effort, the Hunter Valley in Central NSW, the Shoalhaven Valley in southern NSW, Gippsland in eastern Victoria and the Melbourne area.

Tag sightings at wintering locations have shown that Cattle Egrets display a great range in the distance of individual migrations undertaken. These range from only a few kilometres through hundreds to thousands of kilometres. Thus it can be expected that fewer egrets originating from

TABLE 7: Recovery rates of patagial tagged Cattle Egrets greater than 50 km from natal colony

Colony	1993			1994		
	No. Reported	1st Year Reported	% 1st Year Tagged	No. Reported	1st Year Reported	% 1st Year Tagged
Ten Mile Lane, Bundaberg	1	1	0.006	8	7	3.5
Bullyard, Bundaberg	N/T	N/T	N/T	5	5	2.5
Skyring Creek, Gympie	9	9	4.5	11	11	5.5
Murwillumbah	8	5	5.0	6	3	3.0
Ballina	9	6	6.0	5	3	3.0
Lawrence	30	16	8.0	42	32	12.8
Junction Hill	19	13	6.5	17	13	6.5
Boambee	26	24	12.0	26	23	11.5
Shortland	8	7	5.4	8	6	3.8
Seaham	10	7	4.0	7	6	4.8
	120	88	6.1	134	111	6.4

N/T - Not tagged

colonies near Bundaberg may reach the Hunter Valley, a distance of around 870 kilometres, than those from near Grafton, a distance of around 380 kilometres, or Boambee, at around 300 kilometres. The data presented in Table 8 suggests that this is the case but still does not explain why reporting rates from the Hunter Valley colonies, which are closest to the Shoalhaven Valley where observer effort is intense, are proportionately low, and have always been so. It should be noted that tag sightings do not necessarily represent the end point of a particular migration, most tagged birds reported in the Shoalhaven are present for only several days.

The almost complete lack of sightings of Cattle Egrets tagged near Bundaberg in 1992-93 away from that area during the winter of 1993 is also of great interest. Although considered unlikely, birds from this area, the northern-most set of colonies in the northern NSW and southern Queensland concentration of breeding colonies, may have demonstrated a different migration pattern than the more southerly colonies or they may not have migrated at all. The number of Cattle Egrets tagged in the Bundaberg area was increased, with the addition of an extra colony, during the 1993-94 breeding season. Tag sightings for the 1994 winter migration included 13 Bundaberg Cattle Egrets throughout the wintering areas utilised by birds from other, more southern, coastal colonies. Why there should have been a general lack of sightings in 1993 is still open to speculation. A possible explanation may be differing local conditions, in which case birds from this area respond differently from those from other tagged colonies where migration occurs has occurred annually regardless of conditions. More plausibly, differing

**TABLE 8: Distance from natal colony of tagged Cattle Egret sightings
winter 1993 and winter 1994 to September 30**

		Distance from natal colony (km)									Mean	SD
		51- 200	201- 400	401- 600	601- 800	801- 1000	1001- 1200	1201- 1400	1401- 1600	1601- 1800		
Shortland	92	2	2#								161.7	94.9
	93	1	5#	1							273.9	140.3
	94	2	5#	0	1						291.7	193.0
Seaham	92	3	4#	1	2	1	1				450.9	345.0
	93	2	6#	0	0	2	1				408.9	352.7
	94	1	4#	0	0	2					407.7	313.4
Boambee	92	2	6*								249.3	87.4
	93	5	12*	6#	0	0	2	1			419.7	318.7
	94	0	12*	13#	0	0	1				454.5	181.1
Junction Hill	92	8	6*	0	1#	1					306.4	222.0
	93	4	8*	1	2#	0	1	3			518.4	394.6
	94	1	9*	0	7#	0	2				536.7	250.2
Lawrence	92	5	4*	3	3#	0	3				473.8	334.8
	93	7	11*	1	8#	1	2				452.8	283.5
	94	3	17*	8	11#	0	3	1			529.3	264.2
Ballina	92	6	2	1*	1#						236.4	219.9
	93	1	4	4*							334.2	139.8
	94	0	1	1*	1#	0	0	2			797.8	465.8
Murwillumbah	92	0	1	2*	6#	0	1	1			795.5	343.5
	93	1	0	2*	5#						597.4	255.7
	94	0	0	2*	3#	0	0	0	1		774.3	343.9
Gympie	92				Not tagged							
	93	1	0	0	3*	1#	0	1	2	1	1025.8	518.3
	94	1	1	2	6*	1#	0	0	2		800.7	435.8
10 Mile Lane	92				Not tagged							
	93	0	0	1							519.0	-
	94	0	0	1	3	1*	2#	1	1		945.9	334.3
Bullyard	92				Not tagged							
	93				Not tagged							
	94	0	0	1	0	1*	2#	0	1		1011.4	382.4

* Hunter Valley
Shoalhaven Valley

survival rates of nestlings or juveniles between years may be the underlying factor.

Despite these difficulties it is essential that the research be pursued over a much longer time scale. Long term monitoring studies such as Project Egret Watch do not lend themselves to tidy, limited time frame research providing neat solutions but are essential if conservation and management issues are to be properly addressed. Difficulties such as those described above, combined with unpredictable problems arising from climatic variations and idiosyncratic behaviour of the birds means that results evolve slowly.

Associated Satellite Tracking Project

This project is a complimentary one funded by an ARGC small grant. The work done by the project as a whole with NSW Environmental Trust funding contributed directly to this project.

In April, 1994 two adult Cattle Egrets were fitted with satellite tracking transmitters in the Hunter Valley. The transmitters were on an eight hour on, 40 hour off cycle to extend battery life to an estimated six months. Unfortunately equipment failure resulted in one bird being tracked for only 6 weeks and the other for 12 weeks. Nevertheless, excellent data was received on the local movements of the birds as well as the migration, and the influence of weather systems on the migration, of one of the birds from the Hunter to the far south coast of NSW.

FUTURE DIRECTIONS

Project Egret Watch will be continuing, albeit on a smaller scale than that of the period of assistance. Further emphasis will be placed on the tagging of Great, Intermediate and Little Egrets in coming breeding seasons in an effort to understand movement patterns of these species and the implications for their conservation.

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Papers currently in press:

- Bridgman, H.A. & Maddock, M. 1994. Meteorological conditions and Cattle Egret migration: an update. *Notornis*

Papers submitted:

- Geering, D.J. Foraging behaviour of the Cattle Egret on dry and irrigated pasture in coastal NSW. *Corella*.
- Maddock, M. Response of Cattle Egrets to flooding in the Williams River, NSW. *Corella*.

Papers currently in preparation:

- Maddock, M. Cattle Egret breeding success in the Hunter Valley, colonies 1978-1993.
- Maddock, M. & Geering, D.J. Current state of knowledge on migration of Great, Intermediate and Little Egret.

Maddock, M. & Geering, D.J. Possible declining trend in the number of Great, Intermediate and Little Egrets nesting in NSW coastal breeding colonies and implications for conservation.

Maddock, M. & Geering, D.J. Breeding trends of the Cattle Egret in NSW colonies since colonisation.

FINANCIAL REPORT 1991-1994

	1991	1992	1993	1994	Total
Income					
Grant	20000.00	27000.00	32000.00	18000.00	97000.00
Expenditure					
Wages		20865.22	22426.23	18620.36	61911.81
Travel		1559.50	2222.00	2086.00	5867.50
Administration		592.75	7325.46	2739.48	10657.69
Materials	492.57	340.50	735.66	2570.73	4139.46
Equipment		90.00	316.00	341.90	747.90
Permits		22.00	22.00	0.00	44.00
Total Exp.	492.57	23469.97	33047.35	26358.47	83368.36
Balance carried forward	19507.43	23037.46	21990.11	13631.64	13631.64