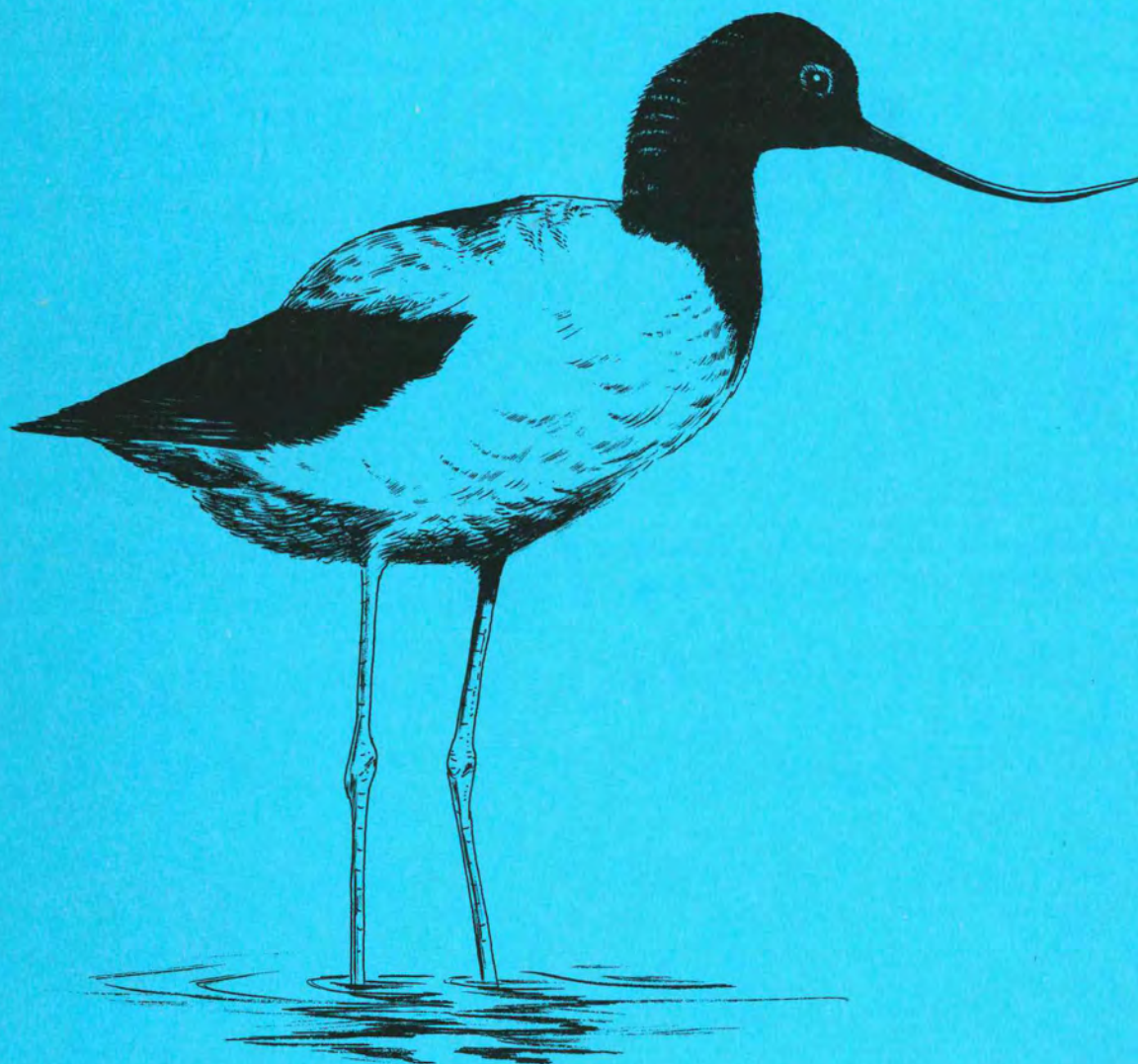


THE SIGNIFICANCE OF MOSQUITO BREEDING AREAS TO THE WATERBIRDS OF PEEL INLET, WESTERN AUSTRALIA



Waterways Commission
Report No 20
June 1990

184 St George's Terrace, PERTH WA 6000



**THE SIGNIFICANCE OF MOSQUITO BREEDING
AREAS TO THE WATERBIRDS OF PEEL INLET,
WESTERN AUSTRALIA**

**Prepared for: MOSQUITO CONTROL REVIEW COMMITTEE
WATERWAYS COMMISSION**

**By: NINOX WILDLIFE CONSULTING
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PERTH WA 6000

COVER SKETCH BY - A. RODERICK

SUMMARY

The aims of this study were primarily to concentrate on tidal saltmarshes and other mosquito breeding areas at Peel Inlet in order to assess their importance to waterbirds in terms of species richness, abundance, habitat utilisation and the activities which take place within them. Mosquito breeding areas of particular significance to waterbirds were to be defined and recommendations based on current mosquito control strategies compatible with maintaining overall waterbird species diversity throughout the inlet were to be explored.

A total of 37 sites were chosen for intensive sampling and were visited on nine occasions between November 1988 and December 1989. In selecting these sites the first priority was to gain as much coverage as possible of the 70 most significant mosquito breeding areas identified in an earlier Public Health Department study (Wright 1988). The waterbird survey was limited to the more developed northern sector of the inlet where the effects of mosquito control measures will be concentrated because of its proximity to residential areas. Including areas adjacent to mosquito breeding sites, 66 species and 45,969 individual waterbirds were recorded.

Mosquito breeding areas are a sub-set of the inlet and showed relatively little variation in waterbird species richness from survey to survey although the number of individuals fluctuated with the arrival or departure of migratory birds; the species-mix also changed depending on the season. Sixty-two species and 26,758 individuals were recorded in an area representing a relatively small proportion of the inlet. To date, 83 species of waterbirds are known to use Peel Inlet, a figure which represents many years of systematic and casual recording and it is highly probable that, given equivalent sampling intensity, the number of species using mosquito breeding areas is liable to be significantly higher than this one-year study has indicated.

The abundance of waterbird species and individuals peaks in mosquito breeding areas during the summer months and coincides precisely with an equivalent peak in populations of the mosquito *Aedes vigilax* which appears to be the main vector of Ross River Virus. Most chemical control of mosquitoes also takes place during summer, a period when large numbers of trans-equatorial migratory shorebirds covered by international agreements and many ducks seeking drought refuge utilise these areas. Young birds which feed on mosquito larvae are still present and vulnerable at this time.

Feeding is the major activity which takes place in mosquito breeding areas, closely followed by roosting. Together, these two categories of behavior account for nearly 85% of all activity records. Periodically inundated samphire and isolated tidal pools in low relief areas absorb the main impact of mosquito control measures,

and as the major activity in these habitats is feeding, there is the potential to adversely affect waterbirds unless mosquito control is carried out in an informed and environmentally conscious manner.

The survey has shown that, taken as a whole, mosquito breeding areas in the northern portion of Peel Inlet are important to waterbirds and require a well-planned and cautious approach to the complex and potentially disruptive problem of reducing mosquito populations. The annoyance value of mosquitoes and the known capacity of certain species to act as vectors of Ross River Fever necessitate that remedial action be taken and that, as a consequence there will inevitably be some impact on waterbirds and their environment. However, not every mosquito breeding area is equally important in terms of its waterbird usage or physical attributes and the compromise between conservation and control measures can be structured bearing this aspect in mind.

The report defines mosquito breeding areas of particular significance to waterbirds, takes account of their proximity or isolation from developed areas and recommends minimal control measures specific to these important conservation areas. Less productive wetlands, in terms of waterbirds, are also individually defined and in these locations well-planned, physical modification of the wetland is proposed if it is small. If the wetland is large and inaccessible, continuing control measures based on aerial application of larvicides is recommended.

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E.M. Goble-Garratt prepared vegetation descriptions for individual waterbird sites and Dr P.G. Wilson of the Western Australian Herbarium kindly assisted in identifying samphire material. We thank E. Cannella for his patient assistance with computing requirements and preparation of tabulations. N. Timperley and S. Cunningham of Thames Holdings Pty Ltd kindly donated the use of their laser printing facilities for the production of diagrams.

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PART A

INTRODUCTION AND STUDY METHODS

A1.0 INTRODUCTION

As a continuation of the Mosquito Eradication Campaign, the Health Department of Western Australia submitted a report to the Mosquito Control Review Committee (MCRC) of the Waterways Commission on the results of a survey of mosquitoes in the Mandurah region (Wright 1988). This document also included mosquito control recommendations approved by the MCRC and represented a companion volume to a similar document prepared for the Bunbury Region (Wright 1986). Both studies were funded by the Mosquito Eradication Campaign and sponsored by the Health Department of Western Australia. The Mandurah study provided much needed data on mosquitoes and showed that by far the greater proportion of mosquito breeding took place in tidal saltmarshes where many waterbirds congregate. The link between these areas and the transmission of epidemic polyarthrititis (also known as Ross River fever) was also explored in detail and it was apparent to the MCRC that mosquito control measures such as filling, draining, fogging and the application of larvicide to control mosquito populations would have to be primarily directed at these tidal saltmarshes if they were to be effective. It was also evident that current control techniques had the potential to seriously affect waterbirds unless work was carried out in an informed and environmentally conscious manner.

Mosquito breeding areas include samphire flats, pools, seasonally exposed mudflats in freshwater areas and shorelines in seasonal or tidal wetlands, all of which are used to a greater or lesser extent by waterbirds and associated passerine species such as the Little Grassbird, White-fronted Chat, Richard's Pipit and Australian Magpie-lark. Intertidal zones are recognised as rich feeding areas for trans-equatorial migratory shorebirds, many of which are protected by international agreements namely the Japan/Australia Treaty and the China/Australia Treaty. In recognition of the potential significance of these areas and the lack of detailed knowledge on the activity and distribution of waterbirds in wetlands, the MCRC contracted Ninox Wildlife Consulting to carry out a detailed, year-long study of the waterbirds of Leschenault Estuary (prior to this current study) and report on their findings (Ninox Wildlife Consulting 1989). Survey work for the Leschenault Estuary study commenced in September 1987 and ended in October 1988 and it was established that mosquito breeding areas within the study area:

- ° were used by at least 60 of the 62 species of waterbird recorded at the estuary;

- supported 38% of all individual waterbirds counted at Leschenault Estuary in an area representing 11% of the estuarine system;
- showed a disproportionate usage per unit area by certain waterbird groups (77% of all herons, egrets and ibis; 49% of all ducks and grebes; 41% of all wading birds);
- acted as refuges for large numbers of birds during very high tides and stormy weather;
- provided rich intertidal and freshwater feeding areas for a large proportion of the waterbird species using the estuary (37% of all individuals recorded in mosquito breeding areas were observed feeding);
- were virtually the only areas where breeding took place and which could provide refuge for young waterbirds;
- were used by a large number of migratory wading birds many of which are protected by international conservation agreements.

In recognition of the significance of these findings, the MCRC commissioned a similar study of sites in the northern portion of Peel Inlet which had already been surveyed for mosquitoes (Wright 1988). Funding for this project was jointly provided by the Waterways Commission, the South-West Development Authority, the Environmental Protection Authority, John Holland Pty Ltd and Town and Country W.A., the latter two private companies proposing development projects in the area. Waterbird sampling commenced in November 1988 and continued until December 1989. The results of this project are presented in the following report.

The report is divided into four main sections. Part A gives a background to and rationale for the study and explains the methodology used. Part B is a local and regional assessment of the Peel Inlet system as a whole. It gives a broad overview of the survey area and its current conservation status based on the results of this and other studies. Part C deals exclusively with the mosquito breeding areas surveyed in 1988 and 1989, catalogues the number of waterbird species and individuals using them, assesses habitat utilisation and the activities which took place within these habitats. Part D explores the effects of mosquito control measures on the waterbird conservation status of individual sites and provides recommendations on mosquito control measures.

A1.1 Study Objectives

The aims of this Peel Inlet waterbird study as outlined by the Mosquito Control Review Committee are given below.

- Assess the local and regional conservation status of the inlet and relate it to other estuarine systems;
- concentrate on tidal saltmarshes and other mosquito breeding areas to assess their importance to waterbirds in terms of species richness, abundance, habitat utilisation and the activities which take place within them;
- define mosquito breeding areas of particular significance to waterbirds;
- recommend mosquito control strategies compatible with maintaining waterbird species diversity and abundance in the above locations.

A2.0 METHODS

A2.1 Sampling Site Choice

A reconnaissance survey was carried out between November 3-4, 1988 and 37 sites, which included 47 mosquito breeding areas, were chosen for intensive sampling (Table A1, Figure B1). In the choice of these sites the first priority was to gain as much coverage as possible of the 70 most significant mosquito breeding areas identified in Figure 1 of Wright (1988). Forty of Wright's sampling locations identified during the reconnaissance as potentially supporting large numbers of waterbirds were selected. Site choice was biased towards Wright's larval sampling areas, since this developmental stage, rather than adults, is obviously more relevant to waterbird dietary and habitat requirements. A further seven relatively inaccessible sites (Figure B1) which, although not sampled by Wright because of logistical problems, were mosquito breeding areas and held, or potentially had the ability to support populations of waterbirds. These sites were therefore monitored for waterbirds.

The nature of waterbird sampling does not lend itself well to individually monitoring large numbers of mosquito breeding sites, some of which may only be isolated pools a few square metres in area, close to one another and in many cases ephemeral. Waterbirds utilise an area as a continuum and most species freely move between

wetlands depending on the availability of resources. For this reason waterbird sampling sites were established such that in some locations several mosquito breeding areas were encompassed by each waterbird site but were not so large that specific recommendations could not be made for the individual locations. Where an individual mosquito breeding site was sampled, the area covered by each waterbird site was significantly larger and included all points to the limits of accurate recording. This approach was considered necessary because the effects of mosquito control measures are not limited to a specific pool but can potentially extend beyond them into surrounding areas by virtue of wind/water transportation of chemicals, or through vegetation changes resulting from filling or draining. The following table shows waterbird sampling site code numbers and their mosquito breeding location equivalents.

Table A1 Waterbird sampling sites and their mosquito breeding equivalents as shown in Figure 1 (Wright 1988).

** = Accessory inlet site included.*

WATERBIRD SAMPLING SITE	MOSQUITO BREEDING SITE(S)
1	23
2*	Not sampled for mosquitoes
3*	"
4*	"
5*	50
6	51
7	Not sampled for mosquitoes
8	52
9	74
10	100
11	56
12	86
13	55
14*	Not sampled for mosquitoes
15*	102
16	44
17*	43
18	87
19	40, 41
20	38, 93
21	33, 34
22	47, 48
23	107
24*	57
25*	58
26*	Not sampled for mosquitoes
27*	59
28*	60
29 (Amalgamated with 30)	-
30*	61, 62, 95, 97
31*	63
32*	64, 65, 66
33 (Amalgamated with 32)	-
34*	Not sampled for mosquitoes
35*	88, 96
36*	89, 91
37*	90
38*	Not sampled for mosquitoes
39	54

A2.2 Field Sampling

Sampling was conducted by three field staff working independently of one another and by dividing the study area into three sectors. One observer sampled the western portion of the inlet while the more complex eastern portion, which included freshwater or brackish areas disassociated from the inlet plus tidal wetlands along the Serpentine River, was split between two observers. In this way it was possible to limit sampling to a single day, thus standardising weather, tidal conditions and reducing variables such as bird movements. Choice of sampling sites and visibility between many sectors ensured that over or under-counting of individuals and errors in identification were kept to a minimum. The inlet was sampled on nine occasions between November 1988 and December 1989 (Table A2) but unlike the much smaller Leschenault Estuary, each session could not be viewed as a total estuary count because of the extremely large area of the inlet and the fact that the survey was limited to the more developed northern sector where the effects of mosquito control measures will be concentrated. An account of Peel Inlet as a whole (excluding Harvey Estuary) is given in Part B of this report and is based on information from other sources.

Table A2 Survey periods conducted at Peel Inlet between November 1988 and December 1989.

SURVEY	DATE		
1	November	18	1988
2	January	7	1989
3	February	21	"
4	April	13	"
5	June	1	"
6	July	25	"
7	September	11	"
8	October	25	"
9	December	12	"

Census periods were not equally spaced; an opportunistic element was introduced to maximise returns during the months when trans-equatorial, migratory shorebirds were present and after the onset of the main waterbird breeding season.

By necessity, effort was channeled into mosquito breeding areas i.e. all points inland and including the bare shorelines of the inlet. In order to overcome this relative lack of sampling in areas where mosquitoes do not breed such as tidal flats, shallows, sandbars and

roosts in open water, 20 sites included accessory portions of the inlet which were censused in association with adjacent mosquito breeding areas. These have been marked with an asterisk in Table A1 and are analysed in Section B1.0. This data has been supplemented in Section B2.0 with the results of a series of extensive waterbird surveys of Peel Inlet carried out by the Department of Conservation and Land Management (CALM), and other sampling conducted by the Royal Australasian Ornithologists Union (RAOU) in Austin Bay Nature Reserve south of the mouth of the Murray River.

A2.3 Data Collection

On arrival at a sampling site the observer picked a vantage point and stayed in position until confident that all visible birds had been identified, counted, allocated to habitats and their activity defined. Telescopes and binoculars facilitated identification and minimised disturbance of birds. Foot transects were conducted within each station where visibility was limited and to ensure that all birds were, as far as possible, recorded. A dinghy was used to sample the series of sites near Yunderup and along the length of the Serpentine River to the southern limits of Goegrup Lake.

Some of the more cryptic or secretive species such as crakes and rails may have been missed; adequately sampling this group is extremely time-consuming and requires very different methods of survey. During the allocation of significance categories to the various wetlands, the potential presence of this group was considered to be a factor raising the loading applied to areas which showed low usage by other waterbirds. In other words, if a wetland was impenetrable to most species because of dense reeds or shrubs, the probability that crakes and rails were present was judged to be extremely high and a subjective loading was therefore applied.

No attempt was made to scale the relative areas of habitat sub-units in individual wetlands since this varied from survey to survey depending on tide height or rainfall. Areas of samphire on one survey could be a large pool on the next. Scaling has therefore been limited to either estimating the area sampled, where access to the whole wetland was restricted, or giving an actual size taken from aerial photography when the whole wetland was visible from observation stations. This information and a brief description of vegetation communities is given in Appendix 2.

A2.4 Data Logging

Field data sheets used in the Leschenault study (Ninox Wildlife Consulting 1989) were once again utilised but were modified to specifically reflect Peel Inlet conditions such as the absence of a mangrove community and the presence of large, open areas of water in freshwater and saline wetlands some distance from the inlet itself. An example of a data sheet is given in Appendix 3. To fulfill one of the main objectives of the survey i.e. establishing the importance of mosquito breeding areas to waterbirds, it was necessary, as in the Leschenault study, to make a distinction between the main body of the inlet and areas subject to periodic inundation by tides or rainfall. In reality such a division does not exist since the inlet and its immediate surrounds are used by waterbirds as a dynamic, interdependent continuum. Similarly, the effects of mosquito control measures do not cease beyond fringing formations.

The mosquito habitat criteria used in the Leschenault study were once again utilised: any area which had the capacity to retain pools of water over a period of several days following high tides or heavy rain was a potential breeding site (see Wright, 1986). In effect, it was assumed therefore that all periodically inundated locations above exposed tidal mudflats (including inland sites with no direct connection to the inlet or dry samphire with depressions which could be filled after rain) were potential breeding areas. All habitats below the upper limits of exposed tidal mudflats were classified as being associated with the inlet and therefore not used as breeding areas by mosquitoes. Tidal saltmarshes, freshwater swamps and ephemeral pools, including all such areas seasonally classified as dry land, were therefore well surveyed.

All species recorded and used in analysis were not strictly waterbirds. Birds such as Richard's Pipit, Whistling Kite and White-fronted Chat were included since these are strongly associated with wetlands and could be affected by mosquito control measures.

Data sheets were logged in the field to reduce transcription errors and categories were kept simple to reduce ambiguities. An example showing the habitat types surveyed and the activity codes used is given in Appendix 3. The habitat category "Within Swamp" refers to any habitat within the main water body of such areas, whether the swamp was tidal, permanently, or seasonally freshwater. This category was used to cover sites such as Goegrup Lake or Black Lake which could be described as saline, tidal extensions of the inlet or primarily freshwater catchments depending on the season. In summer Goegrup Lake had all the attributes of the inlet such as high

salinity, tidal flats and sandbars but in winter, the strong flow of the Serpentine River effectively transformed it into a freshwater area. In order to rationalise the large number of birds using these bodies of water and the fact that most birds move freely between the shore and open water, it was decided to classify them all as mosquito breeding areas despite the limited amount of such activity which takes place away from the main breeding sites around the edges of the water.

During data analysis it was once again apparent that the habitat categories "Bare Other" and "Other" (Appendix 3) tended to overlap, with no single element dominating such that a separate category was warranted. As a result, records from these two units have been combined to produce a single unit (Other) containing diverse habitat elements such as dry mudflats in freshwater swamps, carparks, grassed areas, tracks and other minor elements having little bearing on mosquito control.

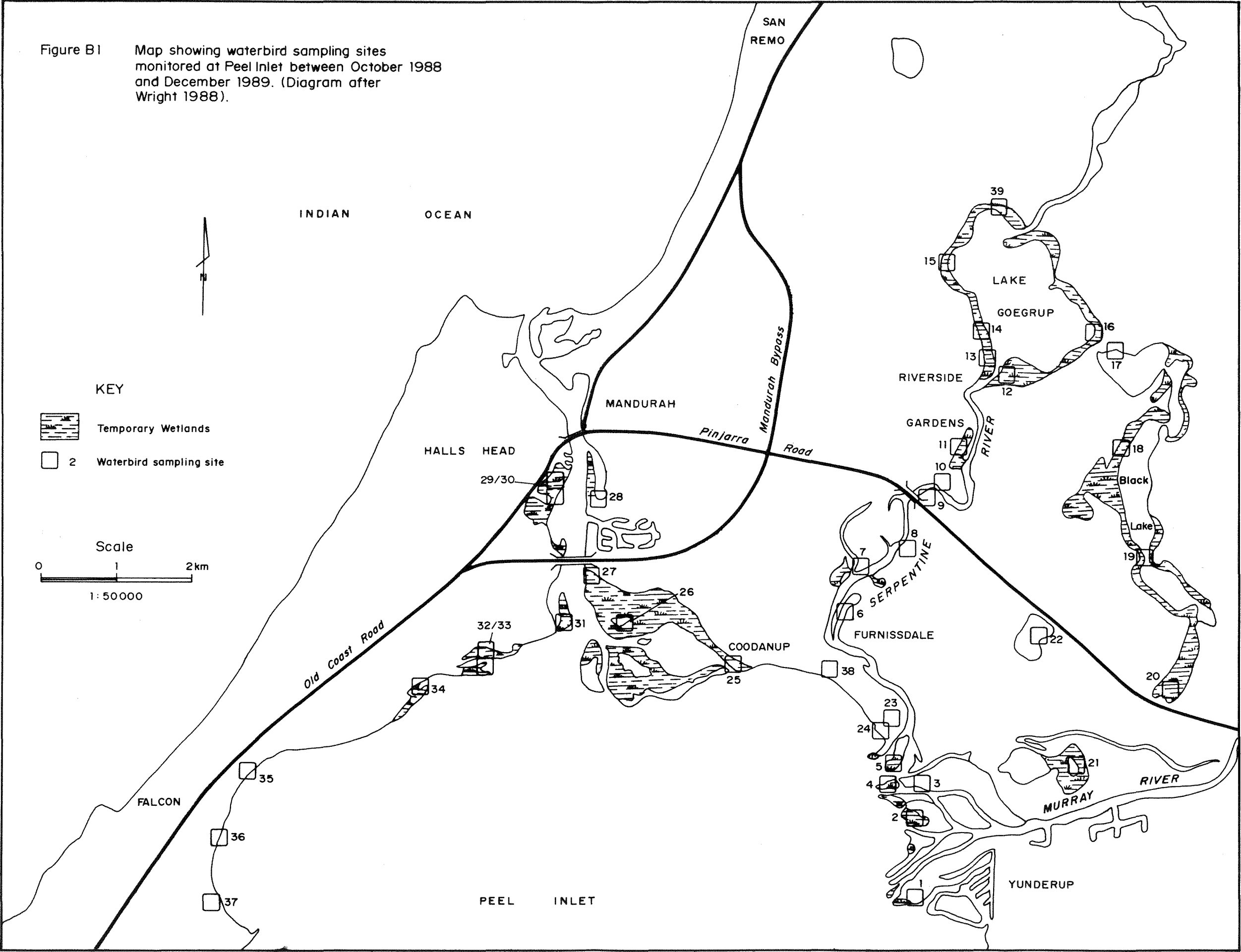
Activity codes are self-explanatory except that for this and the previous study "loafing", which arbitrarily refers to birds resting on either water or land, depending on the interpretation of various authors, has been applied exclusively to aquatic activity. This was done to cover non-specific aquatic behaviour such as directionless drifting which otherwise would have been classified under the activity "Other". Roosting applies to land-based activity only, whether it took place on trees, shorelines or very shallow water. The activity category "Other" refers to those occasions when birds were flushed before their activity was recorded (aerial), when the activity was unspecified (unknown) or when secretive species such as the Little Grassbird were located by call only.

A2.5 Database Management

Each waterbird species was given a Bird Atlas code number (Blakers *et al.*, 1984) and, using a custom-designed DBASE III+ data entry system, transferred with all accessory information to computer hard disk files. The flexibility of the DBASE III+ program allowed data retrieval in almost any combination or permutation of species, habitat and/or activity.

Figure B1

Map showing waterbird sampling sites monitored at Peel Inlet between October 1988 and December 1989. (Diagram after Wright 1988).



PART B

LOCAL AND REGIONAL STATUS
OF PEEL INLET

B1.0 RESULTS - ACCESSORY INLET SITES

B1.1 Survey Efficiency

Figure B2, an accumulation graph of species gained on successive sampling periods shows that by July 1989 the maximum number of species identified in accessory inlet sites had been attained. From this point on the graph stabilises, indicating that adequate sampling had been carried out. Extending the survey well beyond this period would no doubt have added several more species, but it is evident from the graph that a point of diminishing returns for effort had been reached and that these additional birds would have contributed little to the analysis.

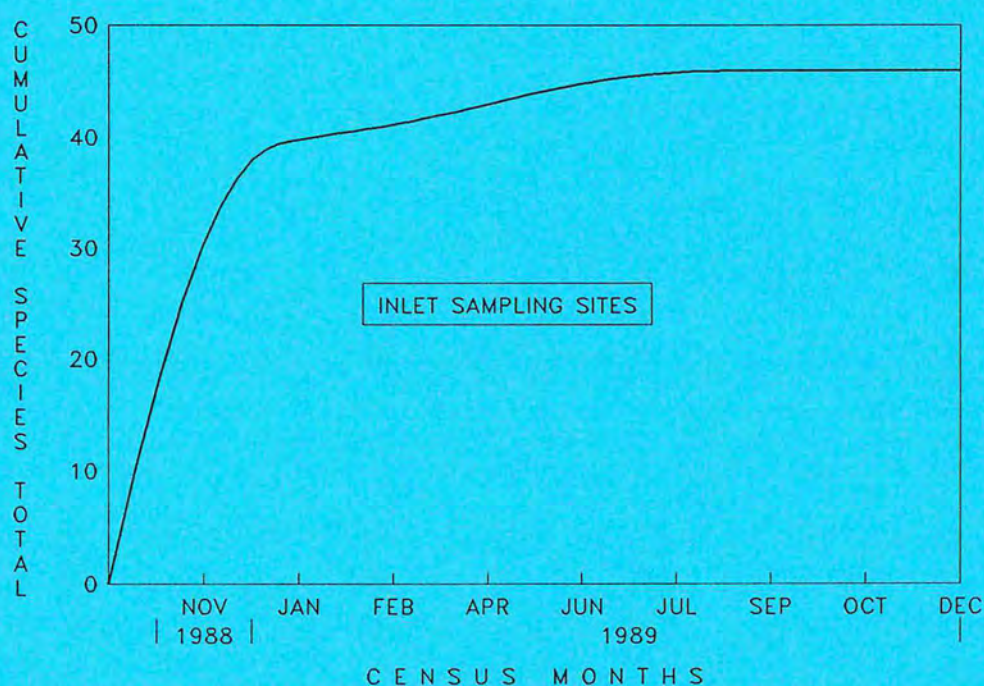


Figure B2 Accumulation graph showing successive gain of waterbird species in accessory inlet sites after each sampling period at Peel Inlet.

B1.2 Species Richness and Abundance

The following table shows the results of sampling accessory inlet sites adjacent to mosquito breeding areas but in no way reflects the

true species diversity of Peel Inlet. This aspect is explored in later sections of the report. A total of 45 species and 19,211 individual birds were recorded over the sampling period.

Table B1 Waterbirds and associated species recorded in inlet habitats adjacent to mosquito breeding sites on Peel Inlet between November 1988 and December 1989. Bold figures represent maximum survey counts.

SAMPLING MONTH	NOV	JAN	FEB	APR	JUN	JUL	SEP	OCT	DEC
PODICIPEDIDAE									
Great Crested Grebe						1			
Hoary-headed Grebe				25		1			
PELECANIDAE									
Australian Pelican	289	88	126	149	124	10	45	102	162
ANHINGIDAE									
Darter	16	14	42	6	26	2		3	2
PHALACROCORACIDAE									
Great Cormorant	29	5	17	1		2		5	22
Pied Cormorant	107	104	46	13	4			22	80
Little Black Cormorant	1032	5		6	13	20	6	16	163
Little Pied Cormorant	55	99	167	246	128	179	9	68	80
ARDEIDAE									
White-faced Heron	21	18	22	40	1	1	24	46	68
Great Egret	5	7	28	3	5	1	12	4	12
Little Egret	3	5	3	7	6			4	1
PLATALEIDAE									
Sacred Ibis	2		3	1				3	2
Yellow-billed Spoonbill					1		3	3	1
ANATIDAE									
Black Swan	68	4	62	8	73	4	7		
Australian Shelduck	207	27	46	6	19	5	33	132	304
Pacific Black Duck	92	50	42	40	41	3	21	37	16
Grey Teal	164	92	268	277	37	4	16	33	464
Pink-eared Duck						2			
Maned Duck	2								
PANDIONIDAE									
Osprey		1	1						
HAEMATOPODIDAE									
Pied Oystercatcher	9							1	1
CHARADRIIDAE									
Grey Plover	26	2	9	4	1			29	2
Red-capped Plover			8					4	3
Black-fronted Plover	2								

Table B1 (Continued).

SAMPLING MONTH	NOV	JAN	FEB	APR	JUN	JUL	SEP	OCT	DEC
RECURVIROSTRIDAE									
Black-winged Stilt	31	182	116	230	7			12	54
Banded Stilt		3000		650					
Red-necked Avocet	184	73	14	7	35	7		128	736
SCOLOPACIDAE									
Ruddy Turnstone	1		4						
Eastern Curlew	3	1	1					1	
Whimbrel	12		2					12	3
Grey-tailed Tattler	1		1						
Common Sandpiper	2		1			1		6	5
Greenshank	191	11	21	1			51	59	22
Marsh Sandpiper	1								
Bar-tailed Godwit	207	161	5					36	3
Red Knot	64	20							
Great Knot	59	212						2	
Sharp-tailed Sandpiper	131	100	25						
Red-necked Stint	19		102	15				10	
Curlew Sandpiper	863	268	2					52	
LARIDAE									
Silver Gull	740	315	746	252	140	27	51	359	633
Whiskered Tern				120					
Caspian Tern	20	6	24	4	47	5		10	37
Fairy Tern	25	1			90		2	13	3
Crested Tern	6	10	21	2	1	1	1	2	
Unidentified small wader	3								
TOTAL	4679	4881	1975	2113	801	274	281	1214	2993

B1.3 Seasonality

Species Richness: in Figure B3 it can be seen that waterbird species richness in the inlet habitats was at a peak in November 1988, dropped markedly in January 1989 then slightly rose again in the following month. From February there is a gradual drop in species until September, when waterbird species richness was at its lowest. The number of species rapidly rises again in October with a large influx of migratory shorebirds from the northern hemisphere. Duck numbers increased, possibly by recruitment from inland breeding areas. Abundance dropped again in December with the absence of several species of shorebirds excluded from rich intertidal areas by a high tide (Table B3). It was apparent during the sampling sessions that tidal influences played a large part in dictating which species or group of species were in a particular location at a given time. When tides were high, certain species had presumably moved elsewhere on the inlet, possibly Harvey Estuary, but reappeared in the following sampling session if this coincided with a low tide.

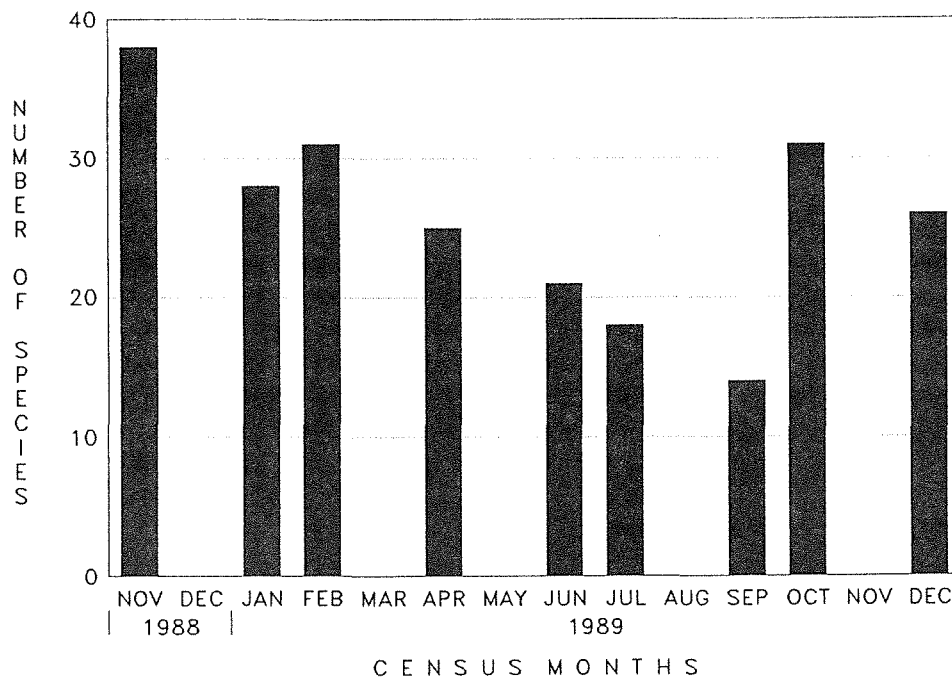


Figure B3 Diagram showing changes in species counts between November 1988 and December 1989 at Peel Inlet (Accessory inlet sites only).

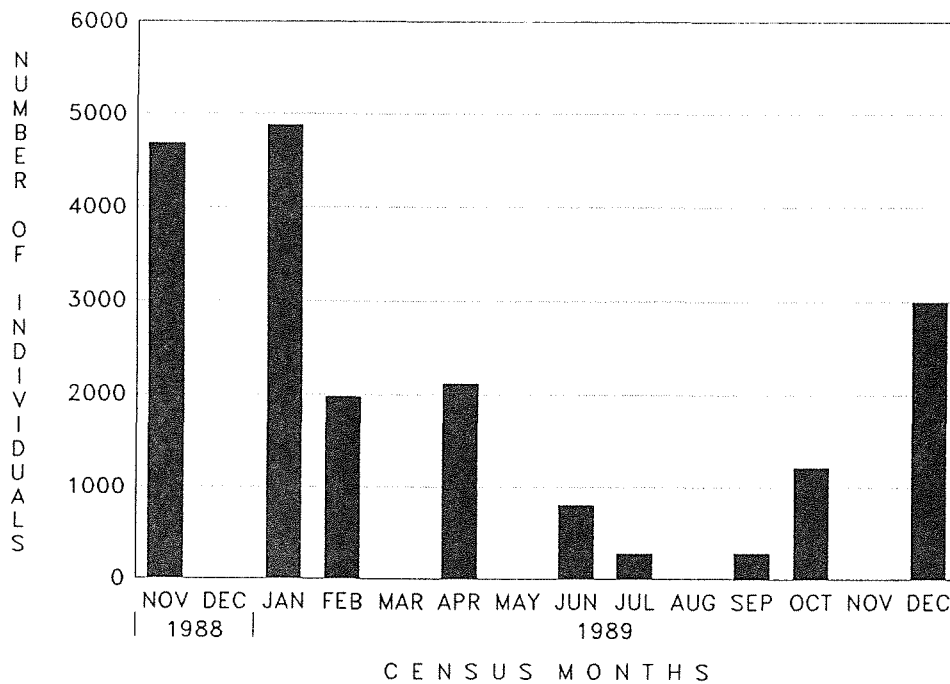


Figure B4 Diagram showing changes in the number of waterbird individuals recorded between November 1988 and December 1989 at Peel Inlet (Accessory inlet sites only).

Abundance: the number of individual birds recorded during sampling periods has been charted in Figure B4 and generally shows a similar pattern to Figure B3 with a peak in summer and a drop in population until October 1988 when numbers again rise again with the influx of migratory species. The January 1989 count was high due to a particularly large flock of 3000 Banded Stilts.

B1.4 Habitat Utilisation

All the species and individuals listed in Table B3 have been used to illustrate how the various inlet habitats were partitioned in terms of the number of species and percentage of the total count recorded in each.

Species: Figure B5 shows that shallows and tidal flats with 41 and 33 species respectively were the most productive habitats with all other locations having at least half as many species. These intertidal zones are generally immediately adjacent to samphire flats (mosquito breeding areas), a feature which has significant implications for current mosquito control measures. This aspect is discussed in detail in Parts C and D.

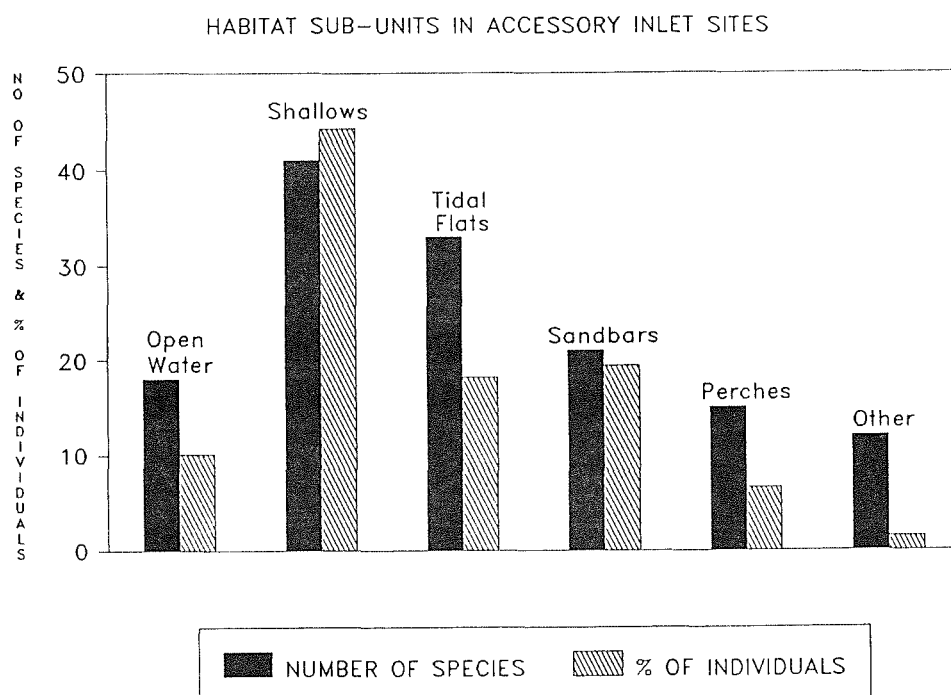


Figure B5 Diagram showing habitat utilisation within accessory inlet sites at Peel Inlet between November 1988 and December 1989.

Individuals: over 62% of all individual birds in the inlet habitats were recorded in shallows or tidal flats adjacent to mosquito breeding areas (Figure B5) . The next highest habitat usage (19%) was sandbars where many Cormorants and Pelicans were recorded roosting. The remaining habitats were relatively poorly used .

B1.5 Activity Patterns

Each of the habitats shown in Figure B5 has been analysed in terms of the waterbird activities which took place within them during the survey. These data have been graphed in Figure B6 and are discussed below.

Open Water (1947 individuals): feeding dominated in this habitat followed by loafing; both activities were mainly carried out by species such as pelicans, cormorants and ducks.

Shallows (8505 individuals): some 86% of all activity in this habitat, which borders on mosquito breeding areas, consisted of feeding or roosting with the latter activity marginally dominating. Migratory wading birds were the most numerous group recorded feeding or roosting followed by ducks, herons and egrets.

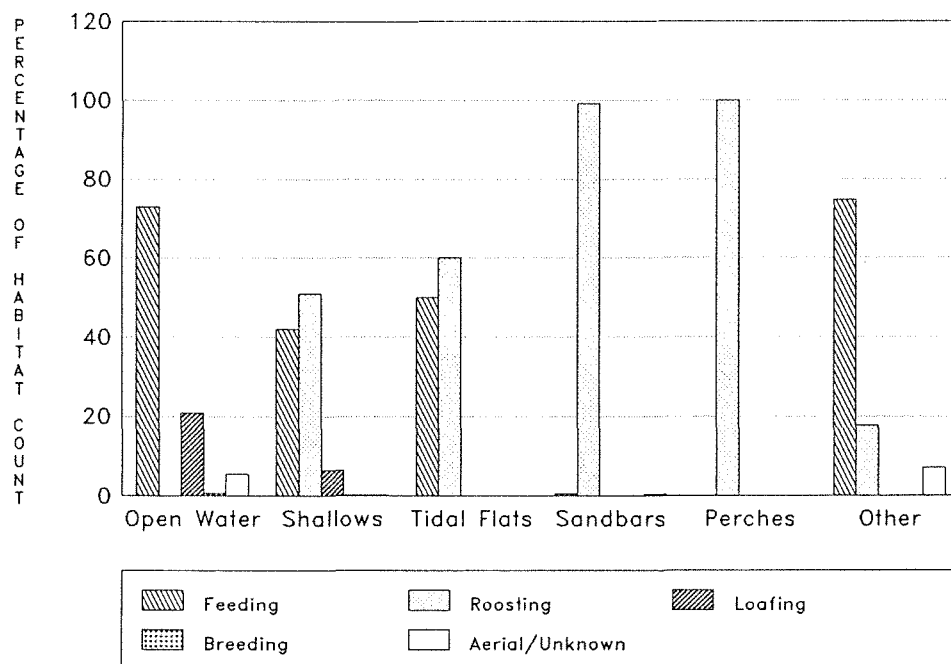


Figure B6 Diagram showing activity patterns within habitat sub-units of accessory inlet sites at Peel Inlet between November 1988 and December 1989.

Tidal Flats (3495 individuals): during the survey, the only activity of any note on sandbars was roosting and tended to be dominated by cormorants, pelicans, ducks and gulls.

Perches (1261 individuals): roosting was the only activity which took place at these sites and consisted mainly of cormorants and gulls.

Other (227 individuals): these unspecified habitats consisted of areas such as carparks, jetties or grassed areas such as occur at Soldier's Cove. The main activities recorded were feeding and roosting with over half the individuals involved being scavenging Silver Gulls.

The activity patterns outlined above represent patterns of behavior recorded on nine single days over a one-year period and it is recognised that if sampling had coincided more often with low tides, the amount of feeding recorded on rich intertidal sites adjacent to mosquito breeding areas may have been substantially higher. Scheduling to this level of accuracy is not feasible and the random series of sampling sessions which were conducted, amply show that mosquito control measures cannot be disassociated from nearby waterbird habitats

B1.6 CALM and South-West Waterbird Project Data

A waterbird survey of the Peel Inlet and Harvey Estuary was conducted from August 1976 to June 1977 by the Department of Fisheries and Wildlife (now Department of Conservation and Land Management). This data is as yet unpublished but has been made available by J.A.K. Lane, Wildlife Research Branch, Department of Conservation and Land Management (CALM). Data were extracted, compiled and summarised by S. McNee.

SWWB data were gathered over 47 surveys with between 5 and 12 individual months being sampled each year. An area including the Peel Inlet Nature Reserve (Austin Bay Nature Reserve) was surveyed up to 500m from the water's edge. This sampling site extends from near Point Birch to just east of the mouth of the Murray River. The results of the South-West Waterbird (SWWB) project are published in Jaensch *et al.* (1988) and these data have also been included to construct a total species list for Peel Inlet (Table B5). Breeding records have been extracted as have maximum counts of individual species.

CALM surveys were conducted every two months between the above dates resulting in six surveys. Larger birds such as the Australian Pelican and Black Swan were counted from aerial photographs taken at the time of the survey and verified at some sites by ground counts. Other waterbird species were recorded by personnel either on foot, on horseback or by boat.

Number of Species: Seventy waterbird species were recorded during the CALM survey. Of these, 66 were recorded from the Peel Inlet (Table B4). Four species were observed only in the Harvey Estuary. These exceptions were: Australian Crake; Purple Swamphen; Maned Duck and Terek Sandpiper. All of the above species with the exception of the Purple Swamphen were recorded during the 1988-1989 MCRC study (Tables B3, C1).

The lowest number of species was recorded at Peel Inlet during August 1976 (39 species) and the highest in February 1977 (49 species). The highest number of individuals was also recorded during this latter month (110,227 birds). Migratory wading birds made up 27% and Banded Stilts 55% of this February total. The highest sampling session species count recorded during the SWWB project was 36 in July 1983.

Table B2 Species present in Peel Inlet during the 1976 to 1977 CALM survey.

SAMPLING PERIOD	AUG	OCT	DEC	FEB	APR	JUN
PODICIPEDIDAE						
Great Crested Grebe			X	X		
Hoary-headed Grebe		X	X	X	X	X
PELECANIDAE						
Australian Pelican	X	X		X		X
ANHINGIDAE						
Darter	X	X	X	X	X	X
PHALACROCORACIDAE						
Great Cormorant	X	X	X	X	X	X
Pied Cormorant	X	X	X	X	X	X
Little Black Cormorant	X	X	X	X	X	X
Little Pied Cormorant	X	X	X	X	X	X
ARDEIDAE						
White-faced Heron	X	X	X	X	X	X
Great Egret	X	X	X	X	X	X
Little Egret	X		X		X	X
Eastern Reef Egret					X	
PLATALEIDAE						
Glossy Ibis	X					
Sacred Ibis	X					X
Straw-necked Ibis		X				
Royal Spoonbill	X					
Yellow-billed Spoonbill	X					X
ANATIDAE						
Black Swan	X	X		X		X

Table B2 (continued)

SAMPLING PERIOD	AUG	OCT	DEC	FEB	APR	JUN
Australian Shelduck	X	X	X	X	X	X
Pacific Black Duck	X	X	X	X	X	X
Mallard					X	X
Grey Teal	X	X	X	X	X	X
Chestnut Teal				X	X	
Australasian Shoveler		X	X	X	X	X
Pink-eared Duck		X		X		
Hardhead						X
Musk Duck				X	X	
PANDIONIDAE						
Osprey		X		X	X	X
ACCIPITRIDAE						
Whistling Kite	X	X	X	X	X	X
Marsh Harrier					X	X
RALLIDAE						
Eurasian Coot		X				X
CHARADRIIDAE						
Grey Plover	X	X	X	X	X	X
Lesser Golden Plover			X	X		
Red-kneed Dotterel						X
Large Sand Plover		X	X	X		
Red-capped Plover	X	X	X	X	X	X
Black-fronted Plover						X
Inland Dotterel					X	
RECURVIROSTRIDAE						
Black-winged Stilt	X	X	X	X	X	X
Banded Stilt	X	X	X	X	X	X
Red-necked Avocet	X	X	X	X	X	X
SCOLOPACIDAE						
Ruddy Turnstone		X	X	X		
Eastern Curlew	X	X	X	X	X	X
Whimbrel	X	X	X	X	X	
Grey-tailed Tattler			X	X	X	
Common Sandpiper	X	X	X	X	X	
Greenshank	X	X	X	X	X	X
Marsh Sandpiper		X				
Black-tailed Godwit	X	X	X	X	X	X
Bar-tailed Godwit	X	X	X	X	X	X
Red Knot		X	X	X	X	
Great Knot		X	X	X	X	
Sharp-tailed Sandpiper		X	X	X		
Pectoral Sandpiper				X		
Red-necked Stint	X	X	X	X	X	X
Curlew Sandpiper	X	X	X	X	X	X
LARIDAE						
Silver Gull	X	X	X	X	X	X
Whiskered Tern	X	X	X	X	X	X
Gull-billed Tern	X	X	X		X	
Caspian Tern	X	X	X	X	X	X
Roseate Tern					X	X
Fairy Tern	X		X	X		
Crested Tern	X	X	X	X	X	X
SYLVIIDAE						
Little Grassbird	X	X	X	X	X	X
EPHITHIANURIDAE						
White-fronted Chat	X	X		X	X	X
Domestic Hybrid Duck				X		
TOTAL NUMBER OF SPECIES	39	44	42	49	44	42

Twenty-seven species were recorded in all six surveys and 21 were only observed in one or two (Table B4). This latter group includes birds such as Eurasian Coot, Yellow-billed Spoonbill, Sacred Ibis, Straw-necked Ibis, Marsh Harrier and the more uncommon wading birds such as Pectoral Sandpiper, Black-tailed Godwit, Marsh Sandpiper, Lesser Golden Plover, Eastern Reef Egret and Royal Spoonbill.

Six species of tern were recorded during this survey compared with five in 1981-85 (SWWB project) and three in 1988-89 MCRC study). Fairy Terns breed near the mouth of the inlet and can occur in high numbers (maximum count 84). Whiskered Terns have also been observed in large numbers with a maximum count of 285, although 827 were recorded in August 1983 (Jaensch *et al.* 1988).

Breeding Species: seven species were recorded breeding during the 1981-5 SWWB study. These are: Grey Teal; Australian Shelduck; Pacific Black Duck; Black Swan; Red-capped Plover; White-faced Heron and Hardhead. No breeding data were extracted from CALM data. Two further species were recorded breeding between 1988 and 1989. These were: Eurasian Coot; Yellow-billed Spoonbill. A young Black-winged Stilt was observed in December 1989.

Number of Individuals: During the 1976-1977 survey period, large congregations of certain species were recorded, for example, the 60,802 Banded Stilts in February 1977. Other notable species include Grey Teal (12,602 in October 1976) and Black Swan (7,706 in October 1976). Migratory wading birds also made up a considerable proportion of the total individuals from October to February (18,171 in October; 20,545 in December; 29,941 in February). The large concentrations of Banded Stilts observed between December and April, particularly in February, are unlikely to occur every year as the use of Peel Inlet by this species will depend largely on the availability of water elsewhere in Australia. However, these high numbers indicate the value of Peel Inlet during dry or drought conditions in inland Australia.

Peel Inlet is also extremely important for migratory wading birds, supporting up to 30,000 in February 1977. Large numbers of the less common or rare species have also been recorded utilising the inlet. These include species such as Whimbrel, Eastern Curlew, Lesser Golden Plover, Large Sand Plover, Marsh Sandpiper, Pectoral Sandpiper and the Black-tailed Godwit which is common in the north-west of the State but is observed less frequently in the south-west.

Species of Conservation Significance: The following birds are listed in Jaensch *et al.* (1988) as being present in less than five wetland

reserves during the course of the 1981-5 study: Grey-tailed Tattler; Whimbrel and White-winged Black Tern. The latter bird was not recorded at the Peel Inlet during 1988-89 MCRC study.

B1.7 Conclusions

Peel Inlet has long been recognised as an extremely important conservation area and has therefore been designated as a wetland of international significance since it at times supports greater than 20,000 waterbirds including 27 species cited in the Japan/Australia (JAMBA) and China/Australia (CAMBA) Migratory Birds Agreement. A total of 83 species of waterbird and associated species have been recorded over time at the Peel Inlet and associated wetlands (Table B5). The importance of the inlet is also highlighted by the extremely large numbers of Banded Stilts which occur during dry years and the frequent, large congregations of Black Swans, duck and cormorant species. Up to 100,000 individual waterbirds have been recorded during a single survey by CALM.

Table B3 Bird species recorded during the CALM survey (unpubl.), South-West Waterbird Project (SWWB - Jaensch *et al.* 1988) and MCRC study at Peel Inlet. Bold indicates recording in only one of these studies.

KEY

= on JAMBA and/or CAMBA list

X = Recorded

* = Recorded in the current study from wetland sites disassociated from the inlet, e.g. Goegrup Lake.

STUDY YEAR/S	CALM 1976-7	SWWB 1981-5	MCRC 1988-9
PODICIPEDIDAE			
Great Crested Grebe	X		X
Hoary-headed Grebe	X	X	X
Australasian Grebe		X	*
PELECANIDAE			
Australian Pelican	X	X	X
ANHINGIDAE			
Darter	X	X	X

Table B3 (Continued).

STUDY YEAR/S		CALM 1976-7	SWWB 1981-5	MCRC 1988-9
PHALACROCORACIDAE				
Great Cormorant		X	X	X
Pied Cormorant		X	X	X
Little Black Cormorant		X	X	X
Little Pied Cormorant		X	X	X
ARDEIDAE				
Pacific Heron			X	
White-faced Heron		X	X	X
Cattle Egret	#		X	
Great Egret	#	X	X	X
Little Egret		X	X	X
Eastern Reef Egret		X		
Rufous Night Heron			X	*
PLATALEIDAE				
Glossy Ibis	#	X	X	
Sacred Ibis		X	X	X
Straw-necked Ibis		X	X	*
Royal Spoonbill		X	X	X
Yellow-billed Spoonbill		X	X	X
ANATIDAE				
Black Swan		X	X	X
Australian Shelduck		X	X	X
Pacific Black Duck		X	X	X
Mallard		X		
Grey Teal		X	X	X
Chestnut Teal		X	X	*
Australasian Shoveler		X	X	*
Pink-eared Duck		X	X	X
Hardhead		X	X	X
Maned Duck			X	X
Blue-billed Duck			X	*
Musk Duck		X	X	*
PANDIONIDAE				
Osprey		X	X	X
ACCIPITRIDAE				
Whistling Kite		X		X
White-bellied Sea-Eagle	#		X	
Marsh Harrier		X	X	X
RALLIDAE				
Australian Crake				*
Spotless Crake				X
Dusky Moorhen				*
Purple Swamphen			X	
Eurasian Coot		X	X	*
HAEMATOPODIDAE				
Pied Oystercatcher				X
CHARADRIIDAE				
Grey Plover	#	X	X	X
Lesser Golden Plover	#	X		
Red-kneed Dotterel		X		
Hooded Plover			X	
Large Sand Plover	#	X	X	
Red-capped Plover		X	X	X
Black-fronted Plover		X	X	X
Inland Dotterel		X		
RECURVIROSTRIDAE				
Black-winged Stilt		X	X	X
Banded Stilt		X	X	X
Red-necked Avocet		X	X	X

Table B3 (Continued).

STUDY YEAR/S		CALM 1976-7	SWWB 1981-5	MCRC 1988-9
SCOLOPACIDAE				
Ruddy Turnstone	#	X	X	X
Eastern Curlew	#	X	X	X
Whimbrel	#	X	X	X
Grey-tailed Tattler	#	X	X	X
Common Sandpiper	#	X	X	X
Greenshank	#	X	X	X
Marsh Sandpiper	#	X	X	X
Terek Sandpiper	#			X
Black-tailed Godwit	#	X		
Bar-tailed Godwit	#	X	X	X
Red Knot	#	X	X	X
Great Knot	#	X	X	X
Sharp-tailed Sandpiper	#	X	X	X
Pectoral Sandpiper	#	X	X	
Red-necked Stint	#	X	X	X
Long-toed Stint	#		X	
Curlew Sandpiper	#	X	X	X
Ruff	#		X	
LARIDAE				
Silver Gull		X	X	X
Whiskered Tern		X	X	X
White-winged Tern	#		X	
Gull-billed Tern		X	X	
Caspian Tern	#	X	X	X
Roseate Tern		X		
Fairy Tern		X	X	X
Crested Tern		X	X	X
SYLVIIDAE				
Little Grassbird		X	X	X
EPHITHIANURIDAE				
White-fronted Chat		X		X
GRALLINIDAE				
Australian Magpie-lark				X
Domestic Hybrid Duck				*

PART C

ASSESSMENT OF MOSQUITO BREEDING
AREAS AT PEEL INLET AND
SURROUNDING WETLANDS

C1.0 RESULTS - MOSQUITO BREEDING AREAS

As described in Methods (Section 2.0), all points inland and including the bare shorelines of the inlet where pools of water gather long enough to encourage breeding mosquitoes were considered as locations potentially subject to mosquito control measures. All 37 of the sampling sites chosen during the reconnaissance included breeding areas which ranged from large patches of inundated samphire to small, isolated pools or deep vehicle tracks.

C1.1 Survey Efficiency

Figure C1 shows that by June 1989 the total of waterbird species recorded in mosquito breeding areas had stabilised at 61. No further species were added until December 1989 when the number of species accumulated rose to 62 with the addition of the Eurasian Coot (Table C1). The species accumulation curve is virtually flat for the last four surveys indicating that mosquito breeding areas were adequately sampled and that while further surveys may have resulted in several more uncommon or vagrant species being added, these are unlikely to have contributed greatly to the analysis.

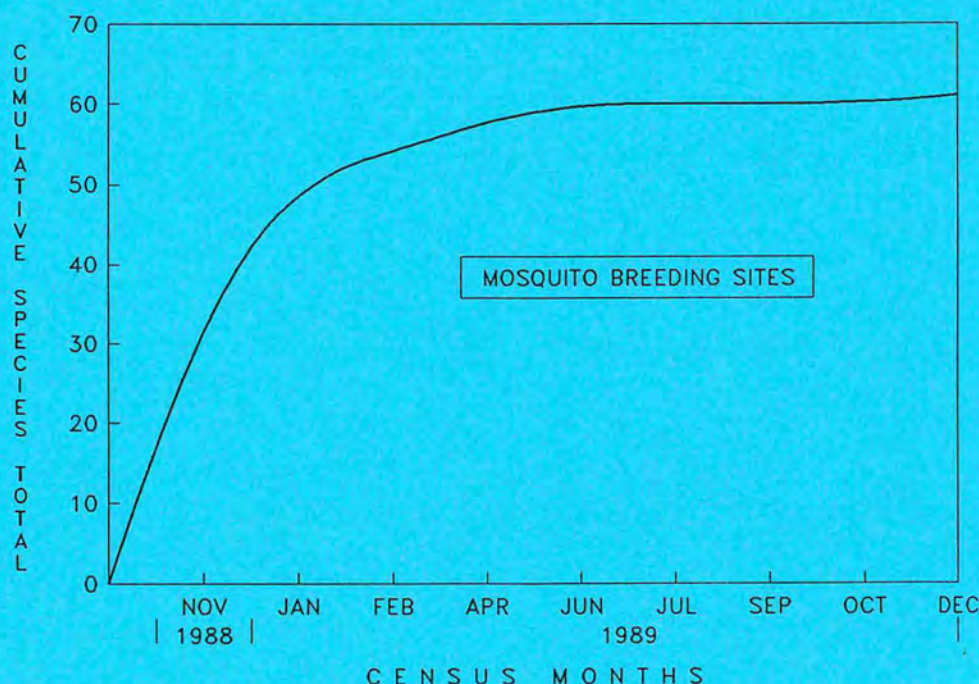


Figure C1 Accumulation graph showing successive gain of waterbird species in mosquito breeding sampling areas after each sampling period at Peel Inlet.

C1.2 Species Richness and Abundance

Table C1 shows that 62 species of waterbird and associated species were recorded in mosquito breeding areas. A total of 26,758 individual birds were counted. Appendix 1 provides details of species richness and abundance for each of the 37 individual sampling sites and has mainly been included to assist in developing control measures for each mosquito breeding site. This aspect is specifically addressed in Part D.

Table C1 Waterbirds and associated species recorded in mosquito breeding sites at Peel Inlet between November 1988 and December 1989. Bold figures represent maximum survey counts.

SAMPLING MONTH	NOV	JAN	FEB	APR	JUN	JUL	SEP	OCT	NOV
PODICIPEDIDAE									
Great Crested Grebe			3						
Hoary-headed Grebe	7					64		4	5
Australasian Grebe		2			134		8		
PELECANIDAE									
Australian Pelican	46	68	64	99	137	116	74	56	58
ANHINGIDAE									
Darter		7	24	24	24	79	11	1	1
PHALACROCORACIDAE									
Great Cormorant			3	25	9	21	7	8	60
Pied Cormorant			7	25	6	3	9	1	
Little Black Cormorant	85	36	65	281	324	76	389	325	105
Little Pied Cormorant	46	219	143	543	662	225	138	83	39
ARDEIDAE									
White-faced Heron	166	51	64	112	81	17	40	68	123
Great Egret	12	12	12	44	149	50	32	24	5
Little Egret	4	6	8	4	30	4	1	16	5
Rufous Night Heron	1								
PLATALEIDAE									
Sacred Ibis	1	11	10	23	39	3	14	1	17
Straw-necked Ibis	3								
Royal Spoonbill				2		2			
Yellow-billed Spoonbill	37	3	22	9	63	22	48	39	1
ANATIDAE									
Black Swan	99	27	11		66	38	40	115	93
Australian Shelduck	1036	342	351	106	56	43	140	84	955
Pacific Black Duck	95	215	171	113	162	100	225	222	617
Grey Teal	315	734	964	666	43	27	172	80	1237
Chestnut Teal			2						
Australasian Shoveler					11				10

Table C1 (Continued).

SAMPLING MONTH	NOV	JAN	FEB	APR	JUN	JUL	SEP	OCT	NOV
Pink-eared Duck		68							44
Hardhead	2			41					
Maned Duck	4				2	3	2		
Blue-billed Duck	3						1	1	
Musk Duck	13	11	5		84	67	13	10	12
PANDIONIDAE									
Osprey	1		1	1	3	1	3	1	2
ACCIPITRIDAE									
Whistling Kite	2		2		2	9	3	2	2
Marsh Harrier	3				1	2		1	1
RALLIDAE									
Australian Crake				1					
Spotless Crake					3	1			
Dusky Moorhen									1
Eurasian Coot	42	14	9		586	350	69	166	300
HAEMATOPODIDAE									
Pied Oystercatcher		8		2		1			
CHARADRIIDAE									
Grey Plover		31	48	3					
Red-capped Plover	64	64	84	10			7	6	52
Black-fronted Plover	1	2		14				1	2
RECURVIROSTRIDAE									
Black-winged Stilt	165	502	291	428	72		5	11	29
Banded Stilt		138	236	23					21
Red-necked Avocet		705	206	11					478
SCOLOPACIDAE									
Eastern Curlew		2	1			1	2		
Whimbrel		5	1						
Common Sandpiper	2	4	4	3			1	2	
Greenshank	70	163	99	19	5	2	212	267	150
Marsh Sandpiper	5							3	
Terek Sandpiper		2	1						
Bar-tailed Godwit		163	88						
Great Knot		33	2						
Sharp-tailed Sandpiper	9	99	149						
Red-necked Stint	5	15	153	88					
Curlew Sandpiper	21	134	8	2					
LARIDAE									
Silver Gull	202	752	408	120	164	51	151	57	399
Whiskered Tern				1					
Caspian Tern		6	4	67			1	1	22
Crested Tern		4		11	1	5		1	
MOTACILLIDAE									
Richard's Pipit	2	1	3		1	1	1	3	

Table C1 (Continued).

SAMPLING MONTH	NOV	JAN	FEB	APR	JUN	JUL	SEP	OCT	NOV
SYLVIIDAE									
Little Grassbird	8	7	10	4	19	14	16	21	18
EPHTHIANURIDAE									
White-fronted Chat	7		3	21	1		15	16	11
GRALLINIDAE									
Australian Magpie-lark				4				1	
Unidentified Grebe		2	1						
Domestic Hybrid Duck						8			
Unidentified Duck	23								

TOTAL	2611	4687	3741	2950	2940	1406	1850	1698	4875

C1.3 Seasonality

Species Richness: Unlike the accessory inlet sites, mosquito breeding areas showed relatively little variation in species richness from survey to survey (Figure C2), with there being only 10 species difference between the highest and lowest count (Table C1). This is brought about by the departure of many migratory shorebirds to the northern hemisphere in the June to September period and their replacement by a series of other species, mainly grebes and ducks, which had arrived before dissipating to nearby breeding areas such as Barragup Lake.

The total number of species peaked in February 1989, was at its lowest in June and from that point began to rise again. In December (Figure C2) there was a drop in the number of species as a result of a high tide excluding several species of shorebirds from roosting and feeding areas such as shorelines. This aspect was only evident in tidally affected locations such as Goegrup Lake and the series of small wetlands adjacent to the Serpentine River, but was enough to reduce the overall number of species present. This latter effect was also observed in the accessory inlet sites (Figure B3).

Individuals: the 26,758 individual birds recorded in mosquito breeding areas have been plotted against sampling period totals in Figure C3 which shows that there is a peak at either end of the year with extremely low counts in the July to October period with the July count being the lowest. The two peaks in January and December,

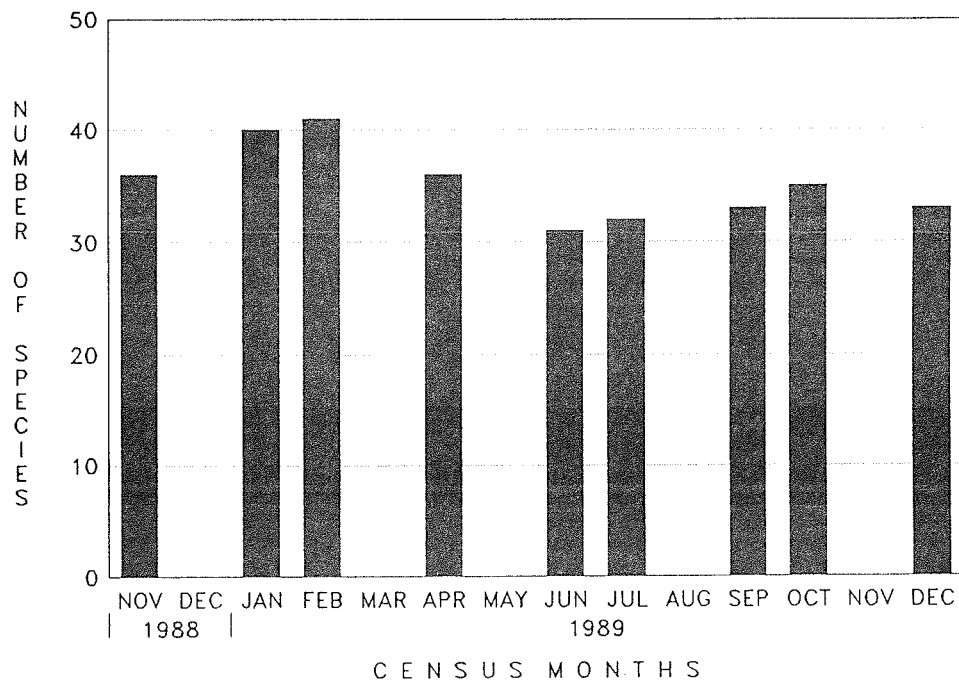


Figure C2 Diagram showing changes in waterbird species counts in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

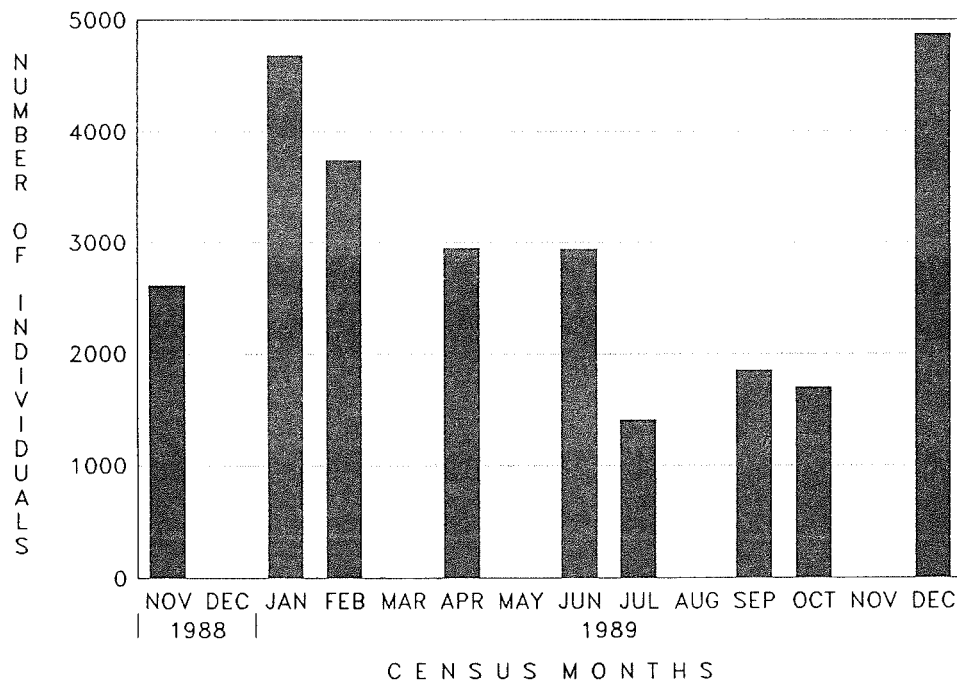


Figure C3 Diagram showing changes in the number of waterbird individuals recorded in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

however, are quite dissimilar in their composition in that the proportions of shorebirds and swans/ducks to the total number of individuals recorded are reversed. In January, 44% of the total was shorebirds while 30% were swans and ducks. In December, 15% were shorebirds while 60% were swans and ducks. This could be due to a high tide disrupting normal patterns of saltmarsh usage but may also be typical of the massive year to year fluctuations documented in the CALM and RAOU data presented in Section B1.6. Whether these fluctuations can be adequately explained by this study are irrelevant. The fact remains that it is difficult to predict on any one day whether large concentrations of waterbirds will coincide with aerial application of larvicides or, indeed, sampling periods. Normal fluctuations due to migration are overlain by event-related factors such as tides, winds and inland, seasonal conditions.

In order to illustrate detailed seasonal patterns of usage, 18 species of waterbirds representative of mosquito breeding areas and making up nearly 85% of all individuals counted, have been analysed in the following series of diagrams. These diagrams and the following text detail some of the species which have produced the monthly totals of individuals given in Figure C3. Data for these diagrams have been drawn from Table C1 and to retain parity between the markedly different total counts for each waterbird, monthly counts for a particular species have been expressed as a percentage of its total count for all surveys.

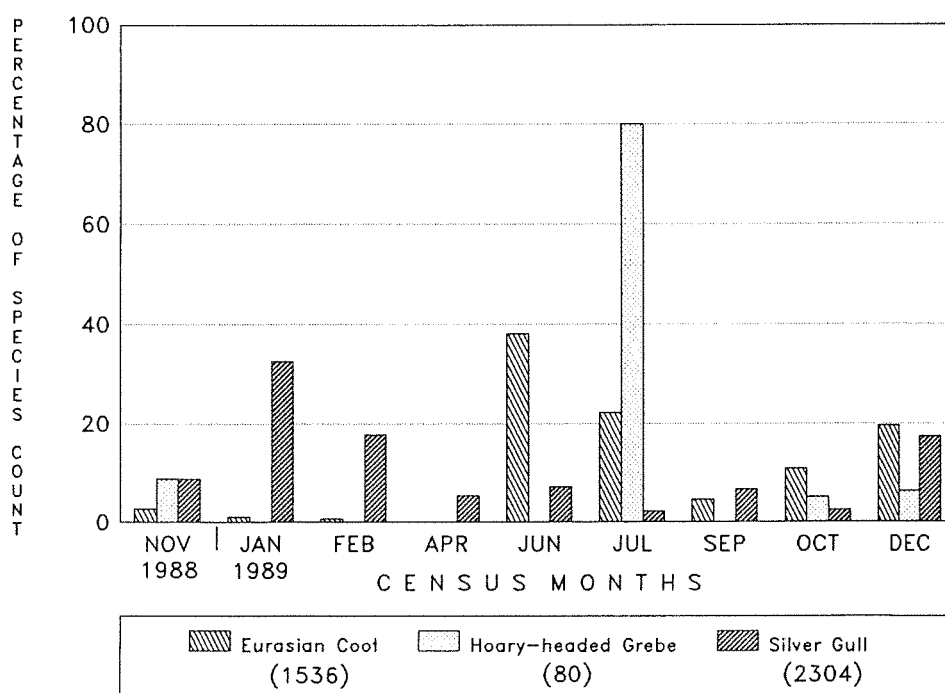


Figure C4-a Seasonal fluctuations of the Eurasian Coot, Hoary-headed Grebe and Silver Gull in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

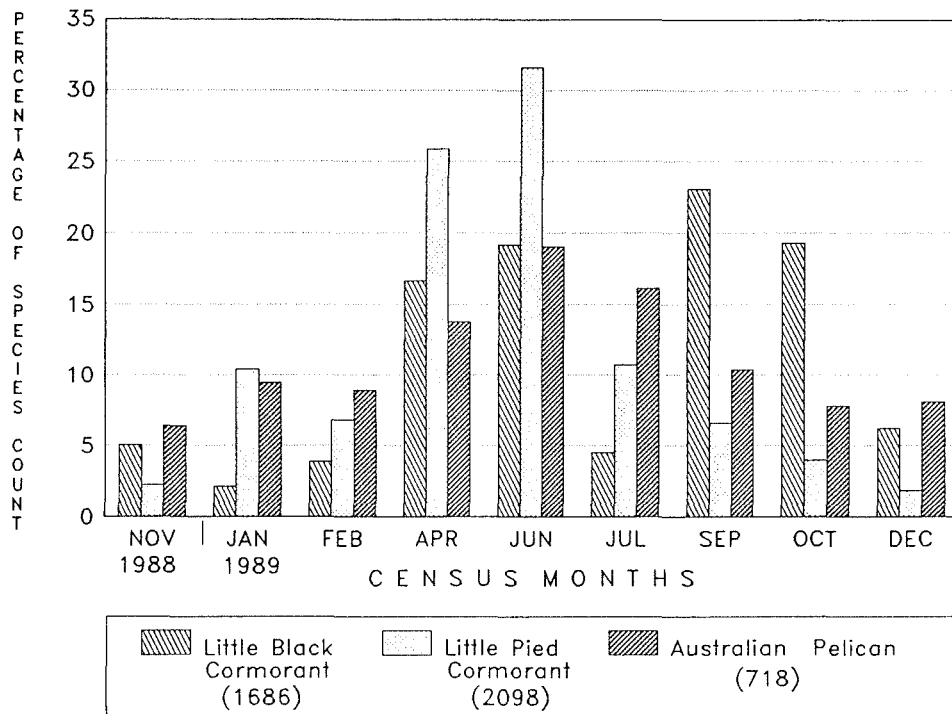


Figure C4-b Seasonal fluctuations of the Little Black Cormorant, Little Pied Cormorant and Australian Pelican in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

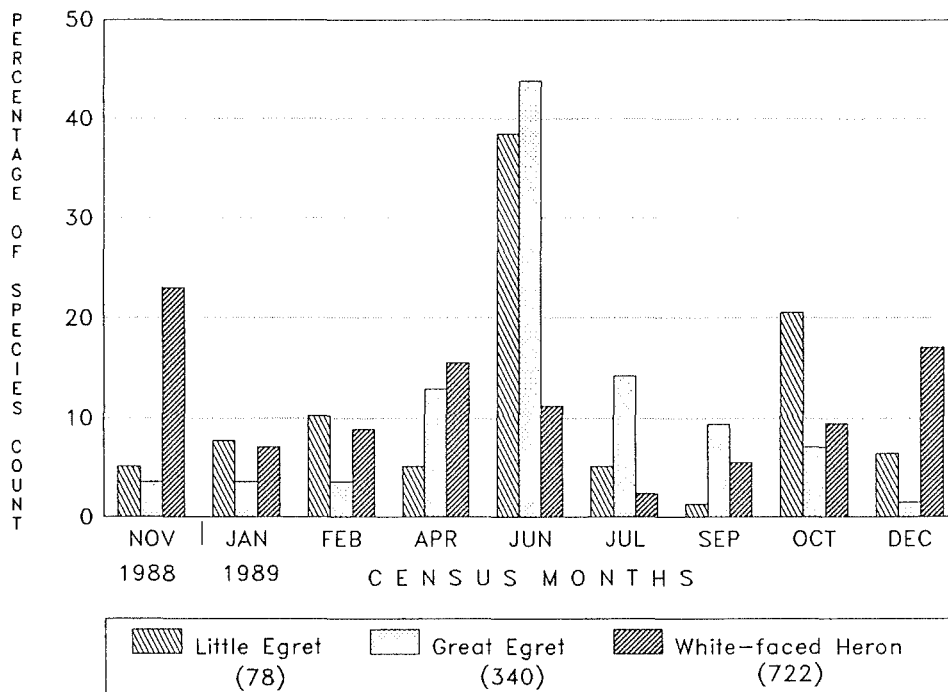


Figure C4-c Seasonal fluctuations of the Little Egret, Great Egret and White-faced Heron in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

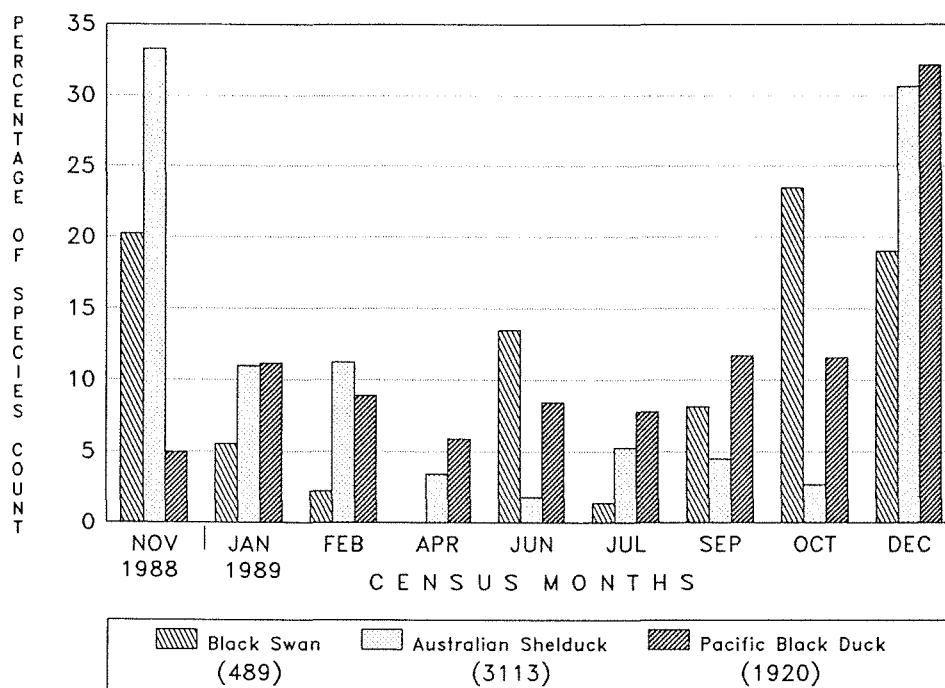


Figure C4-d Seasonal fluctuations of the Black Swan, Australian Shelduck and Pacific Black Duck in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

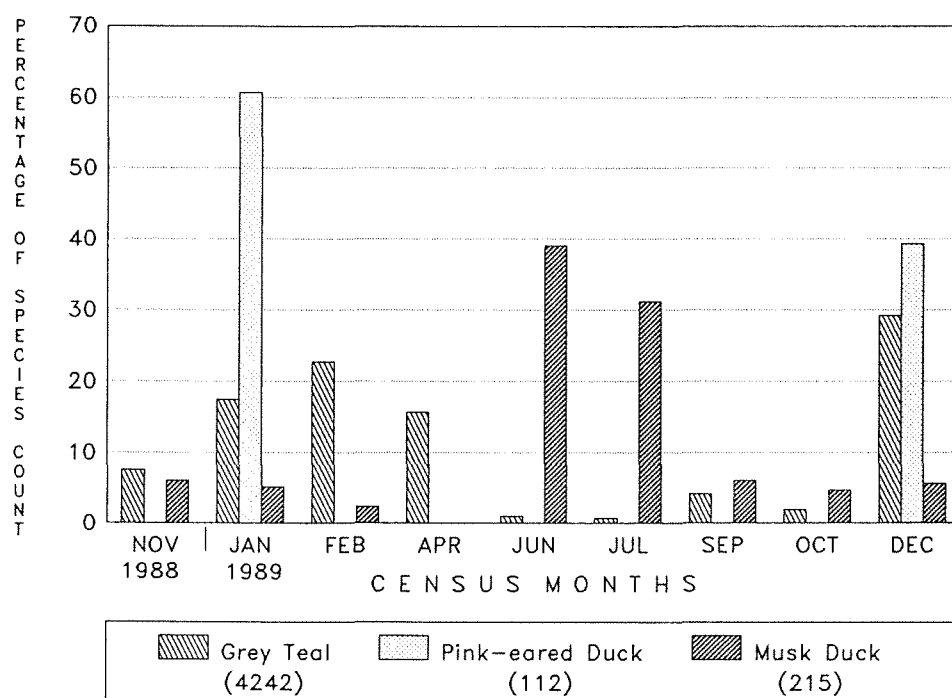


Figure C4-e Seasonal fluctuations of the Grey Teal, Pink-eared Duck and Musk Duck in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

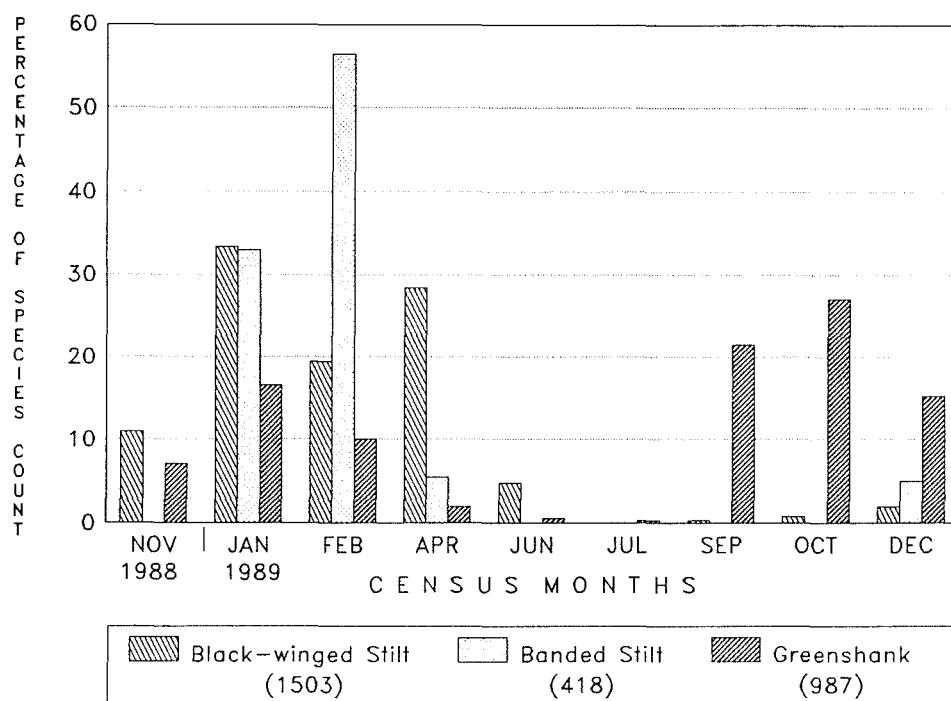


Figure C4-f Seasonal fluctuations of the Black-winged Stilt, Banded Stilt and Greenshank in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

Table C2 Months in which various species reached their highest numbers in mosquito breeding areas at Peel Inlet between November 1988 and December 1989. (Based on Figures C4a-f).

MONTH	WATERBIRD SPECIES
November 1988	White-faced Heron, Australian Shelduck.
January 1989	Silver Gull, Pink-eared Duck, Black-winged Stilt.
February	" Banded Stilt.
April	" None.
June	" Australian Pelican, Little Pied Cormorant, Great Egret, Little Egret, Musk Duck, Eurasian Coot.
July	" Hoary-headed Grebe.
September	" Little Black Cormorant.
October	" Black Swan, Greenshank.
December	" Pacific Black Duck, Grey Teal.

As stated previously the above 18 species were generally the most abundant or representative of the various waterbird groups in mosquito breeding areas and have been selected for this reason. Highest counts for other species are given in Table C1 which shows for example that April, a poor month for more abundant species, was a productive period for the Pied Cormorant, Sacred Ibis, Hardhead, Black-fronted Plover, Caspian Tern, Crested Tern, White-fronted Chat and Australian Magpie-lark although the total number of records for some of these species was very low.

C1.4 Habitat Utilisation

Data sheets for this and the Leschenault Estuary project were divided into two sections (Appendix 3) in order to discriminate between locations where mosquitoes bred and areas where they did not, in effect assuming that the impacts of mosquito control measures, both physical and chemical, were concentrated inland from the upper limits of tidal flats to the boundary between samphire and higher ground. In reality this is not the case because while mosquitoes may not breed in the open water of the inlet and on its associated sub-units such as tidal flats, there remains an intimate connection between breeding areas and non-breeding areas because of tidal interplay and bird movements.

For practical purposes and the problem of adequately quantifying this aspect in any analysis, inlet sub-units have been ignored except to point out that control measures do not exist in isolation. Similarly, while mosquitoes may not breed in the exposed, open water category "Within Swamp/Wetland" of tidal, freshwater or brackish areas such as Barragup Lake (Site 22), Goegrup Lake and Black Lake it has been assumed that the connection between this unit and surrounding samphire breeding areas is much more intimate because of the relatively closed waters of these and similar sampling areas. The category "Within Wetland" has therefore been created for such areas and is described in more detail in Section A2.4.

The 62 species and 26,758 individual waterbirds recorded during the survey used the habitat sub-units of mosquito breeding areas as illustrated in Figure C5.

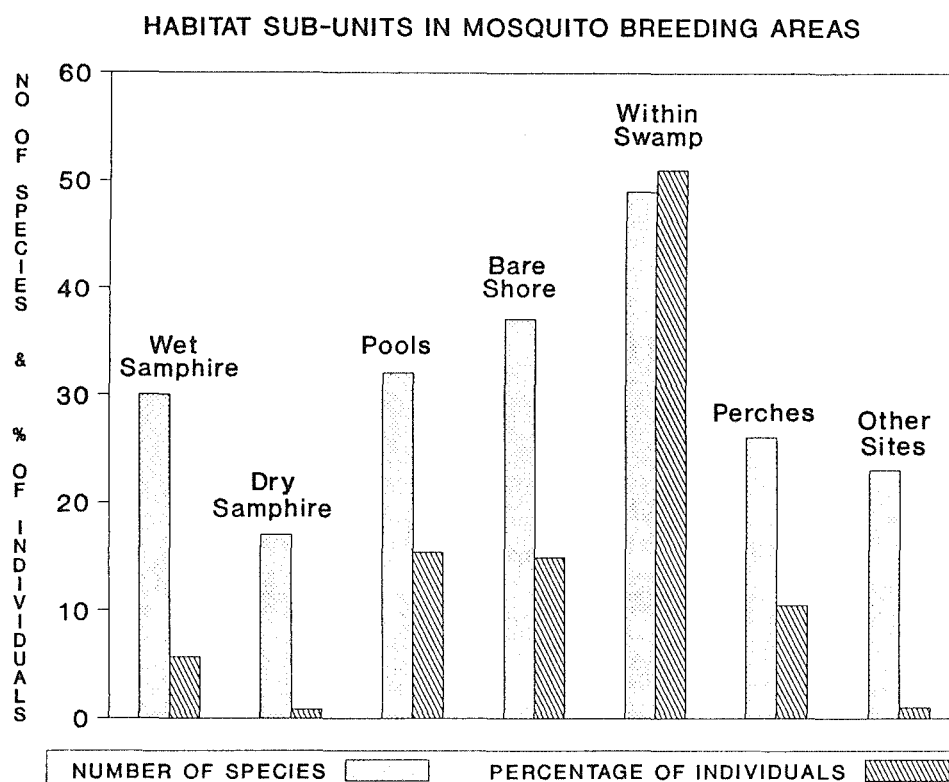


Figure C5 Waterbird utilisation of mosquito breeding area habitat sub-units at Peel Inlet between November 1988 and December 1989.

It is apparent from Figure C5 and Table C2 that the central water body of wetlands supported the greatest number of species (49) and the highest proportion of individuals (51%). However, mosquito control measures both chemical and physical are concentrated on the first four sub-units shown in Table C2 and it can be seen that in total these habitats supported 48 species of waterbirds and 37% of all individuals, a feature which stresses their importance. Figures C6a-f take the 18 species analysed in Section 3.2.3 and show which waterbirds dominated the various habitat sub-units.

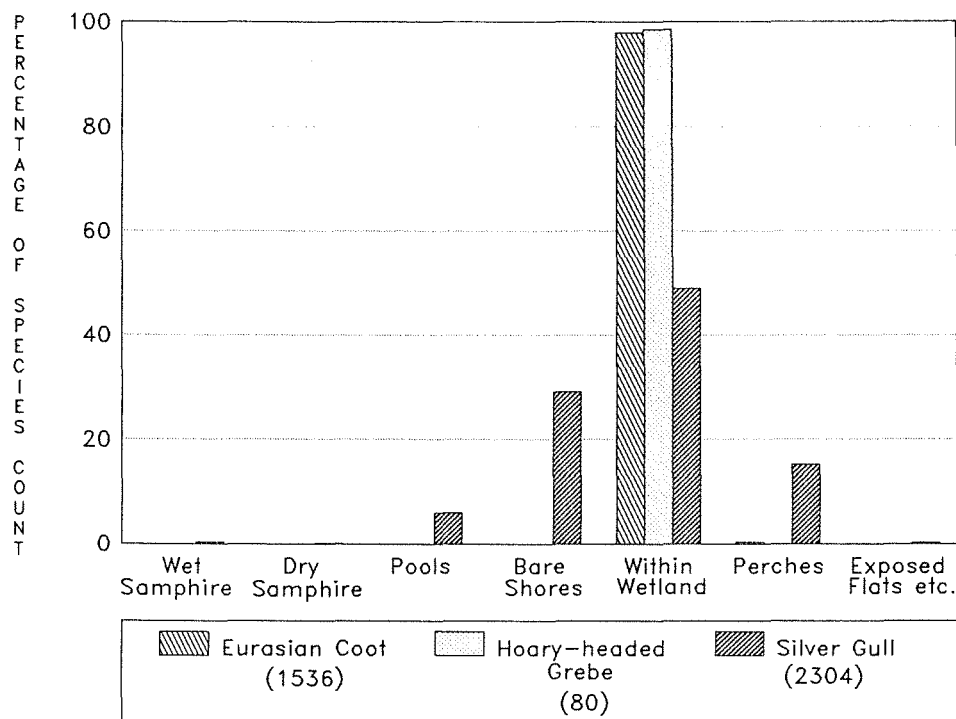


Figure C6-a Utilisation of habitat sub-units in mosquito breeding areas by the Eurasian Coot, Hoary-headed Grebe and Silver Gull.

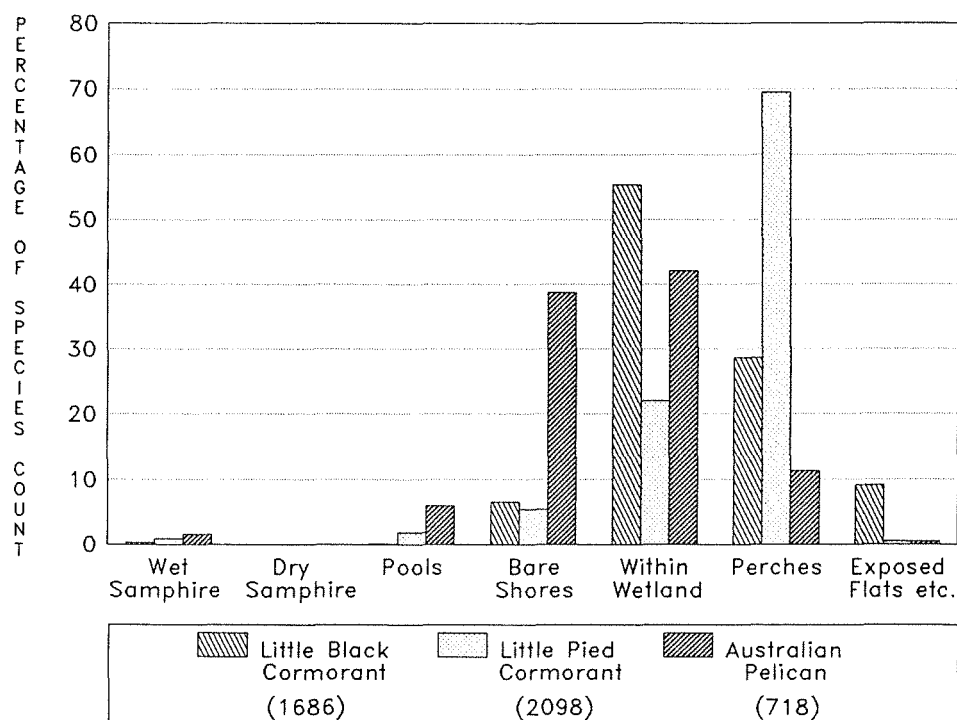


Figure C6-b Utilisation of habitat sub-units in mosquito breeding areas by the Little Black Cormorant, Little Pied Cormorant and Australian Pelican.

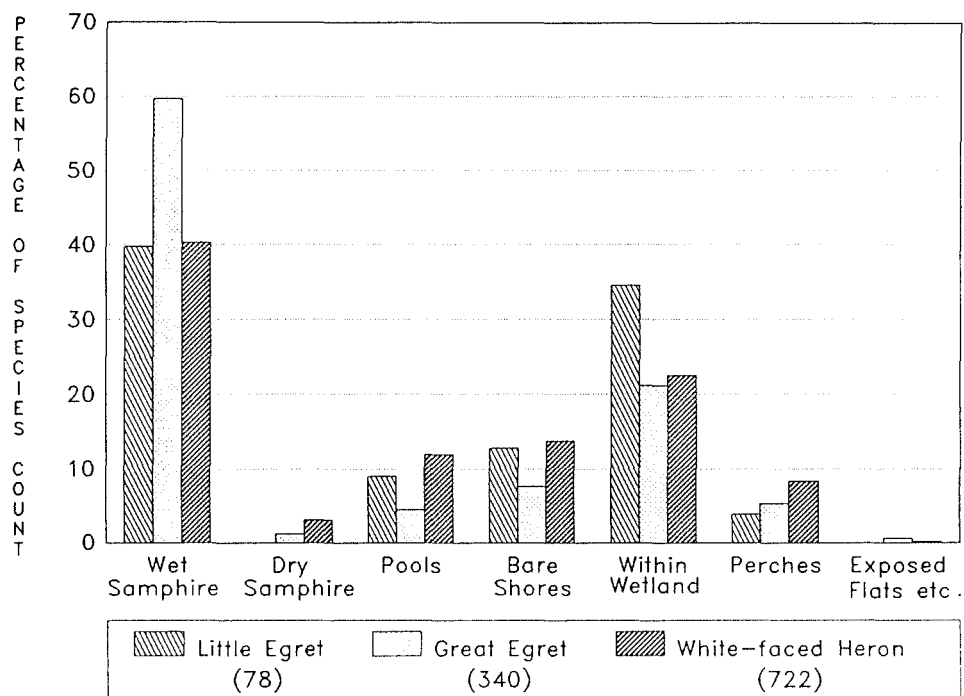


Figure C6-c Utilisation of habitat sub-units in mosquito breeding areas by the Little Egret, Great Egret and White-faced Heron.

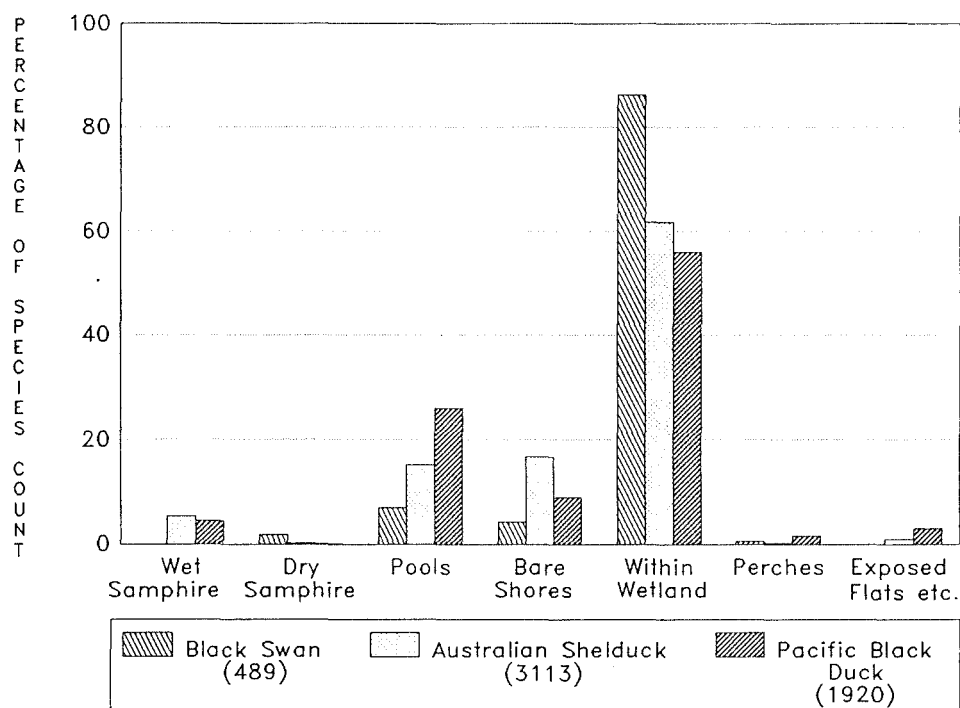


Figure C6-d Utilisation of habitat sub-units in mosquito breeding areas by the Black Swan, Australian Shelduck and Pacific Black Duck.

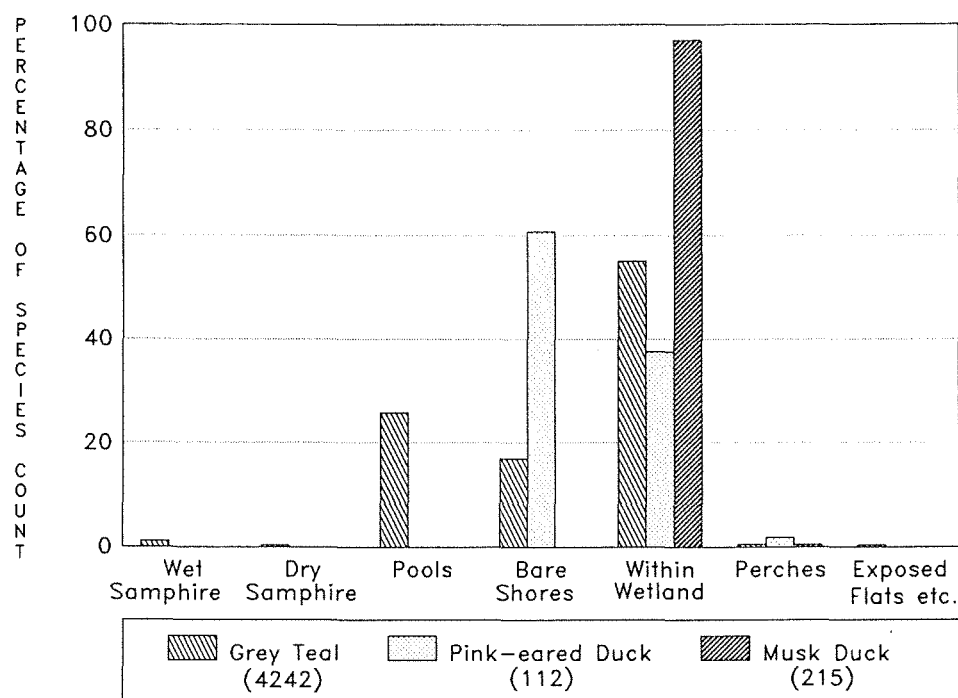


Figure C6-e Utilisation of habitat sub-units in mosquito breeding areas by the Grey Teal, Pink-eared Duck and Musk Duck.

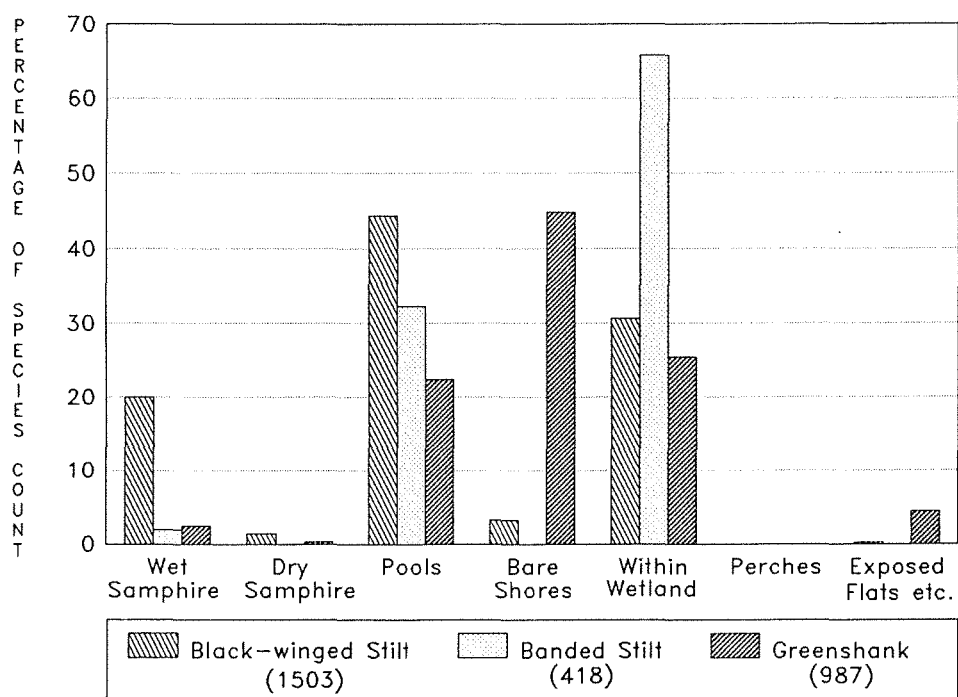


Figure C6-f Utilisation of habitat sub-units in mosquito breeding areas by the Black-winged Stilt, Banded Stilt and Greenshank.

Table C3 Waterbird species dominating in the various habitat sub-units of mosquito breeding areas sampled at Peel Inlet between November 1988 and December 1989. (Based on Figures C6a-f).

<u>HABITAT</u>	<u>WATERBIRD SPECIES</u>
Wet Samphire:	Little Egret, Great Egret, White-faced Heron.
Dry Samphire:	None.
Pools:	Black-winged Stilt.
Bare Shores:	Greenshank, Pink-eared Duck.
Within Wetland:	Eurasian Coot, Hoary-headed Grebe, Silver Gull, Black Swan, Australian Shelduck, Pacific Black Duck, Little Black Cormorant, Australian Pelican, Banded Stilt, Grey Teal, Musk Duck.
Perches:	Little Pied Cormorant.
Other Sites:	None.

The following table shows how all the species of waterbird recorded were distributed throughout the available habitats in mosquito breeding areas.

Table C4 Waterbird utilisation of mosquito breeding area habitat sub-units at Peel Inlet between October 1988 and December 1989 (all species).

KEY

SW = Samphire (wet)	SD = Samphire (dry)
PS = Pools	BS = Bare shore
WS = Within wetland/swamp	PE = Perches
OS = Other sites	

<u>HABITAT</u>	<u>SW</u>	<u>SD</u>	<u>PS</u>	<u>BS</u>	<u>WS</u>	<u>PE</u>	<u>OS</u>
PODICIPEDIDAE							
Great Crested Grebe	3						
Hoary-headed Grebe					80		
Australasian Grebe					128		16
PELECANIDAE							
Australian Pelican	11		43	278	302	81	3
ANHINGIDAE							
Darter		3	1	88	5	73	1

Table C4 (Continued).

HABITAT	SW	SD	PS	BS	WS	PE	OS
PHALACROCORACIDAE							
Great Cormorant			3	76	14	40	
Pied Cormorant			1	15		53	1
Little Black Cormorant	4		2	111	943	482	153
Little Pied Cormorant	17		39	112	463	1458	9
ARDEIDAE							
White-faced Heron	291	22	86	99	163	30	1
Great Egret	203	4	15	26	72	18	2
Little Egret	31		7	10	27	3	
Rufous Night Heron				1			
PLATALEIDAE							
Sacred Ibis	73		16	7	13	9	1
Straw-necked Ibis	3						
Royal Spoonbill			2		2		
Yellow-billed Spoonbill	38		41	9	85	70	1
ANATIDAE							
Black Swan		9	34	21	422	3	
Australian Shelduck	165	6	471	518	1920	5	28
Pacific Black Duck	86	2	497	172	1075	30	58
Grey Teal	43	15	1094	719	2339	19	13
Chestnut Teal					2		
Australasian Shoveler					21		
Pink-eared Duck				68	42	2	
Hardhead			41			2	
Maned Duck					10	1	
Blue-billed Duck					5		
Musk Duck					214		1
PANDIONIDAE							
Osprey					3	10	
ACCIPITRIDAE							
Whistling Kite	1	1		2	14		4
Marsh Harrier	2	1			3	2	
RALLIDAE							
Australian Crake	1						
Spotless Crake	3		1				
Dusky Moorhen	1						
Eurasian Coot					1531	5	
HAEMATOPODIDAE							
Pied Oystercatcher				11			
CHARADRIIDAE							
Grey Plover			45	11			
Red-capped Plover	59	22	1	75	103		27
Black-fronted Plover	2			4	14		

Table C4 (Continued).

HABITAT	SW	SD	PS	BS	WS	PE	OS
RECURVIROSTRIDAE							
Black-winged Stilt	301	21	667	49	461		4
Banded Stilt	8		135		275		
Red-necked Avocet			116	4	1280		
SCOLOPACIDAE							
Eastern Curlew	2		2	2			
Whimbrel				5		1	
Common Sandpiper	1			12	2	1	
Greenshank	24	3	222	443	251		44
Marsh Sandpiper				3	5		
Terek Sandpiper				1	2		
Bar-tailed Godwit			247		4		
Great Knot			29	2	4		
Sharp-tailed Sandpiper	70		81	98	8		
Red-necked Stint	6	4	42	73	131		5
Curlew Sandpiper			6	151	8		
LARIDAE							
Silver Gull	7	1	137	670	1127	351	5
Whiskered Tern					1		
Caspian Tern	1			71	9		20
Crested Tern					5	17	
MOTACILLIDAE							
Richard's Pipit	3	9					
SYLVIIDAE							
Little Grassbird	62	41			11		3
EPHITHIANURIDAE							
White-fronted Chat	9	62		3			
GRALLINIDAE							
Australian Magpie-lark				1			4
Unidentified Grebe					3		
Domestic Hybrid Duck			8				
Unidentified Duck					23		
TOTAL	1527	226	4132	3975	13624	2803	471

C1.5 Activity Patterns

Overall activity patterns in mosquito breeding areas are graphed in Figure C7 which shows that feeding was the major activity which took place, closely followed by roosting. Together, these two categories of behavior accounted nearly 85% of all activity records. Loafing was carried out by 12% of all the waterbirds recorded, with the remaining activities being negligible.

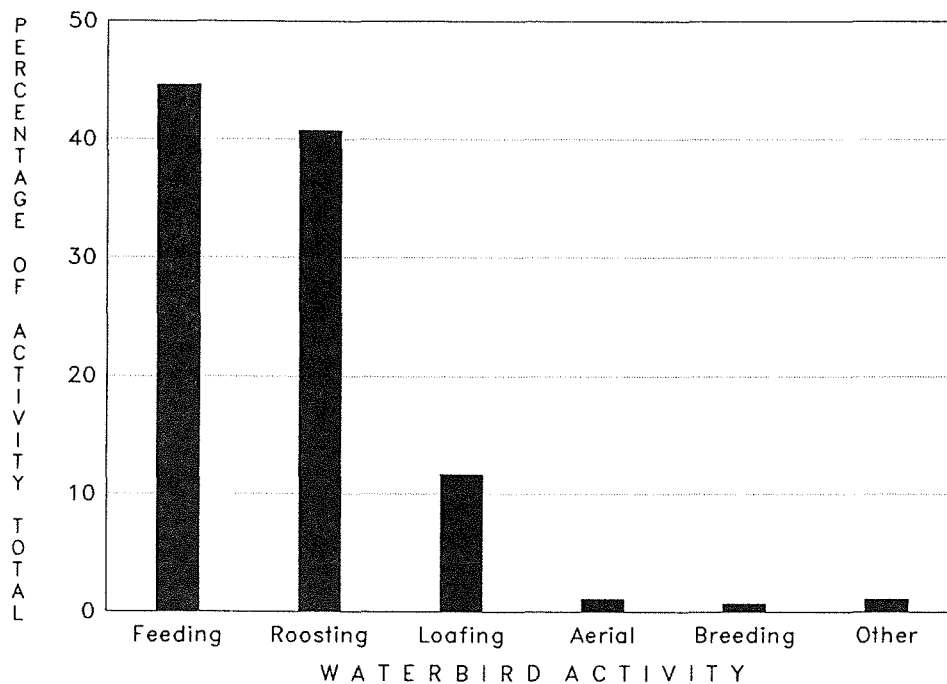


Figure C7 Overall activity patterns in mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

Activity patterns occurring in each habitat sub-unit surveyed have been illustrated in Figure C8 and it can be seen that in wet samphire, pools within samphire and within wetlands the major activity was feeding. Bare shorelines, exposed flats and perches were mainly used for roosting while dry samphire had most waterbirds either flying over or involved in unspecified behaviour. This latter activity was mainly contact calls by unseen Little Grassbirds.

Wet samphire and pools absorb the main impact of mosquito control measures and as the major activity in these habitats is feeding, there is the potential to adversely affect waterbirds.

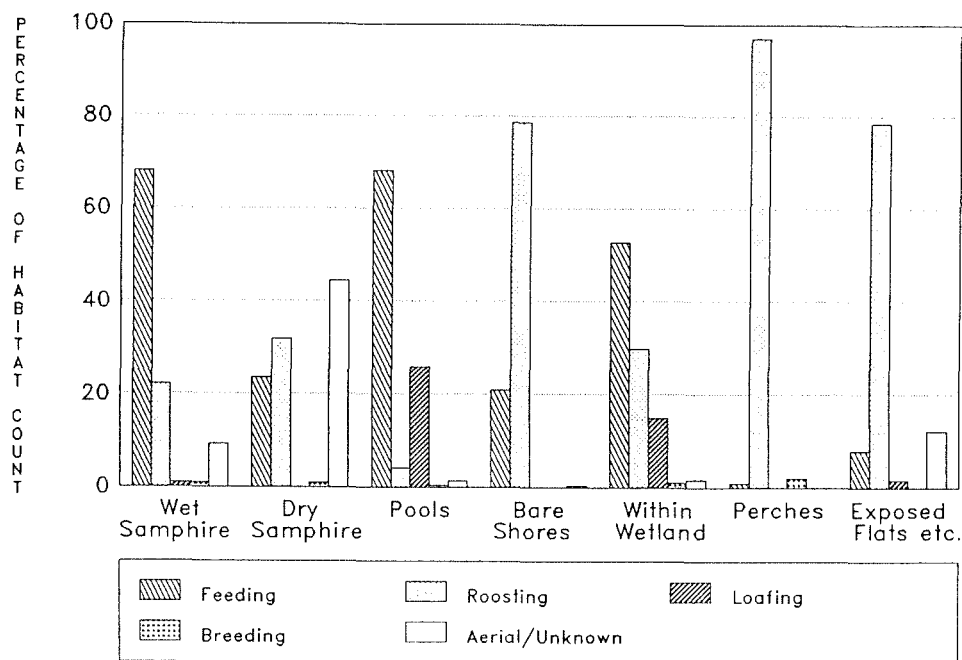


Figure C8 Activity patterns within the various habitat sub-units of mosquito breeding areas at Peel Inlet between November 1988 and December 1989.

C1.6 Breeding

Eight species of waterbird were recorded breeding in mosquito breeding areas during the survey (Table C5) and including both adults and juveniles, 192 individuals were noted. Most breeding activity was recorded in the "within wetlands" category (6 species, 148 individuals) followed by pools in samphire (4 species, 16 individuals). Breeding in all other habitat sub-units was negligible. It is significant that five of the six breeding species and 76 individuals (40%) were recorded in Barragup Swamp adjacent to the Pinjarra road. This fresh water wetland is designated as waterbird sampling site 22 in Figure B1 and mosquito breeding areas 47 and 48 in Wright (1988).

Table C5 Waterbird breeding recorded in mosquito breeding area habitat sub-units at Peel Inlet between October 1988 and December 1989.

KEY

SW = Samphire (wet)	SD = Samphire (dry)
PS = Pools	BS = Bare shore
WS = Within wetland/swamp	PE = Perches
OS = Other sites	

HABITAT	SW	SD	PS	BS	WS	PE	OS
BIRD SPECIES							
Eurasian Coot					20		
Red-capped Plover		1		2			
Yellow-billed Spoonbill						3	
Black Swan			1		19		
Australian Shelduck			5	6	19		
Pacific Black Duck			5		50	13	
Grey Teal	3		5		35		
Unidentified Duck					5		
TOTAL	3	1	16	8	148	16	

C2.0 DISCUSSION AND CONCLUSIONS

Although mosquito breeding areas represent a very small proportion of the total area of northern Peel inlet, 62 species of waterbird and associated species were recorded and 26,758 individual birds counted within them over the 1988-89 sampling period. The species total is high and reflects the diversity and productivity of the available habitats found in these fresh water or tidal locations. Several species were recorded within mosquito breeding areas which have not been recorded to date in the strictly saline environment of the inlet itself by other groups who have carried out sampling (Table B3, Part B).

The number of waterbird species and individuals peaks in mosquito breeding areas during the summer months and coincides precisely with an equivalent peak in populations of the mosquito *Aedes vigilax* which appears to be the main vector of Ross River Fever (Figure 6,

Wright 1988). Chemical control of mosquitoes mainly takes place during summer also, a period when large numbers of trans-equatorial migratory shorebirds covered by international agreements and many ducks seeking drought refuge utilise mosquito breeding areas. Many young birds are still present and vulnerable at this time and there is a recorded instance of shorebirds apparently suffering from Abate toxicity at Forrestdale Lake near Perth (Keeling and McNee 1984).

The central water body of larger wetlands such as Barragup Swamp and Black Lake supported the greatest number of species (49) and the highest proportion of individuals (51%). While birds in this habitat sub-unit are unlikely to be affected to any great extent by physical and chemical mosquito control measures because open water is not specifically targeted, the closed nature of the wetlands themselves necessitates an informed, cautious approach. It may well be the case that many of the individual birds recorded in deep, open water use shoreline habitats at night.

Mosquito control is instead largely concentrated in peripheral samphire habitats which include pools and bare shorelines. The survey has shown that in total these habitats, despite their relatively small area, supported 48 species of waterbirds and 37% of all individuals recorded, although this figure may be conservative due to the influence of tidal fluctuations, bird movements and the difficulty in conducting nocturnal sampling.

Despite these constraints, samphire habitats are evidently important to waterbirds. In flooded samphire 68% of all activity was feeding, with pools in samphire accounting for an equally significant 69%. Roosting was the dominant activity on the shorelines of swamps, lakes, isolated pools and the inlet, all of which are actual or potential mosquito breeding sites and supported 79% of all recorded behaviour. During feeding and roosting, waterbirds are at their most vulnerable to chemical control methods since the habitats in which these major activities take place are specifically targeted. Physical control methods are unlikely to seriously affect roosting birds but may adversely affect the availability of invertebrate food sources.

Most breeding activity was recorded within the open water habitat of swamps and lakes (6 species, 148 individuals) followed by isolated pools in samphire (4 species, 16 individuals). Breeding in all other habitat sub-units was negligible. Many young birds, especially ducklings feed on mosquito larvae and could be affected by control measures which have the potential to reduce food supplies.

The survey has therefore shown that, taken as a whole, mosquito breeding areas in the northern portion of Peel Inlet are significant to waterbirds and require a well-planned and cautious approach to the necessary but potentially disruptive problem of reducing mosquito populations. The annoyance value of mosquitoes and the known capacity of certain species to act as vectors of Ross River Fever require that remedial action be taken and that as a consequence there will inevitably be some impact on waterbirds and their environment. However, not every mosquito breeding area is equally important in terms of its waterbird usage and physical attributes, and the compromise between conservation and control measures can be tailored bearing this aspect in mind. The following section of this report (Part D) deals with the attributes of individual sampling sites and recommends control techniques suitable for each wetland.

PART D

ASSESSMENT OF INDIVIDUAL WATERBIRD
SAMPLING SITES

D1.0 RECOMMENDATIONS

The following series of recommendations are based wholly on the results of the 1988-1989 MCRC survey since work carried out by other groups does not specifically target mosquito breeding areas. The main objective of this section is to structure mosquito control measures such that the major proportion of wetlands are retained, or maintained in their current condition. Improving degraded wetlands, while possible, is beyond the scope of this project

D1.1 Areas of Conservation Significance

Prior to dealing with waterbird sampling sites individually, it is important to take an overview of the conservation significance of larger sectors of the inlet because physical control measures may fragment cohesive, interdependent areas. On this basis, with reference to Figure B1, the following locations which support several waterbird or mosquito sampling sites and which may also include small, unproductive wetlands are of conservation significance because of their productivity. Working from the south-eastern to the south-western limits of the study area and including data from accessory inlet sites:

Goegrup Lake, Black Lake: seasonally freshwater wetlands (Sites 12-16, 39, 17-20: 50 species, 32% of total count);

Murray and Serpentine River Delta: a complex, productive, intertidal and relatively inaccessible area (Sites 1-5, 23, 24: 46 species, 23% of total count);

Coodanup - Creery Lagoon: complex, productive, intertidal area (Sites 25-27: 38 species, 12% of total count);

West of Sticks Channel: complex currently inaccessible sector (Sites 30-32, 34: 38 species, 12% of total count).

D1.2 Assessment of Individual Sampling Sites

The previous section gives a broad outline of the conservation significance of groups of wetlands/mosquito breeding areas fringing

Peel Inlet. The following assessment takes a site by site approach in order to fine-tune mosquito control measures and ensure that locations of known, high conservation value are treated individually by applying techniques which will maintain their current status as far as possible.

It should be stressed, however, that sites designated as low significance do make some contribution to the Peel system and that the cumulative effect of control measures such as earth fills can impinge on high significance sites, or the inlet as a whole.

In order to assess each site, including its potential which may not have been established during the survey, a series of modified criteria developed for the Leschenault survey (Ninox Wildlife Consulting 1989) have been used and are based on:

- actual quantitative field data (Appendix 1);
- physical attributes which control diversity (Appendix 2);
- subjective or qualitative judgments based on experience.

Eight criteria were chosen; some self-explanatory and others requiring clarification. Each criterion was given a series of parameters upon which points were scored for each site.

Species Richness - (1-5 species = 1 point; 6-10 = 2; 11-15 = 3; 16-20 = 4; 21-25 = 5; 25+ = 6).

Number of Individuals - (1-100 individuals = 1 point; 101-200 = 2; 201-300 = 3; 301-400 = 4; 401-500 = 5; 500+ = 6).

Significant Species - the number of species per site protected by international agreements was taken as a convenient measure of site significance (1-3 species = 1 point; 4-6 = 2; 7-12 = 3; 13-15 = 4).

Breeding Potential - this category is composed of actual results and, to a degree, informed judgment. Investigating breeding is time-consuming and beyond the scope of this study (Low potential = 1; Intermediate = 2; High = 3; Very High = 4).

Habitat Quality - highly disturbed sites, in human terms, are not necessarily unattractive to waterbirds. Judgments have been made on

actual bird usage and their potential over a longer survey period (Low quality = 1 point; Moderate = 2; High = 3; Very high = 4).

Habitat Representation - some sites at Peel Inlet were difficult to survey adequately because of vegetation density but have the capacity to support specialised or cryptic birds which may have been overlooked. Allowance has been made for this on a scale of 1-4 points.

Diversity of Habitats - diversity of habitats in an area generally equates with high waterbird productivity. Points have been apportioned on a scale of 1-3 and are based on the descriptions given in Appendix 2.

Site Area - each site differed in area such that direct comparisons could not be made between large areas and small areas. Actual areas sampled are given in Appendix 2. In practise the series of attributes used cancelled out area anomalies in that small, productive areas such as Barragup Swamp (Site 22) retained parity with large, productive areas such as Creery Marsh (Sites 25-27).

Totalling the points accumulated for each site (Appendix 4) gives a functional measure of its significance and a method of establishing relevant mosquito control techniques tailored to individual locations. Ultimately, an approach such as this has a high degree of informed subjectivity and should not be considered as a final statement on a wetland since many attributes are interdependent and in some cases synergistic, although an attempt has been made to compensate for such effects. In many locations the primary aim of the decision-maker should be to minimise all mosquito control measures as far as possible. While this may not appeal to the general public in the vicinity of important wetlands or perhaps local authorities, it is highly probable that the long-term, adverse effects of mosquito control on waterbirds are not fully realised by the scientific community let alone local communities. A public education programme may assist in accomplishing a trade-off between the inevitability of Ross River Fever epidemics near the estuary, an informed acceptance of a certain level of mosquito annoyance and the maintenance of a highly visible, pre-existing and attractive fauna which almost certainly assists in controlling mosquitoes during their larval stage.

Table D1 Waterbird conservation significance of wetlands fringing Peel Inlet. Rankings based on aggregate scores for eight waterbird habitat attributes applied to mosquito breeding areas. (NA = Not applicable - no mosquito sampling.)

RANK	SCORE	WATERBIRD SITE	MOSQUITO SITE/S	CATEGORY
1	30	26	NA	VERY HIGH SIGNIFICANCE
2	29	18	87	"
3	28	19	40, 41	"
3	28	17	43	"
3	28	25	58	"
4	27	16	44	"
5	26	22	47, 48	"
5	26	39	54	"
6	24	12	86	HIGH SIGNIFICANCE
6	24	30	61, 62, 95, 97	"
6	24	31	63	"
6	24	32	64-66	"
6	24	34	NA	"
7	22	2	NA	INTERMEDIATE SIGNIFICANCE
8	21	5	50	"
8	21	15	102	"
8	21	20	38, 93	"
8	21	27	59	"
8	21	35	88, 96	"
9	20	3	NA	"
9	20	14	NA	"
9	20	28	60	"
9	20	37	90	"
10	19	38	NA	"
11	17	23	107	LOW SIGNIFICANCE
12	16	36	89, 91	"
13	14	4	NA	"
13	14	21	33, 34	"
13	14	24	57	"
14	13	1	23	"
14	13	10	100	"
15	12	13	55	"
16	11	6	51	"
17	9	8	52	"
17	9	11	56	"
18	7	9	74	"
19	6	7	NA	"

Individual attribute scores are given in Appendix 4.

D1.3 Recommended Control Options

Various control techniques have already been recommended by Wright (1988) for the numerous mosquito breeding areas in the vicinity of Peel Inlet. The following section reviews these strategies in the light of data from the intensive waterbird surveys. The primary aim of this review is to conserve valuable waterbird habitat while acknowledging that mosquito control in certain sites is seen to be necessary by the MCRC, Local Government Authorities, residents and the Public Health department.

Four categories of wetland have been defined in Table D1, based on their waterbird conservation significance. Preferred control options for each wetland group are listed below.

VERY HIGH SIGNIFICANCE

(Mosquito sampling sites: 87, 40, 41, 43, 58, 44, 47, 48, 54).

1. Selective and precise aerial application of ABATE on large wetlands until the granular formulation of Bti is available.
2. No control measures in locations distant from residential areas if it is found that there is minimal migration of mosquitoes.
3. Backpack spraying of liquid Bti in small, accessible pools with localised breeding.
4. Filling of all wheel-ruts, minor depressions and limiting or prohibiting vehicular access.

HIGH SIGNIFICANCE

Mosquito sampling sites: 86, 61, 62, 95, 97, 63, 64, 65, 66).

1. Accurate aerial application of ABATE on large wetlands until the granular formulation of Bti is available.
2. No control measures in locations distant from residential areas if it is found that there is minimal migration of mosquitoes.

3. Backpack spraying of liquid Bti in small pools with localised breeding.
4. Filling of all wheel-ruts, minor depressions and limiting or prohibiting vehicular access.
5. Hand-dug runnels as a last resort in areas close to residential developments.

INTERMEDIATE SIGNIFICANCE

Mosquito sampling sites: 50, 102, 38, 93, 59, 88, 96, 60, 90).

1. Aerial application of ABATE on large wetlands until the granular formulation of Bti is available.
2. No control measures in locations distant from residential areas if it is found that there is minimal migration of mosquitoes.
3. Filling of all wheel-ruts and manageable larger depressions.
4. Shallow machine-dug spinner drains with lateral feeders if required.
5. Perimeter channels if warranted.

LOW SIGNIFICANCE

Mosquito sampling sites: 107, 89, 91, 33, 34, 57, 23, 100, 55, 51, 52, 56, 74)>

1. Control measures as suited to each site with the objective being to retain as much wetland as possible in locations distant from residential areas.

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A P P E N D I C E S

APPENDIX 1 Waterbirds and associated species recorded in the 37 mosquito breeding areas sampled at Peel Inlet between November 1988 and December 1989.

SAMPLING SITE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30	31	32	34	35	36	37	38	39	TOTAL	
PODICIPEDIDAE																																							
Great Crested Grebe																	3																					3	
Hoary-headed Grebe																	2	48	16				14															70	
Australasian Grebe																	79	23	39			2													1			144	
PELECANIDAE																																							
Australian Pelican	1	1	1	91	5								6	40	19	96	9	68	17	6	2						8	13	133	26	45	32		4		9		86	718
ANHINGIDAE																																							
Darter	1	2		61	4											2			4					3					28	12	21	1			29	2	1	171	
PHALACROCORACIDAE																																							
Great Cormorant	20				70											8		2	1					1	2			3	7	16				1		2	133		
Pied Cormorant	23				5							1																	14	2	25							80	
Little Black Cormorant			150	64			1	2		1		2	2	45	129	533	49	116	14			28	4		10	154	31	1	37	9	148	5	5		4	120	210	1686	
Little Pied Cormorant	3	6	161	64		2	2	2			1	25	13		113	107	136	73	38			11	9	5				101	50	295	91	58	26	10	317	101	81	2098	
ARDEIDAE																																							
White-faced Heron	4	11	2		2	7	2	11	3	9	8	18	13	21	3	33	28	22	36	39	14	22	2		6	22	64	11	12	37	133	33	5	16	1	8	41	28	722
Great Egret	3	13	2		4			1	1	2	4	24	2	5	6	93	17	44	17				1	2	3	13	25	3	3	2	10	5	3		2	17	6	340	
Little Egret	1				4			1				14		2		12	1	1						1	1	1	5	13	1	1	5	1					14	78	
Rufous Night Heron																						1															1	1	
PLATALEIDAE																																							
Sacred Ibis		3			2	1				6		7				1	6	8	5		2	12			10	13	6	1	2	8	5	17	4					119	
Straw-necked Ibis														3																								3	
Royal Spoonbill																																						4	
Yellow-billed Spoonbill	1	4	1		3					1		14		4		1	9	32	2		2	87			2	7	13	23		18	2						14	244	
ANATIDAE																																							
Black Swan																11	67	304	12		2	42				9	25	9									8	489	
Australian Shelduck	3	20	7	19	11	8	2	4		4	17	13	4	8	16	52	86	1202	525	269	56	39			2	82	156	143		26	2	40	214	2	3	8	3	67	3113
Pacific Black Duck	6	16	6		9	4		3		21	16	34	12	14	128	29	215	385	70	7	11	146	26	11	4	218	9	5	37	20	96	114		13	19	41	175	1920	
Grey Teal	10	142			13	14		2		87	5	105	19	2	57	11	510	1545	90	11		304	9	2	200	390	5		19	35	62	264			11	60	68	190	4242
Chestnut Teal																	2																					2	
Australian Shoveler																	13	8																			21		
Pink-eared Duck																		42																			112		
Hardhead		41																																				43	
Maned Duck															5		2																				11		
Blue-billed Duck																																						5	
Musk Duck														3	23	1	121	28	13																		6	215	
PANDIONIDAE																																							
Osprey																	1		1	1							2			4	1	2					1	13	
ACCIPITRIDAE																																							
Whistling Kite		1		2	2								1	4	3		3	1	3								1	1										22	
Marsh Harrier													2				1		1		1	1					1										1	8	
RALLIDAE																																							
Australian Crake																1																						1	
Spotless Crake	1																																					4	
Dusky Moorhen																																						1	
Eurasian Coot																	810	19	265				1															1	
HAEMATOPODIDAE																																							
Pied Oystercatcher				1																							5		3										11
CHARADRIIDAE																																							
Grey Plover					1											4										44	18		10		3	2						82	
Red-capped Plover		13		3	7	7								1		107	4	36	4	75	3			1	25	1												287	
Black-fronted Plover										1	1											18															20		
RECURVIROSTRIDAE																																							
Black-winged Stilt	2	45	1	1	18	7	1			7		173	7	2	6	77	30	98	169	25		23	11	4	188	159	230	30	17	13	20	28		21	8	20	62	1503	
Banded Stilt		23										48				105		160	10							70	2										418		
Red-necked Avocet						7						114		301	12	256	6	1					7	1													695	1400	
SCOLOPACIDAE																																							
Eastern Curlew																										1	1	2	1									6	
Whimbrel																																					6		
Common Sandpiper																1																						16	
Greenshank		2	44		4	1				1		6	9	5	3	80	15	52	19			12	50			29	171	5	2	1	8			1	1		987		
Marsh Sandpiper												5																									8		
Terek Sandpiper																																						3	
Bar-tailed Godwit																																						4	
Great Knot																																						35	
Sharp-tailed Sandpiper		15	48		56							34						7		4			4														257		
Red-necked Stint					44											6	27	32	6	10		76	1			54	2										261		
Curlew Sandpiper					4											1		6				28				6				120							165		
LARIDAE																																							
Silver Gull	1		1	16	1					1		16	1	8	7	676	12	118	192	6																		2304	
Whiskered Tern																																						1	
Caspian Tern			21	65													9																					101	
Crested Tern																4																						22	
MOTACILLIDAE																																							
Richard's Pipit		1			2					1				3				1						1					1		2							12	
SYLVIIDAE																																							
Little Grassbird		9	9		8	1					2	3	1	10	17										14	14	2	6				5		6	2		8	117	
EPHIANURIDAE																																							
White-fronted Chat					10			6																		14	5	21	12		3		3					74	
GRALLINIDAE																																							
Australian Magpie-lark	4	1																									</												

* Unidentified waterbirds not included in species count.

Appendix 2 Vegetation description of mosquito breeding areas/waterbird sites sampled at Peel Inlet between November 1988 and December 1989.

Prepared by: E.M Goble-Garratt

June 1990

METHODS

Vegetation descriptions were compiled after a brief field survey of each waterbird sampling site. During this site inspection, the botanist was accompanied by an ornithologist in order to accurately describe only the waterbird sampling site. Photographs were taken of each location. These vegetation community descriptions were not meant to be detailed but to give a broad indication of communities and habitat quality. Exotic plant species were noted where they contributed a significant part of the community. Significant tree deaths were also noted.

The dominance ranking of the species is subjective and refers to the immediate survey area only; this ranking was based on the relative contributions of the species to the habitat and not on the numbers of individual plants or biomass.

Voucher specimens of many of the samphires were collected for verification of species at the Western Australian Herbarium.

WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 23

Waterbird Site Code: 1

Name: None

Location: Yunderup boat ramp

ATTRIBUTES

Size (ha): 2.9

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: Mixed samphires to 1.5m high in centre of wetland, surrounded by a band of *Juncus kraussii*. Patches of *Bolboschoenus caldwellii* occur close to the water's edge. Fringed by a *Casuarina obesa* thicket to 10m high.

Other species identified: *Cotula coronopifolia*, *Avena* sp., *Holium perenne*, *Briza maxima*, *Watsonia bulbillifera*, *Atriplex hypoleuca*, *Suaeda australis*, *Acacia saligna*, *Viminaria campestre*, *Rumex conglomeratus*, *Gahnia trifida*, *Frankenia* sp., *Sarcocornia quinqueflora*.

Dominants (ranked): (1) *Sarcocornia indica* ssp. *bidens*
(2) *Halosarcia halocnemoides*
(3) *Casuarina obesa*

Comments: Sometimes flooded by rains, but mainly tidal. Fairly heavy weed invasion except for wetter portions. Uninformed dumping of dredging spoil has occluded tidal outflow from this wetland and ruined an extremely productive waterbird feeding and roosting area adjacent to it.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 2

Name: Ballee Island

Location: Murray River mouth

ATTRIBUTES

Size (ha): 9.7

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Intermediate

Vegetation description: *Sarcocornia* species community on lowest lying areas, surrounded by a band of *Halosarcia halocnemoides* and *Halosarcia indica* ssp. *bidens* 1-3m wide. Between the pools and the inlet a broad band of *Bolboschoenus caldwellii* with small patches of *Juncus kraussii* occurs. Fringing community is mainly *Casuarina obesa* with some *Melaleuca hamulosa* and the occasional *Melaleuca preissiana*.

Other species identified: *Isolepis cernua*, *Cotula cornopifolia*, *Polypogon monspeliensis*, *Acacia saligna*, *Sporobolus virginicus*, *Watsonia bulbillifera*, *Atriplex hypoleuca*, *Suaeda australis*, *Lolium perenne*, *Frankenia* sp., *Triglochin mucronata*, *Raphanus raphanistrum*.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Halosarcia halocnemoides*
- (3) *Bolboschoenus caldwellii*
- (4) *Casuarina obesa*
- (5) *Melaleuca hamulosa*

Comments: Sometimes flooded by rains, but mainly tidal. Occasionally has large concentrations of ducks and stilts.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 3

Name: Windmill Point

Location: Serpentine River Mouth

ATTRIBUTES

Size (ha): 1.1

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Intermediate

Vegetation description: The tidal flat/open water is surrounded by dense *Juncus kraussii* with patches of *Bolboschoenus caldwellii*. The samphire flat to the west supports *Sarcocornia quinqueflora*, some *Halosarcia halocnemoides*, *Frankenia* sp. and dense patches of *Bolboschoenus caldwellii* and *Juncus kraussii*. Fringing vegetation is predominantly *Casuarina obesa* to 8m with occasional *Melaleuca preissiana*.

Other species identified: *Atriplex hypoleuca*, *Suaeda australis*.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Juncus kraussii*
- (3) *Casuarina obesa*
- (4) *Bolboschoenus caldwellii*
- (5) *Halosarcia halocnemoides*

Comments: Sometimes flooded by rains, but mainly tidal. No weed invasion. Occasionally has moderate concentrations of ducks and some shorebirds.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 4

Name: None Location: Unnamed island in Serpentine River mouth

ATTRIBUTES

Size (ha): 1.0 Tidal: Mainly Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: No description carried out. Originally had a small vegetated wetland near the southern shore but dumping of dredging spoil has covered this. Some small, bare depressions occur in low relief areas of the spoil and these are occasionally filled with rain or more commonly, high tides.

Comments: Shorelines and dead trees are used extensively by Cormorants, Darters and several species of ducks. Minimal mosquito breeding takes place.

NO PHOTOGRAPH TAKEN

WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 50

Waterbird Site Code: 5

Name: Jenalla Island

Location: Serpentine River mouth

ATTRIBUTES

Size (ha): 2.4

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Intermediate

Vegetation description: Open pools/mudflats surrounded by a samphire community of *Sarcocornia quinqueflora*, with *Halosarcia halocnemoides*, *Suaeda australis*, *Cotula coronopifolia* and *Polypogon monspeliensis* also present. A band of *Juncus kraussii* with discrete patches of *Bolboschoenus caldwellii* separates the pools from the river. The fringing community is mainly *Casuarina obesa* to 6m with the occasional *Melaleuca preissiana*. Some tree deaths; mainly weed free.

Dominants (ranked): (1) *Sarcocornia* sp.
(2) *Halosarcia halocnemoides*
(3) *Juncus kraussii*

Comments: The large pools occasionally support large concentrations of ducks.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 51

Waterbird Site Code: 6

Name: None

Location: Serpentine River, Furnissdale

ATTRIBUTES

Size (ha): 6.3

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: Partly vegetated mudflat dominated by *Halosarcia halocnemoides* and some *Sarcocornia quinqueflora* and *Bolboschoenus caldwellii*. occurs on higher ground with *Halosarcia indica* ssp. *bidens* some *Cotula coronopifolia* and *Frankenia* sp.. The fringing vegetation is a mosaic of *Melaleuca* spp. and *Casuarina obesa* with a disturbed understorey.

Other species identified: *Lolium perenne*, *Polypogon monspeliensis*, *Briza minima*, *Briza maxima*, *Melaleuca cuticularis*, *Arctotheca populifolia* and *Atriplex hypoleuca*.

Dominants (ranked):

- (1) *Halosarcia halocnemoides*
- (2) *Halosarcia indica* ssp. *bidens*
- (3) *Sarcocornia quinqueflora*
- (4) *Melaleuca uncinata*? *longifolia* and *Melaleuca preissiana*

Comments: A weedy fairly disturbed wetland occasionally showing moderate concentrations of ducks when filled with rainwater.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 7

Name: Barragup Island

Location: Serpentine River

ATTRIBUTES

Size (ha): 0.8

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: Shallow pool surrounded by *Sarcocornia quinqueflora* with occasional *Suaeda australis*. Fringing vegetation of *Melaleuca cuticularis* to 2m, *Casuarina obesa* to 6m and thickets of *Melaleuca hamulosa*. Dense band of *Juncus kraussii* with patches of *Bolboschoenus caldwellii* occur between the pool and the river.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Casuarina obesa*
(3) *Melaleuca hamulosa*

Comments: The least productive wetland of all wetlands surveyed, partly because of its small size and ephemeral nature of its water.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 52

Waterbird Site Code: 8

Name: None

Location: Serpentine River, Barragup

ATTRIBUTES

Size (ha): 11.6

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: Well-vegetated flat with a mosaic of communities. Samphires present are *Sarcocornia quinqueflora* and *Halosarcia halocnemoides*. Forming a mosaic with the samphires are dense patches of *Bolboschoenus caldwellii*. Fringing vegetation is dense *Casuarina obesa* to 10m with patches of *Melaleuca cuticularis* on the western edge and mainly *Melaleuca hamulosa* on the eastern side.

Other species identified: *Suaeda australis*, *Frankenia* sp., *Cotula coronopifolia* and occasional *Polypogon monspeliensis*.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Bolboschoenus caldwellii*
- (3) *Melaleuca cuticularis*/*Melaleuca hamulosa*
- (4) *Casuarina obesa*

Comments: A weedy fairly disturbed wetland occasionally showing moderate concentrations of ducks when filled with rainwater.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 74

Waterbird Site Code: 9

Name: None

Location: Barragup Bridge

ATTRIBUTES

Size (ha): 0.8

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: Disjunct pools in a narrow band of samphire running parallel to riverbank. Species are *Sarcocornia quinqueflora*, *Suaeda australis* with an occasional *Halosarcia indica* ssp. *bidens* on slightly higher ground along the edges. Samphires are bordered on both sides by *Casuarina obesa* and an occasional *Melaleuca raphiophylla* or *Eucalyptus rudis*. Understorey species include *Lolium perenne*, *Cotula coronopifolia*, *Isolepis cernua*, *Sporobolus virginicus*, *Atriplex hypoleuca* and *Moenchia erecta*. Some *Juncus kraussii* occurs along the river bank.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Suaeda australis*
(3) *Casuarina obesa*

Comments: A very unproductive, small wetland with a high mosquito breeding potential.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 100

Waterbird Site Code: 10

Name: None

Location: Just east of Barragup Bridge

ATTRIBUTES

Size (ha): 2.4

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: Tidally or seasonally large pool of salt or fresh/brackish water surrounded by a narrow (2-5m wide) band of samphire. Dominant species is *Halosarcia halocnemoides* with some *Halosarcia* sp. *Halosarcia indica*, *Cotula coronopifolia* and *Suaeda australis*. *Halosarcia indica* also occurs with *Frankenia* sp. under *Casuarina obesa* between the pool and the river bank. The landward side is fringed by a dense mosaic of *Casuarina obesa*, *Melaleuca raphiophylla*, *Melaleuca preissiana* and *Melaleuca cuticularis* with occasional *Eucalyptus rudis*.

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *Casuarina obesa*
(3) *Melaleuca raphiophylla*/
M. preissiana/*M. cuticularis*

Comments: The well vegetated fringe has some waterbird breeding potential but with the exception of those periods when rain (rather than tide) fills the pool, the wetland is poorly used by waterbirds.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 56

Waterbird Site Code: 11

Name: None

Location: 1.5km south of Goegrup Lake

ATTRIBUTES

Size (ha): 8.7

Tidal: Mainly

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: Tidally or seasonally large, ephemeral pool of salt or fresh/brackish water surrounded by a band of *Halosarcia halocnemoides* with some *Sarcocornia quinqueflora*. Between the pool and the river these are mixed with *Juncus kraussii*, *Bolboschoenus caldwellii* and some *Cotula coronopifolia*. Fringing vegetation is a diverse, dense thicket of *Melaleuca raphiophylla*, *Melaleuca preissiana* and *Melaleuca cuticularis* with some *Acacia saligna*.

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *Juncus kraussii*
(3) *Bolboschoenus caldwellii*

Comments: With the exception of those periods when rain (rather than tide) fills the pool, the wetland is poorly used by waterbirds and on these occasions the water is shallow and ephemeral.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 86

Waterbird Site Code: 12

Name: Goegrup Lake

Location: Goegrup Lake (south-west)

ATTRIBUTES

Size (ha): 21.2

Tidal: Mainly

Fresh: Seasonally

Waterbird conservation significance: High

Vegetation description: Flat with dense *Sarcocornia quinqueflora* surrounded by *Bolboschoenus caldwellii* and *Juncus kraussii*. Other species include *Atriplex hypoleuca*, *A. prostrata* and *Lolium perenne*. Fringing vegetation is dense *Casuarina obesa* and *Melaleuca cuticularis*.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Bolboschoenus caldwellii*
(3) *Juncus kraussii*

Comments: The very dense vegetation at this site and its proximity to seasonally fresh water encourages duck breeding.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 55

Waterbird Site Code: 13

Name: Goegrup Lake

Location: Goegrup Lake (south-east)

ATTRIBUTES

Size (ha): 4.8

Tidal: Mainly

Fresh: Seasonally

Waterbird conservation significance: Low

Vegetation description: Samphire flat with discontinuous pools of open water. Vegetation is a mosaic of *Sarcocornia quinqueflora* (with some *Suaeda australis* and *Cotula coronopifolia*) and *Bolboschoenus caldwellii*. The river's edge supports open *Casuarina obesa* to 6m with occasional *Melaleuca cuticularis* and an understorey which includes *Atriplex hypoleuca*, *A. prostrata*, *Lolium perenne*, *Suaeda australis*, *Juncus kraussii* and *Bolboschoenus caldwellii*.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Bolboschoenus caldwellii*
(3) *Casuarina obesa*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 14

Name: Goegrup Lake

Location: Goegrup Lake (south-west)

ATTRIBUTES

Size (ha): 23.6

Tidal: Mainly

Fresh: Seasonally

Waterbird conservation significance: Intermediate

Vegetation description: Vegetation around the pools consists of dense *Sarcocornia quinqueflora* with some *Halosarcia pergranulata*. Scattered *Casuarina obesa* occur along the shoreline of the lake. Fringing scrub is of mixed *Melaleuca cuticularis* and *Casuarina obesa* to 6m high. *Acacia saligna* and small *Melaleuca raphiophylla* also occur. Understorey species include *Juncus kraussii*, *Bolboschoenus caldwellii*, *Atriplex prostrata*, *Apium prostratum*, *Regelia ciliata*, *Lepyrodia* (?) *muirii* and *Rumex pulcher*.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Melaleuca cuticularis*
- (3) *Casuarina obesa*
- (4) *Halosarcia pergranulata*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 102

Waterbird Site Code: 15

Name: Goegrup Lake

Location: Goegrup Lake (north-west)

ATTRIBUTES

Size (ha): 20.5

Tidal: Mainly

Fresh: Seasonally

Waterbird conservation significance: Intermediate

Vegetation description: Dense patches of *Juncus kraussii* occur near the waterline, followed by flats covered with *Sarcocornia quinqueflora* and small numbers of *Halosarcia pergranulata*. Fringing vegetation is of dense, tall *Casuarina obesa*. An occasional *Melaleuca cuticularis* occurs near the waterline.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Casuarina obesa*
(3) *Melaleuca cuticularis*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 44

Waterbird Site Code: 16

Name: Goegrup Lake

Location: Goegrup Lake (east)

ATTRIBUTES

Size (ha): 58.8

Tidal: Mainly

Fresh: Seasonally

Waterbird conservation significance: Very high

Vegetation description: Mixture of *Sarcocornia quinqueflora* and *Bolboschoenus caldwellii* with some *Atriplex prostrata* and small patches of *Halosarcia halocnemoides*. *Juncus kraussii* occurs near more permanent water. Fringing vegetation is of dense *Casuarina obesa* with a few scattered *Melaleuca cuticularis*.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Bolboschoenus caldwellii*
(3) *Casuarina obesa*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 43

Waterbird Site Code: 17

Name: Black Lake Location: Black Lake (north)

ATTRIBUTES

Size (ha): 24.4 Tidal: Occasionally Fresh: Mainly

Waterbird conservation significance: Very high

Vegetation description: *Bolboschoenus caldwellii* and *Juncus kraussii* occur along the waterline followed by a narrow band of *Sarcocornia quinqueflora* and *Suaeda australis* with some *Atriplex prostrata*. Fringing vegetation is of tall *Casuarina obesa* with clumps of *Melaleuca raphiophylla*. The understorey is a mixture of annual grasses and *Cynodon dactylon*.

Dominants (ranked): (1) *Bolboschoenus caldwellii*
(2) *Sarcocornia quinqueflora* / *Suaeda australis*
(3) *Casuarina obesa*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 87

Waterbird Site Code: 18

Name: Black Lake Location: Black Lake (north-west)

ATTRIBUTES

Size (ha): 26.7 Tidal: Occasionally Fresh: Mainly

Waterbird conservation significance: Very high

Vegetation description: A broad dense band of *Sarcocornia quinqueflora* with some *Halosarcia halocnemoides*, *H. pergranulata* and *Suaeda australis* occurs to the waterline. The fringing vegetation is a dense thicket of *Melaleuca cuticularis* with some *Casuarina obesa* and an occasional *Melaleuca raphiophylla*. The understorey species are mainly *Frankenia* sp. and *Juncus kraussii*.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Melaleuca cuticularis*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 40, 41

Waterbird Site Code: 19

Name: Black Lake

Location: Black Lake (south central)

ATTRIBUTES

Size (ha): 27.6

Tidal: Occasionally

Fresh: Mainly

Waterbird conservation significance: Very high

Vegetation description: An irregular band of *Sarcocornia quinqueflora*, *Halosarcia halocnemoides*, *Frankenia* sp. and *Suaeda australis* surrounds the exposed mudflats. *Polypogon monspeliensis* is common in dense patches. *Juncus kraussii* occurs around the many small pools. *Melaleuca cuticularis* and *Melaleuca raphiophylla* form the fringing thicket. The many standing dead trees on the samphire areas are *M. cuticularis*.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Juncus kraussii*
(3) *Melaleuca raphiophylla* / *M. cuticularis*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 38, 93

Waterbird Site Code: 20

Name: Black Lake Location: Black Lake (south)

ATTRIBUTES

Size (ha): 16.8 Tidal: Occasionally Fresh: Mainly

Waterbird conservation significance: Intermediate

Vegetation description: Sparse samphire community with *Halosarcia halocnemoides* dominant and *H. syncarpa*, *H. pergranulata* and *Sarcocornia quinqueflora* also present. On higher ground *Suaeda australis* and *Atriplex prostrata* also occur. Fringing vegetation is a dense scrub of *Melaleuca* spp. with *Melaleuca cuticularis* and *Melaleuca raphiophylla* being most common. The understorey includes *Juncus kraussii* and a mix of exotic grasses and herbs.

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *H. syncarpa* / *H. pergranulata*
(3) *Melaleuca* spp.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 33, 34

Waterbird Site Code: 21

Name: None

Location: North Yunderup

ATTRIBUTES

Size (ha): 8.4

Tidal: No

Fresh: Yes

Waterbird conservation significance: Low

Vegetation description: A narrow band of *Sarcocornia quinqueflora* with some *Halosarcia halocnemoides* surrounds the exposed mudflat. On slightly higher ground the samphires include *Halosarcia indica* ssp. *bidens*, *H. pergranulata* and *Halosarcia halocnemoides*. *Frankenia* sp. and *Polypogon monspeliensis* occur throughout this area. The fringing vegetation is mainly a scrub of *Casuarina obesa*.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Halosarcia indica* ssp. *bidens*
- (3) *Casuarina obesa*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 47, 48

Waterbird Site Code: 22

Name: Barragup Lake Location: Pinjarra Road

ATTRIBUTES

Size (ha): 8.4

Tidal: No

Fresh: Yes

Waterbird conservation significance: Very high

Vegetation description: Dense, tall *Melaleuca raphiophylla* woodland surrounding open water and mudflats. On higher ground there are some *M. (?) hamulosa* interspersed with the above woodland. *Eucalyptus rudis* also occurs in low numbers, especially at the northern end of the lake. Tree deaths have been extensive in the central, lower lying area. The peripheral areas are heavily infested with exotic grasses.

Dominants (ranked): (1) *Melaleuca raphiophylla*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 107

Waterbird Site Code: 23

Name: None

Location: Nairns, end of Peel Parade

ATTRIBUTES

Size (ha): 3.2

Tidal: Yes

Fresh: No

Waterbird conservation significance: Low

Vegetation description: Open water surrounded by a narrow (1-4m wide) band of *Halosarcia halocnemoides*, *Bolboschoenus caldwellii* and *Isolepis nodosa*. The vegetation to the landward side is mostly a mixture of weedy species with an occasional emergent *Casuarina obesa*, *Melaleuca raphiophylla* and *Acacia saligna*. There are also some planted Tamarisk *Tamarindus indica* trees.

Other species identified: *Cynodon dactylon*, *Briza minima*, *Watsonia bulbillifera*, *Lupinus* sp. and annual grasses.

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *Juncus kraussii*/*Bolboschoenus caldwellii*
(3) *Isolepis nodosa*

Comments: An artificial wetland showing heavy weed infestations and generally too deep to support much in the way of birdlife. There is occasional shorebird usage of the very narrow shoreline at low tides.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 57

Waterbird Site Code: 24

Name: None

Location: Nairns, end of Peel Parade

ATTRIBUTES

Size (ha): 4.8

Tidal: Yes

Fresh: Occasionally

Waterbird conservation significance: Low

Vegetation description: The pools in the tidal flats are surrounded by a dense, tall (to 0.8m) mixture of *Sarcocornia quinqueflora*, *Suaeda australis*, *Atriplex prostrata*, *A. hypoleuca* with some *Lepyrodia* sp. and exotic grasses in places. *Casuarina obesa* fringe the flat on the landward side.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Suaeda australis*
(3) *Atriplex prostrata* / *A. hypoleuca*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 58

Waterbird Site Code: 25

Name: Creery Marshes Location: Coodanup, beginning of Peel Parade

ATTRIBUTES

Size (ha): 4.8

Tidal: Yes

Fresh: No

Waterbird conservation significance: Very high

Vegetation description: *Sarcocornia quinqueflora* and *Suaeda australis* occur on the lowest lying areas and are surrounded by *Halosarcia indica* ssp. *bidens*, *Halosarcia halocnemoides*, *Frankenia* sp. and patches of *Bolboschoenus caldwellii*.

On the landward side are thickets of *Melaleuca cuticularis* and *M. raphiophylla* to 8m in height. The understorey here includes *Juncus kraussii*, *Bolboschoenus caldwellii*, *Isolepis cernua*, *Atriplex hypoleuca*, *Sporobolus virginicus* and *Gladiolus* sp..

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Halosarcia indica* ssp. *bidens*
(3) *Bolboschoenus caldwellii*

Comments: The narrow channels of open water shorelines and adjacent, low vegetation are well used by large numbers of birds.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 26

Name: Creery Marshes Location: Coodanup, midway to bridge

ATTRIBUTES

Size (ha): 13.9 Tidal: Yes Fresh: Occasionally

Waterbird conservation significance: Very high

Vegetation description: Though the species-mix on these samphire flats may be much the same over large areas, there are changes in density and dominance from place to place. The following description details both site 26 and site 27.

The predominant species are *Sarcocornia quinqueflora* two variants of *Halosarcia halocnemoides*, *Halosarcia indica* ssp. *bidens*, *Halosarcia pergranulata*, and an unnamed species of *Halosarcia*. *Halosarcia syncarpa* and *Sarcocornia blackiana* may occur some distance from the shoreline. Scattered *Casuarina obesa* occur on slightly elevated areas.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Halosarcia halocnemoides*
- (3) *Halosarcia indica* ssp. *bidens*
- (4) *Halosarcia* sp.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 59

Waterbird Site Code: 27

Name: Creery Marshes Location: Coodanup, near new traffic bridge

ATTRIBUTES

Size (ha): 29.2 Tidal: Yes Fresh: Occasionally

Waterbird conservation significance: Intermediate

Vegetation description: Though the species-mix on these samphire flats may be much the same over large areas, there are changes in density and dominance from place to place. The following description details both site 26 and site 27.

The predominant species are *Sarcocornia quinqueflora* two variants of *Halosarcia halocnemoides*, *Halosarcia indica* ssp. *bidens*, *Halosarcia pergranulata*, and an unnamed species of *Halosarcia*. *Halosarcia syncarpa* and *Sarcocornia blackiana* may occur some distance from the shoreline. Scattered *Casuarina obesa* occur on slightly elevated areas.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Halosarcia halocnemoides*
- (3) *Halosarcia indica* ssp. *bidens*
- (4) *Halosarcia* sp.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 60

Waterbird Site Code: 28

Name: Soldiers Cove

Location: West Mandurah

ATTRIBUTES

Size (ha): 9.4

Tidal: Yes

Fresh: No

Waterbird conservation significance: Intermediate

Vegetation description: Samphire flat with *Sarcocornia quinqueflora* *Halosarcia indica* ssp. *bidens* and *Halosarcia halocnemoides* on the point. A few stunted *Melaleuca cuticularis* occur as emergents. On the landward side of the cove is a narrow band of *Sarcocornia quinqueflora* with some *Bolboschoenus caldwellii* and *Isolepis cernua*.

Dominants (ranked): (1) *Sarcocornia quinqueflora*
(2) *Halosarcia halocnemoides*

Comments: The cove is fairly well used by birds despite encroaching suburbia and narrow shorelines; most activity takes place on the islands of samphire within the main channel.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 61, 62, 95, 97

Waterbird Site Code: 29/30

Name: None Location: West of and between old and new bridge

ATTRIBUTES

Size (ha): 15.4 Tidal: Mainly Fresh: Occasional pools

Waterbird conservation significance: High

Vegetation description: Open samphire with isolated *Casuarina obesa*. *Sarcocornia quinqueflora* occurs in the wettest areas and *Halosarcia indica* ssp. *bidens* on the most elevated ground. The areas in between support a mixture of *Halosarcia syncarpa*, two forms of *Halosarcia halocnemoides*, *Frankenia* sp. and *Suaeda australis*. Patches of *Lolium perenne* occur in places.

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *Halosarcia indica* ssp. *bidens*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 63

Waterbird Site Code: 31

Name: The Chimneys Location: Up to 1km south of new traffic bridge

ATTRIBUTES

Size (ha): 8.5 Tidal: Mainly Fresh: Occasional pools

Waterbird conservation significance: High

Vegetation description: Samphire flat with *Halosarcia halocnemoides*, *Sarcocornia quinqueflora* with some *Halosarcia indica* ssp. *bidens* and *Suaeda australis*. *Casuarina obesa* and the occasional *Melaleuca raphiophylla* occur as emergents on the south and inlet sides. These are all severely stressed or dead. On the west of the cove a narrow band of *Sarcocornia quinqueflora* with some *Juncus kraussii* and *Gahnia* sp. occurs at the foot of a steep bank.

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *Sarcocornia quinqueflora*

Comments: A complex continuum varying from lightly to heavily disturbed country. However, its complexity and habitat variation advantages a wide range of waterbirds.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 64, 66

Waterbird Site Code: 32/33

Name: None

Location: Adjacent to Sticks Channel

ATTRIBUTES

Size (ha): 24.4 Tidal: Mainly Fresh: Occasional pools

Waterbird conservation significance: High

Vegetation description: Along the shoreline the vegetation is *Sarcocornia quinqueflora* with some *Suaeda australis*, *Bolboschoenus caldwellii* and *Frankenia* sp.. *Casuarina obesa* and *Melaleuca cuticularis* appear as emergents. Moving inland there are a series of lense shaped tidal pools supporting *Halosarcia halocnemoides*, *Halosarcia indica* ssp. *bidens* and both *Sarcocornia quinqueflora* and *Sarcocornia blackiana*. The banks between the pools carry a dense scrub of *Kunzia ericifolia*, *Hakea* sp., *Regelia ciliata*, *Baeckia* sp. and some *Acacia saligna*. *Melaleuca raphiophylla* also occurs in dense, scrubby patches in places. *Leptocarpus scariosus* is the main understorey species with *Stylidium* spp. and several annual Asteraceae occurring in more open, sandy areas. (Also includes waterbird site 34, following page.)

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *Sarcocornia quinqueflora*

Comments: A complex, fairly isolated series of wetlands with the capacity to act as a refuge area for waterbirds.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 34

Name: None

Location: West of Sticks Channel

ATTRIBUTES

Size (ha): 7.9 Tidal: Mainly Fresh: Occasional pools

Waterbird conservation significance: High

Vegetation description: Along the shoreline the vegetation is *Sarcocornia quinqueflora* with some *Suaeda australis*, *Bolboschoenus caldwellii* and *Frankenia* sp.. *Casuarina obesa* and *Melaleuca cuticularis* appear as emergents. Moving inland there are a series of lense shaped tidal pools supporting *Halosarcia halocnemoides*, *Halosarcia indica* ssp. *bidens* and both *Sarcocornia quinqueflora* and *Sarcocornia blackiana*. The banks between the pools carry a dense scrub of *Kunzia ericifolia*, *Hakea* sp., *Regelia ciliata*, *Baeckia* sp. and some *Acacia saligna*. *Melaleuca raphiophylla* also occurs in dense, scrubby patches in places. *Leptocarpus scariosus* is the main understorey species with *Stylidium* spp. and several annual Asteraceae occurring in more open, sandy areas.

Dominants (ranked): (1) *Halosarcia halocnemoides*
(2) *Sarcocornia quinqueflora*

Comments: A complex, fairly isolated series of wetlands with the capacity to act as a refuge area for waterbirds.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 88, 96

Waterbird Site Code: 35

Name: Owen Road boat ramp

Location: Falcon

ATTRIBUTES

Size (ha): 1.0 Tidal: Mainly Fresh: Occasional winter influx

Waterbird conservation significance: Intermediate

Vegetation description: Along the shoreline of this swamp the vegetation is a dense band of *Juncus kraussii* to 1.2m high with occasional *Atriplex hypoleuca* and *Suaeda australis*. Both *Melaleuca cuticularis* and *Casuarina obesa* occur as scattered emergents. Most of these are severely stressed. Some *Sarcocornia quinqueflora* and *Atriplex prostratus* are present around tidal pools. *Rumex* sp. and *Lolium perenne* occur along the shoreline.

Dominants (ranked): (1) *Juncus kraussii*
(2) *Melaleuca cuticularis*

Comments: A small wetland with dense enough vegetation to act as a refuge area for secretive waterbirds such as crakes and rails.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 89, 91

Waterbird Site Code: 36

Name: Olive Road boat ramp

Location: Falcon

ATTRIBUTES

Size (ha): 5.9 Tidal: Mainly Fresh: Occasional winter influx

Waterbird conservation significance: Low

Vegetation description: Along the shoreline of this swamp the vegetation is a dense band of *Juncus kraussii* to 1m high with *Melaleuca cuticularis* occurring as dense clumps. A few *Halosarcia indica* ssp. *bidens*, *Sarcocornia quinqueflora* and *Bolboschoenus caldwellii* are present.

Dominants (ranked): (1) *Juncus kraussii*
(2) *Melaleuca cuticularis*

Comments: A small wetland with dense enough vegetation to act as a refuge area for secretive waterbirds such as crakes and rails.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 90

Waterbird Site Code: 37

Name: None

Location: Pleasant Grove

ATTRIBUTES

Size (ha): 7.0 Tidal: Mainly Fresh: Occasional winter influx

Waterbird conservation significance: Intermediate

Vegetation description: Along the shoreline of this swamp the vegetation is a dense band of *Juncus kraussii* to 1m high with *Melaleuca cuticularis* occurring as scattered individuals or as small, dense clumps. A few *Halosarcia indica* ssp. *bidens*, *Sarcocornia quinqueflora* and *Bolboschoenus caldwellii* are present. To the landward side is a *Eucalyptus gomphocephalus* woodland with an open, weedy understorey.

Dominants (ranked): (1) *Juncus kraussii*
(2) *Melaleuca cuticularis*

Comments: A small wetland with dense enough vegetation to act as a refuge area for secretive waterbirds such as crakes and rails.



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 38 (a)

Name: None

Location: Peel Parade east, Nairns

ATTRIBUTES

Size (ha): 0.4 Tidal: No Fresh: Yes

Waterbird conservation significance: Intermediate

Vegetation description: Some *Sarcocornia quinqueflora* and *Juncus kraussii* is present along the water's edge and is surrounded by an admixture of *Jacksonia sternbergiana*, *J. furcellata*, *Acacia saligna*, *Viminaria juncea*, *Eucalyptus rudis*, *Melaleuca raphiophylla* and *Melaleuca preissiana* to 6m in height. Understorey is weedy and includes *Juncus kraussii*, *Cotula coronopifolia*, *halosarcia indica* ssp. *bidens*, *Acacia pulchella*, *Lepyrodia* sp. *Rumex pulcher*, *Briza maxima*, *Cynodon dactylon*, *Avena* sp. and *Carpobrotus edulis*.

Dominants (ranked): (1) *Juncus kraussii*
(2) *Melaleuca raphiophylla*
(3) *Acacia saligna*, *Jacksonia sternbergiana*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): None

Waterbird Site Code: 38 (b)

Name: None

Location: Peel Parade east, Nairns

ATTRIBUTES

Size (ha): 1.0 Tidal: No Fresh: Yes

Waterbird conservation significance: Intermediate

Vegetation description: Surrounding vegetation is significantly modified. A narrow band of *Juncus kraussii* and scattered *Melaleuca raphiophylla* occurs at the water's edge. This is surrounded by an open cover of exotic species including several annual Asteraceae, *Raphanus raphanistrum*, *Lupinus* sp., *Briza* spp. and other grasses. Occasional shrubs of *Jacksonia furcellata* and *Acacia saligna* remain in this area. To the north there are *Casuarina obesa* And *Eucalyptus calophylla* trees.

Dominants (ranked): (1) *Juncus kraussii*
(2) *Melaleuca raphiophylla*



WETLAND VEGETATION DATA SHEET

Mosquito Site Code(s): 54

Waterbird Site Code: 39

Name: Goegrup Lake

Location: Goegrup Lake (north)

ATTRIBUTES

Size (ha): 32.4

Tidal: Mainly

Fresh: Seasonally

Waterbird conservation significance: Very high

Vegetation description: The tidal pool is separated from the main water body by a band of *Sarcocornia quinqueflora* and some *Juncus kraussii* along the water's edge. The rest of the flats also support these two species along with *Halosarcia halocnemoides*, *Bolboschoenus caldwellii* and *Suaeda australis*. Fringing thicket is mainly of *Casuarina obesa*, with some *Melaleuca cuticularis* and *Jacksonia sternbergiana*.

Dominants (ranked):

- (1) *Sarcocornia quinqueflora*
- (2) *Casuarina obesa*
- (3) *Bolboschoenus caldwellii*



STUDY: _____
DATE: _____ 19 _____
TIME: _____ to _____ hrs
OBS: _____

SAMPLE SITE NO: _____
DESCRIPTION: _____

WATER LEVEL: ___'___m
MOSQUITO INDEX (0-3)
LARVAE: _____
ADULT: _____

[illegible]

ACTIVITY CODES - F = Feeding, R = Roosting, L = Loafing, A = Flying over, O = Other.
B = Breeding

Appendix 4 Specific attribute scores for mosquito breeding areas censused for waterbirds at Peel Inlet.

SR = Species Richness; NI = Number of Individuals;
 SS = Significant Species; BP = Breeding Potential;
 HQ = Habitat Quality; HR = Habitat Representation;
 DH = Diversity of Habitats;

SITE	SR	NI	SS	BP	HQ	HR	DH	TOTAL
1	3	1	1	2	2	2	2	13
2	4	4	1	4	4	2	3	22
3	3	5	2	3	3	2	2	20
4	3	5	1	1	2	1	1	14
5	5	3	2	3	3	3	2	21
6	3	1	1	1	1	2	2	11
7	1	1	0	1	1	1	2	6
8	2	1	1	1	1	1	2	9
9	1	1	1	1	1	1	1	7
10	3	2	1	2	2	2	1	13
11	3	1	1	1	1	1	1	9
12	4	6	1	4	4	3	2	24
13	3	1	1	2	2	2	1	12
14	4	5	1	3	3	2	2	20
15	4	6	1	3	3	2	2	21
16	6	6	2	3	4	2	4	27
17	6	6	1	4	4	3	4	28
18	6	6	2	4	4	3	4	29
19	6	6	1	4	4	3	4	28
20	3	5	1	3	3	3	3	21
21	2	2	0	2	2	3	3	14
22	5	6	1	4	3	4	3	26
23	4	2	3	2	2	2	2	17
24	3	1	1	2	3	2	2	14
25	5	6	3	3	3	4	4	28
26	6	6	3	3	4	4	4	30
27	5	6	2	2	2	2	2	21
28	4	6	2	2	2	2	2	20
30	5	4	3	3	3	3	3	24
31	4	6	2	3	3	3	3	24
32	4	6	2	3	3	3	3	24
34	4	6	2	3	3	3	3	24
35	4	6	1	2	2	3	3	21
36	3	1	1	3	2	3	3	16
37	4	6	1	3	1	3	3	20
38	3	5	1	3	1	3	2	18
39	5	6	2	3	4	3	3	26

Appendix 5 Monitoring of Abate application by helicopter and follow-up survey to assess any potential impact on waterbirds.

JANUARY 27-28, 1989

Larvicide Application - after a site reconnaissance and an extended media session, larvicide application commenced at about 13:00 hrs. Unfortunately the aerial hopper used to control larvicide flow was not operating efficiently with the result that it was impossible to obtain adequate coverage of mosquito breeding areas. Six or seven abortive flights were made with only one of these being apparently successful. Westcoast Helicopter engineers attempted running repairs and adjustments until about 17:30 hrs, when a decision was made to terminate the session.

Bird Searches - on February 28, 1989 J. Henry and K. Youngson of Ninox Wildlife Consulting, conducted a series of search transects through the area where it was believed that larvicide application was successful. The transect route commenced at the shoreline due south of Kurdal Road, Coodanup, continued on to Creery Island, traversed most of its length then cut across to the estuary shoreline one kilometre north-west of Wanjeep Road. From this point a search was conducted back to the Coodanup car-park.

During the search special attention was paid to the lee shorelines of pools towards which any casualties would have been blown. Searches were also conducted within dense samphire. The estuary shoreline, mudflats and shallows were scanned using binoculars.

No uncoordinated, moribund or dead birds were located in six personnel hours of searching.

Two members of the Royal Australasian Ornithologists Union who were, by coincidence, observing birds on Creery Island also reported no casualties and had recorded many birds within and well beyond the area of larvicide application.

Larval Deaths - no dead larvae were observed on Creery Island and it is presumed that the hopper was not operating during this run. However, within the section of shoreline and associated mosquito breeding areas running for about half a kilometre north-west of Coodanup car-park, many dead and moribund larvae were seen. It was estimated that the density of dead and dying larvae on the surface of several of these pools was from 300-500 per square metre.

Black-winged Stilts and Greenshanks were observed feeding in these areas with apparently no ill-effects, considering that they had probably been using them since 14:00 hrs on the previous day. We are assuming that the toxic effect of a larvicide overdose will be fairly rapid in its onset, but suggest that a PIMA officer conducts a brief search in the next day or so to be on the safe side.

SEPTEMBER 11-12 1989

As part of the continuing Mosquito Control Review Committee programme of larvicide application monitoring, a helicopter session and follow-up survey was planned for September 11-12, 1989. The main objectives were to assess the opening stages of the waterbird breeding season, advise the helicopter pilot on methods of application in locations of breeding significance and review the results on the following day.

I (K. Youngson, Ninox) drove to Mandurah on September 11 and met with Tony Wright of the Public Health Department and the West Coast Helicopter pilot prior to the flight. In discussions with the pilot I was informed that a tightening of Civil Aviation regulations meant that the carrying of more than one passenger in this type of operation was not strictly legal and that given the choice, the pilot would prefer not to do so because of safety aspects. This seemed very reasonable to me and I therefore decided that it would be better for all concerned if I did not participate. Tony and myself discussed larvicide application and the specific problems associated with broods of ducklings at this time of the year and I am sure that he fulfilled my role on the flight more than adequately.

I spent the rest of the morning with Alex McKay of Mandurah Shire who provided me with valuable information on waterbird breeding in his area of operations, checked several of the monitoring sites for broods of ducklings and then returned to Perth.

Because of prior commitments on the following day I was unable to carry out the follow-up monitoring myself and therefore contracted Michael Bamford who has previously acted as a skilled relief observer on both the Leschenault and Peel surveys. Within the Peel study area, most larvicide application took place in the vicinity of Lake Goegrup; Michael therefore concentrated his efforts around the perimeter of the lake and the downstream and upstream shorelines of the Serpentine River.

The following notes were taken on the presence or absence of mosquito larvae and waterbirds in fringing wetlands included in the post-larvicide application monitoring:

Serpentine R. north of Stakehill Bridge - some larvae in wheel-ruts. Three species of waterbirds, 7 individuals.

Between Stakehill Bridge and Goegrup - some larvae in wheel-ruts. Five species of waterbirds, 74 individuals.

Goegrup (north) - many active larvae in pools on the samphire/paperbark interface. Seven species of waterbird and 24 individuals seen.

Goegrup (north-west/Site 15) - many active larvae in pools. Two species of waterbird, 11 individuals.

Goegrup (south-west/site 14) - no evidence of larvae. Five species of waterbird, 16 individuals.

Goegrup (south) - some larvae present. Three species of waterbird, 9 individuals.

Goegrup (south/site 13) - some larvae present, many aquatic invertebrates, 6 species of waterbirds, 30 individuals.

Serpentine R. from Riverview to site 7 - very large numbers of larvae. Two species of waterbird, 13 individuals including 8 Black Duck chicks.

Goegrup (east/site 16) - no larvae but many *Daphnia* etc. Fresh water flowing in from Black Lake.

No evidence of waterbird mortality, uncoordinated or moribund behaviour was observed in the nine locations surrounding Lake Goegrup and fringing the Serpentine River all of which were subjected to intensive foot-transect searches.