# Appendices

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# Appendix I

## *Shorebird Species and Names*

Names of shorebirds dealt with or mentioned in the thesis (Table I.1). Order and binomials are after Silby & Monroe (1990) as adopted by the International Ornithological Congress (Christchurch) and reported in Barter (1991). English names are after Christidis & Boles (1994), except that "Common" is ommitted when referring to Greenshank for brevity. Alternative common names are given due to continued use (Higgins 1994), and are after Marchant & Higgins (1993), Pringle (1987) or Schodde *et al.* (1978). Further names are listed in CSIRO (1969).

### References

Superscripts refer to Table I.1.

Barter, M. (1991) Possible changes to common and scientific names of Australian waders. *The Stilt* **19**:4.

[6]Christidis, L. & Boles, W.E. (1994) *The Taxonomy and Species of Birds of Australia and its Territories.* R.A.O.U. Monograph 2, Melbourne.

CSIRO (1969) *An Index of Australian Bird Names.* CSIRO Div. Wildl. Res. Tech. P. 20.

[1]Higgins, P. (1994) REN or Fairy-wren? The debate continues. Reprinted from *Wingspan* No.13, March *In: The Stilt* **24**: 13-17.

[2]Marchant, S. & Higgins, P.J. (Eds.) *Handbook of Australian, New Zealand & Antarctic Birds.* Vol.2: Raptors to Lapwings. Oxford University Press, Melbourne.

[3]Pringle, J.D. (1987) *The Shorebirds of Australia.* Nat. Photographic Index of Aust. Wildl./Angus & Robertson, Sydney. (Used for nomenclature in Smith, P. (1991) The Biology & Management of Waders in New South Wales. Species Management Report No.9, N.P.W.S., Sydney.)

[4]Schodde, R. , Glover, B., Kinsky, F.C., Marchant, S., McGill, A.R. & Parker, S.A. (1978) Recommended English Names for Australian Birds. *Emu* **77**: 245-307.

[5]Silby, C.G. & Monroe, B.L. (1990) *Distribution and Taxonomy of Birds of the World.* Yale University Press, New Haven & London.

## Table I.1

Shorebird names. Superscripts refer to references.

| **Name in thesis**[6] | **Binomials**[5] | **Alternative Names** |
|---|---|---|
| Latham's Snipe[4] | *Gallinago hardwickii* | Japanese Snipe[3] |
| Black-tailed Godwit[4] | *Limosa limosa* | |
| Bar-tailed Godwit[4] | *Limosa lapponica* | |
| Whimbrel[4] | *Numenius phaeopus* | |
| Eastern Curlew[4] | *Numenius madagascariensis* | Far Eastern Curlew[5] |
| Marsh Sandpiper[4] | *Tringa stagnatilis* | |
| Greenshank[4] | *Tringa nebularia* | Common Greenshank[1,5,6] |
| Wood Sandpiper[4] | *Tringa glareola* | |
| Terek Sandpiper[4] | *Tringa cinerea* | *Tringa terek*[4] *Xenus cinerea*[6] |
| Common Sandpiper[4] | *Tringa hypoleucos* | *Actitis hypoleucos*[6] |
| Tattler (Grey-tailed)[4] | *Tringa brevipes* | *Heteroscelus brevipes*[6] |
| Wandering Tattler[4] | *Tringa incana* | *Heteroscelus incana*[6] |
| Ruddy Turnstone[4] | *Arenaria interpres* | |
| Great Knot[4] | *Calidris tenuirostris* | |
| Red Knot[4] | *Calidris canutus* | |
| Sanderling[4] | *Calidris alba* | |
| Red-necked Stint[4] | *Calidris ruficollis* | Rufous-necked Stint[5] |
| Long-toed Stint[4] | *Calidris subminuta* | |
| Sharp-tailed Sandpiper[4] | *Calidris acuminata* | |
| Pectoral Sandpiper[4] | *Calidris melanotos* | |
| Curlew Sandpiper[4] | *Calidris ferruginea* | |
| Broad-billed Sandpiper[4] | *Limicola falcinellus* | |
| Pied Oystercatcher[2] | *Haematopus longirostris* | |
| Sooty Oystercatcher[2] | *Haematopus fuliginosus* | |
| Pacific Golden Plover[2] | *Pluvialis fulva* | Lesser G. P.[4] *Pluvialis dominica*[4] |
| Grey Plover[2] | *Pluvialis squatarola* | |
| Double-banded Plover[2] | *Charadrius bicintus* | |
| Lesser Sand Plover[1] | *Charadrius mongolus* | Mongolian Plover[2] |
| Greater Sand Plover[1,5] | *Charadrius leschenaultii* | Large Sand Plover[2] |
| Hooded Plover[2] | *Charadrius rubricollis* | *Thinornis rubricollis*[6] |

# Appendix II

## *Measurement Techniques*

This appendix describes the techniques used for measuring the habitat attributes in the research. It is written as instructions for use, because the same methods are required for the use of the guidelines. Use these measuring techniques to:

- manage habitat attributes according to the guide values (Chapters 2 & 6):
- design and construct or restore habitat (Chapters 2 & 6); or
- assess conservation value (Chapter 3).

Some attributes can be measured by any means, and techniques here are a guide. Others need standardised measurement to be comparable to values in this thesis, so instructions need to be followed closely in these cases.

### *(A) Size, Shape and Position*

**Area of Flat**

(1) Define an intertidal flat, for this purpose, by mean high tide shoreline, edge of 100% mangrove cover, shallow (approximately 150mm deep) water at low tide, and any very strongly defined change in substrate type and elevation eg. a boundary between mudflat and a high sand bank.

(2) Use air photos (Good 1978). The New South Wales Coastal Wetlands Colour Run, 1982 (L.I.C.) are suitable and patchy coverage is held in the NPWS head office air photo collection. More recent photography is better. There are many others: old/new, colour/black and white, small/large scale. Details of coverage can be obtained from the Land Information Centre (L.I.C.).

Select on the basis of (I) no reflections of sun on water, and (II) taken at low tide. Better to use an old small scale (>1:45 000) black and white with no reflections, taken at low tide, than a recent large scale colour image that was taken at high tide and has reflections. Use in conjunction with field inspection if unsure of tidal stage, water depth (judged by colour/tone) or change since photography. Estuary mouths change so require routine ground truthing. Avoid topographic maps as they do not allow judgement of low tide limit. Use existing database information with caution because they may not define areas appropriately, and may lack necessary resolution (Morrison et al. 1987).

(3) Most G.I.S. programs eg. E-RMS (NPWS 1992) support a digitising planimeter. A quick, cheap and simple method of measuring small areas is by a clear overlay with a fine (1-2mm) grid or a dot grid. Count the number of squares or dots overlying the area to be measured and multiply by the appropriate scale factor for hectares. This technique is sufficiently accurate at scales larger than about 1:40 000.

## *(A) Size, Shape and Position (cont.)*

### Area of Surrounding Flats within 1km (not including flat in question); Total Intertidal Area within 1km.

These are arbitrarily standardised measures of local habitat availability. Calculate the length at the photo scale of 1km on the ground, describe a circle of this radius on an overlay, and position over the air photo with the circle centre approximately centred on the flat. Measure areas within the circle as in Area of Flat, above.

### Perimeter Length.

A standardised measure of size and shape. Carefully trace total perimeter off the air photo (see Area of Flat, above, for criteria to define perimeter) with planimeter or digitiser. Enlargement of image or carefully traced outline is necessary at most air photo scales when using a cheap planimeter.

### % Open Water Adjoining Flat.

Measure of 'openness' (position) of flat. Open water is defined as greater than 50m breadth and of free tidal flow. An easy way is to describe a circle on a clear overlay with 5% segments marked, and place this over the image, centred on the centre of the flat. % open water can be visually estimated from segments with sufficient accuracy. Can also be estimated in the field.

## *(B) Vegetation*

### % Surrounding Mangrove

Standardised measure of surrounding mangrove fringe on all shores in 360°, from a central point on the flat. Use overlay on a relatively recent air photo as described in (A):% Open Water, above. Field estimate should be from a single central point.

### % Adjoining Mangrove

The proportion of mangrove actually abutting the flat, excluding mangrove separated by water. Measured as in % Surrounding Mangrove, above.

### % Mangrove Cover

This must be estimated in the field. A standardised technique is used for the guide values:

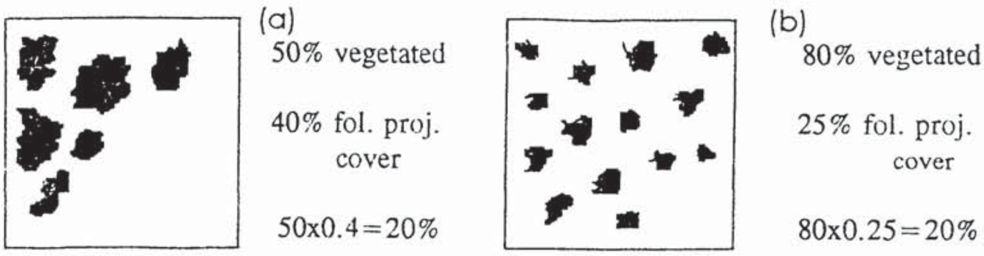
(1) visually estimate proportion or % area of flat vegetated;

(2) visually estimate foliage projection cover (Specht 1970)of vegetation (% of ground obscured by foliage if viewed from directly above);

(3) multiply (1) expressed as a % by (2) expressed as a fraction. Example: 50% of flat vegetated, 40% foliage projection cover of vegetation = 50% x 0.4 = 20% cover (Fig. II.1).

**Figure II .1**

Examples of standardised cover estimation method.




Field estimates of % cover can be aided by referring to prepared diagrams of % black on white in square and circular shapes eg. Northcote (1979). This measure of % mangrove cover may not fully characterise mangrove cover from shorebirds' perspectives because thick bushes may affect shorebird visibility more than thin seedlings of the same % cover.

**% Seagrass Cover**

Estimated visually as % Mangrove Cover, above. Sensitive to tide level (more seagrass exposed on low low tides (0.0 to 0.2m at Middle Head). Monitoring of vegetation area and density needs more accurate quantification for comparisons over time. This can be done by quadrats and/or photography (see Appenndix III: *Further Reading*; consult an experienced researcher).

**% Total Ground Cover**

Visual field estimate. Includes all ground cover (everything except bare soil). See Chapter 4: Tattler - Study Results for constituants of ground cover. Oyster structures include internal areas even if open-topped. (But see Appendix III A9: *Cover by Structures* for area measurement of oysterfarming racks for impact assessment. This needs to include the alienated area between the racks, for species needing open ground).

## *(C) Substrate and Elevation Profile*

**Northcote Texture Class** (Northcote 1979)

Field measurement. Standardised classes (Table II.1) based on sand, silt and clay content (particle size) assessed by manipulation of a surface sample in the hand.

(1) Select a sample which is not soggy, or spread to dry briefly so the moisture content allows cohesiveness (sticking together). Avoid samples with humus.

(2) Compress or roll into a ball and judge cohesiveness by the standards (Table II.1).

(3) Smear a small sample along your forefinger by your thumb and assess, by the standards (Table II.1), the width of the 'ribbon' so produced.

The only distinction between texture classes indicated to be important to shorebirds by the study results is sand/loamy sand. Sand will not show any cohesion; loamy sand will be weakly cohesive if compressed into a ball by clenching your fist.

### Table II.1

Substrate texture classes used in the manual and their tests (after Northcote 1979). Ribbon refers to the strip of soil smeared along the finger by the shearing test. See text for explanation of the tests.

| Name | Clay and (Silt) Content | Test (Ribbon width in mm) |
|---|---|---|
| Sand* | <5% | cannot be moulded; no ribbon (0) |
| Loamy Sand | 5 - 10% | slight coherence; minimal ribbon;some organic matter (6) |
| Sandy Loam etc | 10 - 15% | readily visible grains; just coherent;very sandy to touch(13-25) |
| Light Sandy Clay Loam | 15 - 20% | as Sandy Loam but strongly coherent(20-25) |
| Sandy Clay Loam | 20 - 30% | strongly coherent; sand grains in finer matrix (25-38) |
| Fine** Sandy Loam | 10 - 20% | coherent; grains felt and heard; visible under hand lens(13-25) |
| Loam, Fine Sandy | 25% | like Fine Sandy Loam but spongy(25) |
| Fine Sandy Clay Loam | 30 - 35% | like Fine Sandy Loam but clayey(38-50) |
| Loam | 25% | coherent; spongy, smooth, may be greasy(25) |
| Silt Loam | 25% (25%+) | coherent; silky(25) |
| Clay Loam | 30 - 35% | coherent and plastic; smooth(38-50) |
| Silty Clay Loam | 30 - 35% (25%+) | coherent and plastic; smooth and silky (38-50) |
| Silty Clay | 35 - 40% (25%+) | plastic; smooth and silky(50-75) |

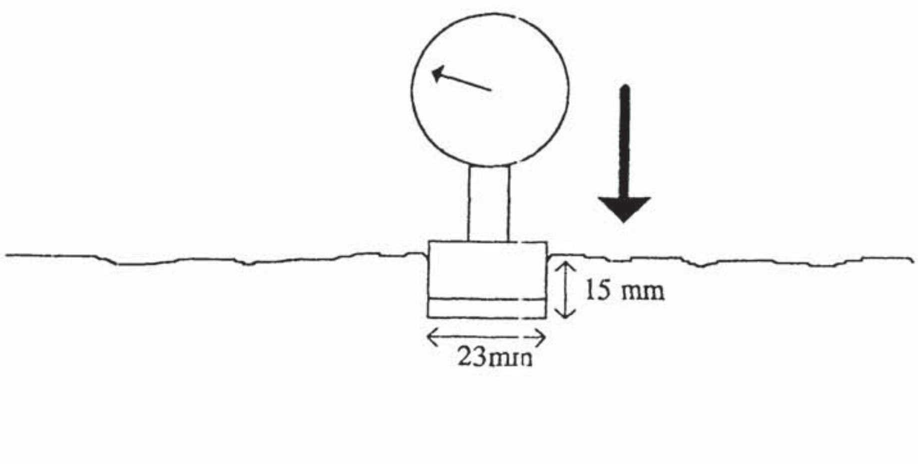
* particle diameter <2mm; ** particle diameter <0.2mm

## Mean Surface Hardness

Standardised measure of surface hardness/softness in kg/cm$^2$. Use any standard hand penetrometer for measuring unconfined compressive strengths of soil or cement (eg. Humboldt R0205 or Penetrometro ST 207, Prospector's Supplies). Modify the probe diameter to 23mm (eg. use inside a plastic container cap of correct diameter) (Fig. II.2). Follow instructions of unit used. Depress evenly to 15mm depth. The values quoted in this thesis are only applicable to this technique.

### Figure II.2

Probe diameter and depth of measurement for mean surface hardness with penetrometer.



### (C) Substrate and Elevation Profile (cont.)

Surface hardness is highly variable over the flat area. Use at least 10 randomly located measurements (Sampford 1966) and calculate the mean. Very soft surfaces will not register, but are acceptable for shorebird foraging.

**Microrelief variance**

Standardised measure of the variation (range and frequency) in surface elevation, as a quantification of 'bumpiness'.

(1) Mark a 2 m straightedge at 250 mm intervals;

(2) lay on the surface and measure the distance from the lower edge of the straightedge to the soil surface at each mark. Repeat this sample at least 4 times, randomly placed.

(3) Calculate variance ('*v* ' or the square of 's' or lower case sigma on most upmarket pocket calculators) of the measurements for each sample, and a mean variance. The unit of measure is actually a product $(mm)^2$, not the area measure: $mm^2$.

**Elevation Profile**

Measures (i) the level of a flat surface in relation to water level in the estuary, and (ii) proportions of areas at the different elevation classes, at mean low tide. Standardised classes used (adapted from Recher (1966)) are:

- Dry: ground that is not soggy and has no surface water or strong reflective sheen;
- Wet: soggy water-logged ground, with a film of water and a sheen;
- Very Shallow: from a noticeable layer of water (2-3 mm) to 50 mm deep;
- 50 mm-150 mm ground covered by water to the maximum depth usable by foraging shorebirds.

Requires field assessment:

Proportions:

(1) Assess at mean low tide (bottom of lows of 0.3 m to 0.6 m at Middle Head - as determined from tide tables eg. Public Works).

(2) Visually estimate % or ratio of each class as described above. Add estimates and re-assess if they don't sum to approximately 100% or 1.

Levels:

Levels in mm are given approximately corresponding to the elevation class boundaries, for construction of habitat (Fig. 2.9). The datum is based on mean high tide as indicated by the lowest level of non-marine wetland vegetation - that is, sedge (Cyperaceae), rush (Juncaceae) or saltcouch (*Sporobolus*) plants. Do not use samphire (eg.*Sarcocornia*), mangrove or seagrass (eg.*Zostera*), or dryland plants (see Chapter 2: *Methods: Elevation Heights*). If a suitable shoreline does not adjoin the site, levels can be transferred from a distant suitable shore using water level, if done within 15 minutes.

Measurement of height from such data to the highest wet ground (excluding puddles) on 13 flats from 6 estuaries from the Pambula to the Macleay gave a 95% confidence interval of the mean datum of 324 mm, which is about the range of normal low tides in New South Wales estuaries anyway (80% of tides are within the range 0.3-0.6 m at Middle Head). Relative height differences between the dry/wet class boundary and the wet/very shallow class boundary on each flat (measured at the same stage of the tide within each flat) gave a 95% confidence interval of 37 mm. This is independent of the datum. When surveying and levelling for this parameter care must be taken to ensure accuracy.

This procedure gives only approximate levels in relation to tide height but is adequate to establish preliminary levels in the variable water level regime of intertidal estuarine flats. The profile may need fine tuning after visual assessment at a range of low tides by the method detailed in Proportions, above.

## *(D) Water Properties*

### Salinity

Saltiness of the water (mostly sodium chloride). Proportion of seawater can be roughly assessed by taste. Accurate measurement is commonly made by electrical conductivity meter (eg. Activon Scientific, CHK Engineering). Follow instrument instructions . Dilute the sample with distilled water if necessary. Measurement is in milliseimens per centimetre (mS/cm) but can be approximately converted to salinity expressed in parts per thousand (ppt, $^{oo}/_{o}$) or grams per litre (g/L) (the same because 1 litre of water = 1 000 grams by definition) by multiplying the reading by 640.

Measurements need to be taken at different depths (salinity can be layered, particularly at the surface where freshwater can 'float', and through the tide cycle (at least, readings on the top and bottom of the tide). Multiple readings must be made and averaged. Be aware of preceeding rainfall and influences of short term runoff. If a single figure must be used to describe the salinity regime use the mean from equal samples of high and low tide, or the mean range (or see Bruton undated; Norris & Georges 1986).

### Secchi Transparency (Wetzel 1975)

Widely used measure of turbidity of the water column.

(1) Use a heavy metal 200 mm diameter disc boldly painted with white segments, and flatly suspended by a measured rope. Mark the rope at 100 mm intervals (only a length of 2 m plus handling space is needed for these guidelines).

(2) Lower over the shaded side of a boat into water to be measured and determine depth at which disc is obsured from view. Raise and note depth at which it just reappears and average the readings.

To standardise with the guidelines in this thesis, take measurements between 9am and 4pm in sunshine, halfway through the outgoing tide in water closely adjacent to the flat.

**Orthophosphate Level**

There are many measures of nutrient level (Golterman et al. 1978), and consistency of measurement even within techniques is typically low. Also, blanket criteria should be used with caution (Hart 1974). Levels appropriate for a large estuary with a high nutrient level may not be appropriate for a smaller estuary with a naturally less nutrient rich ecosystem. Maintenance of the nutrient balance within an estuary may be more important for conservation than comparison to an external criteria (see Appendix III:D5: *Changes to Nutrients*).

Important considerations are: consistancy (measurement precision) within the study or monitoring programme (eg. control of sample contaminants) for comparison over time or within the estuary; and relevance to use by plants/invertebrates (biologically 'available' nitrogen/phosphorus). Local authority water quality labs, state/commonwealth facilities or agronomy labs can be contracted to analyse samples for various nutrient measures.

Any comparison with the levels quoted in this thesis need to be done with the above in mind. The method used was the ascorbic acid method for soluble orthophosphate ($PO_4^{3-}$_P) (manual colorimetric method) (Murphy & Riley 1962, Rayment & Higginson 1992) as modified for use on a Hach DR-EL/2 portable spectrophotometer (Hach Chemical Co. undated) using Hach PhosVer III phosphate reagent powder pillows.

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