

CLARENCE ESTUARY SHOREBIRD ISSUES PAPER



**PREPARED BY SANDPIPER ENVIRONMENTAL
FOR WORLD WIDE FUND FOR NATURE**

29 OCTOBER 2004

Clarence Estuary Shorebird Issues Paper

29 OCTOBER 2004

Sandpiper Environmental
PO Box 401
ALSTONVILLE NSW 2477

Approved by: _____
Project Manager

This report has been prepared in accordance with the scope of services described in the contract or agreement between Sandpiper Environmental (ABN 47 327 438 027) and WWF Australia. The report relies upon data, surveys, measurements and results taken at or under the particular times and conditions specified herein. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by WWF Australia. Furthermore, the report has been prepared solely for use by WWF Australia and Sandpiper Environmental accepts no responsibility for its use by other parties.

TABLE OF CONTENTS

1.	<u>INTRODUCTION</u>	1
1.1	<u>BACKGROUND</u>	1
1.2	<u>STUDY AREA</u>	1
	1.2.1 <i>Extent</i>	1
	1.2.2 <i>Location and Major Features</i>	1
	1.2.3 <i>Contextual Information</i>	2
2.	<u>REVIEW OF PREVIOUS SURVEYS</u>	7
2.1	<u>METHODS</u>	7
	2.1.1 <i>Data Collation</i>	7
	2.1.2 <i>Data Evaluation</i>	7
2.2	<u>RESULTS</u>	8
	2.2.1 <i>Shorebird Surveys in the Clarence Estuary</i>	8
	2.2.2 <i>Evaluation of shorebird data</i>	9
2.3	<u>DISCUSSION</u>	14
	2.3.1 <i>Adequacy of Existing Data Sets for Management & Site Prioritisation</i>	14
	2.3.2 <i>Data Gaps</i>	15
3.	<u>SITE ASSESSMENT</u>	16
3.1	<u>BACKGROUND</u>	16
3.2	<u>METHODS</u>	16
	3.2.1 <i>Site Identification</i>	16
	3.2.2 <i>Site Characteristics</i>	17
	3.2.3 <i>Identifying Important Roost and Feeding Grounds</i>	17
3.3	<u>RESULTS</u>	19
	3.3.1 <i>Zoning and Conservation Status</i>	19
	3.3.2 <i>Refining Roost Sites</i>	19
	3.3.3 <i>Site Characteristics</i>	20
	3.3.4 <i>Important Roost and Feeding Sites</i>	20
3.4	<u>DISCUSSION</u>	21
	3.4.1 <i>Zoning and Tenure</i>	21
	3.4.2 <i>Important Roost and Feeding Sites</i>	23
4.	<u>THREAT ANALYSIS AND PRIORITISATION</u>	26
4.1	<u>METHODS</u>	26
	4.1.1 <i>Identification of Threats</i>	26
4.2	<u>RESULTS</u>	28
	4.2.1 <i>Threat Analysis</i>	28
4.3	<u>DISCUSSION</u>	29
5.	<u>RECOMMENDATIONS</u>	34
5.1	<u>SUMMARY OF THREATS AND ISSUES</u>	34
5.2	<u>PROPOSED MANAGEMENT ACTIONS</u>	34
	5.2.1 <i>Background</i>	34
	5.2.2 <i>Proposed Actions to Manage Threats</i>	35
	5.2.3 <i>Prioritisation of Proposed Actions</i>	41
6.	<u>REFERENCES</u>	45

LIST OF TABLES

<i>Table 1.1:</i> Species of shorebird commonly occurring in the Clarence Estuary.	3
Table 2.1: Sources of shorebird survey data for the Clarence Estuary.	8
Table 2.2: Evaluation of 10 data sources.	12
Table 2.3: Summary of data sources and the roost sites sampled by each of the data sources.	13
Table 2.4: Summary of the number of times that 34 high tide roosts have been sampled.	14
Table 3.1: Variables sampled at 25 high tide roosts situated within the lower Clarence River Estuary.	18
Table 3.2: Summary of general information on the use of 34 sites/locations in the Clarence River Estuary by shorebirds.	22
Table 3.3: Summary of general information on the use of 13 foraging areas in the Clarence River Estuary by shorebirds.	23
Table 4.1: Potential threats and the manner in which the level of threat was assessed.	28
Table 4.2: Summary of potential threats to shorebirds and their predicted occurrence at known shorebird roost site.	32
Table 4.3: Comparison between potential threats and the value of sites to shorebirds.	33
Table 5.1: Summary of priority areas and specific actions proposed to manage shorebirds and their habitat in the Clarence Estuary.	36
Table 5.2: Inter-relationships between priority areas and actions proposed in the EMP and the BAIP.	42
Table 5.3: Prioritisation of proposed management actions based on available funding and demand.	43

LIST OF FIGURES

Figure 1.1: Major features of the study area.	5-6
Figure 2.1: Location of sites sampled during the high tide roost assessment (red dots) and sites referred to in the report.	9-10

EXECUTIVE SUMMARY

BACKGROUND

Sandpiper Environmental was contracted by World Wide Fund for Nature Australia (WWF Australia) to prepare an issues paper on shorebirds in the Clarence River Estuary. WWF Australia is co-ordinating a National Shorebird Conservation Project (SCP) and the Clarence River Estuary has been selected as one of 10 sites throughout Australia for inclusion in this project.

To further the SCP it is necessary to prepare an issues paper on shorebirds in the Clarence Estuary. The objectives of the issues paper include:

- To review the status of knowledge on shorebirds and their habitat.
- To investigate and identify threats to important shorebird habitat, rank threats and identify sites/habitats with the highest level of threat.
- To investigate and identify options for mitigating threats and prioritise these options.
- To recommend opportunities for collaborative approaches to manage threats among local stakeholder groups.

STUDY AREA

The study area extends from the estuary mouth upstream to Munro Island, which is situated adjacent to the small town of Lawrence. The area includes two large estuarine lakes, Wooloweyah Lagoon and Clarence Broadwater, and all of the tidal channels and littoral habitats within the above area. The coastline from Shark Bay south to the northern break wall of the Clarence River is also included in the study area.

REVIEW OF PREVIOUS SURVEYS

Previous shorebird surveys in the study area were collated and evaluated to ascertain their adequacy for identifying management priorities. Ten data sources covering the period 1984 to 2004 were evaluated. These data sources included 66 high tide surveys and 12 low tide surveys.

Analysis of previous surveys identified a high degree of variability, including:

- The number of sites sampled i.e. coverage of the estuary.
- The methods used i.e. number of personnel, duration and frequency.
- The manner in which the data are presented i.e. some surveys have combined data for nearby locations.

No surveys have provided data for all of the identified roost sites (Table A), although four of the 10 data sources have sampled almost all of the study area. All surveys have sampled some sites in the lower estuary and roosts situated in the channel extending from Dart Island through Oyster Channel to the entrance of Wooloweyah Lagoon have been most frequently surveyed.

Data on foraging habitat is limited, with only five data sources including low tide surveys, and only two of these encompassing all, or most of the study area. The data available on foraging

habitat at best provides a broad indication of important locations and further surveys are required to provide definitive information on the location of important foraging habitat.

Table A: Summary of the number of times that 34 high tide roosts have been sampled. * Could include additional surveys.

Location In Estuary	Roost name	No. Surveys – high tide
North Side	Woram Channel	5
	Narrabarribi Island	5
	Eureka Island	3
	Bolorobo Island	4
	Goodwood Island East	4
	Goodwood Is/Collis Wall	4
	Goodwood Island (sth)	3
	Iluka Marina B'Wall	9
Main River Channel	Freeburn Island (3 sites)	11
	Middle Wall	24
South side	Hickey Island	53
	Dart Island	53
	The Peninsula (Shores Drive)	40
	Rabbit Island (sandbar)	30
	Reedy Creek	10
	Sleeper Is	32
	Crystal Waters	34
	Yamba Quays (+ rocks)	33
	Romiaka Channel	4
	Oyster Channel	Micalo Is - nth drain
Micalo Is - sth drain		2
Prawn Farm		8*
Wooloweyah Lagoon	Joss Island	43
	Corokos Island	43
	Palmers Island SE	5
Upper River/Broadwater	Ulgundahi Island	1
	Clarence B'Water	3
	Munro Island	3
Freshwater Wetlands	Lawrence (egret colony)	2
	Kalangadoo	2
Ocean Beach	Woody Head	4
	Shark Bay	4
	Iluka Beach - Frasers Reef	4
	Back Beach	4

A number of data gaps are evident from the review of survey data, including:

- The limited temporal coverage of surveys to document use of the estuary during northwards and southwards migration.
- A low number of high tide surveys that encompass the entire Clarence Estuary.
- A low number of low tide surveys that encompass the entire estuary.
- The management of data i.e. specific information for each site sampled.
- An absence of nocturnal surveys to identify night roost and feeding sites.

- Accessibility of information on methods and timing.
- Use of standard site names.

These knowledge gaps are not unique to the Clarence Estuary, however, they have specific implications for management. For example, an understanding of nocturnal roost sites is fundamental to ensure that shorebird habitat is adequately protected. Likewise, more frequent and comprehensive population surveys that cover the entire study area and improved data management would assist in identifying management priorities.

IDENTIFYING IMPORTANT ROOST AND FEEDING GROUNDS

To identify important roost and foraging sites maximum spring/summer counts, species diversity, number of threatened species and number of migratory species were determined for 34 roosts and 13 foraging areas. Mean values (total/no. surveys) \pm standard deviation⁻¹ were calculated for each site. To satisfy the objectives of this assessment it was necessary to prioritise sites in order of importance to shorebirds. Six criteria were used to provide a basic site prioritisation:

1. 0.5 points were awarded for every 100 individuals recorded at a site under the category of Maximum spring/summer count.
2. 1 point was awarded for every 100 individuals recorded at a site under the category of Mean No. birds.
3. 0.5 points were awarded for each species recorded at a site.
4. 1 point was awarded for each migratory species recorded at a site; and
5. 1 point was awarded for each threatened species recorded at a site.
6. 10 points provided if a site is used as a spring tide roost.

Scores for each criterion were added and the cumulative total used to assess the relative importance of each site. Sites with a cumulative score of 45 or higher were ranked as a high priority, sites scoring between 20 and 45 as a medium priority and sites that scored less than 19 were ranked as a low priority.

Results

Important Roosts

Dart/Hickey Island, Joss Island (& Wooloweyah Entrance) and Prawn Farm were ranked as high priority high tide roosts. These sites regularly support large numbers of birds, including several threatened and migratory species and are available during spring high tides. Goodwood south, Iluka Marina Breakwall, the Peninsula, Freeburn Island, Rabbit Island Sandbar, Yamba Quays, Micalo Is nth, Micalo Is sth, Clarence Broadwater and Shark Bay to Iluka Bluff were ranked as medium priority sites (Table B).

Important Foraging Areas

Foraging areas represent groups of intertidal sand and mudflats that occur in close proximity to each other. Intertidal flats at the northern end of Wooloweyah Lagoon (i.e. around Joss and Corokos Islands) were identified as high priority foraging habitat (Table C). North Arm to Saltwater Inlet, Freeburn Island, Dart/Hickey, Rabbit Island to Crystal Waters, Thorny Island to Oyster Channel Bridge and Oyster Channel were ranked as medium priority foraging areas.

Table B: Summary of general information on the use of 34 sites/locations in the Clarence River Estuary by shorebirds. Spr = spring; sum = summer; Sp = species; thr = threatened; mig = migratory; sd = standard deviation⁻¹; n = number of samples; Cum. = cumulative; High = 45 or greater; Medium = 20 to 44; Low = 1 to 19.

Sites	Priority Ranking	Maximum Count – spr/sum	Mean No. Spr/Sum	Tot. Sp.	No. Thr. Sp.	No. Mig Sp.	Cum. Score	Neap or spring
Eureka Island	Low	115 (11/94)	63 (sd 73.5, n 2)	5	1	5	9.5	Neap
Narrabarribi Island	Low	93 (3/84)	65 (sd 40.8, n 4)	11	2	10	17.5	Neap
Woram Channel	Low	24(3/84)	24 (N/A, n 1)	3	0	3	14.5	Spring
Bolorobo Island	Low	50 (3/84)	41 (sd 12, n 2)	6	1	6	10	Neap
Goodwood East	Low	3 (2/92)	2 (sd 1.41, n 2)	3	0	3	4.5	Neap
Goodwood/Collis	Low	12 (3/84)	12 (N/A, n 1)	3	1	3	5.5	Neap
Goodwood South	Medium	128 (10/94)	49 (sd 68.2, n 3)	7	1	7	22.5	Spring
Iluka Breakwater	Medium	127(2/02)	42 (sd 45.12, n 7)	10	2	7	25	Spring
Dart/Hickey	High	1050 (1/87)	347 (sd 248.3, n 32)	27	9	19	64.5	Spring
The Peninsula	Medium	247 (3/96)	52 (sd 62.1, n 19)	13	4	9	32.5	Spring
Penn to Ariel Island	N/A	713 (2/93)	235 (sd 245.4, n 8)	19	6	13	47.5	N/A
Middle Wall	Low	3 (2/92)	2 (sd 1.41, n 2)	2	1	1	13	Spring
Freeburn Island	Medium	215(3/84)	109 (sd 113.4, n 4)	16	4	12	27	Neap
Reedy Creek	Low	114 (11/95)	75 (sd 37.1, n 3)	3	0	3	15.5	Spring
Rabbit Island - sandbar	Medium	367 (12/91)	110 (sd 173.4, n 4)	11	5	8	22.5	Neap
Sleeper Island	Low	46 (2/04)	33 (sd 19.1, n 3)	6	0	5	8	Neap
Crystal Waters	Low	194 (2/84)	75 (sd 102.6, n 3)	10	2	9	17	Neap
Yamba Quays/Thorny Is	Medium	301(11/95)	127 (sd 91.7, n 10)	14	3	8	32	Spring
Romiaka Ch/Is	Low	94 (2/02)	75 (sd 19.6, n 3)	9	0	7	11.5	Neap
Oyster Channel	Low	143 (3/96)	54 (sd 56.9, n 6)	8	1	6	12	Neap
Micalo Is Nth	Medium	82 (10/94)	32 (sd 27.1, n 8)	13	1	9	26.5	Spring
Micalo Is sth	Medium	309 (11/94)	170 (sd 196.6, n 2)	11	1	7	27.5	Spring
Corokos Island	Low	38 (2/92)	16 (sd 15.6, n 4)	5	2	4	8.5	Neap
Joss Island	High	1284 (11/94)	662 (sd 409, n 13)	22	6	18	63	Spring
Wooloweyah Entrance	N/A	1460 (2/97)	636 (sd 449.6, n 11)	30	6	22	73	N/A
Palmers Is SE	Low	118 (2/03)	53 (sd 58.4, n 3)	5	1	3	17.5	Spring
Prawn Farm	High	1277(10/94)	857 (sd 312.9, n 3)	13	0	9	46.5	Spring
Ulugundahi Island	Low	12 (2/03)	12 (N/A, n 1)	2	0	1	2	Neap
Lawrence Island	Low	52 (3/84)	38 (sd 19.1, n 2)	7	1	3	7.5	N/A
Munro Island to Maclean	Low	20 (2/02)	11 (sd 12.7, n 2)	4	1	1	4	Neap
Clarence Broadwater	Medium	605 (11/94)	605 (N/A, n 1)	8	0	6	32	Neap
Kalangadoo	Low	89 (2/02)	89 (N/A, n 1)	2	0	0	1	N/A
Iluka Beach	Low	29 (2/02)	24 (sd 7, n 2)	6	2	4	19	Spring
Shark Bay to Iluka Bluff	Medium	115 (3/84&2/03)	92 (sd 39.2, n 3)	12	4	7	28	Spring

Table C: Summary of general information on the use of 13 foraging areas in the Clarence River Estuary by shorebirds. Abbreviations are the same as those used in Table B.

Site	Priority Ranking	Maximum Count (date)	Mean No.	Total Species	No. Thr. Sp.	No. Mig. Sp.	Cum. Score
Esk Mouth	Low	121(10/94)	76 (sd 54.1, n 3)	12	1	10	18
Nth Arm – Saltwater Inlet	Medium	279 (3/84)	122 (135.7, n 3)	11	3	10	21.5
Freeburn Island	Medium	432 (1/87)	180 (169.2, n 4)	16	4	12	29
Dart/Hickey	Medium	187 (4/95)	136 (sd 37, n 8)	18	6	14	31
Rabbit Island – Crystal Waters	Medium	183 (10/95)	105 (sd 58.1, n 6)	15	5	11	25.5
Thorny Island - Oyster Ch Bridge	Medium	191 (11/95 & 10/95)	156 (30.3, n 6)	12	3	9	20
Romiaka Ch	Low	75(10/94)	56 (sd 26, n 2)	9	0	7	11.5
Oyster Channel	Low	490 (11/94)	281 (134.7, n 6)	16	3	12	29
Wooloweyah Entrance	High	1668 (1/87)	731 (sd 560, n 9)	25	6	20	61.5
Yards Flat	Low	67 (11/94)	67 (N/A, n 1)	8	1	7	12
Prawn Farm Lagoon	Low	398 (11/95)	398 (N/A, n 1)	5	0	3	11.5
Palmer's Is SE	Low	231 (11/94)	231 (N/A, n 1)	11	0	8	17.5
Munro Island	Low	52 (3/84)	52 (N/A, n 1)	3	1	2	4.5

THREAT ANALYSIS AND PRIORITISATION

Identification of Threats

Numerous factors are known to threaten shorebirds and their habitat, however, there is no published information on specific threatening processes in northern NSW estuaries. The absence of published information was overcome by using general knowledge of threats and applying a broad approach to threat identification. Five threat categories were identified:

- Habitat loss – removal of habitat through reclamation and in severe cases erosion.
- Habitat modification – changes in the characteristics of habitat that reduces its utility for shorebirds.
- Habitat disturbance – activities that result in disturbance to roosting and foraging shorebirds.
- Habitat pollution – accumulation of pollutants in body fat that reduces life span and potentially reproductive ability and the abundance of prey.
- Mortality – Death of individuals through hunting by humans for food, recreation or site protection.

Using the broad threat categories identified above a list of **potential** threatening factors specific to the Clarence Estuary was derived. Sources of information included published papers, unpublished reports on the Clarence Estuary, personal knowledge, experience observing shorebirds in the Clarence Estuary and other estuaries in northern NSW and general observations.

A total of 36 potential threats were identified. Climate Change and associated sea-level rise is considered as a potentially significant threat to shorebird habitat, however, due to a high

degree of uncertainty regarding the influence of sea-level rise on the Clarence Estuary it has not been included in the site specific threat assessment.

A matrix was developed that assessed the level of threats at roost sites. Each threat was given a score of 1, 5 or 10 depending on its proximity to a site. A score of 10 was given to threats that occur on-site, 5 for threats within 100m of a site and 1 for threats within 1km of a site. A score of 20 was given to sites approved for development to reflect the likely removal of roosting habitat from these sites.

Table D: Potential threats and the manner in which the level of threat was assessed.

Threat Category	Specific Threats	Methods of Assessing Level of Threat	
Habitat loss	Erosion	Presence/absence of erosion & the extent: severe >75%; moderate 25-75%; minor <25%)	
	Areas being developed or identified for development – foreshore or adjacent	Identified areas from direct observation and discussions with Clarence Valley Council.	
	Aquaculture	Direct Observation & 1: 25 000 topographic maps.	
Habitat Modification	Mangrove encroachment	Assessed in the field: present or absent on roost/feeding; If absent estimate (with reference to a 1: 25000 topographic map) distance to the nearest stand of mangroves; Estimate of the area (m ²) covered by mangroves; Height or height range (m) of mangroves; Record the species of mangrove. Estimate % cover of mangroves <1m tall. Estimate total area (m ²) covered by mangroves <1m tall. Assess if mangroves will affect roost quality.	
	Artificial lighting	Direct observation and inferred from proximity of site to urban areas.	
	Altered drainage/Drains	Direct observation of drains & 1: 25 000 topographic map; Discussions with Clarence Valley County Council.	
	Shoreline stabilisation	Direct observation of shoreline stabilisation works, which include concrete and rock revetments.	
	Training Wall/Groin	Direct observation and review of topographic maps.	
Habitat Disturbance - Activities	Canal Estate	Direct observation and review of topographic maps.	
	4WD vehicles	Direct observation & Clarence Valley Council	
	Walking/jogging area	Personal observation	
	Commercial fishing site	Discussions with NSW Department of Primary Industries, CRPFA.	
	Recreational fishing site	Direct observation & discussions with Clarence River Fishing Clubs Association.	
	Bait collecting site	Direct observation & discussions with Clarence River Fishing Clubs Association.	
	Formal picnic site	Direct observation and review of topographic maps.	
	Informal picnic site	Direct observation.	
	Dog Exercise Area (formal & informal)	Discussions with Clarence Valley Council and direct observation.	
	Swimming site	Direct observation	
	Sailing boat route	Discussions with local sailing clubs to identify main sailing routes.	
	Jetski/waterski/Kite surf area	Discussions with NSW Waterways Authority.	
	Main boating channel	Discussions with NSW Waterways Authority.	
	Proposed urban expansion	Discussions with Clarence Valley Council planning staff.	
	Sources	Formal boat ramp	Direct observation and review of topographic maps.
		Informal boat ramp	Direct observation.
		Boat hire	Direct observation, tourist pamphlets, yellow pages.
Camp/caravan Park		Direct observation, tourist pamphlets, yellow pages, 1: 25 000 topographic map	
Tourist facility (hotel/motel/restaurant)		Direct Observation	
Marina		Direct observation and review of topographic maps.	
Major road		Direct Observation, topographic maps	
Developed areas (urban) foreshore		Direct observation	
Pollution	High Risk ASS	Maps contained in the EMP	
	Sugar Cane	1: 25 000 Topographic maps, Umwelt (2002)	
Mortality	Introduced pests	NSW Department of Environment & Conservation	

Results

Potential threats were assessed for 32 sites. Hickey Island and Yamba Quays received the highest threat ranking, followed by The Peninsula, Prawn Farm, Goodwood/Collis, Micalo North and Dart Island. All of these sites scored above 70 and are considered to experience a very high level of threat. High levels of threat (scores between 55 and 69) were recorded at Iluka Breakwall, Freeburn Island, Sleeper Island, Crystal Waters and Prawn Farm. Moderate levels of threat (scores between 35 and 54) were recorded at Goodwood east, Goodwood south, Rabbit Island (sandbar) Reedy Creek, Palmers Island, Shark Bay and Woody Head. Low levels of threat (scores below 35) were recorded at Bolorobo Island, Rabbit Island (nest), Romiaka Channel, Middle wall, Corokos Island, Joss Island, Ulgundahi Island, Clarence Broadwater, Munro Island, Kalangadoo and Back Beach.

Potential disturbance was the main threatening factor at Dart Island, Hickey Island and The Peninsula, whilst a high risk of habitat modification was the primary threat at Goodwood/Collis, Yamba Quays and Micalo North. Disturbance was a primary contributor to threat scores at Iluka Breakwall, Freeburn Island, Rabbit Island (sandbar) and Shark Bay. Habitat loss was a primary contributor to threat at Yamba Quays and Prawn Farm.

The highest ranking potential threats were recreational fishing (cumulative score of 137), high risk Acid Sulphate Soils (151), commercial fishing (131), mangrove encroachment (131) and introduced pests (101). Grazing (76), walking/swimming (74) and boating (83) also ranked highly.

Comparing the importance of each site (priority ranking) to the threat scores gives an indication of where conflicts between habitat values and threats exist. Such a comparison indicates that Dart Island is a high priority management site, followed by Hickey Island, Prawn Farm, The Peninsula, Goodwood south, Iluka Breakwall and Yamba Quays (Table E).

THREAT MITIGATION

A broad range of issues has been discussed in the previous chapters. These issues can be summarised into seven broad topics, including:

- The variable coverage of previous population monitoring surveys and the limited number of surveys that have covered the entire estuary.
- Variability in the methods and detail provided by previous surveys.
- The limited information available on the use of foraging habitats.
- The absence of information on nocturnal behaviour and important nocturnal habitats.
- The inappropriate zoning and protection of important shorebird habitat.
- A lack of understanding regarding the impact of numerous potential threatening processes on shorebirds. Prominent examples include, climate change, recreational activities and commercial fishing.
- The absence of guiding principles on how shorebird habitat in the estuary should be managed.

Although the Clarence estuary has been the subject of numerous shorebird surveys there is limited information on important shorebird habitats, the types of shorebird habitat in the estuary and baseline data on the characteristics of shorebird habitat. Likewise, there are no quantitative studies on how shorebirds are affected by various commercial and recreational activities in north coast estuaries. The above issues identify a clear need for further targeted research and

the development of guiding principles to assist state and local government and the community manage shorebird habitat.

Table E: Comparison between potential threats and the value of sites to shorebirds.

Site	Threat Score	Habitat Priority Ranking – High Tide
Narrabarribi Island	27	Low
Woram Channel	37	Low
Eureka Island	11	Low
Bolorobo Island	33	Low
Goodwood East	53	Low
Goodwood/Collis	80	Low
Goodwood south	54	Medium
Iluka Breakwall	65	Medium
Freeburn Island (nth)	63	Medium
Middle Wall	29	Low
Dart Island	75	High
Hickey Island	98	High
The Peninsula	81	Medium
Rabbit Island – sandbar	39	Medium
Rabbit Island – nest	32	N/A
Reedy Creek	48	Low
Sleeper Island	55	Low
Crystal Waters	57	Low
Yamba Quays	91	Medium
Thorny Island - Oyster Ch Bridge	Not Assessed	N/A
Romiaka Channel	31	Low
Micalo North	72	Medium
Prawn farm	73	High
Oyster Channel	Not Assessed	Low
Corokos Island	30	Low
Joss Island	29	High
Palmers Is SE	50	Low
Ulugundahi Island	26	Low
Clarence Broadwater	19	Medium
Munro Island	26	Low
Kalangadoo	31	Low
Shark Bay	41	Medium
Back Beach	30	Medium
Woody Head	52	Medium

PROPOSED MANAGEMENT ACTIONS

Table F lists proposed management actions and identifies those actions that are a high, medium or low priority and potential lead organizations that could be approached to implement the actions. In developing management actions a strategic approach has been adopted in an attempt to improve the consideration of shorebird issues in local planning and provide a framework for the protection of important habitat.

Table F: Prioritisation of proposed management actions based on available funding and demand. SMP = Shorebird Monitoring project; NGO = None Government Organisation; CG = Community Group; CVC = Clarence Valley Council; DEC = Department of Environment & Conservation

Proposed Actions	Prioritisation	Target Organisation
<p>1a) Undertake nocturnal surveys to identify important roost and foraging habitats</p> <p>1b) Research the type and extent of disturbance to shorebirds in the Clarence Estuary</p> <p>1c) Assess the impact of climate change (sea-level rise) on shorebird habitat in the Clarence Estuary.</p> <p>1d) Obtain further information on how shorebirds use different roost and feeding sites</p> <p>1e) Initiate a shorebird population monitoring program</p> <p>1f) Undertake baseline studies on the characteristics of shorebird foraging habitat e.g. sediment structure and invertebrate communities.</p> <p>1g) Monitor changes in the structure of roost and feeding sites</p>	<p>1a) High</p> <p>1b) High</p> <p>1c) High</p> <p>1d) Low</p> <p>1e) Medium</p> <p>1f) Low</p> <p>1g) Medium</p>	<p>1a) SMP/consultant/research students/NGO/CG</p> <p>1b) SMP/consultant/research students/NGO/CG</p> <p>1c) CVC</p> <p>1d) SMP/consultant/research students/NGO</p> <p>1e) NGO</p> <p>1f) University/Research students/NGO</p> <p>1g) SMP/NGO</p>
<p>2a) Using GIS, map the distribution and extent of shorebird roost and foraging habitat throughout the Clarence River Estuary.</p> <p>2b) At a later stage, and with more information at hand, this mapping could be modified to identify primary and secondary habitats.</p>	<p>2a) High</p> <p>2b) Medium</p>	<p>2a) CVC/DEC</p> <p>2b) CVC/DEC</p>
<p>3a) Develop a shorebird management toolbox to assist local government planners to:</p> <ul style="list-style-type: none"> - ensure that the indirect impacts of urban development, such as recreation are considered in assessing future large-scale land releases at Yamba and Iluka. - ensure that impacts on shorebirds from ecotourism, recreation based, dredging or foreshore development proposals are adequately considered. <p>3b) Rezone important shorebird foraging habitat as 7(a) {Environmental Protection (Ecological Significance) Zone} and ensure that all roost sites are zoned 7(a).</p> <p>3c) Review current dog exercise and 4WD areas and identify locations where improved regulation of these activities is warranted.</p> <p>3d) Ensure that roost and feeding ground mapping is linked to the development assessment process within Clarence Valley Council.</p>	<p>3a) Medium</p> <p>3b) High</p> <p>3c) High</p> <p>3d) High</p>	<p>3a) NGO/Consultant/DEC/CG</p> <p>3b) CVC</p> <p>3c) CVC</p> <p>3d) CVC</p>
<p>4a) Identify areas suitable for inclusion in the Clarence Estuary Nature Reserve (to mean low water) and lobby state government for inclusion of these areas in the reserve system.</p> <p>4b) Support the Ramsar nomination of the Clarence Broadwater.</p> <p>4c) Encourage the extension of the Ramsar nomination to include Wooloweyah Lagoon.</p> <p>4d) Identify sites suitable for the development of conservation agreements.</p>	<p>4a) High</p> <p>4b) Medium</p> <p>4c) High</p> <p>4d) Low</p>	<p>4a) NGO/CG/DEC</p> <p>4b) NGO/CG</p> <p>4c) NGO/CG/DEC</p> <p>4d) NGO/CG/DEC</p>
<p>5a) Establish (or link with an already established group) a community group to assist with the implementation of measures proposed in this report.</p> <p>5b) Increase awareness within the local community of shorebirds, the habitat they use and the impact of daily activities with a view to fostering community involvement in shorebird management.</p> <p>5c) Obtain community input to develop measures to protect important shorebird habitats.</p>	<p>5a) High</p> <p>5b) High</p> <p>5c) High</p> <p>5d) Medium</p>	<p>5a) NGO</p> <p>5b) NGO/CG</p> <p>5c) NGO/CG</p> <p>5d) NGO/CG</p>

5d) Initiate negotiations between specific user groups and conservation organizations to develop actions to minimise impacts on shorebirds e.g. develop a Recreational Fishing Code of Conduct for the Clarence Estuary. 5e) Identify target groups that may benefit from additional information such as brochures. 5f) Encourage the local aboriginal community to become involved in shorebird management.	5e) Medium 5f) Medium	5e) NGO/CG 5f) NGO/CG
6a) Support measures to assess the impact of commercial use of Wooloweyah Lagoon. 6b) Support measures to avoid further foreshore development of Wooloweyah Lagoon.	6a) Medium 6b) Medium	6a) CG 6b) CG
7a) Increase awareness of local environmental lobby groups regarding shorebird (waterbird) management and threatening processes to provide a mechanism by which these issues are integrated into management programs, such as the Floodplain Partnership Agreement. 7b) Ensure that shorebirds are considered in floodplain management initiatives such as ASS hotspots program & floodgate management.	7a) Low 7b) Medium	7a) CG 7b) CG
8a) Identify sites that are suitable for habitat remediation or creation 8b) Identify the actions required to remediate or create habitat at the designated sites.	8a) High 8b) High	8a) NGO/CG/CVC 8b) NGO/CG/CVC
9a) Map the distribution of weeds within the estuary 9b) Identify priority areas for weed management and prepare a weed management plan. 9c) Support the current program to control pest species at Dart and Hickey Islands and identify other locations for pest species management.	9a) Low 9b) Low 9c) Medium	9a) Clarence Valley Weeds Authority/Landcare 9b) Clarence Valley Weeds Authority/Landcare 9c) NGO/CG/DEC
10a) Identify key habitats for threatened shorebirds (waterbirds). 10b) Identify threats to important habitat. 10c) Ensure that important habitats are recognised in the PoM and environmental planning assessments.	10a) High 10b) High 10c) High	10a) NGO/CG/DEC/CVC 10b) NGO/CG/DEC/CVC 10c) NGO/CG/DEC/CVC
11 On-ground Actions	11) Low	NGO/CG/CVC

1. INTRODUCTION

1.1 BACKGROUND

Sandpiper Environmental was contracted by World Wide Fund for Nature Australia (WWF Australia) to prepare an issues paper on shorebirds in the Clarence River Estuary. WWF Australia is co-ordinating a National Shorebird Conservation Project (SCP) and the Clarence River Estuary has been selected as one of 10 sites throughout Australia for inclusion in this project. The project is funded by the Natural Heritage Trust and is aimed at increasing awareness of shorebirds and encouraging community involvement in the conservation of shorebird habitat. To date a draft Site Action Plan and Site Assessment Plan have been prepared for the Clarence Estuary (WWF Australia 2003a, b). These draft plans were prepared after consultation with local stakeholders to assess the management needs of shorebirds in the Clarence River Estuary.

To further the SCP it is necessary to prepare an issues paper on shorebirds in the Clarence Estuary. The objectives of the issues paper include:

- To review the status of knowledge on shorebirds and their habitat.
- To investigate and identify threats to important shorebird habitat, rank threats and identify sites/habitats with the highest level of threat.
- To investigate and identify options for mitigating threats and prioritise these options.
- To recommend opportunities for collaborative approaches to manage threats among local stakeholder groups.
- The issues paper will be prepared in consultation with local stakeholders and it is anticipated that the paper will facilitate the preparation of a shorebird management plan.

1.2 STUDY AREA

1.2.1 Extent

The study area extends from the estuary mouth upstream to Munro Island, which is situated adjacent to the small town of Lawrence (Figure 1.1). The area includes two large estuarine lakes, Wooloweyah Lagoon and Clarence Broadwater, and all of the tidal channels and littoral habitats within the above area. The coastline from Shark Bay south to the northern break wall of the Clarence River is also included in the study area (Figure 1.1).

1.2.2 Location and Major Features

The Clarence River is the largest river on the east coast of New South Wales (NSW), with a catchment area in excess of 29 000km². The catchment encompasses much of northern NSW, extending from the Queensland/NSW border west to the New England Tablelands and south to Coffs Harbour. The estuary is situated on the north coast of NSW, approximately 330km south of Brisbane. The estuary experiences a semi-diurnal tidal regime, which means

there are two high and two low tides about every 25 hours. Saline water extends up the river to Grafton (65km) and the tidal influence is noticeable upstream to Copmanhurst (106km) (ERM 1999).

Two small towns, Yamba and Iluka are situated on the southern and northern sides of the estuary respectively. Both towns are popular tourist destinations and visitor numbers fluctuate between seasons, but peak during the summer holidays. Both towns are experiencing high levels of urban growth.

The dominant feature of the lower estuary is Wooloweyah Lagoon, which has a surface area of approximately 22km². The lagoon is connected to the river by several tidal channels, including Oyster Channel, Romiaka Channel and Palmers Channel. The northern section of the lagoon is characterised by several mangrove islands, with expansive intertidal flats, whilst the southern lagoon is characterised by deeper water with fringing mangroves and swamp forest vegetation. The north side of the lower estuary is characterised by several small islands and includes the confluence of the Esk River and the north arm of the Clarence River.

The middle estuary is dominated by the Clarence Broadwater, which has a surface area of approximately 18km². The Broadwater has a wide connection to the Clarence River and is characterised by small areas of intertidal mudflats and expansive areas of open water. Extensive freshwater wetlands extend to the west of the Broadwater.

1.2.3 Contextual Information

Shorebirds

Shorebirds, or waders as they are also known, belong to the order Charadriiformes and include species that are colloquially known as plovers and sandpipers. Shorebirds are less conspicuous than other species of estuarine bird, such as pelicans, cormorants and egrets and are often overlooked by the casual observer. Thirty-one species of shorebird, 22 migrant and 9 resident, are frequently recorded in the Clarence Estuary (Table 1.1), whilst a further three species (sanderling, broad-billed sandpiper & pectoral sandpiper) are uncommon visitors.

Migratory shorebirds breed in the northern hemisphere during the austral winter and migrate to Australia for the spring/summer period. Several species that occur in the Clarence Estuary breed in the Arctic tundra in northern Siberia and Alaska. Resident shorebirds are those species that do not migrate outside of Australia, although some species, such as the black-winged stilt undertake regular movements between inland and coastal wetlands and others move along the coast outside of the breeding season.

Shorebirds have three critical habitat requirements, high tide roosts, feeding areas and nest sites. In estuarine environments habitat use by shorebirds is controlled by the tides. At high tides shorebirds congregate at sites called roosts, moving out to forage on intertidal mud and sandflats as the tide recedes. This pattern of behaviour is followed irrespective of whether it is day or night. Resident shorebirds also have the additional requirement of suitable nest sites that have minimal disturbance from humans and predators have land above spring high water and occur near preferred foraging habitat.

Roost sites vary in type and size, although they are typically above high water and are situated in open environments where birds have a clear line of site. The choice of foraging habitat is complex, although birds typically choose those sites where they can maximise their food intake.

Table 1.1: Species of shorebird commonly occurring in the Clarence Estuary. EPBC = Environment Protection & Biodiversity Conservation Act 1999; TSC = Threatened Species Conservation Act 1995.

Species Name	Common Name	Migratory (M) or Resident (R)	Status
<i>Gallinago hardwickii</i>	Latham's Snipe	M	EPBC
<i>Limosa limosa</i>	Black-tailed Godwit	M	EPBC, TSC
<i>Limosa lapponica</i>	Bar-tailed Godwit	M	EPBC
<i>Numenius phaeopus</i>	Whimbrel	M	EPBC
<i>Numenius madagascariensis</i>	Eastern Curlew	M	EPBC
<i>Tringa stagnatilis</i>	Marsh Sandpiper	M	EPBC
<i>Tringa nebularia</i>	Common Greenshank	M	EPBC
<i>Xenus cinereus</i>	Terek Sandpiper	M	EPBC
<i>Actitis hypoleucos</i>	Common Sandpiper	M	EPBC
<i>Heteroscelus brevipes</i>	Grey-tailed Tattler	M	EPBC
<i>Heteroscelus incanus</i>	Wandering Tattler	M	EPBC
<i>Arenaria interpres</i>	Ruddy Turnstone	M	EPBC
<i>Calidris tenuirostris</i>	Great Knot	M	EPBC, TSC
<i>Calidris canutus</i>	Red Knot	M	EPBC
<i>Calidris ruficollis</i>	Red-necked Stint	M	EPBC
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	M	EPBC
<i>Calidris ferruginea</i>	Curlew Sandpiper	M	EPBC
<i>Esacus neglectus</i>	Beach Stone-curlew	R	TSC
<i>Haematopus longirostris</i>	Pied Oystercatcher	R	TSC
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	R	TSC
<i>Mimantopus himantopus</i>	Black-winged Stilt	R	
<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet	R	
<i>Pluvialis fulva</i>	Pacific Golden Plover	M	EPBC
<i>Pluvialis squatarola</i>	Grey Plover	M	EPBC
<i>Charadrius ruficapillus</i>	Red-capped Plover	R	
<i>Charadrius bicinctus</i>	Double-banded Plover	M	
<i>Charadrius mongolus</i>	Lesser Sand Plover	M	EPBC, TSC
<i>Charadrius leschenaultii</i>	Greater Sand Plover	M	EPBC, TSC
<i>Elsayornis melanops</i>	Black-fronted Dotterel	R	
<i>Erythrogonys cinctus</i>	Red-kneed Dotterel	R	
<i>Vanellus miles</i>	Masked Lapwing	R	

Due to their demanding annual cycle it is essential that migratory shorebirds are able to roost and forage with minimal disturbance and that the open nature of roosts and the abundance of food items is maintained. Birds that are regularly disturbed whilst roosting or foraging will experience increased difficulty accumulating fat reserves that are required for moult and migration. Likewise a reduction in the availability of invertebrate prey will also affect the bird's migration capabilities.

Values of the Clarence Estuary

The Clarence Estuary and floodplain have important natural heritage values (Clancy 1992) and also provide an important source of income for the local economy, through the estuarine fishery and agriculture (Umwelt 2003). The natural heritage values of the estuary and the history of resource management have resulted in numerous management conflicts. Many of

these conflicts are not unique to the Clarence Estuary but due to the size of the estuary and floodplain occur on a large scale.

Healthy Rivers Commission (1999) and Umwelt (2002) provide a good overview and discussion of management issues pertaining to the Clarence estuary and floodplain. Some of these issues are of direct relevance to shorebirds and will be discussed in greater detail in this report.

The importance of the lower estuary for migratory and resident shorebirds has been recognised for some time (Martindale 1984). Initial assessments indicated that the estuary was of national importance for three species and international importance for one species of migratory shorebird (Watkins 1993). However, this finding is not supported by the latest analysis of shorebird populations in the East Asian/Australasian Flyway (D. Watkins pers comm.).

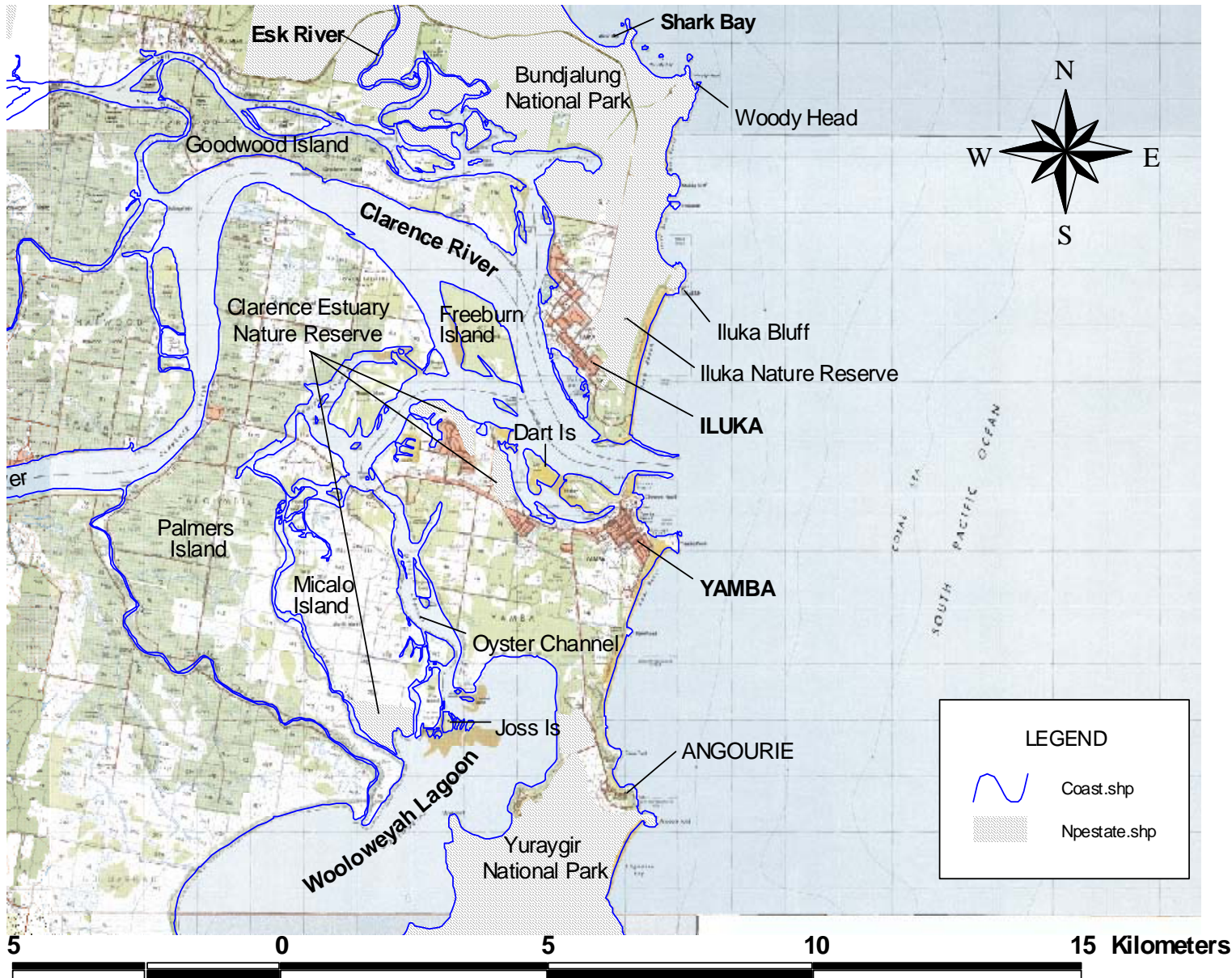


Figure 1.1a: Major features of the study area.

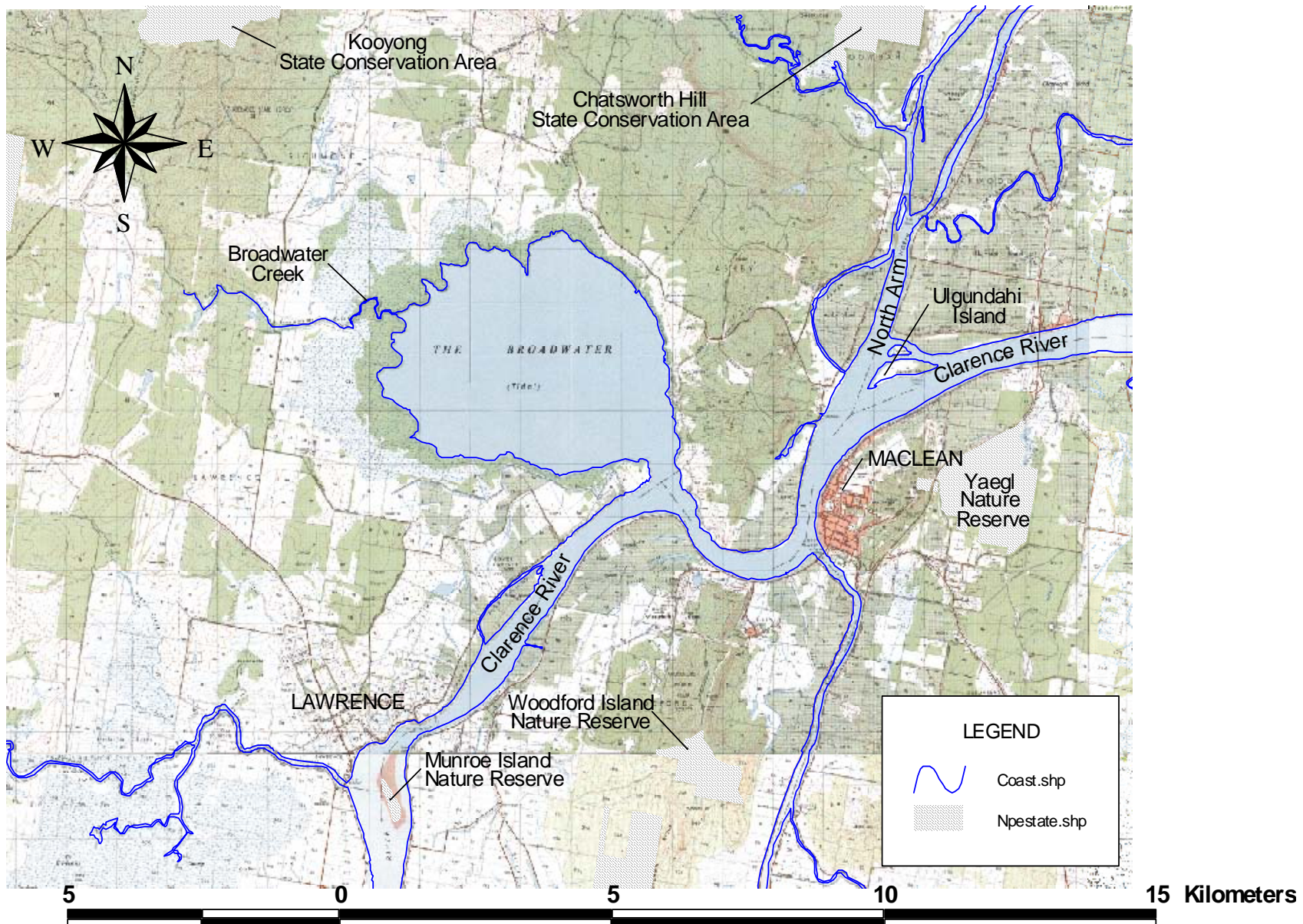


Figure 1.1b: Major features of the study area.

2. REVIEW OF PREVIOUS SURVEYS

2.1 METHODS

2.1.1 Data Collation

Data collation involved a review of background information on the Clarence Estuary to identify data sources pertaining to shorebirds and their habitats. Sandpiper Environmental had access to several survey reports and data at the commencement of this assessment. This information coupled with background knowledge on previous surveys formed the basis for further investigation. Sources of relevant information held by Sandpiper Environmental included: Martindale (1984), Smith (1991), Watkins (1993), Lawler (1994a), Rohweder (unpublished data) several summer and winter counts summarised in the *Stilt* (Journal of the Australasian Wader Studies Group - AWSG) and data from the Natural Resource Audit Council (NRAC) estuarine and coastal bird surveys. It was also understood that the AWSG had coordinated regular summer and winter surveys of the estuary since the early 1980's.

Additional information was gathered by contacting prominent local ornithologists and state and local ornithological groups. Specific information was sought from the NSW Wader Studies Group (NSW WSG), Clarence Valley Birdos (CVB), John Martindale (Department of Environment and Conservation, DEC) and Greg Clancy (GC). Digital or hardcopy data were obtained from the NSW WSG, CVB and GC.

2.1.2 Data Evaluation

There are no specific benchmarks upon which to evaluate the adequacy of shorebird surveys, although there are some obvious standards, such as the use of accepted procedures, standardised methods and comparability with the national count program (Weston *et al.* undated). There are various criteria that could be used to evaluate data sets. The criteria developed for this report considered the broad aim of the report, which was to identify threatening processes and provide recommendations to manage threats.

There are a number of fundamental components that should be adopted by all surveys to ensure that they provide useful information. Requirements that are fundamental to scientific research, such as replication and statistical analysis of data, were not considered relevant in this instance. Data sets were initially divided into high and low tide surveys and each data set was evaluated against a standard set of criteria. The criteria were aimed at assessing basic survey components such as spatial and temporal coverage and survey methods. The objectives of the evaluation were to assess the level of comparability between surveys, determine the adequacy of existing data for management and identify major gaps in knowledge. The criteria used in the evaluation included:

- Duration – The period over which surveys were undertaken.
- Frequency – The number of survey periods (individual surveys).
- Effort – The number of survey days/survey period.
- Methods – General indication of how data were collected.

- Personnel – Number of counters involved in the survey.
- Number of sites sampled – The number of sites listed in the data and sites within the area sampled. Sites within the area sampled were included to account for surveys that summarised data for several roosts into a single location and to account for the non-listing of sites where no birds were recorded.
- Coverage – General appraisal of the area surveyed.
- Data presentation – Notes on the manner in which data are presented. This information is important for assessing the utility of data in identifying important roost and feeding sites.

2.2 RESULTS

2.2.1 Shorebird Surveys in the Clarence Estuary

Ten primary data sources, encompassing 66 high tide surveys and 12 low tide surveys were identified (Table 2.1). These surveys cover the period 1984 to 2004. Additional incidental records at selected sites, prior to 1984, were identified, however these have not been included in this report (G. Clancy unpublished data). Holmes (1983, cited by Martindale 1984) represents possibly the earliest systematic survey of shorebirds in the estuary, however, that report was not accessible at the time of preparing this report. Martindale (1984) summarises the population estimates obtained by Holmes (1983). Morris (1983, cited in Martindale 1984) summarises population estimates from Holmes' 1983 survey and includes additional counts from an unidentified source. Collated data are presented in Tables 1A to 1W, Appendix 1.

Smith (1991), Watkins (1993) and Straw (undated) provide maximum counts of shorebirds in the Clarence estuary. The data included in these assessments is derived from one or more of the above sources and was not interrogated as part of this assessment.

Table 2.1: Sources of shorebird survey data for the Clarence Estuary. HT – high tide; LT – low tide; * surveys undertaken over several consecutive days; ** provides cumulative total only.

Primary Data Source	No. HT Surveys	No. LT Surveys
Martindale (1984)	1*	1*
Martindale (1985-87; unpublished data)	5	0
Clancy (1992)	5	0
Clancy (1983-2001; unpublished data)	26	0
NRAC (1994)	2	2
Rohweder (1995-96; unpublished data)	8	4
Clancy (2002)	1	0
Clarence Valley Birdo's (2003 – 2004)	2	0
Lawler (1994a)	1	1**
NSW WSG (1993 – 2000; unpublished data)	15	4
Total No. Surveys	66	12

2.2.2 Evaluation of shorebird data

There is a high degree of variability between shorebird surveys (Table 2.2). The main sources of variability include:

- The number of sites sampled i.e. coverage of the estuary.
- The methods used i.e. number of personnel, duration and frequency.
- The manner in which the data are presented.

No surveys have provided data for all of the identified roost sites (Table 2.3), although four of the 10 data sources (Martindale 1984, NRAC 1994, Clancy 2002, CVB 2003) have sampled almost all of the study area. All surveys have sampled some of the sites in the lower estuary. Roosts situated in the channel extending from Dart Island through Oyster Channel to the entrance of Wooloweyah Lagoon (Figure 2.1) have been most frequently surveyed (Table 2.4). Roosts on the north side of the Clarence River and along the coast have been sampled occasionally (Table 2.4).

Most surveys have been undertaken by one observer, although surveys encompassing the entire study area have generally included several survey teams. The exception being surveys by Martindale (1984) and Lawler (1994a), which were conducted by a single observer over two or more days. Surveys by the NSW WSG have generally been limited in extent to two sites on any one occasion, although the data includes sporadic sampling at six sites (Table 2.2).

Differences in survey effort and personnel have also influenced the methods used. Simultaneous estimation (i.e. all sites sampled within a small time frame) has been used on surveys with multiple teams, whilst Martindale and Lawler relied on Maximum Counts (i.e. maximum number of birds at a site over a survey period). Surveys by Clancy and Rohweder followed a systematic approach, which involved the sequential sampling of all sites between Dart Island and Wooloweyah Lagoon. The data provided by the NSW WSG consisted of opportunistic surveys at a small number of sites.

Most surveys have sampled birds during high tide only, although Martindale (1984), Lawler (1994), NRAC (1994) and Rohweder (unpublished data) include some systematic low tide surveys. NSW WSG data and Martindale (unpublished data) include low tide counts at selected sites only. NRAC (1994) is the only survey to sample the entire study area at low tide and Martindale (1984) sampled most of the lower estuary at low tide.

The manner in which data have been summarised varies between the data sources (Table 2.2). Martindale (1984 & unpublished data), Lawler (1994a), NRAC (1994), Rohweder (unpublished data), CVBs (2003 & 2004) and NSW WSG provide results for each of the sites sampled. In contrast, Clancy (unpublished data; 1992; 2002) has combined data for several sites into a single location. There is a lack of conformity between surveys and only a small number of surveys provide information on tide height and stage at the time of sampling.

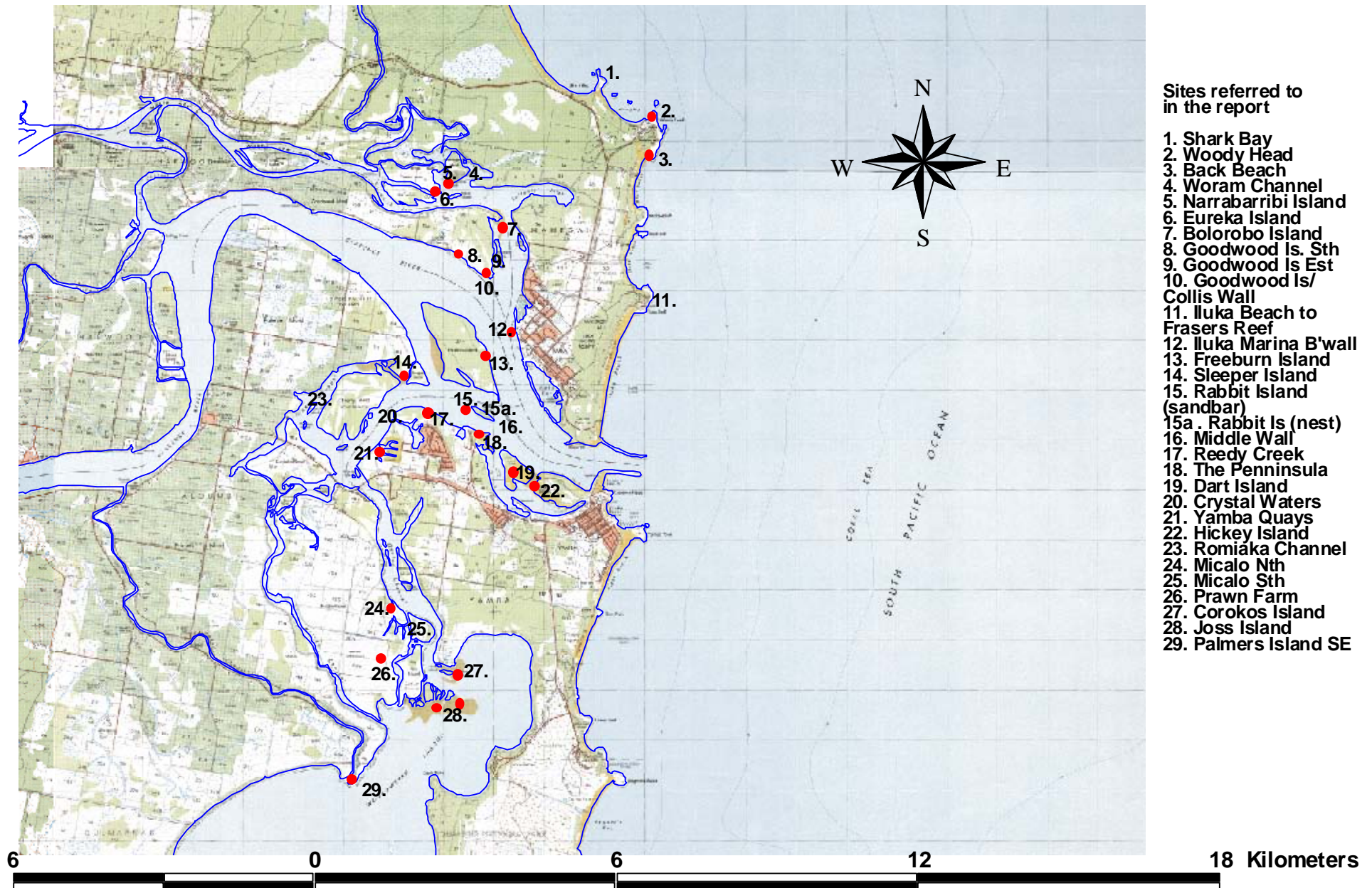


Figure 2.1a: Location of sites sampled during the high tide roost assessment (red dots) and sites referred to in the report

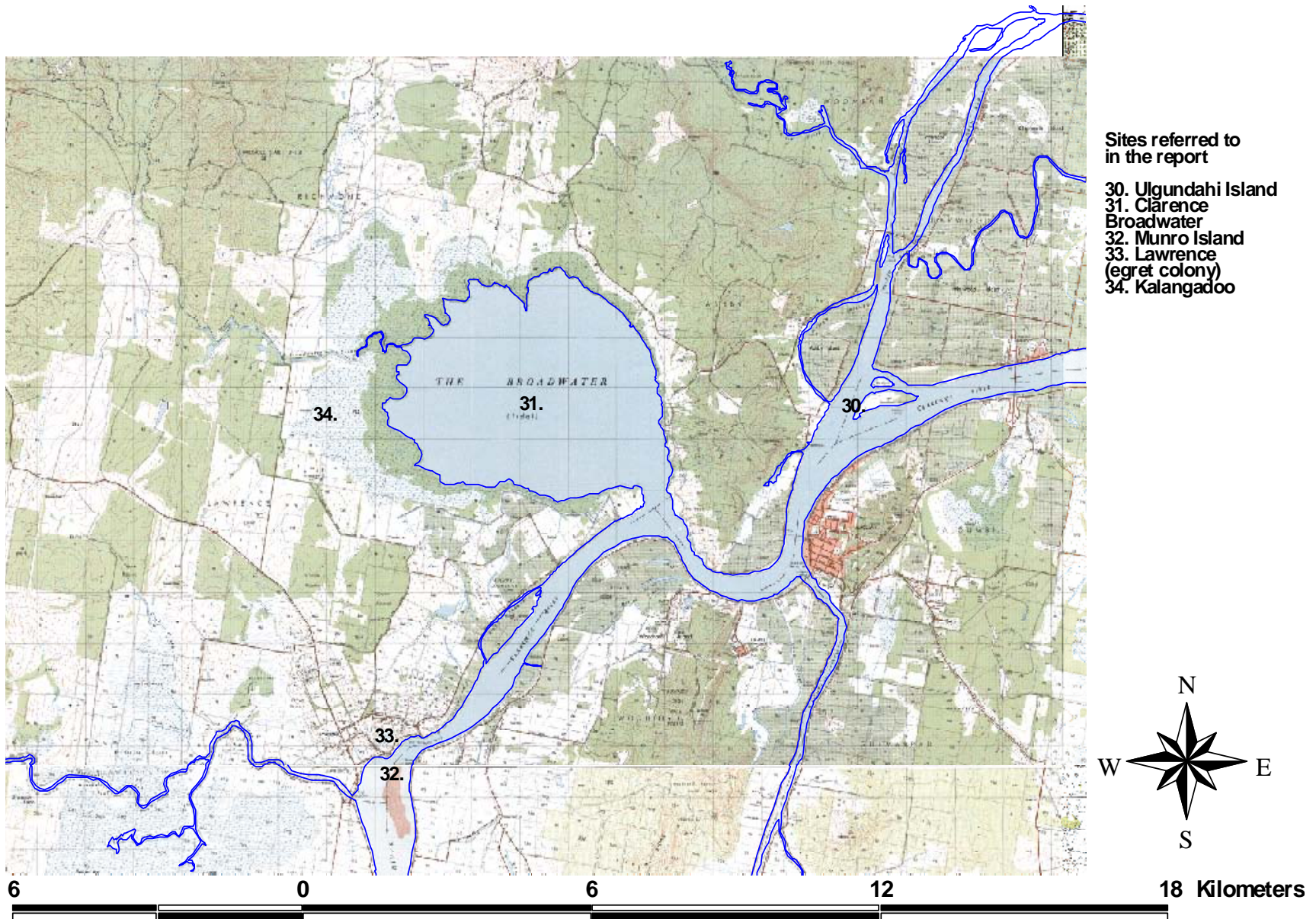


Figure2.1b: Location of sites sampled during the high tide roost assessment (red dots) and sites referred to in the report.

Table 2.2: Evaluation of 10 data sources. HT = high tide, LT = low tide.

Data Source	Duration	Frequency	Effort	Method	Personnel	No. Sites Sampled	Coverage	Data Presentation
Martindale (1984)	30/3 to 12/4/84	1 survey period	14 consecutive days	Maximum Counts: visited each site repeatedly. Followed birds from feeding areas to roosts	1 person	17 roosts 8 feeding areas	Surveyed entire estuary from air & most of lower estuary by boat.	Maximum counts for specific sites.
Martindale (1985-1987; unpublished data)	14/7/85 to 22/6/87	2 x summer; 3 x winter surveys	5 separate HT surveys	Counts at selected roost sites	1 person	5 roosts in total; 3 per survey.	Small number of roosts only	Not all surveys conducted at HW; combined data for nearby roosts.
Clancy (1983-2001; unpublished data)	12/2/83 to 25/6/01	11 x summer 12 x winter	23 separate HT surveys	6/2/88 to 25/6/01 – Systematic sampling from Dart Is to Joss Island. 12/2/83 – surveys at two sites/locations. 27/2/92 – survey at one location.	1 person, with assistants	Variable. Between 6/2/88 and 25/6/01 generally sampled 13 roosts, with occasional surveys at two other sites.	Variable - Part of lower estuary Dart Is to Joss Is, sometimes single site.	Grouped several known roosts into one location. Sampled three broad locations; Dart/Hickey, Rabbit Is, Wooloweyah Entrance
Clancy (1992)	28/6/91 to 27/2/92	5 survey periods	5 separate HT surveys	Variable – on some days sampled one site only, others sampled roosts between Dart Is and Joss Is.	1 person	Variable. Generally sampled 13 roosts	Variable - Part of lower estuary Dart Is to Joss Is, sometimes single site.	Grouped several known roosts into one location. Sampled three broad locations. Two surveys included one site only.
Lawler (1994a)	24-25/2/94	1 survey period	Surveys over 2 days	Unclear - probably maximum counts.	1 person	Sampled 17 roosts; 14% of intertidal area/10 sites at low tide.	Covered entire estuary but over a two day period.	Maximum number of individuals recorded at 17 roosts.
NRAC (1994)	19-20/10/94 & 24-25/11/94	2 survey periods	2 days/period. HT & LT surveys	Simultaneous estimation	3 boat & 2 land teams	Sampled most of estuary; 19 roosts and all feeding areas.	Entire estuary	Atlas of NSW Wildlife – no. individuals & species recorded at each site, difficult to distinguish between HT & LT surveys at some sites.
Rohweder (1995-1996; unpublished data)	25/10/95 to 2/03/96	7 survey periods	7 HT surveys & 4 LT surveys	Systematic sampling from Dart Is to Joss Is during HT and LT.	1 person	8 at HT; 4 at LT	Part of lower estuary Dart Is to Joss Is.	No. individuals of each species recorded at each site sampled.
Clancy (2002)	20/02/02	1 survey period	1 HT survey	Simultaneous estimation	10 teams of 2-4 people	11 locations (25 roosts); each location included several roosts	Covered entire estuary.	No. individuals of each species recorded at each location. Unable to distinguish between roosts.
Clarence Valley Birdo's (2003 & 2004)	14/2/03 & 23/02/04	2 survey periods	2 HT surveys	Simultaneous estimation	unknown	23 sites in 2003; 12 in 2004.	Entire estuary in 2003; Dart Is to Joss Is. in 2004.	No. individuals of each species recorded at each site sampled.
NSW Wader Studies Group.	15/11/93 to 27/11/01	18 survey periods	18 surveys	Sampling at single site.	unknown	6, but max of 2/survey period.	Roosts from Dart Is to Wooloweyah.	No. individuals of each species recorded at each site sampled.

Table 2.3: Summary of data sources and the roost sites sampled by each of the data sources. ? = unsure if site sampled, occ = site sampled occasionally, oyst chan = site included under heading of Oyster Channel.

Roost Name	NSW WSG	Martindale (1984)	Martindale (86-87)	Clancy (1992)	Clancy 88-01	Clancy (2002)	CVB (2003)	NRAC (1994)	Rohweder (unpubl.)	Lawler (1994a)
Woram Channel		x				x?		x		?
Narrabarribi Island		x				x?		x		x
Eureka Island								x		x
Bolorobo Island		x				x?		x		
Goodwood Island East		x						x		x
Goodwood Is/Collis Wall		x				x?		x		
Goodwood Island (sth)		x						x		
Iluka Marina B'Wall		x			x (occ)	x	x (Iluk area)	x		x
Freeburn Island	x	x?	x		x (occ)			x		x
Middle Wall					x		x	x		x
Hickey Island	x	x	x	x	x	x	x	x	x	x
Dart Island	x	x	x	x	x	x	x	x	x	x
The Peninsula	x				x		x	x	x	x
Rabbit Island (sandbar)	x			x	x		x	x	x	x
Rabbit island (nest)								x		
Reedy Creek		x	x		x	x	x	x	x	
Sleeper Is					x		x		x	
Crystal Waters		x			x	x			x	
Yamba Quays (+ rocks)					x?		x	x	x	
Romiaka Channel						x		x		x
Prawn Farm						x	x	x	x	
Micalo Is - nth drain		x	x		x	x	x	x	x	x
Micalo Is - sth drain								x		
Joss Island (east & South)	x	x	x	x	x	x	x	x	x	x
Corokos Island	x		x	x	x	x	x	x	x	x
Palmers Island SE		x				x	x	x		
Ulgundahi Is							x			
Clarence B'Water							x	x		
Munro Is		x				x	x			
Lawrence (egret colony)						x				
Kalangadoo						x	x			
Back Beach						x	x	x		
Woody Head						x	x	x		
Shark Bay		x				x		x		
Iluka Beach - Fraser's Reef						x	x	x		

Table 2.4: Summary of the number of times that 34 high tide roosts have been sampled. * Could include additional surveys.

Location In Estuary	Roost name	No. Surveys – high tide
North Side	Woram Channel	5
	Narrabarribi Island	5
	Eureka Island	3
	Bolorobo Island	4
	Goodwood Island East	4
	Goodwood Is/Collis Wall	4
	Goodwood Island (sth)	3
	Iluka Marina B'Wall	9
Main River Channel	Freeburn Island (3 sites)	11
	Middle Wall	24
South side	Hickey Island	53
	Dart Island	53
	The Peninsula (Shores Drive)	40
	Rabbit Island (sandbar)	30
	Reedy Creek	10
	Sleeper Is	32
	Crystal Waters	34
	Yamba Quays (+ rocks)	33
	Romiaka Channel	4
	Oyster Channel	Micalo Is - nth drain
Micalo Is - sth drain		2
Prawn Farm		8*
Wooloweyah Lagoon	Joss Island	43
	Corokos Island	43
	Palmers Island SE	5
Upper River/Broadwater	Ulgundahi Island	1
	Clarence B'Water	3
	Munro Island	3
Freshwater Wetlands	Lawrence (egret colony)	2
	Kalangadoo	2
Ocean Beach	Woody Head	4
	Shark Bay	4
	Iluka Beach - Frasers Reef	4
	Back Beach	4

2.3 DISCUSSION

2.3.1 Adequacy of Existing Data Sets for Management & Site Prioritisation

Roost Sites

The utility of the survey data varies depending on the purpose for which it is to be used. The data incorporates a wide variety of survey methods, varies in coverage and in the manner in which the data are presented. Variable coverage and the absence of site-specific records have direct implications for systematically assessing roost sites.

Only three of the 10 data sources (Martindale 1984, NRAC 1994, CVB 2003) cover a large part of the study area and include site-specific data, two essential components for a systematic assessment of sites. Data for broad locations that include several roost sites are of limited value for identifying important sites. The high degree of variability in the coverage of survey sites means that any site prioritisation would need to include a correction factor to compensate for uneven survey effort. Greater survey effort is also likely to result in additional records of threatened species. These records are more difficult to correct in a site prioritisation.

Despite the above limitations the data provide a reasonable indication of the population size of shorebirds in the Clarence Estuary and important shorebird roosting sites, two factors that are essential for management. Surveys by Greg Clancy between 1988 and 2001 are particularly valuable as they follow a systematic approach and have been undertaken at set intervals over a long period. Although these surveys have only sampled part of the estuary they include a number of important sites for shorebirds and probably reflect what is happening at other sites.

Foraging Sites

The utility of data on foraging habitat is also limited, with only five data sources including low tide surveys, and only two of these encompassing all, or most of the study area. The data available on foraging habitat is limited and at best provides a broad indication of important locations. Further surveys are required to provide definitive information on the location of important foraging habitat.

2.3.2 Data Gaps

A number of data gaps are evident from the review of survey data, including:

- The limited temporal coverage of surveys to document use of the estuary during northwards and southwards migration.
- A low number of high tide surveys that encompass the entire Clarence Estuary.
- A low number of low tide surveys that encompass the entire estuary.
- The management of data i.e. specific information for each site sampled.
- An absence of nocturnal surveys to identify night roost and feeding sites.
- Accessibility of information on methods and timing.
- Use of standard site names.

These knowledge gaps are not unique to the Clarence Estuary, however, they have specific implications for management. For example, an understanding of nocturnal roost sites is fundamental to ensure that shorebird habitat is adequately protected. Likewise, more frequent and comprehensive surveys that cover the entire study area and improved data management would have a substantial benefit for identifying management priorities.

3. SITE ASSESSMENT

3.1 BACKGROUND

The purpose of the site assessment was twofold, firstly, to provide a general description of roost sites and identify the major features of each site and secondly, to identify important roost and feeding sites. It was initially intended to undertake a habitat prioritisation to identify the most important roost and feeding sites. However, this has not been undertaken for the following reasons:

- Variable coverage between population surveys.
- A lack of specific information on when surveys were conducted in relation to high tide i.e. it seems that some surveys have been conducted prior to high tide.
- Variability in the manner in which survey data have been managed i.e. a number of surveys have combined data for several roosts into a single location.
- The variability noted in the use of sites between surveys and the extant quality of sites, which suggests that some sites may have never been high tide roosts.
- The large temporal variation and variation in methods between the comprehensive surveys undertaken in 1984, 1994 and 2003.
- The low number (3) of complete surveys that provide sufficient data for a site prioritisation.

To undertake a site prioritisation it is necessary to have a standardised data set that includes accepted procedures and adequate spatial and temporal coverage of the study area. Such a data set is not available for the Clarence Estuary. Only three of the 66 roost surveys, Martindale (1984), NRAC (1994) and CVB (2003) provide appropriate data for use in a roost prioritisation and even these surveys include some variability in the methods used. Draft criteria to undertake a roost prioritisation have been prepared for this project (Table 2a, Appendix 2). The criteria were not applied as part of this assessment however, they could be reviewed and applied as part of future surveys should the need arise.

To satisfy the objectives of this project a basic site prioritisation has been undertaken. The following chapter includes two components, a field-based assessment of roosts and an assessment of the importance of roost and foraging habitat.

3.2 METHODS

3.2.1 Site Identification

A list of roost sites was compiled from the review of previous surveys (refer to Section 2). This resulted in the identification of 35 roosts. The large number of potential roosts is attributed to variability in the timing of surveys in relation to high tide. One problem encountered when identifying roosts was variability in site names between surveys. Some of the surveys made no reference to tide height during the survey or timing of the survey in relation to high and low tide making it difficult to determine *a priori* which sites were roosts and which were staging areas. Despite the variability between surveys the high number of roost sites identified by

previous surveys could be indicative of disturbance levels, or variations in environmental conditions between surveys. Due to the large number of potential roost sites it was impossible to sample all sites in the time available, as a consequence the assessment was restricted to the lower estuary where most sites occur. The assessment also focussed on sampling roosts as opposed to feeding sites.

3.2.2 Site Characteristics

Each roost site was visited during neap high tides on 19 (1.39m) and 22 (1.47m) August 2004. A neap tide cycle was selected to ensure that all potential roost sites were assessed. Some neap tide roosts would have been inundated and difficult to sample if surveys were undertaken during spring tides only. During neap tides it was generally possible to see the extent of previous spring high tides by observing the wrack zone.

Thirteen variables were sampled in the field and a further four variables were sampled as part of a desktop assessment (Table 3.1). The assessment focussed on gathering baseline information on roost location, general features, potential threats and suitability for remediation works. The type of variables sampled and the manner in which these variables were sampled was based on the objectives of the assessment. All estimates of area were conducted on-site and where necessary, with reference to a 1: 25 000 topographic map. Personal experience surveying some of the subject sites during spring high tides was used to assist in determining the area of habitat available during spring high tides. It should be noted that the area of habitat exposed varies depending on tide height and the surface area estimates were based on average neap and spring high tides during winter, which tend to be lower than summer. Analysis of recent air photos would be required to accurately calculate the area of each site. Information on land tenure, zoning and proximity of one roost to another was obtained from 1: 25000 topographic maps and published reports (Umwelt 2002, 2003).

3.2.3 Identifying Important Roost and Feeding Grounds

To assist in the identification of important roost and foraging sites maximum spring/summer counts, species diversity, number of threatened species and number of migratory species were determined for 34 roosts and 13 foraging areas. Mean values (total/no. surveys) \pm standard deviation⁻¹ were calculated for each site. The premise of the assessment was that sites that regularly support large numbers of individuals and species are more important than sites that support fewer individuals and species. The limitations of this approach are recognised, however, given the high degree of variability within the survey data the application of a simplistic assessment process was essential. To ensure that the assessment was easy to interpret it was necessary to combine sites with similar names that occurred within close proximity. The data summarised in Appendix One were used in the analysis.

To satisfy the objectives of this assessment it was necessary to prioritise sites in order of importance to shorebirds. This prioritisation was problematic due to the small number of criteria included in the assessment and the variability in temporal and spatial coverage between surveys. Six criteria were used to provide a basic site prioritisation:

4. 0.5 points were awarded for every 100 individuals recorded at a site under the category of Maximum spring/summer count.

5. 1 point was awarded for every 100 individuals recorded at a site under the category of Mean No. birds.
6. 0.5 points were awarded for each species recorded at a site.
7. 1 point was awarded for each migratory species recorded at a site; and
8. 1 point was awarded for each threatened species recorded at a site.
9. 10 points provided if a site is used as a spring tide roost.

The high weighting of the ranking system towards sites available during spring high tides is in recognition of the critical importance of these sites for shorebirds. Scores for each criterion were added together and the cumulative total was used to assess the relative importance of each site. Sites with a cumulative score of 45 or higher were ranked as a high priority, sites scoring between 20 and 45 as a medium priority and sites that scored less than 19 were ranked as a low priority.

Table 3.1: Variables sampled at 25 high tide roosts situated within the lower Clarence River Estuary.

Attribute	Method
DESKTOP ASSESSMENT	
Land Tenure	Review of documents, including the Estuary Management Plan, NPWS GIS layer showing National Parks Estate, Maclean Local Environmental Plan (LEP)
Land Zoning	Maclean LEP
Crown land	Estuary Management Plan (Umwelt 2003).
Proximity of subject roost to other roosts	Recorded the number of known roost sites within a 1km radius of the subject roost.
FIELD ASSESSMENT	
Site Name	Name used in previous surveys, or a name that reflects the geographic location of the site.
AMG Reference	Determined using a GPS. Datum = AGD 66.
Roosting Habitat	Presence or absence of potential roosting habitat. Birds were present at most of the sites visited. At sites with no birds typical roost features such as bare sand/mud, saltmarsh, or open mangroves were considered to determine the suitability of habitat.
Roost Type	Determine if the roost is a spring tide, neap tide or staging roost.
Location Description	Broad description of the geographic location of the roost.
Roost Description	Further details on the characteristics of the roost.
Roost Origin	Natural or constructed
Connectivity	Determined the level of connectivity to the mainland or inhabited island: permanent connection; low tide connection; no connection.
Dominant Land Use	General assessment of what the site is used for. Some typical examples include: conservation, recreation, aquaculture, grazing, cropping, urban, commercial.
Landform	Choice of: sand island, sand spit, sand bar, mangrove fringe, mangroves, saltmarsh, rock wall/groin, rocky shore, rocks, wetland/other.
Area of habitat	Estimate of the area (m ²) of sand/mud, rock, saltmarsh, other vegt exposed at Spring High Water (SHW) and Neap High Water (NHW).
Substratum Type	Dominant substratum type. Choice of: sand, mud, muddy sand, sandy mud, rock, saltmarsh, vegetation other, ocean beach.
Potential protective measures	Identified options for site remediation or protection.
Evidence of Disturbance	Noted disturbance during the survey or obvious signs of disturbance.
Photographs	Photographed each site to assist with site description.
Roost Quality	Appraisal of the quality of the roost based on visibility, access to shoreline, proximity to disturbance, vegetation growth & use by birds. Subjective scale: good, moderate, poor.

3.3 RESULTS

3.3.1 Zoning and Conservation Status

Six of the subject sites occur within conservation reserves. Woody Head, Back Beach, Eureka Island and Narrabarribi Island are all situated within Bundjalung National Park, Reedy Creek saltmarsh is situated within the Clarence Estuary Nature Reserve and Munro Island is situated within Munro Island Nature Reserve (Table 2b, Appendix 2). The Prawn Farm is situated adjacent to the Clarence Estuary Nature Reserve (Figure 2.1). Both the Clarence Estuary Nature Reserve (NR) and Munro Island NR extend to mean low water, whilst Bundjalung National Park extends to mean high water. This means that at least some roosting habitat and all foraging habitat within Bundjalung National Park is situated outside of the conservation reserve.

Conservation reserves are zoned 8(a) {National Parks Zone} under the Maclean Local Environmental Plan (LEP) 2001, although it should be noted that the LEP shows a thin strip of 7(c) {Environmental Protection (Coastal Foreshore) Zone} land along the coast, which includes part of the roost sites at Back Beach and Woody Head. Aquatic habitat around Narrabarribi and Eureka Islands and in Woram Channel is also zoned 8(a) despite the fact that it is not formally part of Bundjalung NP. Six sites are zoned as 7(a) {Environmental Protection (Ecological Significance) Zone}. Seven sites have a combination of 7(a) and 1(w) {Rural (Waterway) Zone}, with 7(a) extending to the SHW mark and 1(w) encompassing intertidal and other aquatic habitat. The Iluka Marina Breakwall is zoned 1(w) only. Goodwood/Collis is zoned 1(w) and 1(b) {Rural (General Rural Land) Zone}. Micalo North and Prawn Farms are zoned 1(b) and Yamba Quays is zoned for residential purposes.

The Clarence Broadwater is zoned 1(w) with surrounding land, which includes Kalangadoo zoned as 7(a). Ulgundahi Island is zoned as 1(a)/1(w). Crown Land outside of conservation reserves includes Bolorobo, Dart, Hickey, Rabbit, Thorny and Joss Islands.

3.3.2 Refining Roost Sites

A total of 25 roost sites were sampled, including all of the known major sites in the lower estuary (Figure 2.1). No sites were sampled in Shallow (Romiaka) Channel or upstream of Freeburn Island and only one site was sampled on Freeburn Island. Lawler (1994a) identified one additional site on the southern side of Freeburn Island, however an inspection of the southern and western edges of Freeburn Island did not detect any potential roost sites. The term 'Esk Mouth' referred to by some observers was considered to include sites near the Esk River mouth as opposed to the confluence of the Esk River and North Arm of the Clarence River.

No definitive evidence of roosting habitat was recorded at three of the survey sites, Eureka Island, Narrabarribi Island and Woram Channel (Table 2b, Appendix 2). Martindale (1984) and Lawler (1994a) identified these sites and it is unclear if habitat at the sites has changed since the aforementioned surveys, or if the sites were initially sampled at mid tide or on a very low neap high tide. Shorebirds may roost in mangroves along Woram Channel. No roosting habitat was recorded on Bolorobo Island, although a small sand spit was recorded on the northern end of the mangrove island to the north of Bolorobo Island.

3.3.3 Site Characteristics

The dominant land use was recreation/conservation (11 sites), followed by grazing (6 sites). Areas used for both conservation and recreation included Woody Head and Back Beach, which are situated within Bundjalung NP. Conservation was identified as the dominant land use at five sites. Aquaculture and urban development were the dominant land uses at Prawn Farm and Yamba Quays respectively (Table 2c, Appendix 2).

Fifteen sites were identified as spring tide roosts, although it is expected that some of these would be inundated on the highest tides (Table 2c, Appendix 2). Four roosts have been constructed (for purposes other than roosting), 11 have a permanent connection with the mainland or an inhabited island, nine have no connection to the mainland or an inhabited island and three are connected to the mainland or an inhabited island at low tide only.

The dominant landform was sand (or mud) bar/spit (11 sites) followed by saltmarsh (6 sites). Two sites had a rocky substrate, one ocean beach and one a mangrove fringe. The estimated extent of roosting habitat during spring tides varied substantially, ranging from nil at three sites to 1ha at Palmers Island (Table 2b, Appendix 2). The dominant substratum type was sand or muddy sand (12 sites), followed by saltmarsh (six sites).

Evidence of erosion was recorded at four sites, all of which consisted of saltmarsh vegetation. Mangroves were recorded at 13 sites, with mangrove seedlings present at 12 sites. The area covered by mangroves ranged from approximately 150m² to 650m². Mangroves were considered likely to affect the long-term quality of roosting habitat at 11 sites (Table 2c, Appendix 2).

3.3.4 Important Roost and Feeding Sites

Roosts

Comparison of maximum spring/summer counts, average spring/summer counts, species diversity and occurrence of threatened species between 34 sites/locations has provided a broad indication of the relative importance of known roost sites (Table 3.2). Dart and Hickey Islands were combined as most counts have combined data for these sites. Dart/Hickey Island, Joss Island (& Wooloweyah Entrance) and Prawn Farm were ranked as high priority high tide roosts. These sites regularly support large numbers of birds, including several threatened and migratory species and are available during spring high tides. Goodwood south, Iluka Marina Breakwall, the Peninsula, Freeburn Island, Rabbit Island Sandbar, Yamba Quays, Micalo Is nth, Micalo Is sth, Clarence Broadwater and Shark Bay to Iluka Bluff were ranked as medium priority sites (Table 3.2).

High standard deviations were recorded for several sites indicating that use of these sites is variable. The high variability in roost use is likely to be due to differences in site availability between spring and neap tides, although it could also be due to disturbance which forces birds to move between sites.

Foraging areas

Thirteen foraging areas were included in the analysis. Foraging areas represent groups of intertidal sand and mudflats that occur in close proximity to each other. These groupings represent mudflat complexes, which are likely to be used for varying periods throughout low tide. The low tide data has similar problems to the high tide data, with different names and groupings of sites used by different observers. This variability has been reduced where possible, although the resulting assessment is considered indicative only.

Intertidal flats at the northern end of Wooloweyah Lagoon (i.e. around Joss and Corokos Islands) are of particular importance to shorebirds, with an average of 731 individuals recorded at this location over nine surveys. A total of 25 species, including six threatened and twenty migratory species have also been recorded at Wooloweyah Entrance. 'Wooloweyah Entrance' was the only foraging area to receive a high priority ranking. North Arm to Saltwater inlet), Freeburn Island, Dart/Hickey, Rabbit Island to Crystal Waters, Thorny Island to Oyster Channel Bridge and Oyster Channel were ranked as medium priority foraging areas. Average counts at all these locations exceeded 100 birds, with all locations used by nine or more species, including three or more threatened species (Table 3.3). Despite its medium priority ranking the importance of Freeburn Island as a foraging area is unclear. It is possible that the maximum count of 432 individuals included surrounding intertidal habitat. Prawn Farm Lagoon and Palmers Island SE have been ranked as low priority sites, although both supported large numbers of birds on the one occasion they have been sampled.

3.4 DISCUSSION

The assessment of roosts provides baseline information on the major features of several sites where shorebirds have been recorded roosting between 1984 and 2004. The absence of potential roosting habitat at some of the sites sampled suggests that habitat at these sites has either changed since the surveys were conducted, or the sites were sampled prior to high tide. Both explanations are feasible and it is impossible to provide more definitive information based on the available data.

3.4.1 Zoning and Tenure

Protection of roosting habitat varies between sites and only one site, Reedy Creek, has an appropriate level of protection. This site is situated entirely within the Clarence Estuary Nature Reserve. At a glance many of the sites appear to be appropriately zoned, with several areas zoned 7(a), however, in many instances zoning extends to high water only, with intertidal habitat below high water zoned as 1(w). This means that at certain tides birds roost in the 1(w) zone and always forage in that zone. The objectives of the 1(w) zone include: clause 2(a) to enable the development of land within this zone for recreational and commercial fishing purposes on sound ecological principles; 2(d) to enable the recreational use of the Clarence River and its tributaries within this zone; 2(e) to protect the ecological and aesthetic values of waterways within this zone.

The 1(w) zone has a strong emphasis on maintaining recreational uses and protecting fish habitat. The objectives of the 1(w) zone are to some extent contradictory, particularly when recreational activities, including fishing, pose a risk of detrimental impact on birds (McPhee *et al.* 2002). Despite the limitations of the 1(w) zone it is pertinent to note that recreation is not prohibited in either the 7(a) or 8(a) zones and sites such as Back Beach and Woody Head experience high levels of recreational activity.

Table 3.2: Summary of general information on the use of 34 sites/locations in the Clarence River Estuary by shorebirds. Spr = spring; sum = summer; Sp = species; thr = threatened; mig = migratory; sd = standard deviation⁻¹; n = number of samples; Cum. = cumulative; High = 45 or greater; Medium = 20 to 44; Low = 1 to 19.

Sites	Priority Ranking	Maximum Count – spr/sum	Mean No. Spr/Sum	Tot. Sp.	No. Thr. Sp.	No. Mig Sp.	Cum. Score	Neap or spring
Eureka Island	Low	115 (11/94)	63 (sd 73.5, n 2)	5	1	5	9.5	Neap
Narrabarribi Island	Low	93 (3/84)	65 (sd 40.8, n 4)	11	2	10	17.5	Neap
Woram Channel	Low	24(3/84)	24 (N/A, n 1)	3	0	3	14.5	Spring
Bolorobo Island	Low	50 (3/84)	41 (sd 12, n 2)	6	1	6	10	Neap
Goodwood East	Low	3 (2/92)	2 (sd 1.41, n 2)	3	0	3	4.5	Neap
Goodwood/Collis	Low	12 (3/84)	12 (N/A, n 1)	3	1	3	5.5	Neap
Goodwood South	Medium	128 (10/94)	49 (sd 68.2, n 3)	7	1	7	22.5	Spring
Iluka Breakwater	Medium	127(2/02)	42 (sd 45.12, n 7)	10	2	7	25	Spring
Dart/Hickey	High	1050 (1/87)	347 (sd 248.3, n 32)	27	9	19	64.5	Spring
The Peninsula	Medium	247 (3/96)	52 (sd 62.1, n 19)	13	4	9	32.5	Spring
Penn to Ariel Island	N/A	713 (2/93)	235 (sd 245.4, n 8)	19	6	13	47.5	N/A
Middle Wall	Low	3 (2/92)	2 (sd 1.41, n 2)	2	1	1	13	Spring
Freeburn Island	Medium	215(3/84)	109 (sd 113.4, n 4)	16	4	12	27	Neap
Reedy Creek	Low	114 (11/95)	75 (sd 37.1, n 3)	3	0	3	15.5	Spring
Rabbit Island - sandbar	Medium	367 (12/91)	110 (sd 173.4, n 4)	11	5	8	22.5	Neap
Sleeper Island	Low	46 (2/04)	33 (sd 19.1, n 3)	6	0	5	8	Neap
Crystal Waters	Low	194 (2/84)	75 (sd 102.6, n 3)	10	2	9	17	Neap
Yamba Quays/Thorny Is	Medium	301(11/95)	127 (sd 91.7, n 10)	14	3	8	32	Spring
Romiaka Ch/Is	Low	94 (2/02)	75 (sd 19.6, n 3)	9	0	7	11.5	Neap
Oyster Channel	Low	143 (3/96)	54 (sd 56.9, n 6)	8	1	6	12	Neap
Micalo Is Nth	Medium	82 (10/94)	32 (sd 27.1, n 8)	13	1	9	26.5	Spring
Micalo Is sth	Medium	309 (11/94)	170 (sd 196.6, n 2)	11	1	7	27.5	Spring
Corokos Island	Low	38 (2/92)	16 (sd 15.6, n 4)	5	2	4	8.5	Neap
Joss Island	High	1284 (11/94)	662 (sd 409, n 13)	22	6	18	63	Spring
Wooloweyah Entrance	N/A	1460 (2/97)	636 (sd 449.6, n 11)	30	6	22	73	N/A
Palmers Is SE	Low	118 (2/03)	53 (sd 58.4, n 3)	5	1	3	17.5	Spring
Prawn Farm	High	1277(10/94)	857 (sd 312.9, n 3)	13	0	9	46.5	Spring
Ulugundahi Island	Low	12 (2/03)	12 (N/A, n 1)	2	0	1	2	Neap
Lawrence Island	Low	52 (3/84)	38 (sd 19.1, n 2)	7	1	3	7.5	N/A
Munro Island to Maclean	Low	20 (2/02)	11 (sd 12.7, n 2)	4	1	1	4	Neap
Clarence Broadwater	Medium	605 (11/94)	605 (N/A, n 1)	8	0	6	32	Neap
Kalangadoo	Low	89 (2/02)	89 (N/A, n 1)	2	0	0	1	N/A
Iluka Beach	Low	29 (2/02)	24 (sd 7, n 2)	6	2	4	19	Spring
Shark Bay to Iluka Bluff	Medium	115 (3/84&2/03)	92 (sd 39.2, n 3)	12	4	7	28	Spring

Table 3.3: Summary of general information on the use of 13 foraging areas in the Clarence River Estuary by shorebirds. Abbreviations are the same as those used in Table 3.2.

Site	Priority Ranking	Maximum Count (date)	Mean No.	Total Species	No. Thr. Sp.	No. Mig. Sp.	Cum. Score
Esk Mouth	Low	121(10/94)	76 (sd 54.1, n 3)	12	1	10	18
Nth Arm – Saltwater Inlet	Medium	279 (3/84)	122 (135.7, n 3)	11	3	10	21.5
Freeburn Island	Medium	432 (1/87)	180 (169.2, n 4)	16	4	12	29
Dart/Hickey	Medium	187 (4/95)	136 (sd 37, n 8)	18	6	14	31
Rabbit Island – Crystal Waters	Medium	183 (10/95)	105 (sd 58.1, n 6)	15	5	11	25.5
Thorny Island - Oyster Ch Bridge	Medium	191 (11/95 & 10/95)	156 (30.3, n 6)	12	3	9	20
Romiaka Ch	Low	75(10/94)	56 (sd 26, n 2)	9	0	7	11.5
Oyster Channel	Low	490 (11/94)	281 (134.7, n 6)	16	3	12	29
Wooloweyah Entrance	High	1668 (1/87)	731 (sd 560, n 9)	25	6	20	61.5
Yards Flat	Low	67 (11/94)	67 (N/A, n 1)	8	1	7	12
Prawn Farm Lagoon	Low	398 (11/95)	398 (N/A, n 1)	5	0	3	11.5
Palmers Is SE	Low	231 (11/94)	231 (N/A, n 1)	11	0	8	17.5
Munro Island	Low	52 (3/84)	52 (N/A, n 1)	3	1	2	4.5

If zoning is to provide appropriate recognition of high conservation value land (and protection of shorebird habitat) then stricter controls may be required on those activities that are known to affect shorebirds. Despite some limitations the 7(a) and 8(a) zones provide recognition of important habitats and a mechanism to control activities occurring within these habitats.

To improve protection of shorebird habitat and recognise the conservation value of such habitat the intertidal areas on Dart Island, Joss Island, Rabbit Island, and within Oyster Channel should be zoned 7(a) or included in an appropriate conservation reserve. Likewise, 7(a) is a more appropriate zoning for Micalo Island north, which is currently zoned 1(b). The 1(b) zone has a primary aim of reserving rural land and encouraging use of this land for agriculture.

3.4.2 Important Roost and Feeding Sites

As is the case with any habitat/site prioritisation there is a risk that the identification of 'important' sites detracts from other areas that are either unknown or play a vital role in the daily, lunar and annual cycle of shorebirds. To satisfy their non-breeding requirements shorebirds need a matrix of roost and foraging habitats that are available during different tides, weather conditions and times of the day. The maintenance of a matrix of habitats is even more critical in areas, such as the Clarence Estuary that experience high levels of human activity. The roost and feeding ground assessment identifies priority areas for management and protection, however these areas should not become the focus of attention to the detriment of other sites.

It is essential to note that the assessment is based on data gathered during the day only and therefore is indicative of important daytime sites. Shorebirds are known to utilise different roost and feeding areas between day and night (McNeil *et al.* 1992; Rohweder 2001; Rohweder & Baverstock 1996). Nocturnal roost and feeding ground surveys are required to

definitively assess the importance of all sites and ensure that management actions target the most important sites (Rohweder 2000).

Roosts

The roost assessment reinforced the general consensus among local ornithologists that Dart Island, Joss Island and Prawn Farm are critically important diurnal roost sites for shorebirds in the Clarence Estuary. Further surveys may show that the Broadwater and associated freshwater wetlands are more important than current data suggests. Detailed surveys of the Clarence Broadwater are limited and further systematic sampling is required to fully determine the importance of this site.

The importance of Joss and Dart Islands and Prawn Farm as shorebird roosts is well accepted. Both Martindale (1984) and Clancy (1992) highlighted the importance of Joss and Dart Islands and recommended that these areas be protected. These sites often support the majority of the estuaries migratory shorebird population (Appendix 1) and are supported by a network of smaller sites that provide specific habitat for selected species, supplementary habitat during high spring tides and alternative sites during days of high recreational activity, or poor weather. Important secondary sites include The Peninsula, Yamba Quays, Micalo Island Nth and Goodwood Island sth. Despite its ranking as a medium priority site, the importance of Freeburn Island requires further investigation. Sites such as Sleeper Island, Rabbit Island and Crystal Waters are used primarily during either low spring tides or neap tides.

There are several roosts in the North Arm, the most prominent being Goodwood Island south, Narrabarribi Island, Iluka Breakwall and Eureka Island. The available data suggests that none of these sites are used by large numbers of shorebirds, however, they provide an essential function for birds that use the North Arm. Goodwood Island sth is particularly important as it provides an extensive area of habitat that is available during spring high tides. Roosts in the North Arm have not been intensively surveyed and further work is required to determine the actual importance of these sites. Habitat between Shark Bay and Iluka Bluff was ranked as a medium priority. This ranking recognises the importance of parts of the area as a spring tide for sand plovers.

The identification of important roost sites has ignored three important issues, nocturnal habitat use, nesting sites and roost function (i.e. spring, neap or staging). At present there are no data on nocturnal roosts in the Clarence Estuary and such information is considered an urgent priority. Management decisions based on diurnal information alone may not target the most important sites and unidentified nocturnal roosts could remain unprotected. No specific information was gathered on nest sites during this assessment, although, it is understood that pied oystercatchers and beach stone-curlews have nested on Dart and Rabbit Islands, with pied oystercatchers also nesting on Hickey Island.

Foraging areas

Comparison of foraging areas has once again emphasised the importance of intertidal mudflats at the northern end of Wooloweyah Lagoon (i.e. around Joss & Corokos Islands) to shorebirds, a conclusion that is supported by previous surveys (Martindale 1984; Clancy

1992). Martindale (1984) also identified intertidal habitat around Narrabarribi Island as being important. The expansive intertidal habitat at the northern end of the lagoon (Joss & Corokos Islands), in Oyster Channel, at Prawn Farm lagoon and near the end of Palmers Island provide a critical matrix of intertidal habitat that is used by a large number of individuals and species. Sandy habitat between the Oyster Channel bridge and Dart Island are also of high importance. Birds roosting on Dart Island tend to follow the receding tide stopping to forage at sites between Rabbit Island and Wooloweyah Entrance as the tide ebbs (pers obs). This pattern of behaviour makes it essential to consider the manner in which birds use a site not just the number of birds at a site at low tide.

At present there is no baseline information on the size of mudflats or their benthic invertebrate community. Although a number of variables may influence a birds choice of foraging habitat (Lawler 1996), the density and availability of preferred prey is of high importance (Evans & Dugan 1984, Piersma *et al.* 1993; Kalejta & Hockey 1994). Data on species diversity and abundance of invertebrates can provide an insight into habitat changes and impacts on shorebirds. This information is essential given the documented concerns regarding commercial activities in Wooloweyah Lagoon (Umwelt 2002; 2003) and the recognition that intertidal mudflats in the lagoon are of high importance to shorebirds.

4. THREAT ANALYSIS AND PRIORITISATION

4.1 METHODS

4.1.1 Identification of Threats

Numerous factors are known to threaten shorebirds and their habitat (Lane 1990; Lawler 1996; Melville 2001, Priest *et al.* 2002; Saintilan 2003), however, there is no published information on specific threatening processes in northern NSW estuaries. The absence of published information was overcome by using general knowledge of threats and applying a broad approach to threat identification. Five threat categories were identified:

- Habitat loss – removal of habitat through reclamation and severe erosion. The removal of habitat reduces the number of high-tide roosts, which can affect energy expenditure during spring tides or periods of high recreational activity.
- Habitat modification – changes in the characteristics of habitat that reduce its utility for shorebirds. Vegetation growth on roosts is a good example of habitat modification. Shorebirds require open habitats with a clear line of site, generally over water.
- Habitat disturbance – activities that result in disturbance to roosting and foraging shorebirds. Disturbance at high tide increases energy expenditure and affects the ability of birds to build fat reserves to satisfy their annual cycle i.e. moult, migration, breeding. Disturbance at low tide reduces food intake, which also affects the ability of birds to fulfil their annual cycle.
- Habitat pollution – accumulation of pollutants in body fat that reduces life span and potentially reproductive ability and the abundance of prey.
- Mortality – Death of individuals through hunting by humans for food, recreation or site protection.

The above threat types are broad and encompass a large number of specific threatening processes. For example, habitat disturbance incorporates a large number of human activities that can affect shorebirds. Examples include, walking, dog exercise, boating (power, sail, jet boats), bait collection, fishing, off-road vehicles, jogging and picnicking (Buick & Paton 1989; McPhee *et al.* 2002; Priest *et al.* 2002).

Using the broad threat categories identified above a list of **potential** threatening factors specific to the Clarence Estuary was derived. Sources of information included published papers, unpublished reports on the Clarence Estuary, personal knowledge, experience observing shorebirds in the Clarence Estuary and other estuaries in northern NSW, general observations during the roost assessment and information provided by Lawler (1994b; 1996).

A total of 36 potential threats were identified. Some of the threats relate to more than one threat category, however they have been included in the threat category to which they are most closely related (Table 4.1). In respect of habitat disturbance two facets of threat have been considered, sources of disturbance (i.e. location of infrastructure) and types of disturbance (i.e. activities that may affect shorebirds). For example, boat ramps, boat hire facilities and camping and caravan parks do not disturb shorebirds, however, these facilities

represent a source of disturbance that may affect shorebirds and their habitat. It is not unreasonable to assume that the more disturbance sources you have in an area the greater the level of disturbance. Although the construction of infrastructure may have previously affected shorebird habitat the consideration of this affect is beyond the scope of this assessment.

Climate Change and associated sea-level rise is considered as a potentially significant threat to shorebird habitat, however, due to a high degree of uncertainty regarding the influence of sea-level rise on the Clarence Estuary it has not been included in the site specific threat assessment. The implications of climate change for shorebirds in the Clarence Estuary is considered further in the discussion.

The occurrence and proximity of each potential threat to a site was determined from field observations, discussions with state government agencies (Department of Primary Industries, NSW Waterways, DEC), local recreation clubs (Big River Sailing Club & Clarence River Fishing Clubs Association), Clarence River Professional Fishermans Association, Clarence Valley Council, Clarence River County Council, information held by the Clarence Valley Tourist Information Centre, 1: 25 000 topographic maps and personal observation (Table 4.1).

Pursuant to these discussions six potential threats, dredging, ecotourism, aircraft, weeds, point source discharges and shooting were removed from the list. These potential threats were removed due to a lack of specific information on their distribution within the study area. Although it is acknowledged that some of these factors could have a substantial negative impact on shorebirds. Based on the information collated from the above sources a threat matrix was developed that compared threats at each site. The threat assessment is specific to roosting habitat, although it is also relevant to foraging habitat in the vicinity of each of the identified roosts.

The assessment of mangrove encroachment considered only those mangroves that were growing in potential roosting habitat. For example, some sites had fringing mangroves but no evidence of mangrove seedlings growing within the site.

Each threat was given a score of 1, 5 or 10 depending on its proximity to a site. A score of 10 was given to threats that occur on-site, 5 for threats within 100m of a site and 1 for threats within 1km of a site. A score of 20 was given to sites approved for development. Such a high score was deemed necessary to reflect the strong likelihood that the site would be removed once the development proceeds. Threat scores were then added together to give a combined threat score. Sites were ranked from highest to lowest based on the total threat score. The higher the score the greater level of threat experienced. A general indication of which threats are most prevalent was obtained by adding threats across sites to obtain a total threat score.

Table 4.1: Potential threats and the manner in which the level of threat was assessed.

Threat Category	Specific Threats	Methods of Assessing Level of Threat	
Habitat loss	Erosion	Presence/absence of erosion & the extent: severe >75%; moderate 25-75%; minor <25%)	
	Areas being developed or identified for development – foreshore or adjacent	Identified areas from direct observation and discussions with Clarence Valley Council.	
Habitat Modification	Aquaculture	Direct Observation & 1: 25 000 topographic maps.	
	Mangrove encroachment	Assessed in the field: present or absent on roost/feeding; If absent estimate (with reference to a 1: 25000 topographic map) distance to the nearest stand of mangroves; Estimate of the area (m ²) covered by mangroves; Height or height range (m) of mangroves; Record the species of mangrove. Estimate % cover of mangroves <1m tall. Estimate total area (m ²) covered by mangroves <1m tall. Assess if mangroves will affect roost quality.	
	Artificial lighting	Direct observation and inferred from proximity of site to urban areas.	
	Altered drainage/Drains	Direct observation of drains & 1: 25 000 topographic map; Discussions with Clarence Valley County Council.	
	Shoreline stabilisation	Direct observation of shoreline stabilisation works, which include concrete and rock revetments.	
	Training Wall/Groin	Direct observation and review of topographic maps.	
Habitat Disturbance - Activities	Canal Estate	Direct observation and review of topographic maps.	
	4WD vehicles	Direct observation & Clarence Valley Council	
	Walking/jogging area	Personal observation	
	Commercial fishing site	Discussions with NSW Department of Primary Industries, CRPFA.	
	Recreational fishing site	Direct observation & discussions with Clarence River Fishing Clubs Association.	
	Bait collecting site	Direct observation & discussions with Clarence River Fishing Clubs Association.	
	Formal picnic site	Direct observation and review of topographic maps.	
	Informal picnic site	Direct observation.	
	Dog Exercise Area (formal & informal)	Discussions with Clarence Valley Council and direct observation.	
	Swimming site	Direct observation	
	Sailing boat route	Discussions with local sailing clubs to identify main sailing routes.	
	Jetski/waterski/Kite surf area	Discussions with NSW Waterways Authority.	
	Main boating channel	Discussions with NSW Waterways Authority.	
	Proposed urban expansion	Discussions with Clarence Valley Council planning staff.	
	Sources	Formal boat ramp	Direct observation and review of topographic maps.
		Informal boat ramp	Direct observation.
		Boat hire	Direct observation, tourist pamphlets, yellow pages.
Camp/caravan Park		Direct observation, tourist pamphlets, yellow pages, 1: 25 000 topographic map	
Tourist facility (hotel/motel/restaurant)		Direct Observation	
Marina		Direct observation and review of topographic maps.	
Major road		Direct Observation, topographic maps	
Developed areas (urban) foreshore		Direct observation	
Pollution		High Risk ASS	Maps contained in the EMP
	Sugar Cane	1: 25 000 Topographic maps, Umwelt (2002)	
Mortality	Introduced pests	NSW Department of Environment & Conservation	

4.2 RESULTS

4.2.1 Threat Analysis

Potential threats were assessed for 32 sites (Table 4.2, Table 3a, Appendix 3). Hickey Island and Yamba Quays received the highest threat ranking, followed by The Peninsula, Prawn Farm Goodwood/Collis, Micalo North and Dart Island. All of these sites scored above 70 and are considered to experience a very high level of threat. High levels of threat (scores between

55 and 69) were recorded at Iluka Breakwall, Freeburn Island, Sleeper Island, Crystal Waters and Prawn Farm. Moderate levels of threat (scores between 35 and 54) were recorded at Goodwood east, Goodwood south, Rabbit Island (sandbar) Reedy Creek, Palmers Island, Shark Bay and Woody Head. Low levels of threat (scores below 35) were recorded at Bolorobo Island, Rabbit Island (nest), Romiaka Channel, Middle wall, Corokos Island, Joss Island, Ulgundahi Island, Clarence Broadwater, Munro Island, Kalangadoo and Back Beach.

Potential disturbance was the main threatening factor at Dart Island, Hickey Island and The Peninsula, whilst a high risk of habitat modification was the primary threat at Goodwood/Collis, Yamba Quays and Micalo North (Table 4.2). Disturbance was a primary contributor to threat scores at Iluka Breakwall, Freeburn Island, Rabbit Island (sandbar) and Shark Bay. Habitat loss was a primary contributor to threat at Yamba Quays and Prawn Farm.

The highest ranking threats were recreational fishing (cumulative score of 137), high risk Acid Sulphate Soils (151), commercial fishing (131), mangrove encroachment (131) and introduced pests (101). Grazing (76), walking/swimming (74) and boating (83) also ranked highly (Table 3a, Appendix 3).

Comparing the importance of each site (priority ranking) to the threat scores gives an indication of where conflicts between habitat values and threats exist (Table 4.3). Such a comparison indicates that Dart Island is a high priority management site, followed by Hickey Island, Prawn Farm, The Peninsula, Goodwood south, Iluka Breakwall and Yamba Quays (Table 4.3).

4.3 DISCUSSION

The threat assessment provides a preliminary indication of which roost sites experience a high risk of threat and which potential threats pose the greatest risk to shorebirds. Although climate change (& sea level rise) was not included in the assessment it is considered to pose a very high risk to the extent and quality of shorebird roosting habitat. The actual effect of climate change on shorebird habitat is unknown and specific research is required to fully determine how shorebird habitat will respond to rising sea levels. Potential impacts could include the expansion of mangroves into saltmarsh and over extant sand and mudflats. Changes in depositional processes and the expansion of intertidal sand and mudflats could lead to increased demands for dredging of shorebird habitat.

The threat assessment is regarded as preliminary only. Although the assessment uses the best available information it was prepared within a short timeframe and without specific data on the extent to which shorebirds in the Clarence Estuary are affected by the various threatening factors. Furthermore, the assessment is based on brief discussions. Whilst these constraints do not negate further use of the assessment they highlight the need for a cautious approach and the most appropriate application of the threat assessment is to identify those activities that require further investigation.

Umwelt (2002) undertook a threat and values assessment of the estuary and floodplain, with the end result being the delineation of values and risks (threat) within different reaches (Figure 5.2a in Umwelt 2002). The assessment included a range of ecological values, indicators of use and indicators of risk/threat and there are a number of similarities in the

criteria used by Umwelt (2002) and those used in this study. Umwelt (2002) also weighted their values to improve the delineation between reaches. A similar approach was initially considered for this assessment (refer to Chapter 2), however, it was not implemented due to concerns over the quality of the information available. The Umwelt assessment suffers from similar data limitations and they acknowledge that their weighting allocation must be considered to be tentative (page 5.7, Umwelt 2002).

In most instances the results of the present assessment are not surprising. For example, it is generally accepted that Dart and Hickey Islands and The Peninsula experience high levels of threat particularly from disturbance. Likewise, a high risk of threat at Yamba Quays and Prawn Farm is not surprising as development has been approved at both these sites. The high level of threat recorded at Goodwood/Collis and Micalo North is more surprising, although both sites experience a number of threats that could result in habitat modification.

The assessment shows a general pattern of higher threat at sites close to urban areas and lower threat in remote locations where the environment is less inviting for recreational activities and access may be difficult. A similar pattern of threat was documented in the Tweed River Estuary (Rohweder 2003), and is expected to occur in other north coast estuaries. The 'uninviting' nature of muddy habitats in Wooloweyah Lagoon and the isolation of the Clarence Broadwater limit disturbance related threats. The magnitude of disturbance related threats is relative to the demand for space to undertake these activities. As the population of Yamba and Iluka increase there is likely to be a subsequent increase in human activity in areas such as Joss Island and Oyster Channel, which may increase the level of disturbance related threat at sites like Joss Island.

The ranking of individual threats supports the common understanding that recreational activities pose a threat to shorebirds (Buick & Paton 1989; Pfister *et al.* 1992; Melville, 1997; McPhee *et al.* 2002; Priest *et al.* 2002). Four of the eight high-ranking threats are disturbance related. The ranking of threats is strongly influenced by the extent of a potential threat within the study area. For example, potential threats that occur over large areas and in close proximity to shorebird sites, such as commercial fishing rank more highly than others. Whilst this relationship does not diminish the potential influence of a threat it does raise the need to confirm if that threat actually affects shorebirds.

Walking, dog exercise and recreational fishing are activities that regularly disturb shorebirds. In contrast, the impact of commercial fishing, which occurs mainly at night, is unknown. Further information on the timing of commercial fishing activities in relation to high tide and the use of sites at night is required to quantify the impact of this activity. The impact of grazing, boating and mangrove encroachment also warrants further investigation. Mangroves have been identified as a potential threat to shorebird roosting habitat, particularly saltmarsh (Saintilan & Williams 1998; Saintilan 2003) and direct evidence of the expansion of mangroves at the expense of shorebird roosting habitat is available in the Tweed and Richmond Rivers (pers obs). The occurrence of mangrove seedlings at several roosts in the study area is cause for concern and the expansion of mangroves warrants further investigation.

The results of the threat assessment are supported by the results of a baseline survey conducted by WWF (2003b). In that survey community responses identified high levels of threat at Dart, Hickey and Micalo Islands and Wooloweyah Lagoon. Issues of concern in

Wooloweyah Lagoon related to commercial and recreational fishing, impacts on water quality, altered drainage and erosion.

WWF (2003b) also identified weed invasion as a high priority issue at Dart & Hickey Islands. Although weed invasion was not included in the threat analysis it is known to be an issue of concern at both the above sites and possibly at the stone-curlew and oystercatcher nest site on Rabbit Island. Despite the concern regarding weeds at the identified sites and the knowledge that weeds represent a definite environmental problem the exact impact of weeds, on shorebirds is unclear. Weeds would become a direct threat to most shorebirds only when they invade the littoral and intertidal areas, where they can disrupt line of sight or when they alter the structure of nesting habitat.

There are some similarities and differences between the findings of this assessment and that of Umwelt (2002). The main discrepancy occurs around Dart and Hickey Islands and The Peninsula. Umwelt identified these areas as having moderate value and moderate threat, whilst this study has identified high threat and medium to high values (Table 4.3). Comparing values and threats assists in identifying those sites that are the highest priority for management (Table 4.3). Dart and Hickey Island, The Peninsula, Yamba Quays, Prawn Farm, Woody Head, Goodwood South and Iluka Breakwall are all sites that have high levels of threat and medium or high shorebird values (Table 4.3).

Table 4.2: Summary of potential threats to shorebirds and their predicted occurrence at known shorebird roost sites. Ranking system = 20 – loss of site imminent, 10 – on-site, 5 – within 100m of site, 1- within 1km of a site.

Category	Type	Nar	Eur	Wor	Bol Is	GW east	GW/ Col	GW sth	Il BW	FB Nth	Mid Wall	Dart Is	Hick Is	The Pen	Rab Is - sand	Rab Is - nest	Re Ck sm	Slee Is	Cry Wat	Yam Qu	Rom Cha	Mic Nth	Pra Far	Cor Is	Joss Is	Pal Is SE	Uigu Is	Clar BW	Mun Is	Kal'd Bay	Sha Bay	Back Bch	Wdy Head	
Habitat Loss	Sub-Total	0	10	0	1	5	10	10	0	1	0	1	1	0	1	0	10	5	1	20	0	6	20	1	1	10	0	0	0	0	0	1		1
Habitat Modification	Sub-Total	10	10	0	11	21	27	16	21	17	10	13	8	13	3	11	7	13	16	35	11	30	20	11	10	12	0	10	0	10	0	1	5	
Habitat Disturbance	Sub-Total	7	7	6	13	4	19	8	22	28	17	43	52	50	31	8	4	16	23	23	10	15	3	7	7	7	15	6	15	0	30	16	21	
Predation	Introduced pests (predicted)	0	0	0	0	5	5	5	5	0	1	5	5	5	0	0	5	5	0	0	0	5	5	5	5	5	5	0	5	5	5	5	5	5
Sources of Disturbance	Sub-Total	0	0	0	3	8	8	5	16	16	1	12	22	12	3	12	12	6	16	12	0	6	5	5	5	5	5	1	5	5	5	8	20	
Pollution	Sub-Total	10	10	5	5	10	10	10	1	1	0	1	10	1	1	1	10	10	1	1	10	10	10	1	1	11	1	2	1	11	0	0	0	
	TOTAL	27	37	11	33	53	80	54	65	63	29	75	98	81	39	32	48	55	57	91	31	72	63	30	29	50	26	19	26	31	41	30	52	

Table 4.3: Comparison between potential threats and the value of sites to shorebirds.

Site	Threat Score	Habitat Priority Ranking – High Tide
Narrabarribi Island	27	Low
Woram Channel	37	Low
Eureka Island	11	Low
Bolorobo Island	33	Low
Goodwood East	53	Low
Goodwood/Collis	80	Low
Goodwood south	54	Medium
Iluka Breakwall	65	Medium
Freeburn Island (nth)	63	Medium
Middle Wall	29	Low
Dart Island	75	High
Hickey Island	98	High
The Peninsula	81	Medium
Rabbit Island – sandbar	39	Medium
Rabbit Island – nest	32	N/A
Reedy Creek	48	Low
Sleeper Island	55	Low
Crystal Waters	57	Low
Yamba Quays	91	Medium
Thorny Island - Oyster Ch Bridge	Not Assessed	N/A
Romiaka Channel	31	Low
Micalo North	72	Medium
Prawn farm	73	High
Oyster Channel	Not Assessed	Low
Corokos Island	30	Low
Joss Island	29	High
Palmers Is SE	50	Low
Ulugundahi Island	26	Low
Clarence Broadwater	19	Medium
Munro Island	26	Low
Kalangadoo	31	Low
Shark Bay	41	Medium
Back Beach	30	Medium
Woody Head	52	Medium

5. RECOMMENDATIONS

5.1 SUMMARY OF THREATS AND ISSUES

A broad range of issues has been discussed in the previous chapters. These issues can be summarised into seven broad topics, including:

- The variable coverage of previous population monitoring surveys and the limited number of surveys that have covered the entire estuary.
- Variability in the methods and detail provided by previous surveys.
- The limited information available on the use of foraging habitats.
- The absence of information on nocturnal behaviour and important nocturnal habitats.
- The inappropriate zoning and protection of important shorebird habitat.
- A lack of understanding regarding the impact of numerous potential threatening processes on shorebirds. Prominent examples include, climate change, recreational activities and commercial fishing.
- The absence of guiding principles on how shorebird habitat in the estuary should be managed.

Although the Clarence estuary has been the subject of numerous shorebird surveys there is limited information on important shorebird habitats, the types of shorebird habitat in the estuary and baseline data on the characteristics of shorebird habitat. Likewise, there are no quantitative studies on how shorebirds are affected by various commercial and recreational activities in north coast estuaries.

The above issues identify a clear need for further targeted research and the development of guiding principles to assist state and local government and the community manage shorebird habitat. The deficiencies identified should not be regarded as a criticism of previous surveys and assessments. It is understood that these surveys have either been undertaken with a specific set of objectives or on a voluntary basis.

5.2 PROPOSED MANAGEMENT ACTIONS

5.2.1 Background

Management of catchments, floodplains and estuaries in NSW is currently undergoing a transition. The establishment of Catchment Management Authorities (CMAs) will result in a substantial change in the way funding is allocated to Natural Resource Management (NRM) projects and hopefully an improvement in the outcomes of these projects. Any proposals to improve the management of shorebird habitat must recognise the role of the CMAs.

The Northern Rivers CMA, which covers the Clarence Estuary, is in the initial stage of being established. This CMA extends from the Qld/NSW border south to Port Macquarie and encompasses the former Northern Rivers, Upper North Coast and Mid-North Coast

Catchment Management Boards. Catchment Blueprints prepared by these boards have been combined into a draft Blueprint Action Integration Plan (BAIP). When finalised the actions specified in this plan will guide natural resource management in northern NSW.

The recently completed Clarence Estuary Management Plan (Umwelt 2003) provides specific information on NRM within the estuary. This plan includes a number of important actions that are directly relevant to shorebirds. Although there are alternative sources of funding it is strongly recommended that actions proposed in this report be linked to the EMP and draft BAIP.

5.2.2 Proposed Actions to Manage Threats

Eleven priority areas have been identified to improve the conservation of shorebirds and their habitat in the Clarence Estuary (Table 5.1). A number of specific actions have been identified within each priority area to address specific issues. There are five key components to the management of threats:

1. Further research to clearly identify threats (priority area 1),
2. Community awareness and involvement (priority areas 6, 7, 8, 9)
3. Improved environmental planning and regulation (priority areas 2, 4, 5, 9, 10, 11).
4. Habitat conservation and remediation (priority areas 4 & 8).
5. On-ground works (priority area 11).

The preparation of a Shorebird Plan of Management would be the most appropriate means of providing specific details on how to manage threats. The preparation of such a plan is identified as a future action by WWF (2003a). It is presently unclear who would be responsible for implementing the Plan of Management and this must be a topic for discussion at the community forum.

Relationships between proposed actions, the EMP and the draft BAIP are detailed in Table 5.2. There is a clear link between several of the priority areas and actions specified in the EMP and BAIP, although actions in the BAIP have a broad scope and it is unclear how projects with a narrow focus such as the SCP would be considered. One potential means of attracting funding would be to focus on the protection and management of threatened shorebirds, as threatened species are a specific focus within the BAIP.

The issue of restricting assessments to a narrow focus, such as a group of birds (i.e. shorebirds) warrants some consideration. It is possible that projects with a narrow scope become less relevant in the context of catchment management. Although shorebirds represent a unique and important component of estuarine and floodplain ecosystems there are numerous species of aquatic bird (waterbirds) that also warrant protection and management. To ensure that the management of shorebirds remains relevant it is suggested that the scope of future bird assessments be expanded to encompass all waterbirds.

Potentially significant threats such as Acid Sulphate Soils are being addressed by other projects and have not been considered in this assessment, although it is recommended that shorebirds be considered in the assessment of these projects.

Table 5.1: Summary of priority areas and specific actions proposed to manage shorebirds and their habitat in the Clarence Estuary.

Priority Area	Rationale	Scope/Actions
1. Research, Assessment & Monitoring	There are a number of research projects that are required to provide the necessary information for the management of shorebirds and their habitat. The information obtained from these projects could be integrated into management as it becomes available. Some actions are more critical than others and the actions have been listed in their order of priority.	<p>1a) Undertake nocturnal surveys to identify important roost and foraging habitats</p> <p>1b) Research the type and extent of disturbance to shorebirds in the Clarence Estuary.</p> <p>1c) Assess the impact of climate change (sea-level rise) on shorebird habitat in the Clarence Estuary.</p> <p>1d) Obtain further information on how shorebirds use different roost and feeding sites</p> <p>1e) Initiate a shorebird population monitoring program</p> <p>1f) Undertake baseline studies on the characteristics of shorebird foraging habitat e.g. sediment structure and invertebrate communities.</p> <p>1g) Monitor changes in the structure of roost and feeding sites</p>
2. Site and habitat mapping	Good quality habitat mapping is essential to improve site management and planning. The proposed action would utilise a GIS to provide clear maps of the distribution and extent of shorebird roost and foraging habitat within the Clarence Estuary.	<p>2a) Using GIS, map the distribution and extent of shorebird roost and foraging habitat throughout the Clarence River Estuary.</p> <p>2b) At a later stage, and with more information at hand, this mapping could be modified to identify primary and secondary habitats.</p>
3. Improved environmental planning & regulation	Planning at the local government level plays a fundamental role in the protection of shorebird habitat. It is essential that local planners be provided with the resources and knowledge required to ensure that impacts on shorebirds are adequately considered during the development assessment process.	<p>3a) Develop a shorebird management toolbox to assist local government planners to:</p> <ul style="list-style-type: none"> - ensure that the indirect impacts of urban development, such as recreation are considered in assessing future large-scale land releases at Yamba and Iluka. - ensure that impacts on shorebirds from ecotourism, recreation based, dredging or foreshore development proposals are adequately considered. <p>3b) Rezone important shorebird foraging habitat as 7(a) {Environmental Protection (Ecological Significance) Zone} and ensure that all roost sites are zoned 7(a).</p> <p>3c) Review current dog exercise and 4WD areas and identify locations where improved regulation of these activities is warranted.</p> <p>3d) Ensure that roost and feeding ground mapping is linked to the development assessment process within Clarence Valley Council.</p>
4. Habitat conservation & protection	The extension of the Clarence Estuary Nature Reserve to include important shorebird roost and foraging habitat would provide a further means of protecting habitat and managing disturbance. Key areas of inclusion in the Nature Reserve are Joss and Corokos Islands and associated intertidal habitat.	<p>4a) Identify areas suitable for inclusion in the Clarence Estuary Nature Reserve (to mean low water) and lobby state government for inclusion of these areas in the reserve system.</p> <p>4b) Support the Ramsar nomination of the Clarence Broadwater.</p> <p>4c) Encourage the extension of the Ramsar nomination to include Wooloweyah Lagoon.</p> <p>4d) Identify sites suitable for the development of conservation agreements.</p>

Table 5.1: cont

Priority Area	Rationale	Scope/Actions
5. Community involvement & understanding	Community involvement is an essential component of managing shorebird habitat. It is necessary to obtain input from the community on appropriate management strategies to increase the application of these strategies.	5a) Establish (or link with an already established group) a community group to assist with the implementation of measures proposed in this report. 5b) Increase awareness within the local community of shorebirds, the habitat they use and the impact of daily activities with a view to fostering community involvement in shorebird management. 5c) Obtain community input to develop measures to protect important shorebird habitats. 5d) Initiate negotiations between specific user groups and conservation organizations to develop actions to minimise impacts on shorebirds i.e. develop a Recreational Fishing Code of Conduct for the Clarence Estuary. 5e) Identify target groups that may benefit from additional information such as brochures. 5f) Encourage the local aboriginal community to become involved in shorebird management.
6. Support Programs	The Estuary Management Plan and Catchment Blueprints include a number of important recommendations that have direct implications for the protection and management of shorebird habitat. Ideally a mechanism should be developed whereby support is provided for these actions.	6a) Support measures to assess the impact of commercial use of Wooloweyah Lagoon. 6b) Support measures to avoid further foreshore development of Wooloweyah Lagoon.
7. Promote involvement of persons with shorebird (waterbird) knowledge in Floodplain Management Committees.	There are a variety of broad (floodplain-wide) strategies that may have implications for shorebirds. These strategies are often implemented by organizations with limited understanding of waterbird ecology. Whilst the potential value of these strategies for the floodplain ecosystem is acknowledged it is also important to ensure that shorebirds are considered in the assessment process.	7a) Increase awareness of local environmental lobby groups regarding shorebird (waterbird) management and threatening processes to provide a mechanism by which these issues are integrated into management initiatives such as the Floodplain Partnership Agreement. 7b) Ensure that shorebirds are considered in floodplain management initiatives such as ASS hotspots program & floodgate management.
8. Habitat creation and remediation	There is direct evidence that at least two important roosts (Prawn Farm and Yamba Quays) will be heavily impacted in the near future and several other sites may be modified through disturbance and mangrove encroachment. Given the impending loss of roost sites it is essential that potential sites for habitat creation or remediation be identified.	8a) Identify sites that area suitable for habitat remediation or creation 8b) Identify the actions required to remediate or create habitat at the designated sites.
9. Weed and pest species management	Environmental weeds and pest species pose a threat to shorebirds, however, the magnitude of this threat in the Clarence Estuary is at present unclear. Further work is required to determine the level of threat to shorebirds from weeds and pest species.	9a) Map the distribution of weeds within the estuary 9b) Identify priority areas for weed management and prepare a weed management plan. 9c) Support the current program to control pest species at Dart and Hickey Islands and identify other locations for pest species management.

Table 5.1: cont.

<p>10. Threatened Species Management</p>	<p>Threatened species represent an important component of the estuaries shorebird (waterbird) population and warrant special consideration.</p>	<p>10a) Identify key habitats for threatened shorebirds (waterbirds). 10b) Identify threats to important habitat. 10b) Ensure that important habitats are recognised in the PoM and environmental planning assessments.</p>
<p>11. On-ground Action</p>	<p>There is a range of on-ground activities that would have a direct benefit to shorebirds.</p>	<p>On-ground actions include: The provision of signs on Hickey Island that detail restrictions to dog and vehicle access; The provision of signs at boat ramps that provide details of important shorebird habitat; The distribution of information brochures targeting specific user groups; Ongoing workshops to increase community awareness; On-ground regulation of activities by NSW Waterways, Council and NSW Fisheries staff; Wardening of important nest and roost sites during peak visitor days; Control of weeds and predators.</p>

Research & assessment

Ideally management decisions should be based on sound information. In the present case there needs to be a good understanding of important diurnal and nocturnal roost and foraging sites and the role that these sites play in the daily activity of shorebirds (i.e. staging areas, neap tide roosts, spring tide roosts). Baseline information is required on the characteristics of roost and feeding areas. Quantitative data are also required to determine how shorebirds in the Clarence Estuary respond to recreational and commercial activities.

At present there is detailed information on a number of diurnal roosts, but no information on nocturnal roost or feeding sites. Baseline information on the characteristics of shorebird habitat is also limited and there is a poor understanding of the importance of the Clarence floodplain to shorebirds.

Filling all these gaps in knowledge will take a considerable amount of effort, time and resources. The Clarence Estuary Shorebird Monitoring Project is currently underway and should provide further information on population size and use of high tide roosts. It is possible that this project can be expanded to cover some of the floodplain wetlands and to undertake surveys of foraging habitats and collect baseline data on disturbance. However, any expansion of the project will place further pressure on volunteers and the limited resources available for that project.

Research into the effects of climate change on shorebird habitat will require specialist input. The EMP recommended that such a survey be undertaken and it is suggested that Clarence Valley Council (CVC) be lobbied to commission such a study.

Ongoing monitoring of the physical and biological attributes of shorebird habitat is also necessary. This information would complement count data and assist in prioritising sites for management or on-ground work. Monitoring could take various forms depending on the funding available and organization involved. A minimum requirement would be to establish photo point/s at each roost and feeding area.

Community awareness & involvement

The community has three important roles to play in shorebird management. Firstly, to lobby state and local government to improve the management and protection of shorebird habitat, secondly, to foster the development of practices that minimise impacts on shorebirds and thirdly, to monitor shorebird populations and habitat. Community education is essential to ensure that important sites are widely known and appropriately managed. The proposed community forum will assist in raising community awareness and identifying community priorities. The impetus gained from the forum will need to be followed through to ensure that priorities identified by the community are implemented.

The community forum will hopefully establish a framework for future community involvement in the management and protection of shorebird habitat. The Clarence Wetland Network (CWN) represents an established group with an interest in the protection of wetlands. This group could be approached to adopt the recommendations of the community forum. In whatever form it takes the community group would have a fundamental role in facilitating

discussion with recreational and industry groups and lobbying local councils and state agencies to implement actions. Some issues that the community group may wish to address include: the development of a Recreational Fishing Code of Conduct in consultation with local fishing clubs; the preparation of resource material (e.g. a shorebird management toolbox) aimed at different levels of management (community and local government); the preparation of information brochures that target different user groups and discussions with NSW Waterways regarding boating activities.

Improved environmental planning & regulation

The CVC has a fundamental role to play in the management of shorebird habitat particularly through the actions specified in the EMP. Council also has an obligation to ensure that the impact of coastal development is fully assessed. A number of issues have been identified that could be addressed by Council, whilst other issues may require more time and resources. Council could improve the management of Dart and Hickey Island by imposing stricter controls on dogs and 4WD vehicles and enforcing these controls. This could be achieved by prohibiting dogs and vehicles from the western end of Hickey Island.

Areas of important shorebird habitat, including intertidal foraging habitat, that are currently zoned 1(w) should be rezoned as 7(a) to better reflect their conservation value. Council staff should also be provided with additional resources to assist in assessing the impacts of development on shorebirds. Additional resources could include GIS maps that show the location of important shorebird habitats and resource material that discusses impacts on shorebirds in northern NSW. The proposed Shorebird Management Toolbox could be modified to suit the needs of Council planners.

Habitat conservation, protection & remediation

The current reserve system must be expanded to ensure that important shorebird habitats are given an appropriate level of protection. It is essential that any additions to the reserve system extend to mean low water and not mean spring high water. The proposed Ramsar nomination of the Clarence Broadwater is one means of improving protection of shorebird habitat, however, this nomination should be expanded to include Wooloweyah Lagoon.

Joss and Corokos Islands and associated intertidal mudflats and Dart Island should be included in the Clarence Estuary Nature Reserve in recognition of the importance of these habitats. Important habitats within Oyster Channel should also be assessed for inclusion in the Nature Reserve. Although the inclusion of these sites into the Nature Reserve will not have an immediate benefit to shorebirds the mechanism would be in place for improved management. Alternatives, such as the creation of an aquatic reserve in the northern section of Wooloweyah Lagoon and including part of Oyster Channel could also be explored.

Conservation agreements between government agencies and landholders are another potential means of improving the protection and management of important sites. Two sites that may lend themselves to such an agreement are Micalo North and Goodwood South.

Habitat remediation and creation are important components in the long-term management of shorebird habitat. At present two important shorebird roosts are under imminent threat and

alternative sites for remediation or habitat creation should be identified. The encroachment of mangroves onto shorebird roosting habitat also needs to be addressed and areas requiring mangrove control should be identified and approvals obtained. The issue of mangrove encroachment is not unique to the Clarence Estuary and approvals for the removal of mangroves from roost sites have been obtained in the Hunter and Richmond Estuaries. Typically mangrove control is applied to only a small area at identified roost sites and the number of mangroves removed is minor in the context of the estuary. In many instances mangroves are encroaching on saltmarsh, which is protected under both the *Fisheries Management Act 1994* and *Threatened Species Conservation Act 1995*.

On-ground actions

There are a variety of on-ground actions that can be implemented to improve the protection of shorebird habitat. Specific actions include:

- The provision of signs on Hickey Island that detail restrictions to dog and vehicle access.
- The provision of signs at boat ramps that provide details of important shorebird habitat.
- The distribution of information brochures targeting specific user groups.
- Ongoing workshops to increase community awareness.
- On-ground regulation of activities by NSW Waterways, Council and NSW Fisheries staff.
- Wardening of important nest and roost sites during peak visitor days.
- Control of weeds and predators.

Important roost sites within conservation reserves such as Back Beach provide an ideal opportunity to implement on-ground works. Management of recreational activity at Back Beach through the use of signage and information brochures could have a positive benefit for birds using the site.

5.2.3 Prioritisation of Proposed Actions

Table 5.3 lists the proposed management actions and identifies those actions that are a high, medium or low priority and potential lead organizations that could be approached to implement the actions. For the proposed actions to be implemented it is essential that sources of funding be identified and submissions for funding developed. A submission to the CMA to fund activities that relate to actions in the BAIP should be a high priority. An appropriate research institution should be approached to discuss the development of research projects. The prioritisation of actions is based on the demand for information to improve management of shorebird habitat in the estuary and considers gaps in knowledge, deficiencies in planning and site protection and potential threats identified in this report.

Table 5.2: Inter-relationships between priority areas and actions proposed in the EMP and the BAIP.

Issues Paper	Related Actions in EMP – Action ID Nos.	Related Actions in the Draft Blueprint Action Integration Plan
1. Research, Assessment & Monitoring	S18, W21, E25	Theme 16 – Wetlands*; Theme 26 – Estuary Management (3), Theme 18 – Threatened Species & Ecosystems (1, 3).
2. Site and habitat mapping		
3. Improved environmental planning	S16, W11, W14, W23, E5,	Theme 26 – Estuary Management (3)
4. Habitat conservation, protection and management	E24, E1, U10, E3	Theme 18 – Threatened Species & Ecosystems (1); Theme 26 – Estuary Management (3)
5. Community involvement & understanding	S9	Theme 26 – Estuary Management (3); Theme 28 – Aboriginal Cultural Heritage (5, 6); Theme 29 – Community Capacity Building (1).
6. Support Programs		
7. Provide local lobby groups with further information on issues affecting shorebirds (waterbirds).	S8, E15	Theme 8 Priority areas – Hotspots (1, 3) Theme 13 – Coastal Floodplain Management/ASS (1, 5); Theme 26 – Estuary Management (3)
8. Habitat creation and remediation		
9. Weed and pest species management	E7	Theme 26 – Estuary Management (3)
10. Threatened Species		Theme 18 – Threatened Species & Ecosystems (1, 3).
11. On-ground Actions		

* The proposed research and assessment actions relate closely to several; activities proposed in the Blueprint Action Integration Plan, however, separate activities were not numbered in the draft plan.

Table 5.3: Prioritisation of proposed management actions based on available funding and demand. SMP = Shorebird Monitoring project; NGO = None Government Organisation; CG = Community Group; CVC = Clarence Valley Council; DEC = Department of Environment & Conservation

Proposed Actions	Prioritisation	Target Organisation
<p>1a) Undertake nocturnal surveys to identify important roost and foraging habitats</p> <p>1b) Research the type and extent of disturbance to shorebirds in the Clarence Estuary</p> <p>1c) Assess the impact of climate change (sea-level rise) on shorebird habitat in the Clarence Estuary.</p> <p>1d) Obtain further information on how shorebirds use different roost and feeding sites</p> <p>1e) Initiate a shorebird population monitoring program</p> <p>1f) Undertake baseline studies on the characteristics of shorebird foraging habitat e.g. sediment structure and invertebrate communities.</p> <p>1g) Monitor changes in the structure of roost and feeding sites</p>	<p>1a) High</p> <p>1b) High</p> <p>1c) High</p> <p>1d) Low</p> <p>1e) Medium</p> <p>1f) Low</p> <p>1g) Medium</p>	<p>1a) SMP/consultant/research students, NGO, CG</p> <p>1b) SMP/consultant/research students, NGO, CG</p> <p>1c) Clarence Valley Council as per EMP</p> <p>1d) SMP/consultant/research students, NGO</p> <p>1e) WWF</p> <p>1f) University/Research students, NGO</p> <p>1g) SMP, NGO</p>
<p>2a) Using GIS, map the distribution and extent of shorebird roost and foraging habitat throughout the Clarence River Estuary.</p> <p>2b) At a later stage, and with more information at hand, this mapping could be modified to identify primary and secondary habitats.</p>	<p>2a) High</p> <p>2b) Medium</p>	<p>2a) CVC/DEC</p> <p>2b) CVC/DEC</p>
<p>3a) Develop a shorebird management toolbox to assist local government planners to:</p> <ul style="list-style-type: none"> - ensure that the indirect impacts of urban development, such as recreation are considered in assessing future large-scale land releases at Yamba and Iluka. - ensure that impacts on shorebirds from ecotourism, recreation based, dredging or foreshore development proposals are adequately considered. <p>3b) Rezone important shorebird foraging habitat as 7(a) {Environmental Protection (Ecological Significance) Zone} and ensure that all roost sites are zoned 7(a).</p> <p>3c) Review current dog exercise and 4WD areas and identify locations where improved regulation of these activities is warranted.</p> <p>3d) Ensure that roost and feeding ground mapping is linked to the development assessment process within Clarence Valley Council.</p>	<p>3a) Medium</p> <p>3b) High</p> <p>3c) High</p> <p>3d) High</p>	<p>3a) NGO/Consultant/DEC, CG</p> <p>3b) CVC</p> <p>3c) CVC</p> <p>3d) CVC</p>
<p>4a) Identify areas suitable for inclusion in the Clarence Estuary Nature Reserve (to mean low water) and lobby state government for inclusion of these areas in the reserve system.</p> <p>4b) Support the Ramsar nomination of the Clarence Broadwater.</p> <p>4c) Encourage the extension of the Ramsar nomination to include Wooloweyah Lagoon.</p> <p>4d) Identify sites suitable for the development of conservation agreements.</p>	<p>4a) High</p> <p>4b) Medium</p> <p>4c) High</p> <p>4d) Low</p>	<p>4a) NGO/CG/DEC</p> <p>4b) NGO/CG</p> <p>4c) NGO/CG/DEC</p> <p>4d) NGO/CG/DEC</p>

Proposed Actions	Prioritisation	Target Organisation
<p>5a) Establish (or link with an already established group) a community group to assist with the implementation of measures proposed in this report.</p> <p>5b) Increase awareness within the local community of shorebirds, the habitat they use and the impact of daily activities with a view to fostering community involvement in shorebird management.</p> <p>5c) Obtain community input to develop measures to protect important shorebird habitats.</p> <p>5d) Initiate negotiations between specific user groups and conservation organizations to develop actions to minimise impacts on shorebirds e.g. develop a Recreational Fishing Code of Conduct for the Clarence Estuary.</p> <p>5e) Identify target groups that may benefit from additional information such as brochures.</p> <p>5f) Encourage the local aboriginal community to become involved in shorebird management.</p>	<p>5a) High</p> <p>5b) High</p> <p>5c) High</p> <p>5d) Medium</p> <p>5e) Medium</p> <p>5f) Medium</p>	<p>5a) NGO</p> <p>5b) NGO/CG</p> <p>5c) NGO/CG</p> <p>5d) NGO/CG</p> <p>5e) NGO/CG</p> <p>5f) NGO/CG</p>
<p>6a) Support measures to assess the impact of commercial use of Wooloweyah Lagoon.</p> <p>6b) Support measures to avoid further foreshore development of Wooloweyah Lagoon.</p>	<p>6a) Medium</p> <p>6b) Medium</p>	<p>6a) CG</p> <p>6b) CG</p>
<p>7a) Increase awareness of local environmental lobby groups regarding shorebird (waterbird) management and threatening processes to provide a mechanism by which these issues are integrated into management programs, such as the Floodplain Partnership Agreement.</p> <p>7b) Ensure that shorebirds are considered in floodplain management initiatives such as ASS hotspots program & floodgate management.</p>	<p>7a) Low</p> <p>7b) Medium</p>	<p>7a) CG</p> <p>7b) CG</p>
<p>8a) Identify sites that are suitable for habitat remediation or creation</p> <p>8b) Identify the actions required to remediate or create habitat at the designated sites.</p>	<p>8a) High</p> <p>8b) High</p>	<p>8a) NGO/CG/CVC</p> <p>8b) NGO/CG/CVC</p>
<p>9a) Map the distribution of weeds within the estuary</p> <p>9b) Identify priority areas for weed management and prepare a weed management plan.</p> <p>9c) Support the current program to control pest species at Dart and Hickey Islands and identify other locations for pest species management.</p>	<p>9a) Low</p> <p>9b) Low</p> <p>9c) Medium</p>	<p>9a) Clarence Valley Weeds Authority/Landcare</p> <p>9b) Clarence Valley Weeds Authority/Landcare</p> <p>9c) NGO/CG/DEC</p>
<p>10a) Identify key habitats for threatened shorebirds (waterbirds).</p> <p>10b) Identify threats to important habitat.</p> <p>10c) Ensure that important habitats are recognised in the PoM and environmental planning assessments.</p>	<p>10a) High</p> <p>10b) High</p> <p>10c) High</p>	<p>10a) NGO/CG/DEC/CVC</p> <p>10b) NGO/CG/DEC/CVC</p> <p>10c) NGO/CG/DEC/CVC</p>
11 On-ground Actions	11) Low	NGO/CG/CVC

6. REFERENCES

- Buick, A. M. & Paton, D. C. (1989). Impact of off-road vehicles on the nesting success of hooded plovers *Charadrius rubricollis* in the Coorong region of South Australia. *Emu*: **89**, 159-172.
- Clancy, G. P. (1992). *Clarence estuary natural heritage study, northeast New South Wales*. NSW NPWS.
- Clancy, G. P. (2002). *Report on Clarence estuary wader count*. Unpublished report to the NSW WSG.
- Evans, P. R. & Dugan, P. J. (1984). Coastal birds: numbers in relation to food resources. PP 8-28 in *Coastal Waders & Wildfowl in Winter* (Eds P. Evans, J. Goss-Custard & W. Hale), Cambridge University Press, Cambridge.
- ERM (1999). *Regional Water Supply Project – Environmental Impact Statement*. Volume 1. Lower Clarence County Council.
- Healthy River Commission (1999). *Independent Inquiry into the Clarence River System – Final Report*. Healthy Rivers Commission of New South Wales.
- Kalejta, B. & Hockey, P. A. R. (1994). Distribution of shorebirds in the Berg River Estuary, South Africa, in relation to foraging mode, food supply and environmental factors. *Ibis*: **136**, 233-239.
- Lane, B. & Davies, J. (1987). *Shorebirds in Australia*. Thomas Nelson, Melbourne.
- Lawler, W. (1994a) *Shorebird counts on New South Wales North Coast Estuaries*. Environmental Survey & Research Branch, NSW NPWS.
- Lawler, W. (1994b). *Draft management manual for migratory shorebird feeding habitat in New South Wales estuaries*. Environmental Survey & Research Branch, NSW NPWS.
- Lawler, W. (1996). *Guidelines for management of migratory shorebird habitat in southern east coast estuaries, Australia*. Unpublished Masters of Resource Science, University of New England, Armidale.
- Martindale, J. (1984). *A study of estuarine birds in the lower Clarence River*. NSW NPWS.
- McNeil, R., Drapeau, P. & Goss-Custard, J. D. (1992). The occurrence and adaptive significance of nocturnal habits in waterfowl. *Biological Review*: **67**, 381-419.
- McPhee, D. P., Leadbitter, D. & Skilleter, G. A. (2002). Swallowing the bait: is recreational fishing in Australia ecologically sustainable. *Pacific Conservation Biology*: **8**, 40-51.
- Melville, D. S. (1997). Threats to waders along the East Asian-Australasian Flyway, pages 15 – 34 in *Shorebird Conservation in the Asia-Pacific Region*, (ed P. Straw), Australasian Wader Studies Group, Melbourne.
- NRAC (1994). Natural Resource Audit Council (NRAC) surveys in October and November 1994 – data obtained from the NSW NPWS Wildlife Atlas. Survey methods and results are summarised in NPWS (1995).
- Piersma, T., Hoekstra, R., Dekinga, A., Koolhaas, A., Wolf, P., Battley., & Wiersma, P. (1993). Scale & intensity of intertidal habitat use by knots *Calidris canutus* in the western Wadden Sea in relation to food, friends & foes. *Netherlands Journal of Sea Research*: **31**, 331-357.
- Pfister, C., Harrington, B. A. & Lavine, M. (1992). The impact of human disturbance on shorebirds at a migration staging area. *Biological Conservation*: **60**, 115-126.

- Priest, B., Straw, P. & Weston, M. (2002). *Shorebird Conservation in Australia*. Supplement to Wingspan, vol 12, no. 4. Birds Australia, Melbourne.
- Rohweder, D. A. (2000). Day- night habitat use by five species of migratory shorebird in the Richmond River Estuary, northern NSW, Australia. Unpublished PhD Thesis, Southern Cross University, Lismore.
- Rohweder, D. A. (2001). Nocturnal roost use by migratory waders in the Richmond River Estuary, northern NSW, Australia. *Stilt*: **40**, 23-28.
- Rohweder, D. A. (2003). *Monitoring estuarine birds in the Tweed River Estuary 1997-2002. Summary Report*. Unpublished report prepared by Sandpiper Ecological Surveys for Tweed Shire Council.
- Rohweder, D. A. & Baverstock, P. R. (1996). Preliminary investigation of nocturnal habitat use by migratory waders in northern NSW. *Wildlife Research*: **23**, 169-184.
- Saintilan, N. (2003). Balancing shorebird habitat requirements with mangrove conservation, pages 15-19 in *Status and Management of Migratory Shorebirds in Sydney* (ed P. Straw), Sydney Olympic Park Authority, Sydney.
- Saintilan, N. & Williams, R. (1999). Mangrove Transgression into saltmarsh environments in eastern Australia. *Global Ecology & Biogeography*: **8**, 117-124.
- Smith, P. (1991). *Biology and management of waders in NSW*. NSW NPWS, Hurstville.
- Straw, P. (undated). - Raw count data for each site in the Clarence – NSW oil spill response atlas.
- Umwelt (2002). *Pathways to a living estuary: estuary management study, Clarence Estuary*. Prepared for the Clarence Estuary Management Committee.
- Umwelt (2003). *Pathways to a living estuary: estuary management plan, Clarence Estuary*. Prepared for the Clarence Estuary Management Committee.
- Watkins, D. (1993). *A National Plan for Shorebird Conservation in Australia*. Australasian Wader Studies Group.
- Weston, M., Watkins, D. & Priest, B. (undated). *Monitoring and the Shorebird Conservation Project*. Unpublished Report prepared by the SCP Taskforce.
- WWF Australia (2003a). Draft Site Action Plan. Unpublished report.
- WWF Australia (2003b). Draft Clarence Estuary site assessment. Unpublished report.

Acknowledgements

Sandpiper Environmental appreciates the assistance provided by the following individuals and organizations: Bianca Priest (WWF Australia), Greg Clancy, NSW Waterways Authority, Karen Schiller (Clarence River Professional Fishermans Association), Nicole Strehling (NSW Department of Primary Industries), Neville Frost (Clarence Valley Council), Greg Haines (Yamba Yacht Club), Harriet King (Big River Sailing Club), Jennifer Kingston (NSW Department of Environment and Conservation), Jeff Thomas (NSW Department of Environment & Conservation), Phil Straw (NSW Wader Studies Group), Gary Whale (Clarence Valley Birdos), Mark Aston (Clarence River Fishing Clubs Association), Northern Rivers Aero Club, Julie Mousley (Clarence Landcare), Lyn Starling (Clarence Valley Council) and everyone who has participated in shorebird surveys in the Clarence River Estuary. Phil Straw, Gary Whale, Bianca Priest and the Clarence River Professional Fishermans Association provided comments on the draft report.

APPENDIX ONE COUNT DATA

Table 1A: NRAC Data – high tide

Common Name	19-20/10/94		Dart/Hick	The Penn	Middle Wall	Folbigg Point	Reedy Ck SM	Iluka B'Water	Yamba Quays	Clarence Broadwater	Corokos Island	Palmer's Is SE	Micalo Is Nth	Micalo Is Sth	Joss Is - Sth	Prawn Farms
	Narrabarri bi Is	G'wood Sth														
Latham's Snipe						1				1				3		
Black-tailed Godwit															176	
Bar-tailed Godwit		83	160	6					150	26		3	11		251	3
Little Curlew																
Whimbrel	5	14	40	4			40	2	4				33			
Eastern Curlew		20	16	4		1		1	14		2		22		5	3
Marsh Sandpiper													9	10		142
Common Greenshank										1				2	2	14
Terek Sandpiper		6														
Common Sandpiper																
Grey-tailed Tattler		2	1	3											19	
Wandering Tattler																
Ruddy Turnstone		2														
Great Knot															66	
Red Knot			7												199	
Sanderling														1		
Red-necked Stint			6												13	8
Sharp-tailed Sandpiper		1								75			3		65	756
Curlew Sandpiper															36	69
Broad-billed Sandpiper																
Comb-crested Jacana																
Bush Stone-curlew																
Beach Stone-curlew																
Pied Oystercatcher			2		1				2			1			2	
Sooty Oystercatcher																
Black-winged Stilt													4	15		273
Red-necked Avocet																
Pacific Golden Plover			12													
Grey Plover																
Red-capped Plover			1													
Double-banded Plover																
Lesser Sand Plover															70	
Greater Sand Plover																
Black-fronted Dotterel																
Red-kneed Dotterel																9
Masked Lapwing										1		1				
Godwit/Whimbrel																
Knot																
Small S'pipers																

Table 1B: NRAC data – high tide

Common Name	24-25/11/94													
	Clarence B'water	Eureka Island	Narr Island	G'wood sth	Bolorobo Is	Dart/Hick	The Penn	Yamba Quays	Iluka B'wall	Micalo Is - Nth	Micalo Is sth	Prawn Farms	Joss Island	Palmers Is SE
Latham's Snipe	16													
Black-tailed Godwit													144	
Bar-tailed Godwit	2	67	34		7	136	7	30					376	
Little Curlew														
Whimbrel		34	14	12		6	7			9		1	23	
Eastern Curlew			24		4	41	5	11		1		4	31	
Marsh Sandpiper	13										35	127	5	
Common Greenshank	8		1		5				1		7	4	22	
Terek Sandpiper					13								9	
Common Sandpiper														
Grey-tailed Tattler					4	2			1				6	
Wandering Tattler														
Ruddy Turnstone														
Great Knot													239	
Red Knot		4										7	12	
Sanderling														
Red-necked Stint											6	3	49	
Sharp-tailed Sandpiper	508									5	187	406	162	5
Curlew Sandpiper	2										3	7	31	
Broad-billed Sandpiper													2	
Comb-crested Jacana														
Bush Stone-curlew														
Beach Stone-curlew														
Pied Oystercatcher			1			5	2	1					2	
Sooty Oystercatcher														
Black-winged Stilt	40	10									48	142	26	
Red-necked Avocet											17	24		
Pacific Golden Plover						3							53	31
Grey Plover														
Red-capped Plover													2	
Double-banded Plover														
Lesser Sand Plover													102	
Greater Sand Plover														
Black-fronted Dotterel														
Red-kneed Dotterel											3			
Masked Lapwing	16								2		2			
Godwit/Whimbrel														
Knot														
Small S'pipers														

Table 1C: NSW WSG Data – high tide

Common Name	H. Doughty	H. Doughty	H. Doughty	H. Doughty	H. Doughty	H. Doughty	A. Tarrant	H. Doughty				Dick Branch		
	15/11/93	14/01/95	19/02/95	22/02/95	26/02/95	14/03/95	25/06/96	3/11/96	29/03/97	14/09/98	30/09/00	21/09/01	Rabbit Is flats	The Penn flats
Latham's Snipe														
Black-tailed Godwit								14		18		5		
Bar-tailed Godwit	1	61	30	25	6	20	250	46	43		17	57		
Little Curlew														
Whimbrel		3	1	1	14	1	150	31	11		7	13	5	4
Eastern Curlew	1	2			22	4	120	37	7	31	14	24	61	1
Marsh Sandpiper														
Common Greenshank							5							
Terek Sandpiper														
Common Sandpiper														
Grey-tailed Tattler				10			25							
Wandering Tattler											2			
Ruddy Turnstone							50							
Great Knot							40							
Red Knot														
Sanderling														
Red-necked Stint							70							
Pectoral Sandpiper														
Sharp-tailed Sandpiper														
Curlew Sandpiper														
Broad-billed Sandpiper														
Comb-crested Jacana														
Bush Stone-curlew														
Beach Stone-curlew							3	2	2	2				
Pied Oystercatcher	2	2	1				14	9	4	8	5			2
Sooty Oystercatcher							5							
Black-winged Stilt														
Red-necked Avocet														
Pacific Golden Plover														
Grey Plover														
Red-capped Plover							50							1
Double-banded Plover														
Lesser Sand Plover							48		1					
Greater Sand Plover														
Black-fronted Dotterel														
Red-kneed Dotterel														
Masked Lapwing				1			4	5	2		1			
Godwit/Whimbrel														
Knot														
Small S'pipers														

Table 1D: NSW WSG Data – high tide

Common Name	D. Branch		D. Branch	
	16/11/01 The Penn	Wool Ent	21/11/01 Dart/Hick	The Penn
Latham's Snipe				
Black-tailed Godwit		125		
Bar-tailed Godwit		200	300	
Little Curlew				
Whimbrel	1	7	11	19
Eastern Curlew		26	80	
Marsh Sandpiper				
Common Greenshank				
Terek Sandpiper		5		4
Common Sandpiper				
Grey-tailed Tattler	39			25
Wandering Tattler				
Ruddy Turnstone				
Great Knot		78		
Red Knot				
Sanderling				
Red-necked Stint		32		2
Pectoral Sandpiper				
Sharp-tailed Sandpiper		7		
Curlew Sandpiper				
Broad-billed Sandpiper				
Comb-crested Jacana				
Bush Stone-curlew				
Beach Stone-curlew				
Pied Oystercatcher	1		4	
Sooty Oystercatcher				
Black-winged Stilt				
Red-necked Avocet				
Pacific Golden Plover		8		
Grey Plover				
Red-capped Plover	11			9
Double-banded Plover				
Lesser Sand Plover				
Greater Sand Plover				
Black-fronted Dotterel				
Red-kneed Dotterel				
Masked Lapwing	2			2
Godwit/Whimbrel				
Knot				
Small S'pipers				

Table 1E: CVB Data – high tide

Common Name	14/02/03 Dart/Hick	Shores Chann	Rabbit Flat	Sleeper	Thorny/Q uays	Oyster Ch	Wool	Micalo Is	Shallow Ch	Munroe Is	Ulugunda h	Clarence B'Water	Iluka Area	Woody Hd - Iluka Bluff	SE Palmers Is	Kalangad oo
Latham's Snipe																
Black-tailed Godwit							166									
Bar-tailed Godwit	8	68			10		203				4		2			
Little Curlew																
Whimbrel	2	4		4		11	5							1		
Eastern Curlew	9	79		1	11		13	32								
Marsh Sandpiper								1				26				
Common Greenshank		1		3			3	24								
Terek Sandpiper					18											
Common Sandpiper																
Grey-tailed Tattler					30		2									
Wandering Tattler																
Ruddy Turnstone	3												8	18		
Great Knot							269	23								
Red Knot																
Sanderling																
Red-necked Stint														63		
Pectoral Sandpiper																
Sharp-tailed Sandpiper							1									
Curlew Sandpiper								94								
Broad-billed Sandpiper																
Comb-crested Jacana																
Bush Stone-curlew																
Beach Stone-curlew																
Pied Oystercatcher	2						2			2			4			
Sooty Oystercatcher													5	11		
Black-winged Stilt								232	55		8	21				
Red-necked Avocet								119								
Pacific Golden Plover															118	
Grey Plover																
Red-capped Plover																
Double-banded Plover																
Lesser Sand Plover															9	
Greater Sand Plover															13	
Black-fronted Dotterel								6								
Red-kneed Dotterel								2								
Masked Lapwing	2	6		3			4	9								
Godwit/Whimbrel								542								
Knot																
Small S'pipers																

Table 1F: G. Clancy Data – high tide

Common Name	6/02/88		Crystal Waters	Oyster Ch	Joss	3/07/88		Penn-Ariel	11/02/90		Penn-Ariel	Iluka B'Wall
	Dart/Hick	Freeburn				Wool Ent	Freeburn		Dart/Hick	Wool Ent		
Latham's Snipe												
Black-tailed Godwit						8						
Bar-tailed Godwit	400	2		20	220	102	7		39	303	6	2
Little Curlew												
Whimbrel	32	9		5	20				2	30	20	
Eastern Curlew	116				49	3	6		3	45	16	
Marsh Sandpiper											1	
Common Greenshank	1			1	1						2	
Terek Sandpiper			10									
Common Sandpiper												1
Grey-tailed Tattler									12			2
Wandering Tattler												13
Ruddy Turnstone												
Great Knot					153	21			9	18		
Red Knot					3							
Sanderling												
Red-necked Stint	30	1							1			
Pectoral Sandpiper												
Sharp-tailed Sandpiper		3										
Curlew Sandpiper						1						
Broad-billed Sandpiper												
Comb-crested Jacana												
Bush Stone-curlew												
Beach Stone-curlew												
Pied Oystercatcher	4	3			2		2		2	2		
Sooty Oystercatcher												
Black-winged Stilt				7								
Red-necked Avocet												
Pacific Golden Plover												3
Grey Plover	1											
Red-capped Plover	8								6			
Double-banded Plover									26			
Lesser Sand Plover												
Greater Sand Plover												
Black-fronted Dotterel												1
Red-kneed Dotterel												
Masked Lapwing												5
Godwit/Whimbrel				5		2						
Knot												

Table 1G: G. Clancy Data – high tide

Common Name	15/07/90			5/02/91			28/06/91			3/07/92			9/02/93		
	Wool Ent	Dart/Hick	Penn-Ariel	Dart/Hick	Penn-Ariel	Wool Ent	Wool Ent	Penn-Ariel	Dart/Hick	Wool Ent	Penn-Ariel	Dart/Hick	Wool Ent	Penn-Ariel	Dart/Hick
Latham's Snipe													1		
Black-tailed Godwit	9			50	180					10			258		
Bar-tailed Godwit	219	19	30	135	140	13	157	116	20	140	54	34	45	351	
Little Curlew													38		
Whimbrel	3	2	6	35	37	11	7	12	6	1		11		51	
Eastern Curlew	9	4	17	33	80	15	6	17	3	4	26	4	40	85	
Marsh Sandpiper													10		
Common Greenshank						1							10	1	
Terek Sandpiper						4								10	
Common Sandpiper															
Grey-tailed Tattler		5	5		2					14		3		13	
Wandering Tattler															
Ruddy Turnstone												3			
Great Knot				80	12		47			98				150	
Red Knot				28	10		25			8		1		50	
Sanderling															
Red-necked Stint		2		7			4	2		43		1			
Pectoral Sandpiper															
Sharp-tailed Sandpiper													21		
Curlew Sandpiper							3			16					
Broad-billed Sandpiper															
Comb-crested Jacana															
Bush Stone-curlew															
Beach Stone-curlew		2							3			2			
Pied Oystercatcher	1	4	4	7	4			12	4	2	2	5	5	2	4
Sooty Oystercatcher								7							
Black-winged Stilt							348						18		
Red-necked Avocet							4								
Pacific Golden Plover	2	5			3										
Grey Plover															
Red-capped Plover	12	4		3				5		14					
Double-banded Plover		40										1			
Lesser Sand Plover		2		23				2							
Greater Sand Plover															
Black-fronted Dotterel															
Red-kneed Dotterel															
Masked Lapwing	12	4	1	1		2	4			3			4	2	
Godwit/Whimbrel						6							4		
Knot															
Small S'pipers															

Table 1H: G. Clancy Data – high tide

Common Name	7/07/93		Penn-Ariel	14/02/94		Penn-Ariel	Dart/Hick	3/07/94		Diff tide ht Dart/Hick	5/02/95		Penn-Ariel	7/07/95		
	Dart/Hick	Wool Ent		Wool Ent	Penn-Ariel			Wool Ent	Penn-Ariel		Dart/Hick	Wool Ent		Dart/Hick	Penn-Ariel	Dart/Hick
Latham's Snipe					1											
Black-tailed Godwit		22			200						150		8			38
Bar-tailed Godwit	25	88	166	392	33	220	19	64	14	153	140	34	45			281
Little Curlew																
Whimbrel	9	4	6	15		36	13	29	5	10	47	6				3
Eastern Curlew	7	28	54	62	38	73	12	29	6	28	23	59	36	7		4
Marsh Sandpiper				3						1						
Common Greenshank		7		21				1		1						
Terek Sandpiper								2		1			14			
Common Sandpiper																
Grey-tailed Tattler	1	7		14				10					11			
Wandering Tattler																
Ruddy Turnstone														2		
Great Knot	30	31	39	166				28			120	20				75
Red Knot	3			84				30			4					
Sanderling																
Red-necked Stint				104				5			8	22				
Pectoral Sandpiper																
Sharp-tailed Sandpiper				242												
Curlew Sandpiper				3							1					
Broad-billed Sandpiper																
Comb-crested Jacana																
Bush Stone-curlew																
Beach Stone-curlew	2					2			2		2					
Pied Oystercatcher	8	3	2	2		4	2	5	4	2	9	3	6	5		3
Sooty Oystercatcher																
Black-winged Stilt		15		10				30								18
Red-necked Avocet		77														
Pacific Golden Plover				2							9		1			
Grey Plover																
Red-capped Plover				9				1			2					
Double-banded Plover	9		8						6							5
Lesser Sand Plover				60				6			43	16				
Greater Sand Plover											1					
Black-fronted Dotterel																
Red-kneed Dotterel																
Masked Lapwing		4	4	1	3						4		4	2		2
Godwit/Whimbrel								30								
Knot																
Small S'pipers																

Table 11: G. Clancy Data – high tide

Common Name	24/02/97			4/07/97			14/07/98			11/02/99				
	Dart/Hick	Penn-Ariel	Wool Ent	Wool Ent	Penn-Ariel	Dart/Hick key	Dart/Hick ey	Penn to Ariel	Wool Ent	Iluka B'Wall	Dart/Hick	Penn-Sleep	Crystal W	Wool Ent
Latham's Snipe			212	20										152
Black-tailed Godwit			448	171	47	12	63	63	126	1	154	150		138
Bar-tailed Godwit	194													
Little Curlew													22	20
Whimbrel	1	1	14			5	8		1		33	35		
Eastern Curlew	37	30	20	11	16	9	6	32	14		24	80		15
Marsh Sandpiper			6											50+
Common Greenshank			4							2			1	
Terek Sandpiper		7												
Common Sandpiper														
Grey-tailed Tattler		37	27	8						27		36		20+
Wandering Tattler														
Ruddy Turnstone	4									4	3			
Great Knot	1		360	173				31	2	3	276	5		10+
Red Knot							2							
Sanderling														
Red-necked Stint			8								9			
Pectoral Sandpiper														
Sharp-tailed Sandpiper			63											51
Curlew Sandpiper														
Broad-billed Sandpiper														
Comb-crested Jacana														
Bush Stone-curlew						2								
Beach Stone-curlew						6								
Pied Oystercatcher	3		3	2	2	7	2	2	4	2	4			
Sooty Oystercatcher										1				
Black-winged Stilt		2		18										111
Red-necked Avocet				1										8
Pacific Golden Plover			216	1										
Grey Plover														
Red-capped Plover			8											
Double-banded Plover														
Lesser Sand Plover			42								35			
Greater Sand Plover			26								31			
Black-fronted Dotterel														
Red-kneed Dotterel														
Masked Lapwing	2		3							2		1		
Godwit/Whimbrel														
Knot														
Small S'pipers														100

Table 1J: G. Clancy Data – high tide

Common Name	5/07/00			22/02/01			25/06/01			
	Iluka B'Wall	Dart/Hickey	Penn to Ariel	Wool Ent	Dart/Hick	Penn-Ariel	Wool Ent	Wool Ent	Penn-Ariel	Dart/Hick
Latham's Snipe							170			
Black-tailed Godwit							255	52	28	2
Bar-tailed Godwit		20	47	107	86	10				
Little Curlew										
Whimbrel		2		1	2	1	3		5	1
Eastern Curlew			30		27	5	29	5	21	4
Marsh Sandpiper										
Common Greenshank						4				
Terek Sandpiper						13				
Common Sandpiper										
Grey-tailed Tattler				1	6	35	23		14	
Wandering Tattler										
Ruddy Turnstone										
Great Knot				1	1		210	2		
Red Knot										
Sanderling										
Red-necked Stint						2				
Pectoral Sandpiper										
Sharp-tailed Sandpiper							1			
Curlew Sandpiper				1						
Broad-billed Sandpiper										
Comb-crested Jacana										
Bush Stone-curlew										
Beach Stone-curlew										
Pied Oystercatcher		2			2		4		4	3
Sooty Oystercatcher	6									
Black-winged Stilt				53						
Red-necked Avocet										
Pacific Golden Plover							2			
Grey Plover										
Red-capped Plover				3		23			5	
Double-banded Plover									26	
Lesser Sand Plover							12			
Greater Sand Plover							19			
Black-fronted Dotterel										
Red-kneed Dotterel										
Masked Lapwing		1	3	2		1		2	6	
Godwit/Whimbrel										
Knot										
Small S'pipers										

Table 1K: Rohweder Data – high tide

Common Name	25/10/95						26/10/95							
	Dart Island	The Penn	Reedy SM	Yamba Quays	Micalo North	Corokos Is	Joss Island	Dart Island	The Penn	Reedy SM	Yamba Quays	Micalo Prawns	Corokos Island	Joss Island
Latham's Snipe														
Black-tailed Godwit						2	160							140
Bar-tailed Godwit	587				5		380	413	2		140	5		377
Little Curlew														
Whimbrel	1			20	22		4	9	3	2	25	21		3
Eastern Curlew	86	7			26	3	19	4		70	12	9	7	5
Marsh Sandpiper														
Common Greenshank						11	5					1		
Terek Sandpiper				4			1				4			
Common Sandpiper														
Grey-tailed Tattler				32			21	15			33			2
Wandering Tattler														
Ruddy Turnstone	2							1						
Great Knot							103							
Red Knot	5						20	2						
Sanderling														
Red-necked Stint							20							23
Pectoral Sandpiper														
Sharp-tailed Sandpiper							24					3		2
Curlew Sandpiper							1							
Broad-billed Sandpiper														
Comb-crested Jacana														
Bush Stone-curlew														
Beach Stone-curlew											1			
Pied Oystercatcher	6	2			2	2		4	2		2		2	
Sooty Oystercatcher														
Black-winged Stilt												21		
Red-necked Avocet														
Pacific Golden Plover														
Grey Plover														
Red-capped Plover							1							1
Double-banded Plover														
Lesser Sand Plover							17							27
Greater Sand Plover							4							3
Black-fronted Dotterel														
Red-kneed Dotterel														
Masked Lapwing											2	2		
Godwit/Whimbrel														
Knot														256
Small S'pipers														

Table 1L: Rohweder Data – high tide

Common Name	21/11/95				29/02/96				3/03/96							
	Dart Island	The Penn	Reedy SM	Yamba Quays	Oyster Channel	Micalo-prawn	Micalo-nth	Joss Island	Joss Island	Dart Island	The Penn	Yamba Quays	Oyster Channel	Micalo-prawn	Micalo-nth	Joss Island
Latham's Snipe					100				153							161
Black-tailed Godwit																161
Bar-tailed Godwit	390	19	66	189	2	48	6	17	439	80	104	88	10			374
Little Curlew																
Whimbrel				48			1		9	41	4	3	1		3	6
Eastern Curlew	1		48	16	4	7	7	2	17	36	10					17
Marsh Sandpiper														3		
Common Greenshank				1	1	2		7	1			1		19	9	1
Terek Sandpiper				10					1			2				1
Common Sandpiper																
Grey-tailed Tattler	4			30					20			36				38
Wandering Tattler																
Ruddy Turnstone																
Great Knot	148							60	245?							227
Red Knot	1							42	2							
Sanderling																
Red-necked Stint									2							5
Pectoral Sandpiper																
Sharp-tailed Sandpiper								6	6					3		9
Curlew Sandpiper																
Broad-billed Sandpiper																
Comb-crested Jacana																
Bush Stone-curlew	1															
Beach Stone-curlew										2						
Pied Oystercatcher	5			2		2			2	6					2	2
Sooty Oystercatcher																
Black-winged Stilt										3		3				
Red-necked Avocet																
Pacific Golden Plover				3					125					1		88
Grey Plover																
Red-capped Plover									2					2		
Double-banded Plover																1
Lesser Sand Plover									19							43
Greater Sand Plover																2
Black-fronted Dotterel																
Red-kneed Dotterel																
Masked Lapwing	1			2						2		1			4	
Godwit/Whimbrel																
Knot																
Small S'pipers									5							

Table 1M: Rohweder Data – high tide

Common Name	12/03/96								25/07/96				
	Dart Island	The Penn	Yamba Quays	Oyster Channel	Micalo prawns	Micalo - nth	Joss west	Joss east	Dart Island	The Penn	Yamba Quays	Micalo - nth	Joss Island
Latham's Snipe								141					
Black-tailed Godwit								330	25				190
Bar-tailed Godwit	101	150		115	1	5	39						
Little Curlew													
Whimbrel	16	25	1	17	6	10	2	7	4			2	5
Eastern Curlew	12	55			5	4	12	16	26			1	10
Marsh Sandpiper													
Common Greenshank	1				1	6	4	3					
Terek Sandpiper			9	5									
Common Sandpiper													
Grey-tailed Tattler			20	6			6	30	1		7		
Wandering Tattler													
Ruddy Turnstone													
Great Knot	1						28	242					6
Red Knot	2												
Sanderling													
Red-necked Stint	6						1	5					1
Pectoral Sandpiper													
Sharp-tailed Sandpiper							12	3					
Curlew Sandpiper								6					11
Broad-billed Sandpiper													
Comb-crested Jacana													
Bush Stone-curlew									2				
Beach Stone-curlew	2												
Pied Oystercatcher	4	2	2			2	2	2	2	2	2	2	4
Sooty Oystercatcher													
Black-winged Stilt								3				4	72
Red-necked Avocet													
Pacific Golden Plover							90						
Grey Plover													
Red-capped Plover							18						7
Double-banded Plover		13					3	1					2
Lesser Sand Plover	55	2						31					
Greater Sand Plover	7							11					
Black-fronted Dotterel													
Red-kneed Dotterel													
Masked Lapwing													
Godwit/Whimbrel													
Knot													
Small S'pipers													

Table 1N: Clancy (1992) data – high tide

Common Name	28.6.91			18.7.91			28.9.91			17.12.91			27.2.92		
	Dart Island	Rabbit Island	Joss Is	Dart Island	Rabbit Island	Joss Is	Dart Island	Rabbit Island	Joss Is	Dart Island	Rabbit Island	Joss Is	Dart Island	Rabbit Island	Joss Is
Latham's Snipe					NS	NS								NS	NS
Black-tailed Godwit					NS	NS				92	10	15		NS	NS
Bar-tailed Godwit	20	116	157	151	NS	NS	126	1	10	94	264	110	240	NS	NS
Little Curlew					NS	NS								NS	NS
Whimbrel	6	12	7		NS	NS	15		6	43	5	33	21	NS	NS
Eastern Curlew	3	17	6	35	NS	NS	81		37	21	75	22	16	NS	NS
Marsh Sandpiper					NS	NS								NS	NS
Common Greenshank					NS	NS			4			1		NS	NS
Terek Sandpiper					NS	NS				3		1		NS	NS
Common Sandpiper					NS	NS								NS	NS
Grey-tailed Tattler				8	NS	NS	5			25	4	2	1	NS	NS
Wandering Tattler					NS	NS								NS	NS
Ruddy Turnstone					NS	NS	3						2	NS	NS
Great Knot			47	42	NS	NS	24			34	3	43		NS	NS
Red Knot			25	29	NS	NS				10	5		9	NS	NS
Sanderling			4		NS	NS								NS	NS
Red-necked Stint					NS	NS	18			75		40	74	NS	NS
Pectoral Sandpiper					NS	NS								NS	NS
Sharp-tailed Sandpiper					NS	NS						32		NS	NS
Curlew Sandpiper			3		NS	NS				3		25	1	NS	NS
Broad-billed Sandpiper					NS	NS								NS	NS
Comb-crested Jacana					NS	NS								NS	NS
Bush Stone-curlew					NS	NS								NS	NS
Beach Stone-curlew	3			2	NS	NS	1						2	NS	NS
Pied Oystercatcher	4	12		2	NS	NS	8	6	2	4			5	NS	NS
Sooty Oystercatcher		7			NS	NS					1		1	NS	NS
Black-winged Stilt			348		NS	NS						18		NS	NS
Red-necked Avocet			4		NS	NS								NS	NS
Pacific Golden Plover					NS	NS	10		10	1			6	NS	NS
Grey Plover					NS	NS								NS	NS
Red-capped Plover		5			NS	NS	1			2			9	NS	NS
Double-banded Plover					NS	NS								NS	NS
Lesser Sand Plover		2			NS	NS				3			90	NS	NS
Greater Sand Plover					NS	NS	1							NS	NS
Black-fronted Dotterel					NS	NS								NS	NS
Red-kneed Dotterel					NS	NS								NS	NS
Masked Lapwing			4		NS	NS			3			3	2	NS	NS
Unidentified					NS	NS	8					16		NS	NS

Table 10: CVB data – high tide

CVB 23/2/04 Common Name	Dart/ Hickey	The Penn.	Rabbit Is	Sleeper Is	Thorny Is Yamba Quays	Oyster Channel	Wool. Mouth
Latham's Snipe							
Black-tailed Godwit	1						181
Bar-tailed Godwit	80	34		36			126
Little Curlew				2			4
Whimbrel				2			4
Eastern Curlew	23	2		1		2	51
Marsh Sandpiper							
Common Greenshank				5		1	
Terek Sandpiper					16		
Common Sandpiper							
Grey-tailed Tattler					24		1
Wandering Tattler							
Ruddy Turnstone							
Great Knot	5	22					43
Red Knot							1
Sanderling							
Red-necked Stint							
Pectoral Sandpiper							
Sharp-tailed Sandpiper							6
Curlew Sandpiper							
Broad-billed Sandpiper							
Comb-crested Jacana							
Bush Stone-curlew							
Beach Stone-curlew							
Pied Oystercatcher	2						2
Sooty Oystercatcher							
Black-winged Stilt							
Red-necked Avocet							
Pacific Golden Plover							86
Grey Plover							
Red-capped Plover					7		
Double-banded Plover					2		
Lesser Sand Plover							
Greater Sand Plover							
Black-fronted Dotterel							
Red-kneed Dotterel							
Masked Lapwing		5			5	12	

Table 1P: Martindale data – high tide

Common Name	9/02/86		17/06/86			24/01/87	22/06/87	
	Freeburn	Dart Is	Joss/Wool	Freeburn	Dart/Hick	Dart	Freeburn	Dart
MARTINDALE TIDE	1	1	1	1	1	1	1	1
Latham's Snipe								
Black-tailed Godwit								
Bar-tailed Godwit	127	291	57	17	29	250		80
Little Curlew								
Whimbrel	47	61			2	26		
Eastern Curlew		14	11		21	45	10	20
Marsh Sandpiper								
Common Greenshank						5	1	
Terek Sandpiper						7		
Common Sandpiper								
Grey-tailed Tattler	26	11	18		17	17	7	
Wandering Tattler								
Ruddy Turnstone						14		
Great Knot								
Red Knot		7				8		
Sanderling								
Red-necked Stint		21	3			200		
Pectoral Sandpiper								
Sharp-tailed Sandpiper						10		
Curlew Sandpiper		37				120		
Broad-billed Sandpiper								
Comb-crested Jacana								
Bush Stone-curlew								
Beach Stone-curlew		1				1		
Pied Oystercatcher		11			11	26		8
Sooty Oystercatcher					7	4		
Black-winged Stilt								
Red-necked Avocet					7			
Pacific Golden Plover						30		
Grey Plover		21						
Red-capped Plover		21				37		30
Double-banded Plover			13		30			30
Lesser Sand Plover		115				180		
Greater Sand Plover		1				70		
Black-fronted Dotterel								
Red-kneed Dotterel								
Masked Lapwing								
Unidentified								
Sandplover								
Knot								
Small S'pipers								
Plover sp								

Table 1Q: Martindale (1984) data – high tide

Common Name	30/3-12/4/84																	
MARTINDALE	Woram Channel	Narrabarr Island	Goodwood East	Bolorobo Island	Goodwood-Collis B'Water	Freeburn East	Iluka B'Water	Crystal Waters	Hickey (Dredge)	Dart Island	Goodwood Sth	Micalo - nth	Joss East	Joss west	Palmers SE	Lawrence ls	Shark Bay	Elsewhere
Latham's Snipe																		
Black-tailed Godwit													80					
Bar-tailed Godwit	1	35		6		140		120	1	327			140	50			15	40
Little Curlew																		
Whimbrel	1	4				30		6		70								
Eastern Curlew		1		1				30		50			4	4				
Marsh Sandpiper																		
Common Greenshank	22		1	25		4	2		7									
Terek Sandpiper				5	1													24
Common Sandpiper																		
Grey-tailed Tattler		12		12	9	41			47	51			33					
Wandering Tattler																		1
Ruddy Turnstone		4		1	2		1	1	2	4	8							30
Great Knot													10					
Red Knot		9								10			6					
Sanderling																		
Red-necked Stint		7						20		40			40	30				32
Pectoral Sandpiper																		
Sharp-tailed Sandpiper													15					
Curlew Sandpiper										20			25	10				
Broad-billed Sandpiper																		
Comb-crested Jacana																		
Bush Stone-curlew																		
Beach Stone-curlew										2								
Pied Oystercatcher							3			4								17
Sooty Oystercatcher							2											4
Black-winged Stilt																		
Red-necked Avocet																		
Pacific Golden Plover		19						3		22			24	30		41		
Grey Plover										1								
Red-capped Plover								10		20			26				8	10
Double-banded Plover																		
Lesser Sand Plover		2						4		117			57	70		7	8	
Greater Sand Plover										3								
Black-fronted Dotterel																		2
Red-kneed Dotterel																		
Masked Lapwing												2				4		10
Unidentified Sandplover																		
Knot																		

Table 1P: Lawler (1994a) data – high tide

Common Name	24-25/2/95															
	Dart Island	Hickey Island	The Penn	Middle Wall	Rabbit Island	Freeburn (sth)	Palmers NE Pt	Palmers (Romiakach)	Ungundam Is (Romiaka)	Micalo-nth	Corokos Island	Joss Island	Iluka B'Water	Goodwood East	Eureka Island	Narrabarr. Island
Latham's Snipe																
Black-tailed Godwit												13				
Bar-tailed Godwit	132	13					38	14		25	26	50	8	1		75
Little Curlew																
Whimbrel	60				2	5	1		4	20				1		12
Eastern Curlew	32		2				1			3	12	1	1		8	
Marsh Sandpiper																
Common Greenshank							2	14		3				1	3	1
Terek Sandpiper																
Common Sandpiper																
Grey-tailed Tattler		30						4					57			
Wandering Tattler																
Ruddy Turnstone				3									5			
Great Knot																
Red Knot																
Sanderling																
Red-necked Stint	18															
Pectoral Sandpiper																
Sharp-tailed Sandpiper																
Curlew Sandpiper																
Broad-billed Sandpiper																
Comb-crested Jacana																
Bush Stone-curlew																
Beach Stone-curlew																
Pied Oystercatcher																
Sooty Oystercatcher																
Black-winged Stilt																
Red-necked Avocet																
Pacific Golden Plover																
Grey Plover																
Red-capped Plover																
Double-banded Plover																
Lesser Sand Plover																
Greater Sand Plover																
Black-fronted Dotterel																
Red-kneed Dotterel																
Masked Lapwing																
Unidentified																
Sandplover	84															
Knot	215															

Table 1R: Clancy (2002) data – high tide

SITE	Latham's Snipe	Black-tailed Godwit	Bar-tailed Godwit	Whimbrel	Eastern Curlew	Marsh Sandpiper	Common Greenshank	Terek Sandpiper	Common Sandpiper	Grey-tailed Tattler
Back Beach to Shark Bay				1						
Iluka Beach-Frazers Reef			9	1						1
Iluka Breakwater-Esk River				40	3		1	5		52
Dart Island		4	147	44	100	1				17
Wooloweyah Lagoon		100	142	12	21		1			4
Thorny Island			70	26	39			13	2	30
Romiaka Island					3		3			
Micalo Island					2	51	21			
Munro Island to Maclean Lawrence (egret colony)	1			1						
Kalangadoo (The Broadwater)										

SITE	Ruddy Turnstone	Great Knot	Red-necked Stint	Sharp-tailed Sandpiper	Beach Stone-curlew	Pied Oystercatcher	Sooty Oystercatcher	Black-winged Stilt	Pacific Golden Plover	Double-banded Plover
Back Beach to Shark Bay	13		16			4	1			1
Iluka Beach-Frazers Reef							18			
Iluka Breakwater-Esk River	10					6	1			
Dart Island	6				2	8			24	
Wooloweyah Lagoon		187	6	28		2			26	
Thorny Island										
Romiaka Island				23				21	20	
Micalo Island			7	457				334	2	
Munro Island to Maclean Lawrence (egret colony)						4		1		
Kalangadoo (The Broadwater)								10		
								80		

SITE	Lesser Sand Plover	Greater Sand Plover	Black-fronted Dotterel	Red-kneed Dotterel	Masked Lapwing	unidentified wader	Gull-billed Tern	Caspian Tern	Common Tern	Little Tern
Back Beach to Shark Bay	7	2			2					
Iluka Beach-Frazers Reef							2		2	3
Iluka Breakwater-Esk River					9		2			6
Dart Island					4		3	2		66
Wooloweyah Lagoon	34	15			9					22
Thorny Island					17			3		5
Romiaka Island					24					
Micalo Island			1		9					
Munro Island to Maclean Lawrence (egret colony)			5	1	14		1	21	1	
Kalangadoo (The Broadwater)					8					
					9	6				

Table 1S: Various low tide surveys

Common Name	10/3-12/4/84					Martindale				H. Doughty	27/11/93	22/05/94	9/04/95	26/12/95
	Martindale Wool Ent	Dart Is - Oyster Ch Bridge	Nth Arm - S'water inlet	Esk Mouth	Munroe Island	9/02/86 Wool Ent	24/01/87 Wool Ent	24/01/87 Freeburn	22/06/87 Wool Ent	30/10/94 Freeburn Is Flats	Doughty Shallow Channel	Doughty The Penn	Tarrant Dart Island	Tarrant Dart Island
Latham's Snipe														
Black-tailed Godwit	81					7	21							
Bar-tailed Godwit	192	460	145	36		137	600	100	140	40		22	58	45
Little Curlew														
Whimbrel	7	73	29	5			80	15		40		26		17
Eastern Curlew	7	85				10	52	30	15	18		8	26	37
Marsh Sandpiper							7							
Common Greenshank		12	35	20			30	12		20			13	2
Terek Sandpiper			6				10	7						
Common Sandpiper								2						
Grey-tailed Tattler	30	97	52	10		38	40	100			12		32	
Wandering Tattler														
Ruddy Turnstone		12	12	5			4	23					2	12
Great Knot	7					6	3							
Red Knot	7	12		10		11	90							8
Sanderling														
Red-necked Stint	67	60		5		37	200	70						12
Pectoral Sandpiper														
Sharp-tailed Sandpiper	15					4	200							
Curlew Sandpiper	37	24				20	70							
Broad-billed Sandpiper														
Comb-crested Jacana														
Bush Stone-curlew														
Beach Stone-curlew										2		1	3	2
Pied Oystercatcher		12						1		4		2	2	2
Sooty Oystercatcher														
Black-winged Stilt							30							
Red-necked Avocet														
Pacific Golden Plover	52	24			41	20	90	60						
Grey Plover							2							
Red-capped Plover	30	36					18	2					3	
Double-banded Plover									15					
Lesser Sand Plover	126	121			7		100	10					46	
Greater Sand Plover														
Black-fronted Dotterel														
Red-kneed Dotterel						61								
Masked Lapwing					4		21		4			2	2	1
Godwit/Whimbrel														
Knot														
Small S'pipers														

Table 1T: Rohweder data – low tide

Common Name	25/10/95													26/10/95												
	Dart Island	Rabbit Sandflat	Crystal Waters	Thorny Island	Araiel Island	Oyster Ch Bridge-nth	Oyster Ch Bridge-sth	Oyster Channel - ramp	Ramp flat	Corokos Island	Mid Channel	Joss Is East	Joss Is South	Dart Island	Rabbit Sandflat	Crystal Waters	Thorny Island	Araiel Island	Oyster Ch Bridge-nth	Oyster Ch Bridge-sth	Oyster Channel - ramp	Ramp flat	Coroko s Island	Mid Channel	Joss Is East	Joss Is South
Latham's Snipe																										
Black-tailed Godwit									11		150									159		4				
Bar-tailed Godwit	48	42	99	34	49	25	20	12	8	65	6	133	48	49	29	89	43	36	2	17	24		31		25	29
Little Curlew																										
Whimbrel	6	3	14	15	7	4	6	16	3	1		3	6	5	3	6	8	3	1	5	8		2		4	9
Eastern Curlew	12	9	6	11	9	3	9	2	1	1	4	4	9	13	9	6	9	2	3	5	10		2	3	5	8
Marsh Sandpiper																										
Common Greenshank			1		11		2		1	1			17					6	1	3	1					3
Terek Sandpiper				2																						
Common Sandpiper																										
Grey-tailed Tattler	3		2	4	16							7	3	9	3	2	1	8								
Wandering Tattler																										
Ruddy Turnstone																										
Great Knot										72	45	54		20				16		1	24		30	1		
Red Knot		4		1						49	2	141											4		75	10
Sanderling																										
Red-necked Stint										3	1	22	7											1		1
Pectoral Sandpiper																										
Sharp-tailed Sandpiper										2	1	7	2												2	
Curlew Sandpiper												3	3												6	
Broad-billed Sandpiper																										
Comb-crested Jacana																										
Bush Stone-curlew																										
Beach Stone-curlew	1																									
Pied Oystercatcher	3		2				3	1	1	2											4		2			
Sooty Oystercatcher																										
Black-winged Stilt													1													
Red-necked Avocet																										
Pacific Golden Plover														2											5	11
Grey Plover	1																									
Red-capped Plover															1	6										
Double-banded Plover																										
Lesser Sand Plover			1								2	23	2	10	9								1	1		
Greater Sand Plover												2			9											
Black-fronted Dotterel															9											
Red-kneed Dotterel																										
Masked Lapwing																										
Godwit/Whimbrel																										
Knot																										
Small S'pipers																										

Table 1V: NRAC data – low tide

Common Name	20/10/94	Nth Side Goodwood Is	Narabibbi Island	Saltwater Inlet - Nihill Island	Nth Arm between ramps	Iluks B' wall flats	Dart Island	Upper Hickey Island	Lower Hickey Island	NE Freeburn Island	Freeburn Island	Rabbit Sandflat	Crystal Waters	Thorny Island	Araiel Island-Whyna Is	Romiaka Island - sth bridge	Oyster Ch west side	Periko Island	Oyster Channel - East Side	Micalo Is - sth channel	Corokos Island	Joss Is East	
Latham's Snipe																							
Black-tailed Godwit																					42	14	
Bar-tailed Godwit	18		31	26			27	20		16	48	20	20	15	28	6	23	28	8		38	76	
Little Curlew																							
Whimbrel	2		5	2		2	12	6			6	8	2	8	2	1	16	5	3				
Eastern Curlew	1		10	5		1	13	3		2	8	3	2	11	9	1	16	6	5		1	8	
Marsh Sandpiper				1									2				3	2					
Common Greenshank	2		11	1							4		1		1	1	2	2	1	2		4	1
Terek Sandpiper				3			1	1			1				2								
Common Sandpiper																							
Grey-tailed Tattler	5		16	4				2		1	4			5	11						3	2	
Wandering Tattler																							
Ruddy Turnstone																							
Great Knot	1							29						2					13		13		
Red Knot																			39		23		
Sanderling																							
Red-necked Stint							1														13	49	
Pectoral Sandpiper																							
Sharp-tailed Sandpiper			12					6									66	2		25		105	
Curlew Sandpiper													1				2						
Broad-billed Sandpiper																	2						
Comb-crested Jacana																							
Bush Stone-curlew																							
Beach Stone-curlew							1																
Pied Oystercatcher							4														2		
Sooty Oystercatcher																							
Black-winged Stilt	5										4				6				1				
Red-necked Avocet															34								
Pacific Golden Plover							9	3	12												4	8	
Grey Plover																							
Red-capped Plover																							
Double-banded Plover																							
Lesser Sand Plover							1	1													6	24	
Greater Sand Plover					5			8															
Black-fronted Dotterel																							
Red-kneed Dotterel																							
Masked Lapwing	2				3												2			2			
Godwit/Whimbrel																							
Knot																							
Small S'pipers																							

Table 1W: NRAC data – low tide

Common Name	25/10/94																								
	Nth Side Goodwo od Is	Narabbi bbi Island	Saltwater r Inlet - Nihill Island	North Arm - west side	Nth Arm between ramps	Iluks B' wall flats	Dart Island	Upper Hickey Island	Lower Hickey Island	Yards Flat	Freeburn Island	Rabbit Sandflat	Crystal Waters	Thorny Island	Araiel Island- Whyna Is	Romiaka lchannel	Oyster Ch west side	Micalo Is Sthh Channel	Nth Joss Chan nel	Prawn Farm Lagoon	Oyster Channel - East Side	Channel NE Prawn Farm	Corokos Island	Joss Is	Palms Is S
Latham's Snipe																									
Black-tailed Godwit																							6	143	
Bar-tailed Godwit					11		40	5	11	25	27	13	11	21	45	9	26		6		26		74	229	15
Little Curlew																									
Whimbrel			4	2			10	3	2	4	13	4	2	6	15	8	10		3		10		4	5	
Eastern Curlew		7	2		2		13	2	2	13	11	6	3	12	27	11	11		4	3	9		4	3	1
Marsh Sandpiper																	2	35		66	2		1	7	3
Common Greenshank			3	2	1	1				2	4	1			8	4	7		2		7		4	22	3
Terek Sandpiper															8				2					7	
Common Sandpiper					1										1										
Grey-tailed Tattler				3	2	1	5	1	2	12	6	2		1	15	2	1		1		1		12	5	
Wandering Tattler																									
Ruddy Turnstone																									
Great Knot																	10				10		46	203	
Red Knot																							24	4	
Sanderling																									
Red-necked Stint																		4						14	2
Pectoral Sandpiper																									
Sharp-tailed Sandpiper				5	3					5	2							200	1	205			236	353	61
Curlew Sandpiper																		3					17	56	110
Broad-billed Sandpiper																								2	
Comb-crested Jacana																									
Bush Stone-curlew																									
Beach Stone-curlew																									
Pied Oystercatcher						3	2	2				2		2			7		1		7		1	1	
Sooty Oystercatcher																									
Black-winged Stilt										1	4				1	1	5	32		101	5		5	14	13
Red-necked Avocet																		33		23					
Pacific Golden Plover						1	14	3															5	41	15
Grey Plover																									
Red-capped Plover																									
Double-banded Plover																							1	1	2
Lesser Sand Plover										5														63	
Greater Sand Plover																									
Black-fronted Dotterel																									
Red-kneed Dotterel																		4							
Masked Lapwing						2										2	2	2			1				2
Godwit/Whimbrel																									
Knot																									
Small S'pipers																									

APPENDIX TWO

**DRAFT CRITERIA FOR HABITAT PRIORITISATION
AND RESULTS OF ROOST ASSESSMENT**

Table 2a: Draft attributes to prioritise estuarine bird habitat in the Clarence River Estuary.

Attribute	Method of Assessment
Number of Species	Score of 0.1 for each species recorded at a site over the period of the survey.
Number of migratory species	Score of 0.1 for each migratory species recorded at a site over the period of the survey. Migratory species are those listed under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
Threatened Species listed on the <i>Threatened Species Conservation Act 1995</i> and/or the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .	Score of 2 points for each Threatened Species recorded at a site over the period of the survey.
Breeding Records	Score of 1 point for each species recorded breeding at a site over the period of the survey.
Function	Utility of roosts – Score of 1 for neap tide roost; 3 for low spring tide roost; 5 for spring tide roost. Utility of feeding grounds – Score of 1 for a predominantly spring tide feeding ground and 2 for a spring and neap tide feeding ground.
Frequency of Occurrence of species listed on the <i>Threatened Species Conservation Act 1995</i> and/or the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .	Score of 0.1 for each time (survey) that a threatened species was recorded at a site over the period of the survey.
Importance to the local shorebird population.	Score of 1 for every 10% of the total shorebird population present at a site.
Importance to the local population of each species.	Score of 1 for every 10% of the total population of each species present at a site.

Table 2b: Name, location and general description of 26 high tide roosts in the lower Clarence Estuary.

Site Name	Australian Map Grid Reference		Location Description	Roost Description
	Easting	Northing		
Hickey Is	533943	6744324	Western end of hickey island	Small area of exposed sand with areas of dense grass, small raised knoll on nth side
Prawn Farm	530956	6740804	3rd prawn farm pond from east	Large area of saltmarsh in disused prawn farm - assessed only nth half of pond 3
Joss Is west	532173	6739838	South end of Joss Is	Narrow sandbars that extend south from Mangrove Islands
Palmers SE	530355	6738353	SE corner of Palmers Is @ entrance to canal	Saltmarsh
Joss Is east	532599	6739981	Flats east of Joss Island	Several nth/sth sand bars separated by narrow channels
Yamba Quays	530841	6744861	Sth side, first bend as enter canal, extending from rocks	Sandy & rocky shore along edge of canal estate, on south side - yet to be developed.
Micalo Nth	531118	6741825	East side of drain leading into prawn farm	Bare earth on bank verging into saltmarsh to east - open view but numerous mangroves present along drain.
Corokos Is	532395	6740491	Stouthern sandbar on Corokos Is	East-west sandbars extending from Corokos Island
The Peninsula	532911	6745340	Island with bar connected to ML by shallow channel @ LW, long fromntal bar on north side where birds roost, fronts oyster channel	Sandbar fronting oyster channel
Rabbit Island	532414	6745668	Highest point on sth side of foraging area	sandbar on sth side of sand flat adjacent to oyster channel
Reedy Creek SM	532108	6745543	Saltmarsh situated to the west of the Yamba Shores Tavern	Large expanse of saltmarsh adjacent to Reedy Creek
Iluka Marina (breakwall)	533375	6747350	Northern end of Iluka Breakwall	Rock wall
Narrarabibbi Is	532228	6750222	SW corner of Narrarabibbi Is	No roost habitat present; small spit covered with water and mangrove seedlings during neap high tide; site not explored further
Eureka Is			SE corner of Eureka Is no obvious roosting habitat; site not explored further	No obvious roosting habitat; site not explored further
Woram Channel			Channel between mainland & Narrarabibbi Is	No sandbars but some mangroves with open traunks, branches and canopy, possible whimbrels.
Bolorobo Is nth	533313	6749564	Nth end of island that is north of Bolorobo Island	small spit of sand on nth end of small mangrove island
Goodwood/Collis	533034	6748423	SE corner of Goodwood Is	Narrow fringe of sand around se corner of Goodwood Is, with mature mangroves on east side.
Esk Mouth			No obvious roost site in the vicinity of the Esk River Mouth.	Thick band of seedling mangroves around point at entrance to river - no potential roosting habitat.
Dart Island	533595	6744525	Western edge of sandbar adjacent to spinefex	Upper part of sandbar that extends of sand island
Freeburn Is nth	532683	6747484	Sandy shoreline along nth side of Freeburn Island	Sandy shoreline
Goodwood Sth	532527	6748845	Saltmarsh on sth side of Goodwood Island - 200m east of house near mangrove inlet	Saltmarsh
Thorny Island	530665	6745287	Sandbars on east side of Thorny Island - 2 neap roosts	Two sandbars, one adjacent to mangrove island the other along Oyster Channel
Woody Head	536289	6751612	Adjacent to main camping area; rocky shore with sandbar. Sampled area immediately adj to camp ground not all of rocky shore	Rocky shore with sandbank
Back Beach	536171	6750877	Area adjacent to rocks	Sandy beach adjacent to sth end of rocky shore
Palmers NE			Gap in mature mangroves on NE corner of Palmers Is	shoreline/saltmarsh edge between mature mangroves that line the shoreline. Site does not appear suitable

Table 2c: Summary of the major features of 26 roosts sampled in the lower Clarence Estuary.

Site Name	Tenure	Zone	Dominant Land use	Roosting Habitat	Roost Type	Roost Origin	Connected to Land	Landform	Area of habitat		Dominant Substratum Type
									SHW M ²	NHW M ²	
Eureka Is	CR-adj	8(a)/1(w)	cons	absent	neap/ stage	natural	no	Bar/spit	nr	nr	nr
Narrarabibbi Is	CR-adj	8(a)/1(w)	cons	absent	neap/ stage	natural	no	Bar/spit	nr	nr	nr
Woram Channel	CR-adj	8(a)/1(w)	cons	Poss mangrove	spring	natural	no	Mangro.	nr	nr	nr
Bolorobo Is nth	Crown	7(a)/1(w)	rec/cons	present	neap/ stage	natural	no	Bar/spit	nil	180	sand
Goodwood/Collis	FH	1(b)/1(w)	grazing	present	neap	natural	yes	mang fringe	nil	390	sand
Goodwood Sth	FH	7(a)	grazing	present	spring tide	natural	yes	saltmarsh	5000	5000	saltmarsh
Iluka Marina (breakwall)	Crown	1(w)	maritime	present	spring tide	constructed	yes	rock groin	200	300	rock
Freeburn Is nth	FH	7(a)	grazing/ rec	present	neap	natural	no	Bar/spit	80	300	sand/sm
Dart Island	Crown	7(a)/1(w)	rec/cons	present	spring tide	natural	low-tide only	Bar/spit	450	2500	sand
Hickey Is	Crown	7(a)/1(w)	rec/cons	present	spring tide	natural	yes	Bar/spit	200	300	sand
The Peninsula	Crown	7(a)	rec/cons	present	spring tide	natural	low-tide only	Bar/spit r	250	800	muddy sand
Rabbit Island	Crown	7(a)/1(w)	rec/cons	present	neap/ stage	natural	no	Bar/spit	nil	25	muddy sand
Reedy Creek SM	CR	8(a)	cons	present	spring tide	natural	yes	saltmarsh	7500	7500	saltmarsh
Sleeper Is/Palmers Is	FH	7(a)	grazing	present	neap/ stage	natural	no	Saltmarsh /shore	nr	nr	sand
Yamba Quays	FH	Unknown	urban	present	spring tide	constructed	yes	Bar/spit	100	200	sand
Micalo Nth	FH	1(b)	grazing	present	spring tide	both	yes	saltmarsh	4180	4240	sandymud/ saltmarsh
Corokos Is	Crown	7(a)/1w)	cons/rec	present	neap tide	natural	low-tide only	Bar/spit	160	250	muddy sand
Joss Is east	Crown	7(a)/1w)	cons/rec	present	spring tide	natural	no	Bar/spit	150	2500	sandy mud
Joss Is west	Crown	7(a)/1w)	cons/rec	present	spring tide	natural	no	Bar/spit	100	1000	sandy mud
Palmers SE	FH	7(a)	grazing	present	spring tide	natural	yes	saltmarsh	10 000	10 000	saltmarsh
Prawn Farm	FH, CR-adj	1(b)	Aquacult.	present	spring tide	constructed	yes	saltmarsh	5000	5000	saltmarsh
Woody Head	CR	8(a)/7(c)	Cons/rec	present	spring tide	natural	yes	rocky shore/ beach	1200	4000	rock/sand
Back Beach	CR	8(a)/7(c)	Cons/rec	present	spring tide	natural	yes	ocean beach	2000	4000	sand

Table 2d: Summary of the major features of 26 roosts sampled in the lower Clarence Estuary.

Site Name	Prox roosts	Erosion	Mangroves				% cover of seedlings	Area covered by seedlings	Affect roost quality	
			Pres/Abs	Distance	Area covered	Height				Species
Eureka Is	2	nr	on-site	nr	nr	nr	nr	nr	nr	
Narrarabibbi Is	2	nr	on-site	nr	nr	nr	nr	nr	nr	
Woram Channel	1	nr	on-site	nr	nr	nr	nr	nr	nr	
Bolorobo Is nth	1	absent	on-site	N/A	150m2	0.5-2m	Av. Mar	20%	40m2	yes
Goodwood/Collis	2	present (mod)	on-site	N/A	300m2	0.5-3m	Av. Mar; Ag	50%	300m2	yes
Goodwood Sth	1	present (mod)	on-site	N/A	500m2	0.5-3m	Ag, av	8%	400m2	yes
Iluka Marina (breakwall)	2	absent	nil	20m	N/A	N/A	N/A	N/A	N/A	N/A
Freeburn Is nth	1	absent	on-site (no encorachment)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dart Island	3	absent	on-site	N/A	250m2	<0.5m	Av. Mar	10%	250m2	yes
Hickey Is	2	absent	on-site	N/A	<1%	0.3m	Av. Mar	<1%	<1m2	no
The Peninsula	4	absent	on-site	N/A	200m2	0.5-2m	Av. Mar	10%	200m2	Yes - in long term
Rabbit Island	3	absent	nil	100m	N/A	N/A	N/A	N/A	N/A	N/A
Reedy Creek SM	3	present (mod bank)	nil	edge of sm	N/A	N/A	N/A	N/A	N/A	N/A
Sleeper Is/Palmers Is	1	absent	pres	N/A	nr	nr	nr	nr	nr	nr
Yamba Quays	2	absent	nil	400m	N/A	N/A	N/A	N/A	N/A	N/A
Micalo Nth	1	historic al-dredging	on-site	N/A	650m2	1.5m	Av. Mar;	25%	650m2	yes - limited by grazing
Corokos Is	2	absent	on-site	N/A	150m2	0.5m	Av. Mar	<5%	150m2	yes - reduce visibility to north
Joss Is east	2	absent	on-site	N/A	500m2	0.5-1m	Av. Mar	2%	500m2	yes in long term
Joss Is west	1	absent	on-site	N/A	50%	<1m	Av. mar	<1%	50%	yes in long term
Palmers SE	0	present (mod bank)	on-site	N/A	1ha	<0.5m	Av. Mar.	1%	1ha	yes in long term
Prawn Farm	1	absent	on-site	N/A	200m2	<1m	Av. Mar	<1%	200m2	yes
Woody Head	1	absent	nil	unknown	N/A	N/A	N/A	N/A	N/A	N/A
Back Beach	1	absent	nil	unknown	N/A	N/A	N/A	N/A	N/A	N/A

APPENDIX THREE THREAT ASSESSMENT

Table 3a: Assessment of potential threats affecting shorebird roosts in the Clarence Estuary.

Category	Type	Bol Is	G'wo od east	G'wo od/C ollis	G'wo od sth	Iluka B'Wa ll	F'bur n Nth	Middl e Wall	Dart Islan d	Hick ey Is	The Penn	Rabb Is - sand	Rabb Is - nest	Reed y Ck sm	Slee per Is	Cryst al Wate rs	Yam ba Quay s	Rom. Chan	Mical o Nort h	Praw n Farm	Cor Islan d	Joss Islan d	Palm Is SE	Ugu. Is	Clar B'wa ter	Mun Is	Kal'd oo	Shar k Bay	Back Beac h	Woo dy Head		
Loss	Erosion	1	5	10	10		1					1		10	5							10						1		1		
	Areas being developed - foreshore															1	20															
	Areas proposed for development																			20	1	1										
	Aquaculture								1	1									1	10												
	Sub-Total	1	5	10	10	0	1	0	1	1	1	1	10	5	1	20	6	30	1	1	10						1		1			
Modification	Mangrove	10	10	10	5		1		10	5	10							10	10	10	10	10										
	Encroachment																															
	Grazing		10	10	10		10							10				1	10						5		10					
	Street lighting			1		1			1	1	1	1		1		1	5															
	Altered drainage/drains					5								1		10	5	10	10	1			1		5							
	Shoreline stabilisation	1		1		5	5		1	1	1	1		5	1	5	10	5					1						1	5		
	Training Wall/Groin		1	5	1	10	1	10	1	1	1	1	1																			
	Weeds												10																			
	Canal Estate													1	1	10	10															
	Dredging operations																															
	Sub-Total	11	21	27	16	21	17	10	13	8	13	3	11	7	13	16	35	11	30	20	11	10	12	0	10	0	10	0	1	5		
Disturbance	Commercial fishing site	5	1	10	1	5	1	1	5	5	5	5	1	1	5	5	5	5	5	1	5	5	1	10	1	10		5	1	1		
	Popular rec fishing site	1	1	1	1	5	10	5	10	5	10	10	5	1	5	5	5	5	5	1	1	1	1	5	5	5		10	5	10		
	Bait collecting site			1			10	1	10	5	10	10	1		1	5	1															
	Dog Exercise area	1						1	1	10	10					1	5															
	Walking/swimming area	1	1	1		5	1	1	10	10	10	1		1		1	1										10	10	10			
	Sailing boat route			1	1	1	1	1																								
	Jetski/waterski/Kite surf							1	1	1																						
	Main boating channel	5	1	5	5	5	5	5	5	5	5	5	1	1	5	5	5		5	1	1	1	5									
	4WD vehicles							1			10																					
	Major road					1			1	1						1	1															
	Sub-Total	13	4	19	8	22	28	17	43	52	50	31	8	4	16	23	23	10	15	3	7	7	7	15	6	15	0	30	16	21		
Predation	Introduced pests (predicted)		5	5	5	5		1	5	5	5			5	5			5	5	5	5	5	5	5	5	5	5	5	5	5		

Table 3a: cont.

Category	Type	Bol Is	G'wo od east	G'wo od/C ollis	G'wo od sth	Iluka B'Wa ll	F'bur nNth	Middl e Wall	Dart Islan d	Hick ey Is	The Penn	Rabb Is - sand	Rabb Is - nest	Reed yCk sm	Slee per Is	Cryst al Wate rs	Yam ba Quay s	Rom. Chan	Mical o Nort h	Praw n Farm	Cor Islan d	Joss Islan d	Palm Is SE	Ulgu. Is	Clar B'wa ter	Mun Is	Kal'd oo	Shar k Bay	Back Beac h	Woo dy Head
Sources (dist)	Formal boat Ramp	1	1	1		5	1		1	1					1	5			1						1			1	5	
	Marina/Mooring site					1	1		1	1	1	1	1			5	5												1	5
	Formal picnic site	1				1				1					1	5	1													
	Informal picnic site						10		1	10			10																	
	Boat hire					1	1		1	1																				
	Camp/caravan park	1	1	1		1	1		1	1																			1	5
	Tourist facility (hotel/motel/restaurant)					1	1		1	1	1	1		1																
	Developed areas (urban) foreshore Landing Strip		1	1		1	1		1	1	5	1	1	5		5	1													
Sub-Total		3	8	8	5	16	16	1	12	22	12	3	12	12	6	16	12	0	6	5	5	5	5	5	1	5	5	5	8	20
Sources (poll)	High Risk ASS	5	10	10	10	1	1		1	10	1	1	1	10	10	1	10	10	10	1	1	10			1			10		
	Sugar Cane																						1	1	1	1	1			
	Sub-Total	5	10	10	10	1	1	0	1	10	1	1	1	10	10	1	1	10	10	10	1	1	11	1	2	1	11	0	0	0
	TOTAL	33	53	80	54	65	63	29	75	98	81	39	32	48	55	57	91	31	72	73	30	29	50	26	19	26	31	41	30	52