Surveys of waterbirds in selected wetlands of south-western Australia in spring-summer 2008-9

with an assessment of changes in habitat and waterbird usage over 2-3 decades

conducted by Wetlands International
in collaboration with the
Western Australian Department of Environment and Conservation

Department of Environment and Conservation
Our environment, our future

Roger Jaensch, Alan Clarke and Jim Lane

March 2009

WETLANDS INTERNATIONAL

Citation

Jaensch, R.P., Clarke, A.G. and Lane, J.A.K. 2009. Surveys of waterbirds in selected wetlands of south-western Australia in spring-summer 2008-9, with an assessment of changes in habitat and waterbird usage over 2-3 decades. Unpublished report by Wetlands International – Oceania, Brisbane, for the Western Australian Department of Environment and Conservation.

Authors' addresses

Roger Jaensch
Wetlands International – Oceania
c/- Queensland Herbarium, Mt Coot-tha Road, Toowong QLD 4066, Australia
roger.jaensch@wetlands-oceania.org

Alan Clarke and Jim Lane
Department of Environment and Conservation
14 Queen Street, Busselton, WA 6280, Australia
alan.clarke@dec.wa.gov.au
jim.lane@dec.wa.gov.au

Copyright

Disclaimer

Cover image caption

Australian Little Bittern in *Baumea articulata* tall sedgeland at Shark Lake, Esperance, December 2008

Photo by R Jaensch, Wetlands International

CONTENTS

LIST OF FIGURES & TABLES

ACKNOWLEDGMENTS

The project was funded by the Western Australian Department of Environment and Conservation (DEC) under the State Salinity Strategy (State Salinity Council 2000; Government of Western Australia 2002).

Most of the surveyed wetlands are on conservation reserves vested in the Conservation Commission of Western Australia and managed by DEC. District and Regional staff of DEC are acknowledged for their support regarding our visits to local wetlands. Yellilup Lake is on freehold land and thanks are due to Ian Peacock and family for permission and guidance during our visits there.

Birds Australia volunteer John Graff assisted with field surveys at Yarnup Lagoon, Boat Harbour Lakes, Lake Pleasant View and Mettler Lake in January 2009. Additional assistance with field surveys at Lake Pleasant View was provided by Sarah Comer and several other staff of DEC Albany, and by Ray Garstone, Wayne Zadow, Anne Bondin and Tony Bush.

Yvonne Winchcombe of DEC Busselton assisted with administrative and data management tasks and prepared the graphs of Appendix 3.

Executive Summary

Having measured significant changes in water levels and salinities at many south-western wetlands over two to three decades, in 2008 the Western Australian Department of Environment and Conservation (DEC) commissioned a survey of waterbirds in nine of the monitored wetlands. Broadly, the aim of the work was to identify any significant long-term changes in waterbird habitats and waterbird use of the wetlands. The survey was led by a waterbird specialist who had surveyed waterbirds at the same wetlands in the 1980s and 1990s, and was supported by DEC scientific staff.

The selected wetlands were: Nine Mile Lake (DEC Swan Region); Lake Davies (South West Region); Yarnup Lagoon and Boat Harbour Lake 1 (Warren Region); and Lake Pleasant View, Mettler Lake, Yellilup Lake, Esperance reserve 26410 and Shark Lake (South Coast Region). Being aware of loss of live trees, shrubs and sedges from some of these wetlands, DEC sought a focus on waterbirds that depend on that cover, especially for nest sites. These 'sensitive' species were identified as bitterns, crakes, small rails, Blue billed and Freckled Ducks, and tree-nesting colonial herons, egrets, ibises, spoonbills and cormorants.

The surveys were conducted by two observers in November - December 2008 and January 2009, matching dates of previous surveys and records of nesting by bitterns, crakes and small rails. Searching by wading or from a boat, the observers employed methods for finding secretive birds and concealed nests modelled on methods used in previous decades. Nest searching at all wetlands was at least as comprehensive as in the past and more so at some. The present surveys typically took 3-7 hours to complete and, where habitat was judged appropriate, included periods of listening at night for calling bitterns. The location of each nest was geo-referenced by GPS and other information that would benefit future surveys, such as listening positions and routes walked, were documented or mapped.

The January 2009 surveys at four of the nine wetlands were to compensate for probable dispersal of birds and delay or disruption of nesting caused by exceptional rainfall and increases of up to 0.5 metres in wetland water levels during the weeks of the November-December surveys.

The 2008-9 surveys were only snapshots of habitats and waterbird use and the number and intensity of past surveys varied greatly between wetlands, nevertheless some marked changes in habitat and waterbirds were apparent:

- At Nine Mile Lake, inundated *Typha* tall sedgeland (and some *Baumea* tall sedge and *Melaleuca* shrubs) had replaced former open lake, thereby providing nesting habitat for Australian Little Bittern and Spotless Crake, which otherwise seems to have been lost from fringing swamps that now – though still vegetated – apparently are too dry to support nesting. Some other waterbird species may have been disadvantaged by the loss of open water. These habitat changes have coincided with a substantial decline in water levels at Nine Mile over the past 2-3 decades.
- Fringing thickets of *Melaleuca laterita* and fine sedge at Yarnup Lagoon had mostly died and were no longer suitable to support the many nests of Australian

Little Bittern and Spotless Crake found there in the 1980s. No bitterns, crakes or small rails were recorded here despite two surveys in 2008-9, although a limited presence in remnant tall *Baumea* sedgeland seems feasible. Nesting by Hoary-headed Grebe, which commonly occurs in brackish and even saline wetlands, was recorded for the first time. Salinities have been increasing at Yarnup over the past two decades and water levels and pH have been unusually low on two occasions since 2001.

- Formerly supporting extensive tall woodland of yate *Eucalyptus occidentalis* and paperbark *Melaleuca cuticularis*, Yellilup Lake now has no live trees in the zone of frequent inundation. No old or recent breeding colonies were observed and nesting by colonial waterbirds is unlikely to reoccur, given the habitat changes that have taken place. Blue-billed and Freckled Duck were not recorded in 2008-9 and the now saline conditions are likely to be unsuitable for nesting by these species. Prolonged inundation (1988-94 at least) is thought to have been the primary cause of death of the formerly extensive woodland. There has been an associated increase in salt inputs from the catchment, and hence higher salinities.
- At the Esperance 26410 wetland, a narrow inner zone of dead yate woodland was evident (with some regeneration). At this time the water level was not ideal for waterbird nesting. Future broad expansion of tree death may decrease opportunities for breeding and for use by sensitive species. The salinity of this wetland appears to be increasing.
- Previous surveys of Lake Davies were in the early 1990s. The present re-survey showed an apparent loss of patchiness in fringing low sedgeland, but despite absence of formerly-recorded crakes, no firm conclusions were reached about waterbird use. Davies' salinity is increasing.

No significant losses of habitat or waterbird occurrence were evident at Boat Harbour Lake 1, Lake Pleasant View, Mettler Lake or Shark Lake. Each wetland continued to support one to three of the bittern and crake species commonly associated with dense live vegetation. Furthermore, in 2008-9 one or more of this suite of waterbirds was recorded for the first time and/or at least one species was found breeding for the first time (e.g. Australian Little Bittern nests at Mettler and Shark Lakes) at each of these four wetlands.

At Mettler Lake, 74 nests of eight waterbird species were found, whereas in the 1980s no breeding was recorded. This is a reflection of survey focus and effort, and experience at finding nests, rather than habitat or other changes, and demonstrates the need for more intensive surveys of other under-surveyed south-western Australian wetlands with healthy vegetation.

Three of the surveyed wetlands (Boat Harbour Lake 1, Lake Pleasant View and Mettler Lake) could potentially be considered internationally important because they have supported the globally-threatened Australasian Bittern in the past 2-3 decades and currently.

Recommendations:

On the basis of the findings of this report, the authors recommend that the Department of Environment and Conservation:

1. *Maintain its management focus on Yarnup Lagoon, with an objective of restoring breeding habitat for the Australian Little Bittern and other sensitive species.*
2. *Further investigate Esperance 26410 to more conclusively determine its significance for waterbirds, particularly sensitive species. If its significance proves to be high, the threats posed by potential hydrological changes should be assessed and potential for mitigation considered.*
3. *Maintain a watching brief on Davies, Boat Harbour 1, Mettler, Pleasant View and Shark Lakes, and possibly other wetlands, with the objectives of further identifying and documenting values for waterbirds, particularly sensitive species, and identifying and addressing any substantial threats, particularly hydrological.*
4. *More fully document the hydrological, habitat and waterbird changes at Nine Mile, Yarnup and Yellilup Lakes, and their causes, links and likely future scenarios with and without management interventions, as a case study of the major human-induced changes that have occurred at many south-western Australian wetlands in recent decades.*
5. *Consider undertaking further surveys to determine whether Boat Harbour 1, Pleasant View and Mettler Lakes, and possibly other wetlands, meet criteria for listing as internationally important for the Australasian Bittern under Ramsar Criterion 2 (threatened species and communities).*
6. *Use the results of the present project in support of efforts to identify and, where necessary, further investigate hydrological threats to high value waterbird habitats, particularly of sensitive waterbird species, in south-western Australia.*
7. *Seek and support efforts to obtain resources for: (1) identification of key habitats of the Australasian Bittern, particularly for breeding and for survival during drought; (2) comprehensive investigation of the ecological requirements of the Australasian Bittern; (3) regular surveillance of use of vulnerable wetlands by the Australasian Bittern and other sensitive species, particularly colonial nesting waterbirds.*
8. *Further consider the suitability for listing of (1) key drought and breeding habitats of the Australasian Bittern and (2) key breeding habitats of sensitive colonial nesting waterbird species, of south-western Australia, as Threatened Ecological Communities (TECs) under the federal Environment Protection and Biodiversity Conservation Act 1999, and to initiate and support efforts to obtain the information required to progress these TEC nominations.*

Photographic Summary

The wetlands surveyed

Nine Mile Lake (RJ-WI, 25Nov08)

Lake Davies (AC-DEC, 3Dec08)

Yarnup Lagoon (RJ-WI, 26Nov08)

Boat Harbour Lake 1 (RJ-WI, 2Dec08)

Lake Pleasant View (RJ-WI, 27Nov08)

Mettler Lake (RJ-WI, 28Nov08)

Yellilup Lake (RJ-WI, 29Nov08)

Esperance 26410 (RJ-WI, 1Dec08)

Shark Lake (AC-DEC, 30Nov08)

Using a boat to access nest sites (RJ-WI)

Waterbird habitats

Tall Sedge, YARN (AC-DEC, 8Jan09)

Typha, NINE (RJ-WI, 25Nov08)

Gahnia tussock, METT (RJ-WI, 28Nov08)

Low Sedge, BOA1 (RJ-WI, 3Dec08)

Shrub thicket
YARN

(RJ-WI, 27Nov08)

Wooded swamp, METT
(RJ-WI, 28Nov08)

Wooded swamp, ESP1 (RJ-WI, 1Dec08)

Mixed Tall & Low Sedge, BOA1 (AC-DEC, 9Jan09)

Shrubs, *Typha* & sedge, NINE (RJ-WI, 26Nov08)

Mixed sedge, shrubs, trees, METT (RJ-WI, 28Nov08)

Mixed sedge and trees, METT (RJ-WI, 28Nov08)

Mixed Gahnia and low sedge, BOA1
(AC-DEC, 9Jan09)

Changes to habitats

Typha dominating the lake bed, NINE
(RJ-WI, 25Nov08)

Increased extent of open water, YARN
(AC-DEC, 8Jan09)

Dead thicket of *Melaleuca laterita*, YARN (RJ-WI, 26Nov08)

Loss of all live trees on lake bed, YELL (RJ-WI, 29Nov08)

Dead paperbarks, YELL

(above & right) Dead yate trees, ESP1 (RJ-WI, 1Dec08)

Sensitive waterbirds

Aust. Little Bittern, adult female, QLD (Bob Black)

Aust. Little Bittern, adult male, SHAR (RJ-WI, 30Nov08)

Australasian Bittern
Owingup Swamp
(RJ-WI, 1992)

Blue-billed Ducks (3 males), SHAR
(RJ-WI, 30Nov08)

Waterbird nests

Musk Duck, in tall sedge, PLEA (AC-DEC, 10Jan09)

Musk Duck, in tall sedge, YARN (AC-DEC, 8Jan09)

Musk Duck, under shrubs, YARN
(RJ-WI, 26Nov08)

(left and above) Musk Duck, in *Gahnia* tussock, METT
(AC-DEC, 11Jan09)

Blue-billed Duck, in tall sedge, SHAR (RJ-WI, 30Nov08)

Pacific Black Duck, in tall sedge, PLEA (AC-DEC, 10Jan09)

Hardhead, in tall sedge, PLEA

Hoary-headed Grebe, under shrubs, YARN
(RJ-WI, 26Nov08)

Hoary-headed Grebe, in low sedge, DAVI
(RJ-WI, 3Dec08)

Crake nest, in mixed tall and low sedge, BOA1

(AC-DEC, 9Jan09)

Crake nest, in mixed sedge, NINE
(RJ-WI, 26Nov08)

Crake nest habitat, shrubs with sedge, NINE
(RJ-WI, 26Nov08)

Little Bittern nest site PLEA (AC-DEC, 10Jan09)

Aust. Little Bittern nest site, SHAR
(RJ-WI, 30Nov08)

Australian Reed-Warbler nest, in tall sedge near shrubs, METT

(RJ-WI, 28Nov08)

Australian Little Bittern nest, in tall sedge near shrubs, METT

(AC-DEC, 12Jan09)

Purple Swamphen nest, in tall sedge, PLEA
(AC-DEC, 10Jan09)

Swamphen nest site, SHAR (RJ-WI, 30Nov08)

Purple Swamphen nest, in mixed sedge, BOA1

(AC-DEC, 9Jan09)

Purple Swamphen eggs
(AC-DEC)

Little Pied Cormorant nests, live trees, METT
(RJ-WI, 28Nov08)

Little Pied Cormorant, METT (AC-DEC, 12Jan09)

Cormorant nest, tall shrubs, YARN
(RJ-WI, 26Nov08)

Little Pied Cormorant METT

(AC-DEC, 12Jan09)

See Appendix 4 for additional photographs of the wetlands and waterbird habitats.

Hoary-headed Grebe eggs

(RJ-WI)

Introduction

The study area

This report presents the results of a wetland and waterbird survey project conducted in south-western Australia in 2008-9. The study area extended from north of Bunbury to Albany and Esperance (Fig. 1). Hence it included parts of the Swan, South West, Warren and South Coast regions of the WA Department of Environment and Conservation (DEC) and parts of the Swan Coastal Plain, Jarrah Forest, Warren and Esperance Plains bioregions (http://florabase.calm.wa.gov.au/help/ibra). It experiences cool wet winters and hot dry summers with mean annual rainfall between about 500 and 1000 mm.

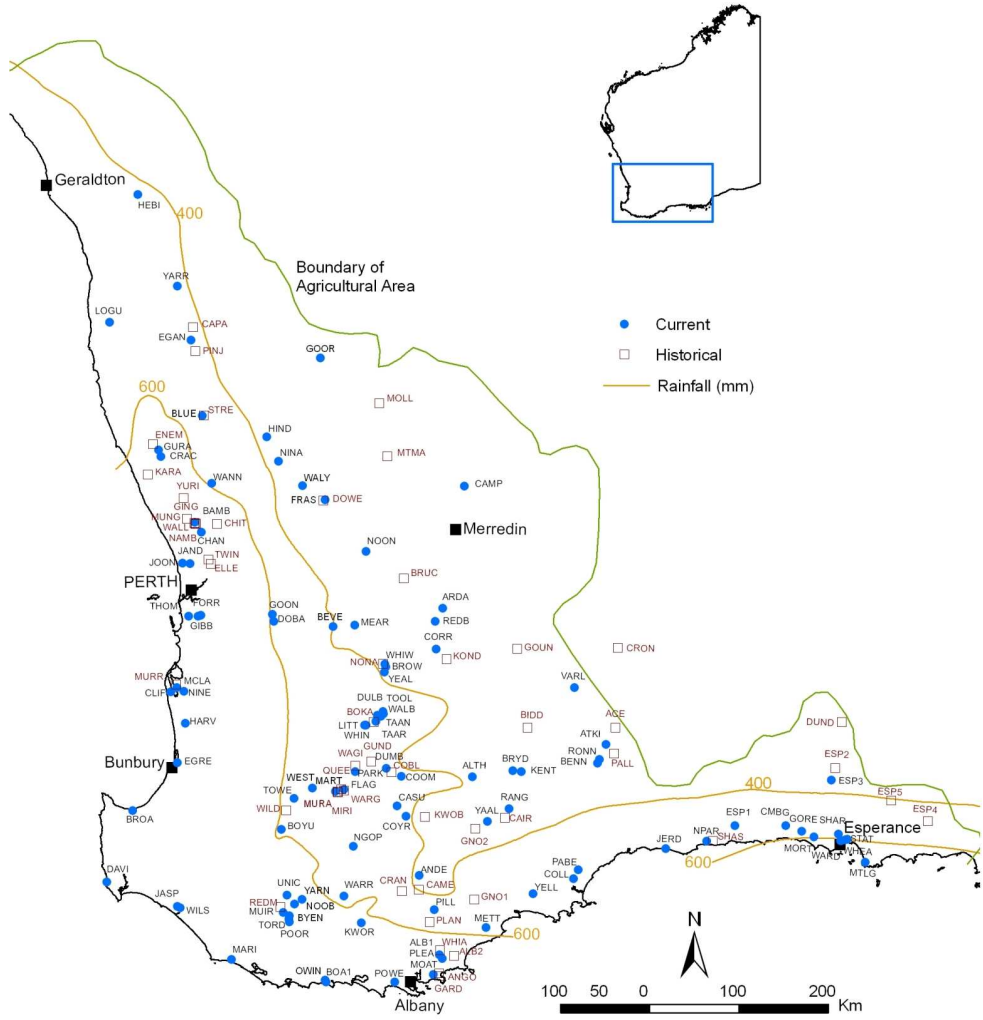


Figure 1. Map of the project study area showing rainfall isohyets and wetlands monitored by DEC (from Lane *et al.* 2004)

Origins of the project

The project arose from the findings of two surveillance ('monitoring') programs concerning wetlands and waterbirds.

Since 1977, DEC[1] has been monitoring water levels, salinities and pH at up to 152 lacustrine and palustrine wetlands in south-western Australia (Fig. 1) and this work has shown significant changes in these parameters at many wetlands (Lane *et al.* 2004, 2009). Consequent changes in vegetation, such as death of trees and loss of sedges in the wetland basin, have become obvious at some affected wetlands. Probable causes of hydrological and consequent vegetational change at these wetlands have been proposed (Gibson *et al.* 2004, Lane *et al.* 2004, 2009, Lyons *et al.* 2007) and include long term decline in regional rainfall, prolonged inundation due to extreme rainfall events, and secondary salinisation.

Over a similar period DEC has funded or conducted several studies concerning numbers and breeding of waterbirds in south-western Australia. During the 1980s, the Department commissioned comprehensive waterbird surveys at nearly 200 wetland nature reserves (Jaensch *et al.* 1988; Jaensch & Vervest 1988a, 1989). The surveys were principally conducted by amateur ornithologists under the coordination of Birds Australia[2] and many non-reserve wetlands also were surveyed (Jaensch & Vervest 1988b,c). In subsequent years several more regional surveys were conducted (Halse *et al.* 1990, 1992, 1994, 1995; Storey *et al.* 1993) and a number of waterbird surveys were completed at single or clustered wetlands including south coastal wetlands from Dunsborough to Albany (Jaensch 1992, Jaensch & Clarke 1993). Collectively, these and other works (Lane *et al.* 2002a,b; Lane & Pearson 2002) demonstrated that certain wetlands and groups of wetlands in south-western Australia are internationally or nationally important for waterbirds. This awareness resulted in a suite of Ramsar site nominations (Government of Western Australia 1990, 2000) and listings in the Directory of Important Wetlands in Australia (DEWHA 2009). Aspects of waterbird use of special significance include occurrence of species listed globally as threatened (Australasian Bittern: globally Endangered, IUCN Red List: IUCN 2009) and aggregation and breeding by geographically isolated, small populations (south-western Australian population of Blue-billed Duck: Wetlands International 2006).

Aware of previously-established importance for waterbirds, but also more-recent changes (some ongoing) to wetland water levels, salinity and (in several cases) fringing and emergent vegetation, DEC (JL) sought to obtain information on present waterbird use and habitat availability at a small number of carefully selected wetlands in south-western Australia. This would be compared with knowledge from the same sites from previous surveys; the largest body of waterbird data being from surveys 20-27 years ago.

Coincidentally, Birds Australia was concerned about an apparent decline in reporting of the Australasian Bittern, Australian Little Bittern and some other secretive waterbirds

[1] Reference to DEC includes its predecessors, the Department of Conservation and Land Management (1985-2006) and the Department of Fisheries and Wildlife (to 1985).

[2] At that time, known only as the Royal Australasian Ornithologists Union.

(Birds Australia 2009). These species depend on dense, live wetland vegetation such as beds of emergent tall sedge or inundated[3] shrub thickets for shelter and nest sites (RJ pers. obss.) and on freshwater ecosystems more generally for their food resources (fish, frogs and invertebrates: Marchant & Higgins 1990). These ecological requirements were likely to be negatively affected by rising salinity.

In addition, DEC and Birds Australia both saw a need for transfer of skills in finding secretive waterbirds and waterbird nests generally, to local nature conservation professionals and amateur ornithologists.

Project objectives

In 2008 DEC commissioned Wetlands International – Oceania (WIO) to address the abovementioned issues. WIO specialises in wetland and waterbird surveys and staff (RJ) have had considerable firsthand experience with wetlands and waterbirds of the study area, specialising in secretive species and nest surveys. Objectives of the project were:

1. to identify and describe any **significant long-term changes** (or clear indicators of change) in waterbird usage and habitat availability at a small number of carefully selected wetlands of south-western Australia 2-3 decades after substantial, previous, waterbird survey effort.

2. to obtain information on **present usage by sensitive waterbird species** (see below for definition) especially those that are threatened, that are secretive and thus difficult to find, and/or that breed on-site, with an emphasis on bitterns (this work was to be primarily for the purpose of achieving objective 1).

3. to **facilitate future monitoring** of waterbirds through establishing well documented survey procedures at each wetland, and by building the survey capabilities of local people, initially near Albany.

DEC resources extended to providing a technical officer (Alan Clarke), 4WD vehicle, boat and other field equipment and water chemistry analyses for the surveys, and funding for WIO to undertake a two-week survey program in Nov-Dec 2008. (DEC also conducted a follow-up survey at four wetlands in Jan 2009.) Though only 'snapshots' for comparison with previous surveys, nevertheless it seemed likely that any pronounced changes in waterbird habitat and usage would be readily apparent and important to document.

Target wetlands and waterbird species

The part (southern) of south-western Australia that became the study area for this project was determined by budgetary constraints (the project budget did not allow for wetlands *throughout* the south-west to be surveyed) and by most of the wetlands that

[3] Throughout this report, 'inundated' vegetation refers to vegetation the lower parts of which are flooded, but the upper parts are not.

would meet the principal criteria for selection (see Methods section below, and Appendix 2) being located on or near the south coast, or on the way there from Perth (RJ's point of arrival and departure from WA for this project). This was also the known range of principal occurrence of a species of sensitive waterbird that is also considered threatened, the Australasian Bittern. Past surveys have shown that this secretive waterbird principally occurs in the Muir-Unicup wetlands and the south coast from Owingup Swamp to Mettler Lake, with a third cluster of localities between Esperance and Cape Arid (Birds Australia waterbird database 1981-1989; Jaensch & Vervest 1988a, Jaensch 1992, Jaensch & Clarke 1993), though its range was formerly more extensive (Marchant & Higgins 1990, p. 1058).

For this as well as previous survey projects, the common definition of waterbirds as being birds that depend on wetlands for at least a part of their life cycle was adopted. A list of waterbird species mentioned in this report, with their scientific names, is in Appendix 1.

All waterbirds seen or heard were recorded in the field and details are in the report appendices (see Methods below) but analysis of results focuses on certain 'sensitive' species. In this report the term **sensitive** species refers to waterbird species that:

- typically depend on inundated, dense live vegetation (sedge beds/tussocks, shrub thickets) or live trees for shelter and/or breeding, *and*
- that are, or may become, of conservation concern because:
    - they have numerically small populations in the study area (Australasian Bittern, Blue-billed Duck, Freckled Duck: Wetlands International 2006), *or*
    - they are rarely recorded in large numbers (bitterns, crakes and small rails: Jaensch *et al.* 1993) because they are highly secretive *or*
    - they are known to occur in relatively few wetlands (bitterns, Blue-billed Duck, Freckled Duck: Jaensch *et al.* 1988; Halse *et al.* 1990) *or*
    - they breed in relatively few wetlands (bitterns, Freckled Duck, and colonial herons, egrets, ibises, spoonbills, cormorants: Jaensch *et al.* 1988, Blakers *et al.* 1984).

Several species meet the first but not second criterion above and so were excluded from the category 'sensitive'. Thus Purple Swamphen and Dusky Moorhen were excluded because they occur in many wetlands and sometimes occur in large numbers (hundreds: Jaensch *et al.* 1988, pp. 87, 257; Jaensch *et al.* 1993) and so are not presently of conservation concern. Australian Reed-Warbler and Little Grassbird were excluded because they occur in many wetlands, probably in all wetlands of the study area that have tall sedge beds or *Typha* (based on RJ pers. obss.), and so are not presently of conservation concern. Musk Duck was excluded because, while not as abundant as many other duck species, it meets none of the four conditions under the second criterion above.

Detailed descriptions and ecological notes on Australasian Bittern and Australian Little Bittern are in the Handbook series (Marchant and Higgins 1990) and recent notes and colour photographs to aid identification have been produced by Birds Australia (2009).

The importance of live trees for nesting by a number of Australian waterbird species has previously been reported. In a study of wetlands on the Murrumbidgee River in New South Wales, Briggs *et al.* (1997) found that 'Little Black Cormorants, Little Pied Cormorants, White-faced Herons and Yellow-billed Spoonbills used wetlands where

River Red Gums *Eucalyptus camaldulensis* were flooded for at least four months, but not long enough to kill the trees'. The conservation of breeding habitat for Great Egret and Australian White Ibis in River Red Gum wetlands also requires the conservation of appropriate nest trees (Briggs & Thornton 1995) and appropriate hydrological regimes. Briggs *et al.* (1997) emphasised that, in order to retain their suitability for nesting by species that do not nest in dead trees, River Red Gums 'must not be flooded for more than 18 months' as they 'can die after 18 months of continuous inundation and certainly die after three years of flooding'. Dead River Red Gums, while they persist, may be used for nesting by Darters, Great Cormorants and Pacific Herons, however in time they rot and fall (Briggs *et al.* 1997).

Comparable studies of tree and waterbird nesting associations have not been reported from south-western Australia, however Halse *et al.* (1993b) did find that a group (statistical) consisting mostly of brackish wetlands with live trees supported the most breeding. Efforts to save the live trees, mainly Swamp Sheoak *Casuarina obesa*, of Toolibin Lake, in south-western Australia's wheatbelt region, are also based partly on the concern that breeding species will be lost if all the trees die (Halse 1987, Wallace 2003). In the principal author's (RJ's) experience across Australia, cormorants (often) and colonial herons/egrets, spoonbills and night herons (occasionally) may nest in dead trees but seem to mainly nest in live trees. In this context it is important to note that where tree death is due to salinisation there may also be an associated local loss of suitable prey species, due to inability to persist in saline conditions.

Methods

Selection of target wetlands

Target wetlands for survey in 2008-9 were selected (by JL) through close consideration of the project objectives, trends in depth and salinity (Lane *et al.* 2004 and more-recent data), changes in vegetation, prior use by waterbirds, survey logistics, budgetary constraints and consultation among the co-authors (Table 1; Appendix 2). Graphs of depths and salinities of the nine selected wetlands over the entire DEC monitoring period to the end of 2008 are in Appendix 3.

Table 1. Wetlands selected for survey by WIO and DEC in 2008-9 and long-term trends in depth and salinity (ns = not significant)

wetland name	***code***	***selection criteria met***	***trend in depth at 2006***	***Trend in salinity at 2006***
Nine Mile Lake	NINE	2, 3, 4, 6, 8, 9.	decrease	ns
Lake Davies	DAVI	1, 2, 3, 4, 7, 9.	ns	increase
Yarnup Lagoon	YARN	2, 3, 4, 6, 8, 9.	ns	increase
Boat Harbour Lake 1	BOA1	1, 2, 3, 5, 7, 8, 9.	decrease?	increase?
Lake Pleasant View	PLEA	1, 2, 3, 5, 7, 8, 9, 10.	decrease?	ns
Mettler Lake	METT	1, 2, 3, 4, 5, 7, 8, 9.	increase	ns
Yellilup Lake	YELL	1, 2, 3, 4, 6, 8, 9.	decrease	increase
Esperance Res. 26410	ESP1	1, 2, 3, 4, 5, 7, 9.	increase?	increase
Shark Lake	SHAR	1, 2, 3, 5, 7, 8, 9, 10.	ns	decrease?

Selection criteria variously met by these wetlands (Table 1) are summarised as follows:

1. located on or near the south coast
2. vegetated at present or in the past
3. depth and salinity have been monitored by DEC over a long period (all of the selected wetlands have been monitored at least 15 years and most for more than 25 years)
4. monitoring has shown a definite long-term change in depth and/or salinity
5. there are early indications of possible long-term change in depth and/or salinity
6. a substantial change in vegetation structure and/or arrangement has occurred
7. vegetation structure and/or arrangement will be substantially affected if long term change in depth and/or salinity occurs
8. early in the depth/salinity monitoring period the wetland was important for waterbirds that were highly dependent on emergent/fringing vegetation
9. known to support sensitive waterbirds (see definition above).
10. in the DEC South Coast Region and suitable for training in survey of secretive waterbirds

There are three broad groups within this set of wetlands in terms of dominant vegetation: those where the vegetated areas are dominated by trees (paperbarks such as Saltwater

Paperbark *Melaleuca cuticularis* or Flat-topped Yate *Eucalyptus occidentalis*) but with tall sedges absent (YELL, ESP1); those dominated by sedges such as *Baumea* spp. (DAVI, PLEA, SHAR); and those with substantial areas of both trees and sedges (NINE, YARN, BOA1, METT). Survey methods suitable for each situation needed to be adopted for the project.

It is important to note that only one (PLEA) of the nine selected wetlands is also included in the set of 25 south-western Australian (mainly Wheatbelt) wetlands that have been intensively monitored by DEC under the State Salinity Strategy since 1997 (Cale *et al.* 2004, Cale & Halse 2006a-u, Gibson *et al.* 2004, Lyons *et al.* 2007). This is because the objectives, criteria, geographic extent and time scales of the two projects are different.

Field survey methods

Original field notebooks (RJ), datasheets stored at DEC's Woodvale library, and project reports from surveys in the 1980s and 1990s were extensively reviewed during preparation for field surveys of the nine selected wetlands. This enabled the survey team (RJ and AC) to understand, wetland by wetland, the geographic extent and routes of previous surveys and the waterbird species recorded and/or breeding. Other literature such as documents on other aspects of the ecology of the wetlands and vertical and oblique aerial photographs (where available) from across the 30 years also was studied. Hard copies from the literature search have been retained by DEC (JL).

Drawing on the literature review and project objectives, the following principles and procedures were used to guide the field team for this survey:

- An **observer** who had surveyed the wetlands in the 1980s-1990s should participate in the fieldwork: one of us (RJ) had surveyed waterbirds (at least twice) at each of the nine selected wetlands and AC had surveyed waterbirds (at least once) at several of the selected wetlands (AC also was familiar with all of the wetlands through DEC depth/salinity monitoring)
- the **season** of survey should be as close as possible to the most common season of 1980s-1990s surveys, which proved to be spring-summer
- the **month** of survey should be as close as possible to a month in which surveys were conducted previously at all (or most) of the nine wetlands, which was (late) November
- the 2008 surveys should be conducted in the likely **breeding** season of sensitive species (particularly bitterns) which, based on previous survey results and general experience of the authors in south-western Australia, is spring-summer with a tendency on the south coast to be late spring and early summer (Australian Little Bittern and Spotless Crake are considered summer breeding species: Halse & Jaensch 1989)
- at each wetland, where possible at least the same **sectors** of the wetland should be surveyed in 2008 as in the 1980s-1990s surveys
- photocopies of a satellite image and/or vertical aerial **photograph** of each wetland, on waterproof paper, should be prepared and carried during surveys to guide navigation and ensure optimal survey coverage of the wetland
- wherever possible, the entire wetland should be surveyed since this is normally necessary to ensure that survey results truly reflect the diversity and numbers of waterbirds present (because individuals and species are often patchily distributed within wetlands); thus, use of a **boat** would be desirable at some wetlands

- if habitat for bitterns was present at the wetland, the observers should **listen** for calling bitterns for at least 15 minutes around dusk or later in the evening; ideally, listening should be done for 30 or more minutes, at each of several vantage points, on more than one day
- observers where necessary were to familiarise themselves with the advertising calls of Australasian Bittern and Australian Little Bittern from recordings of those calls and should use, briefly, amplified **playback** on-site to induce a response from bitterns present but not calling at the time
- a substantial portion of any inundated dense vegetation in the wetland, which may harbour **nests** of ducks, bitterns, crakes, small rails, waterhens and swamp warblers, should be searched intensively; hence, wading in the wetland was essential
- inundated and recently-inundated (previous 12-24 months or so) trees would be examined for indications of nesting by sensitive colonial species such as spoonbills and cormorants
- **depth**, **salinity** and pH would be recorded by DEC (AC) at each of the wetlands during the surveys, consistent with DEC monitoring protocols
- **safety** of observers when wading should be addressed by working closely in pairs, carrying flotation or other recovery devices such as a boat oar when in boggy or 'floating' substrate, and wearing leg protection and carrying a compression bandage in snake habitat.

One of us (RJ) led the surveys at each wetland and AC was the second observer (but see also below). At Lake Pleasant View, RJ presented training in survey and searching for bitterns and other secretive waterbirds, and their nests (see below), and the 13 local participants subsequently assisted with part of the survey of that lake.

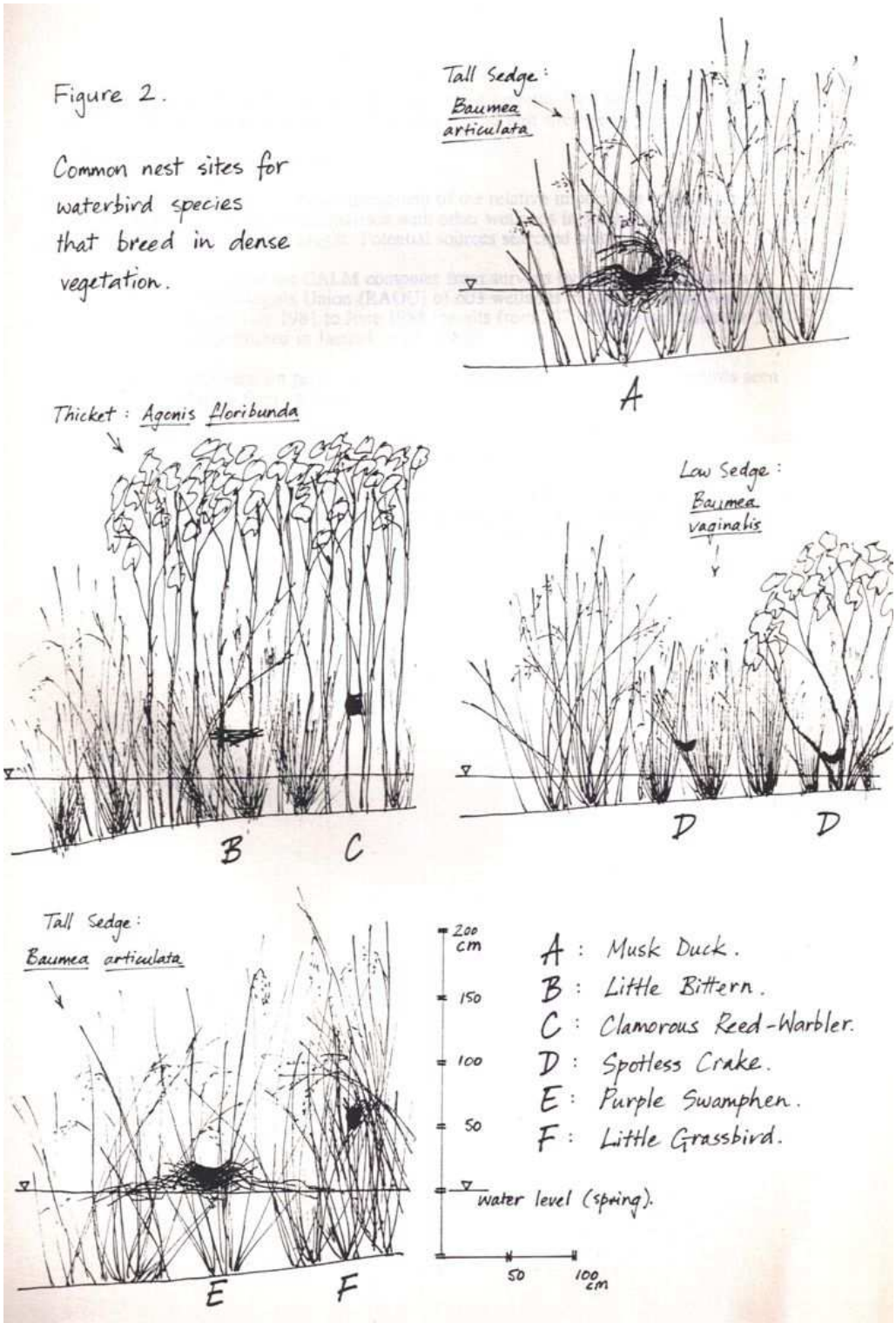
Waterbirds were found, identified and counted using standard, largely commonsense methods as described for previous surveys (e.g. Jaensch *et al.* 1988, Jaensch 1992). Total counts of all waterbirds present at the wetland were attempted, though secretive species perhaps were missed and undoubtedly were undercounted in some cases, particularly at large water bodies with extensive dense sedgeland such as at BOA1. A tripod-mounted telescope was used to identify birds at great distance from the observers.

In densely vegetated wetlands some nests were found simply by thorough searching of all inundated dense sedge/shrub habitat, but, where habitat was extensive and time or energy limited, some prioritisation or focus of effort on most-suitable areas was needed. This depended heavily on the experience of the observers and one of us (RJ) was able to lead on this drawing on over 30 years of nest searching; AC also had some experience to draw upon and this grew rapidly as the project progressed. Figure 2 illustrates typical nest sites of six waterbird species in the study area.

Data recording and management

To ensure adequate capture of information and provision of a record that could be used in planning the conduct of any future surveys at the same wetlands, the following procedures were followed for data capture and management:

Figure 2. Common nest sites for waterbird species that breed in dense vegetation (from Jaensch 1992)



- counts of waterbirds and descriptions of nests and vegetation were entered in pocket **notebooks**
- the **route** taken at each wetland was captured and saved on a Garmin GPS unit
- the positions of all active **nests** and most old nests were recorded on GPS
- digital **photographs** were taken of active nests and some old nests (especially where identity of bird species was unknown), habitat at nests, vegetation change (e.g. recently dead shrubs or trees) and other relevant subjects; the GPS positions of some non-nest photos (e.g. of feeding platforms, which, in some instances, resemble nests) were noted
- digital photographs were stored on computer and file names were labelled according to wetland name and general location within; **keywords**/tags to describe the subject/s were added to the file properties to aid interpretation and file searches
- a **datasheet** was designed for the survey and all field data were transferred to a digital version (using a tablet computer and handwriting), or to a hard copy, within 12 hours of the survey to ensure accuracy and comprehensiveness of the record
- at the same time, the approximate extent of surface water and route of survey, and key points of interest, were annotated by hand on a pre-prepared **map** (digital or hard copy) of the wetland based on a vertical satellite image or aerial photograph
- daily **back-ups** of digital files were made to a portable hard drive
- datasheets, maps and photographs (digital or scanned) were copied to the DEC computer **network** at the end of the survey trip, with backup off-site (WIO); field notebooks (of RJ) were retained by WIO
- a **CD** of the same files was lodged with DEC at project completion.

Summary datasheets and route maps for each of the nine wetlands are in Appendix 4.

Coverage achieved

Surveys were conducted from Tuesday 25 November to Wednesday 3 December (Table 2). The typical daily routine for wetlands with dense sedgeland was as follows:

- late afternoon to dusk (or when visibility was lost): count waterbirds and search for nests (4-6 hours)
- within two hours after sunset: listen for calling bitterns (up to one hour)
- early morning (e.g. 08:00-10:00): conduct a follow-up waterbird/nest survey if warranted and if time permitted
- mid morning to early afternoon: travel to next wetland (several hours)

This was the most effective use of time and effort because past experience (RJ) indicated more records of bitterns calling in the evening than before sunrise, though this may have been partly an artefact of observer effort. Furthermore and given the long day length (hence early sunrise) in November-December, after conducting evening surveys an adequate sleeping period for observers precluded surveying very early the next day.

At wetlands without dense low cover or that were relatively small, surveys could be completed more easily and survey duration was shorter (1-3 hours); also the time of day was less important, because listening for bitterns was not warranted.

Table 2. Dates of surveys, hours of survey effort and approximate area of water and percentage of inundated area surveyed, November-December 2008

wetland	*survey date/s*	*hours of survey effort **	*approx. area ** of water (ha)*	*% of inun-dated area surveyed*	*boat used ?*
NINE	25 & 26 November 2008	5.8	14.6	40	
DAVI	3 December 2008	1.3	1.4	~100	
YARN	26 & 27 November 2008 *	7.0	21.2	67	
BOA1	2 & 3 December 2008 *	5.2	ca. 125.0	~70	yes
PLEA	27 & 28 November 2008 *	6.5	185.5	~75	
METT	28 November 2008 *	5.2	46.3	80	
YELL	29 November 2008	3.0	ca. 250.0	75	yes
ESP1	1 December 2008	3.0	23.1	~100	yes
SHAR	30 November 2008	3.8	7.4	95	yes

* not including additional survey conducted by AC in January 2009 – see Table 4

** measured from Google Earth satellite image, guided by field survey maps. This is also the inundated area.

Coverage of the water area ranged from nearly 100% at small wetlands to 75% or less (minimum 40%) at some larger wetlands and wetlands with extensive, dense low vegetation.

Training delivered

Acting on an offer (by JL) to DEC's South Coast Region, we arranged training for DEC staff (ecologists) and community volunteers in survey of secretive waterbirds at Lake Pleasant View, near the Region's headquarters in Albany, during the project field program. DEC proposed to deploy this workforce in future surveys of bitterns and other waterbirds in South Coast wetland conservation reserves. The training took place at 0830-1230 on Saturday 28 November 2008 and comprised instruction, listening to call recordings and discussion/questions followed by illustration of points made by all wading through bittern habitat at the south end of the lake. It was reinforced by involvement of some of the same staff in a follow-up survey led by AC in January 2009 (see below).

Wetland and weather conditions

At the regional scale, rainfall for the 2008 southern wet season (April to November) in the study area was generally average (4th to 7th deciles) in the west and parts of the south-east coast, but above average to very much above average (8th to 10th deciles) in the far south coast and much of the south-east (Bureau of Meteorology website www.bom.gov.au). Wetland water levels and salinities in spring 2008 reflected this varied distribution of rainfall. Note, however, that water levels and salinities at any point in time are also influenced by conditions in previous years and by long-term trends.

Long-term depth (water level) and salinity records from the selected wetlands are presented in graphical form in Appendix 3. These data are collected routinely by DEC in mid September and early November each year and indicate wetland conditions following

the preceding winter wet season. The routinely-collected DEC data of 2008, together with depths and salinities recorded on the days of wetland survey during this project, are shown in Table 3 and the graphs of Appendix 3.

Table 3. Depths and salinities of the nine selected wetlands in spring 2008 and (for four of the wetlands) in January 2009.

wetland	*depth (m), early Sep 08*	*depth (m), early Nov 08*	*depth (m), late Nov 08*	**depth (m), early Jan 09*
NINE	0.66	0.63	0.57	
DAVI	4.60	4.51	4.43	
YARN	1.00	0.99	1.03	0.85
BOA1	0.78	0.88	1.07	1.01
PLEA	0.46	0.57	1.10	0.96
METT	0.55	0.58	1.01	1.03
YELL	1.02	1.07	1.32	
ESP1	0.76	0.77	0.76	
SHAR	2.18	2.32	2.36	

wetland	*salinity (ppt), early Sep 08*	*salinity (ppt), early Nov 08*	*salinity (ppt), late Nov 08*	**salinity (ppt), early Jan 09*
NINE	0.2	0.2	0.3	
DAVI	2.5	2.4	2.5	
YARN	3.0	3.7	3.7	5.0
BOA1	0.9	0.9	0.7	0.9
PLEA	0.7	0.6	0.3	0.4
METT	0.5	0.5	0.2	0.2
YELL	63.4	59.8	39.7	
ESP1	5.4	5.9	6.2	
SHAR	1.2	1.2	1.1	

* see below regarding the second (January 2009) survey

From Appendix 3 we see that, in early November 2008:

- depth was relatively low (compared with depths of previous Novembers) at NINE, PLEA and arguably also BOA1, METT, YELL and ESP1
- depth was typical or 'mid-range' at DAVI, YARN and SHAR
- salinity was relatively high at DAVI, YARN, BOA1, YELL, ESP1 and arguably also METT
- salinity was relatively low or 'mid range' at NINE, PLEA and SHAR.

Typically, it could be expected that (apart from perhaps the highest rainfall areas on the mid-west of the south coast), by November, water depths generally would have reached their peak and in many cases begun to decline with the onset of the dry season. However, between the first week of November 2008 and the survey weeks, and especially during the first few days of the survey, unseasonally heavy rainfall occurred on parts of the south and south-east coasts. This is illustrated by mean November versus November 2008 rainfall for Denmark (mean 53 mm; recorded 153 mm), Albany Airport (46; 137) and Mettler (45;162); 63-77% of these monthly totals fell during 20-24 November (Bureau of Meteorology data www.bom.gov.au). This event caused rapid rises in depth at several wetlands: BOA1 (19 cm), PLEA (53 cm), METT (43 cm), and

YELL (25 cm). Depths at some of the wetlands were, no doubt, continuing to rise in late November as considerable surface inflow was seen at YARN, BOA1 and PLEA during the surveys.

As waterbirds tend to delay completion of nest building and laying of eggs until water levels have stopped rising – at least partly because nests and their contents (eggs and/or in some cases young) may otherwise be drowned – one impact of the rapid rises in water levels in November 2008 would have been the destruction, halt or delay of breeding by many waterbirds. Also, heavy rain can fill shallow wetlands that have not yet filled and so offer alternative feeding and/or breeding habitat for waterbirds. Accordingly, it was likely that less breeding and fewer species/individuals of waterbirds would be present compared with expectations, in the affected wetlands in late November 2008.

Second survey

In order to at least partially compensate for the impacts of the unusually heavy November rainfall on this snapshot survey program, DEC decided to conduct follow-up surveys at wetlands that were both affected by rising water levels and high priority in relation to the project objectives. Accordingly, one of us (AC), assisted by volunteer John Graff, re-surveyed YARN, BOA1, PLEA and METT on 8-12 January 2009 (Table 4). Objectives and procedures were essentially as for the first survey but with special attention given to:

- prime bittern habitat where no bitterns were recorded in the first survey (on the basis that bitterns may have dispersed in November but returned by January)
- prime nesting habitat where no nests were recorded in the first survey (on the basis that conditions, especially water levels, were better for nesting in January)
- wetlands where wet or windy weather had impaired surveys in November (mainly YARN and PLEA, in part)
- areas of bittern and/or nesting habitat not searched fully (due to time constraints) in the first survey.

Table 4. Dates of surveys, hours of survey effort and approximate area of water and percentage of inundated area surveyed, January 2009

wetland	*survey date/s*	*hours of survey effort **	*approx. area * of water (ha)*	*% of inun-dated area surveyed*	*boat used ?*
YARN	8 January 2009	4.8	21.2	50	yes
BOA1	9 January 2009	5.3	ca. 125.0	60	yes
PLEA	10 January 2009	6.5	185.5	70	yes
METT	11 & 12 January 2009	5.7	46.3	40	

* measured from Google Earth satellite image, guided by field survey maps; assumed largely unchanged since late November 2008

For each of these four wetlands, two datasheets are shown in Appendix 4 but results are combined in the body of this report (below).

Additional skills transfer was achieved, to John Graff (a Birds Australia member) and also to a small group of volunteers and DEC staff who again assisted at PLEA.

Limitations

A number of limitations have been recognised in presenting the results and conclusions of this report and readers should bear them in mind:

- The November-December 2008 and January 2009 surveys are just two **temporal snapshots** of wetland habitat and waterbird usage of the surveyed wetlands and therefore cannot capture the considerable natural variability that may occur on-site over one year let alone several or more years. However, the surveys were timed to coincide with the optimal time of year for detecting the priority waterbird species and their nesting activity. Also, we contend that long-term changes in habitat (e.g. dead trees) were readily detectable in a single survey, and that present habitat together with trends in depth and (especially) salinity have enabled us to draw meaningful conclusions about present and likely future changes in waterbird usage.
- Waterbirds, including sensitive species, are highly mobile; variability in patterns of usage are driven both by on-site factors and by availability of **habitat elsewhere** in the region and even farther afield. Therefore, in the absence of a concurrent survey of all similar habitat in the study area and beyond, it is not possible to be entirely definitive about reasons for presence or absence of species and/or breeding at the local wetland. However, we consider that our collective detailed experience of wetlands and waterbirds outside the nine surveyed wetlands, over 30 years, together with results of the present surveys, provide sufficient basis for our conclusions.
- **Limitations of time** available for survey precluded 100% coverage being achieved at most of the wetlands; less than a full day was available per wetland, due to large distances to travel between wetlands. Hence, some species and nests may have been missed. However, we applied our collective experience to targeting both representative and optimal areas of waterbird habitat at each wetland, to ensure that survey results broadly represented the total situation.
- Information from **previous surveys** (1980s-1990s) of waterbirds at the selected wetlands varied greatly in detail and scope, hence our accuracy in replicating previous surveys was inconsistent, wetland-to-wetland. In some cases (e.g. METT) we conducted more intensive nest searching than was done in the past. Nonetheless, we consider that the methods of our present survey were appropriate and sufficient to address the primary objective in terms of whether or not certain sensitive species still occur or could occur at the wetland.
- Finding **secretive waterbirds** and their nests are inherently difficult tasks even for experts and our time for this work was quite limited. Thus it is likely that we missed some secretive species and their nests at some of the nine surveyed wetlands. However, we consider that our collective experience in understanding the habitat and nesting requirements of most of the waterbird species surveyed enables us to draw meaningful conclusions about the continued suitability of the subject wetlands for supporting secretive (and other sensitive) species.
- Some **old nests** cannot be identified as to the waterbird species that used them and the year when the nest was last active can, in some instances, be impossible to discern, especially if no eggshells or feathers remain in the nest. However, although some valuable knowledge remained unattainable, this loss generally was not significant with respect to our project objectives.

Results

Changes in habitat over 2-3 decades

A picture of change in waterbird habitat has been formed by drawing on our collective personal experience of previous conditions, photographs (mainly vertical and oblique aerial) and survey datasheets and reports from the 1980s – 1990s, and from the 2008-9 surveys (Table 5). This process was assisted by reference to two early surveys of the vegetation and floristics of a number of the target wetlands; the Robinson (1992) surveys of DAVI and BOA1 and the Halse *et al.* (1993a) surveys of ESP1, METT, NINE, PLEA, SHAR and YARN. Additional information concerning vegetational change at PLEA was also obtained from Cale *et al.* (2004).

Maintaining our focus on sensitive species, the following classes of inundated habitat have been used:

- TS = Tall sedgeland: tall (1-3 m high) beds and/or clumps of sedge, principally *Baumea articulata.* Often including low thin rush and occasional shrubs. Shelter and nest sites for bitterns, crakes and small rails, and nest sites for ducks
- TY = Typha beds: tall (1-3 m high) beds and/or clumps of *Typha* (probably *T. orientalis*) typically as monospecific stands. Shelter and nest sites for bitterns, crakes and small rails, and nest sites for ducks
- GA = Gahnia tussocks: low (up to 1.5 m high) tussocks and beds of saw-sedge *Gahnia trifida*. Shelter for Australasian Bittern, crakes and small rails, and when deeply inundated may support duck nests
- LS = Low sedgeland: low (up to 1.5 m high) beds of dense sedge dominated by *Baumea juncea*, *B. vaginalis, Leptocarpus* sp., *Lepyrodia* sp. and/or similar sedge/rush species. Feeding habitat for Australasian Bittern, but on its own generally not structurally adequate to support bittern, crake, small rail or duck nests
- SH = Shrub thicket: relatively low (up to 3 m high) dense thickets and clumps of *Melaleuca laterita*, *M. teretifolia*, *M. cuticularis* and *Agonis* spp. Shelter and nest sites for Australian Little Bittern, crakes, small rails, and ducks if plenty of sedge is included
- WO = Wooded swamp: tall (3-15 m high) woodland and/or clumps of trees in the zone of inundation, mainly Saltwater Paperbark *Melaleuca cuticularis*, Warren River Cedar *Agonis juniperina* and Flat-topped Yate *Eucalyptus occidentalis*. Substantial trees provide nest sites for colonial-breeding cormorants, herons, egrets, ibis and spoonbills, and Freckled Ducks may nest in trunk junctions near water level.

Table 5. Change in habitat for sensitive waterbird species at the surveyed wetlands, 1980s-90s to 2008-9

wetland	***habitat present in 1980s and/or early 1990s***	***habitat present in 2008-9***	***summary of change***
NINE	Mainly open water in main lake, small variable areas of TS[4], small areas of SH; satellite swamps occupied by SH and WO.	Mostly (over 95%) TY in main lake with fringing patchy TS and SH; satellites' vegetation unchanged.	Major **loss** of open water; major **gain** of dense cover.
DAVI	Mainly open water with narrow fringe of semi-continuous LS; some LS clumps. This is suggested also by Photo 1 of Robinson (1992).	Similar but LS with no clumps and possibly more dense.	Possible **loss** of varied structure; otherwise unchanged
YARN	Mainly TS with some open water (depth dependent); most of margin with SH and WO narrow zone. No definite signs of salinity increase in swamp in 1987-8 (Halse *et al.* 1993a)[5]	Area of TS reduced markedly, especially in south, and open water increased; TS no longer the dominant habitat. In SH zone, the prominent *Melaleuca laterita* element dead or nearly so and the formerly common, tall, thin sedge element mostly lost.	Major **loss** of dense cover in broad basin and margins.
BOA1	Large area of open water; also large areas of LS with complex mosaic of GA, TS and SH; broad to narrow areas of WO, SH and TS at some margins and in back-swamps; small areas of TY at NE margins.	Unchanged.	No discernible loss or gain.

[4] Halse *et al.* (1993a) suggested that NINE had only 3% open water some time between 1969 and 1978, but the present authors have been unable to find evidence to support this. 1965 and 1980 aerial photography indicate >95% open water.

[5] Halse *et al.* (1993a) described YARN as being at an early stage of change in 1987-8. Salt scalds were reported to have appeared in the YARN nature reserve ≈200m south of the wetland in 1983 or 1984.

Table 5 continued

wetland	***habitat present in 1980s and/or early 1990s***	***habitat present in 2008-9***	***summary of change***
PLEA	Some open water (depth dependent) but dominated by LS with patches of TS especially at some margins; small patches of SH and GA in margins[6]. In 1987-8 GA was the main sedge in the lake (Halse *et al.* 1993a)	Unchanged except for probable increase in occurrence and extent of SH, notably in the north. Cale *et al.* (2004) estimated open water comprised only 5% of PLEA's 'wetted area' in 1999-00[7].	No net loss or gain of dense cover; probably some LS & TS replaced by SH
METT	Extensive live WO and broad area of TS; mixed WO, SH and TS in eastern margins and interior; GA scattered under western WO; some open water.	Unchanged; incidence of (the few) dead trees in deepest areas seemed 'natural' though some *Melaleucas* had thin canopies.	No discernible loss or gain.
YELL	Extensive live WO and broad eastern area of open water; low shrubs in open water zone exposed at low water levels.	All trees below 2.5 m gauge depth dead; some live seedlings and a few live paperbarks in 2.5-2.8 m zone; samphire common on outer bed.	Total **loss** of dense live tree cover in lake interior (also salinisation effects).
ESP1	Extensive live WO and interior area of open water; GA scattered under some WO.[8]	Similar, but zone up to 50 m wide of dead yates around W to N sides of open water; some regrowth (seedlings 0.3-2.0 m) above 0.8 m depth.	Some **loss** of dense live tree cover.
SHAR	Mainly open water but with semi-continuous narrow zone of TS and some SH.	Unchanged.	No discernible loss or gain.

In summary, major loss of habitat for sensitive waterbirds has occurred at two wetlands (YELL, YARN), minor loss has occurred at two wetlands (ESP1, DAVI), and no significant net loss has occurred at four wetlands (BOA1, PLEA, METT and SHAR). Major gain of habitat for some sensitive waterbirds (crakes, small rails, bitterns) has occurred at one wetland (NINE).

Habitat gains and losses for other (non-sensitive) waterbirds have not been thoroughly examined. However, notable changes have been:

---

[6] Note that Cale *et al.* (2004) suggested the amount of open water in PLEA is variable, on the basis that Halse *et al.* (1993a) reported <1% of PLEA's area being open water (at time of field investigation between Dec 1987 and Feb 1998 or from aerial photography between 1969 and 1978?), whereas Cale's estimate (based on personal observation) of area of open water in 1985-6 was 75%. Note also that the map on p.92 of Halse *et al.* (1993a) indicates a much larger area (≈30%) of open water than stated in the text (0.04%).

[7] See previous footnote.

[8] Extensive shrub *Acacia glaucoptera, Melaleuca glaberrima* understorey flooded in 1986 was dead by Jan 1988 (Halse *et al.* 1993a). These shrubs may have invaded during the extended dry period before 1986 (see Appendix 3).

- loss of open (and deeper) water at NINE, which has greatly reduced suitability for several waterbird species including diving species such as Great Cormorant and for shorebirds such as dotterels
- loss of sedgeland at YARN, which has reduced the area of habitat for non-sensitive waterbirds such as grassbirds and reed-warblers.

Numbers of waterbird species recorded, and species recorded breeding

Table 6 compares survey effort, number of species and number of breeding species recorded at each wetland, before and during the 2008-9 surveys. All waterbird species, not just sensitive species, are considered.

Table 6. Number of waterbird species recorded and number of species recorded breeding, at each wetland, in 2008-9 and in previous surveys

Wetland	*No. of surveys*		*Species Recorded*		*Breeding Species*	
	pre-2008	*2008-9*	*pre-2008*	*2008-9*	*pre-2008*	*2008-9 **
NINE	32	1	22	9	6	3
DAVI	2	1	5	3	4	1
YARN	23	2	14	11	4	6
BOA1	22	2	34	13	0	3
PLEA	35	2	24	13	5	5
METT	19	2	16	13	0	7
YELL **	9	1	40	15	11	2
ESP1	5	1	12	15	3	3
SHAR	60	1	43	15	8	7

* Breeding data for 2008-9 include unidentified nests where the nest was of a species not otherwise recorded breeding at the time, and include old nests (up to about three years old).

** Includes 2 species (Night-Heron, Wood Duck) found breeding only in October 1979 (J Lane & G Pearson).

Pre-2008 data are from the RAOU Waterbirds Database 1981-9 (partly reported in Jaensch *et al.* 1988), Jaensch 1992, Jaensch & Clarke 1993, Storey *et al.* 1993, Clarke & Lane 2003, and some 1979 DEC datasheets (J Lane).

The number of species recorded or recorded breeding tends to increase with number of surveys (Jaensch *et al.* 1988; Halse *et al.* 1993b); hence results for 2008-9 alone could be expected to be poorer than suggested by previous (accumulated) knowledge, especially at wetlands with a large number of pre-2008 surveys (e.g. SHAR, PLEA). However, at one wetland (ESP1) the number of species recorded was higher in 2008-9 and in two other wetlands it was at least 75% of the pre-2008 number. Furthermore, the number of species recorded breeding was higher in 2008-9 than pre-2008 at three wetlands: YARN, BOA1 and METT. Some of these increases reflect a greater intensity of effort and/or expansion of survey methods applied; nest searching by experts probably had not occurred previously at METT. Others may reflect seasonal or inter-annual variability in wetland water levels and thus the area and type of habitat that is inundated.

Notwithstanding the above, some of the marked changes (Table 6) can be confidently attributed to changes in habitat extent or quality. At YELL, both the lower number of

waterbird species and lower number of breeding species are surely due to loss of live tree habitat and changes to food resources with the rise in salinity. At NINE, the lower 2008-9 number of species may be partly due to the loss of open water habitat, but the lower number of breeding species probably reflects the lower number of 2008-9 surveys. At DAVI, the lower number of breeding species in 2008-9 is perhaps due to increased salinity.

Sensitive species

Table 7 compares the number of individuals counted, and breeding activity recorded, in 2008-9 and previously ('pre-2008'), for each wetland, and is confined to sensitive species. The 2008-9 records are drawn from both the first (nine wetlands) and second (four wetlands) surveys in spring 2008 – summer 2009.

Table 7. Number counted and breeding activity of sensitive species at each wetland, 2008-9 and in previous surveys

(Numbers and breeding: AusB = Australasian Bittern, ALiB = Australian Little Bittern, SpCk = Spotless Crake, BaCk = Baillon's Crake, ASCk = Australian Spotted Crake, BbaR = Buff-banded Rail, BbiD = Blue-billed Duck, and FreD = Freckled Duck; Breeding only: YbSl = Yellow-billed Spoonbill; LPiC = Little Pied Cormorant; WnHe = White-necked Heron; NaNH = Nankeen Night-Heron. **Br** = breeding, one nest/brood unless otherwise indicated, and on only one occasion unless otherwise indicated.)

wetland	***sensitive species pre-2008***	***sensitive species 2008-9***
NINE	ALiB (1, **Br**); SpCk (8, **Br?**: several old crake nests).	ALiB (1); SpCk (10, **Br?**: 3 old crake nests).
DAVI	SpCk (1, **Br**).	No crakes or their nests recorded.
YARN	AusB (2); ALiB (**Br**: in 4 years in 1980s, up to 19 nests, with 12 active nests in 1983-4 season); SpCk (18; **Br,** 3+ nests, mid 1980s).	LPiC (**Br**: 11 nests probably of this species). No bitterns or crakes recorded and no old nests found of these species.
BOA1	AusB (3); SpCk (13).	AusB (up to 3); ALiB (3); SpCk (up to 6, a possible old nest); BbiD (6).
PLEA	AusB (5, **Br**: a nest reported in Dec 1986 by Tony Bush); ALiB (1, **Br**); SpCk (4).	AusB (2); ALiB (2, **Br**: an old nest and a probable new nest); SpCk (6).
METT	AusB (2); ALiB (1); SpCk (3).	AusB (1); ALiB (1, **Br**: old nest, new nest); LPiC (**Br**: 40 nests).
YELL	BbiD (30); FreD (2); **Br**: by NaNH (20 nests), LPiC (17 nests), a few YbSl & WnHe.	No BbiD or FreD; no colonial nesting recorded (one very old heron nest was recorded).

Table 7 continued

wetland	*sensitive species pre-2008*	*sensitive species 2008-9*
ESP1	BbiD (1). Potential for small breeding colonies in live trees.	BbiD (1); FreD (2). Potential for small breeding colonies in live trees.
SHAR	AusB (1); SpCk (11, **Br**); BaCk (4); ASCk (6, **Br**); BbaR (1); BbiD (9).	ALiB (1, **Br**: a new nest); BbiD (13, **Br**: a nest with eggs); SpCk (1, **Br**: an old nest).

Pre-2008 data are from the RAOU Waterbirds Database 1981-9 (partly reported in Jaensch *et al.* 1988), Jaensch 1992, Jaensch & Clarke 1993, Storey *et al.* 1993, Clarke & Lane 2003, and some 1979 DEC datasheets (J Lane).

The table shows records of colonial tree-nesting species only in relation to their breeding.

See datasheets in Appendix 4 for details of 2008-9 records.

Marked differences between 2008-9 and pre-2008 occurrence of sensitive species occurred at two wetlands (Table 7):

- At YARN (despite two 2008-9 surveys), there was loss of all previously-recorded sensitive species, both breeding and non-breeding. It is not yet apparent as to whether or not these losses, due at least partly to major changes in habitat on-site, are reversible. One sensitive species was newly recorded at YARN: breeding by (presumed) Little Pied Cormorant in fringing live paperbark trees.
- At YELL there was loss of all previously-recorded sensitive species, both breeding and non-breeding. This is likely to be an irreversible loss arising from major changes in habitat on-site.

At DAVI there has been a possible loss of a sensitive species but more surveys would be needed to confirm this.

At three wetlands, no real or net difference seems to have occurred:

- At NINE, usage by sensitive species seemed highly similar (the ALiB was calling so it may have been nesting) although areas of occupancy have shifted from the now-drier satellite swamps to the now-more-vegetated main basin (see Appendix 4).
- At PLEA, results were similar but with fewer Australasian Bitterns despite two surveys in 2008-9 (but numbers have always been low: less than 10 birds).
- At SHAR: one sensitive species (BbiD) persisted; four sensitive species not recorded in 2008-9 were only occasionally recorded in the past and/or are difficult to find; and one sensitive species was gained (ALiB: probably overlooked) despite 60 previous surveys.

No real differences are believed to have occurred at the three remaining wetlands, even though there were some small gains in sensitive species recorded and/or recorded breeding. At BOA1, two sensitive species (ALiB, BbiD) were newly listed in 2008-9 but these changes probably reflect previous oversight and are not considered to indicate any change in wetland health. Similarly, at METT, two breeding sensitive species (ALiB, LPiC) were gained and SpCk was not recorded; these results also probably reflect oversight. And at ESP1, one sensitive species (FreD) was gained but this species probably has occurred in the past: this was the first comprehensive boat survey at ESP1.

Distribution of the non-colonial sensitive species among the nine surveyed wetlands in 2008-9 was as follows: Australian Little Bittern (5 wetlands); Spotless Crake (4); Australasian Bittern (3); Blue-billed Duck (3); and Freckled Duck (1).

Waterbird breeding efforts

The numbers of waterbird nests, of any age, found at each wetland during surveys in 2008-9 are shown in Table 8. Where a second (2009) survey was conducted it was possible to determine, from records of survey paths and GPS positions of nests, which nests were additional to those found in the first (2008) survey.

Table 8. Number of waterbird nests of any age found at each wetland in 2008-9

(HhGb = Hoary-headed Grebe; MusD = Musk Duck; PuSn = Purple Swamphen; LPiC = Little Pied Cormorant; AReW = Australian Reed-Warbler; LiGd = Little Grassbird; PaBD = Pacific Black Duck; Hard = Hardhead; Coot = Eurasian Coot; ChTl = Chestnut Teal; Swan = Black Swan; ALiB = Australian Little Bittern; SpCk = Spotless Crake; BbiD = Blue-billed Duck.)

wetland	***number of active or recent (2008-9) nests***	***number of older nests *****	***breeding species (number of nests of any age)***
NINE	0	7	AReW (3), crake (3), duck (1).
DAVI	3	0	HhGb (1), grebe (2).
YARN *	20	9	LPiC? (11), PuSn (7), HhGb (3), MusD (2), LiGd (2), AReW (1), duck (2), other (1).
BOA1 *	3	1	PuSn (2), Swan (1), crake? (1).
PLEA *	7	1	ALiB (2), Hard (2), MusD (2), PaBD (1), PuSn (1).
METT *	24	43	LPiC (40), MusD (8), AReW (5), PuSn (4), duck (3), crake? (3), ALiB (2), Coot? (1), PaBD (1); also other nests not counted.
YELL	1	1	ChTl (1 brood), heron? (1 old nest).
ESP1	2	1	HhGb? (1), PaBD? (1), Coot? (1).
SHAR	6	8	AReW (7), PuSn (2), ALiB (1), BbiD (1), SpCk (1), HhGb (1), Coot? (1).

* Surveyed twice in the present project.

** Includes nests of unknown age (up to about three years old).

See Appendix 4 for details. Data include unidentified nests.

Similar data on numbers of nests are not available consistently for all wetlands for the pre-2008 period so comparisons with previous surveys are difficult or impossible. Also, nest searching in 2008-9 was not exhaustive at all wetlands (see Limitations, above).

However, we consider the following observations from 2008-9 to be noteworthy, bearing in mind that more nesting was undoubtedly occurring than was discovered:

- A significant quantity of breeding (at least 10 nests/broods) has occurred in recent years at three wetlands (METT 67 nests/broods, YARN 29, SHAR 14), and probably also at another two wetlands (PLEA 8, NINE 7).
- Four wetlands (DAVI 3, BOA1 4, YELL 2, ESP1 3) seem to be less important for breeding with respect to number of nests/broods.
- Wetlands with highest numbers of nests (METT, YARN) – and greatest diversity of breeding species (METT, YARN, SHAR) – have diverse habitats including areas of dense trees, shrubs and sedges though this characteristic does not necessarily guarantee a large number of nests (cf. BOA1).
- Wetland area is not the critical factor: small wetlands (e.g. SHAR) can have significant breeding activity both in terms of number of nests and number of breeding species.
- 14 breeding species were identified across the surveyed wetlands.
- The most prolific breeding species were: Little Pied Cormorant (51 nests), Australian Reed-Warbler (at least 16), Purple Swamphen (14), and Musk Duck (13).
- Breeding by sensitive species (for this project) comprised: Little Pied Cormorant (51 nests), Australian Little Bittern (5 nests), Spotless Crake (1), unidentified crakes (7) and Blue-billed Duck (1).
- Most of the wetlands had a mix of current/recent and past breeding activity.

Other compositional differences

A number of differences in species composition with respect to occurrence and/or breeding are evident in the results of the 2008-9 surveys. Salient points not already revealed in the above sections are as follows:

- Australasian Grebe was recorded at DAVI pre-2008 but not in 2008-9: this species commonly avoids saline waters.
- Small colonies of old cormorant nests, probably of Little Pied Cormorant, were recorded at YARN (possibly) for the first time. There is no obvious explanation for this result unless perhaps an abundance of freshwater crayfish had arisen locally, on-site or in nearby stocked farm dams.
- The project realised first records of Hoary-headed Grebe at PLEA, YARN, METT and ESP1 and first record of breeding by this species at YARN, ESP1 (?) and SHAR. These may be indicators of either a short term or long term influx of the species to the study area, or due to increases in salinity of wetlands (YARN, ESP1) though that trend has not occurred at all applicable sites (SHAR). In south-western Australia, Hoary-headed Grebe often breed in brackish (Goodsell 1990) and even saline (D. Cale, unpublished data) wetlands. During 1981-5, this species was reported breeding at 17 of 197 surveyed wetlands, 11 of these being above 3 ppt, however it was not recorded breeding at any of the 20 surveyed wetlands in the south coast and Muir-Unicup districts (Jaensch *et al.* 1988).
- In January 2009, Hardhead was recorded breeding (2 nests) for the first time at PLEA; this species is known to commonly exploit flood conditions (RJ pers. obss.), so the result may be due to the unusually heavy rain and local flooding in November-December 2008.

- Notable among the breeding species recorded at METT in 2008-9, all being new records, were extensive use of *Gahnia* tussocks for duck nests (especially Musk Duck) and several small colonies of Little Pied Cormorant (of varied antiquity, some active) in inundated live yate and paperbark trees.
- At YELL, there was a first record of nesting by Chestnut Teal (one brood). Noteworthy numbers of Australasian Shoveler (40) were present despite elevated salinity. Many hundreds of the several thousand Australian Shelducks at YELL were moulting.
- At least five duck species at ESP1 were moulting, though only relatively small numbers were present (see Appendix 4).
- The first record of Great Crested Grebe at Shark Lake occurred in 2008-9.

Numbers of waterbirds

Data on total numbers of all waterbird species were recorded in the 2008-9 surveys but this was not a priority outcome because our focus was on the occurrence of sensitive species and their habitats. For completeness and possible application in wetland management, summary information on total numbers and most-abundant species is given in Table 9.

Apart from the omission of perhaps tens or (at larger swamps) possibly a few hundreds of the smaller secretive waterbirds (total numbers of which are, in practice, impossible to determine in densely-vegetated swamps), these totals are considered in most instances to reasonably reflect the actual total numbers present.

Highest numbers, by an order of magnitude, were at the highly saline (and large) Yellilup Lake. Numbers counted at the other wetlands, five being very fresh (< 1.0 ppt) and three brackish (3<10ppt), were only between a few tens and a few hundreds of waterbirds. In our collective first-hand experience this difference in numbers according to salinity is common among wetlands in south-western Australia, especially on the south coast, although, in more than a few instances, fresh wetlands can hold large numbers and saline wetlands very few waterbirds. Many other factors also influence waterbird numbers (Halse *et al.* 1993b), e.g. wetland area, bathymetry, nutrient levels, water clarity and pH, and factors external to the wetland, such as availability of food nearby (e.g. cereal grain in paddocks surrounding YELL attracts thousands of Shelduck to the area: Ian Peacock pers. com.).

The most abundant species across the surveyed wetlands were those that tend to congregate in large numbers on open lakes including saline lakes such as YELL: Australian Shelduck, Grey Teal and Pink-eared Duck. Among the fresh and low-salinity wetlands surveyed, species that favour large areas of open water and/or deep water were numerically dominant, e.g. Black Swan, Hoary-headed Grebe, Pacific Black Duck, Hardhead and Little Pied Cormorant.

Several wetlands (NINE, BOA1, PLEA) held so few birds that secretive species such as Spotless Crake were among the most abundant species in the 2008-9 surveys.

Table 9. Total number of waterbirds counted at each wetland in 2008-9 and species that were most abundant

(HhGb = Hoary-headed Grebe; PuSn = Purple Swamphen; LPiC = Little Pied Cormorant; AReW = Australian Reed-Warbler; LiGd = Little Grassbird; PaBD = Pacific Black Duck; Hard = Hardhead; Coot = Eurasian Coot; Swan = Black Swan; SpCk = Spotless Crake; BbiD = Blue-billed Duck; Shel = Australian Shelduck; GyTl = Grey Teal; PeaD = Pink-eared Duck.)

wetland	***total number of waterbirds Nov-Dec 2008***	***total number of waterbirds Jan 2009***	***the 3 most abundant species in either 2008-9 survey*** *(5 or more individuals counted)*
NINE	39	ns	SpCk (10); LiGd (8); AReW (7).
DAVI	27	ns	HhGb (13); PaBD (12).
YARN *	25	29	PuSn (8).
BOA1 *	39	150	Swan (104); LPiC (9); SpCk (6); PuSn (6); BbiD (6), PaBD (6).
PLEA *	21	45	PuSn (8); LiGd (8); SpCk (6); AReW (6); Hard (6).
METT *	96	131	PaBD (50); LPiC (34), GyTl (30);
YELL	4876	ns	Shel (3000); GyTl (1200); PeaD (300).
ESP1	253	ns	HhGb (97); GyTl (52); Coot (28).
SHAR	174	ns	Hard (90); PaBD (39); BbiD (13).

* Surveyed twice in the present project. ns = not surveyed.

Numbers of LiGd and AReW are minima: often many more were present than were recorded. Some other species were probably present in higher numbers than were counted but only the numbers seen/heard were recorded.

Importance of the wetlands

The importance of wetlands for waterbirds can be described in a number of terms including species, breeding species, threatened species, sensitive species and migratory species richness, number of individuals occurring, size of breeding effort and percentage of species' population occurring.

Drawing on past and present survey data, the importance of six of the nine surveyed wetlands is summarised in Table 10. NINE, YARN and YELL have been omitted from this table as these wetlands have undergone substantial hydrological and vegetational change over the past 2-3 decades and it would therefore be unsound to combine waterbird data from the 1980s – early 1990s with 2008-9 data to indicate the wetlands' current (or former) importance.

Table 10. Importance of selected wetlands in terms of multiple measures, using all available survey data (SP = number of species recorded; BR = number of breeding species recorded; TH = number of globally threatened species recorded; SS = number of sensitive species recorded; MG = number of migratory shorebird species recorded (with maximum number of individuals counted in any one survey in brackets); NC = maximum number of waterbirds counted in any one survey; BE = maximum number of breeding efforts recorded in one survey, including old nests.)

wetland	*SP*	*BR*	*TH*	*SS*	*MG*	*NC*	*BE*
DAVI	5	4		1		27	4
BOA1 *	36	3	1	4		403	4
PLEA *	25	9	1	3		119	8
METT *	21	7	1	4		131	67
ESP1	18	5		2		253	3
SHAR	45	11	1	7	6 (18)	2642	14

Sources of data: 2008-9 data are from Tables 6-9 above. Pre-2008 data are from the RAOU Waterbirds Database 1981-9 (partly reported in Jaensch *et al.* 1988), Jaensch 1992, Jaensch & Clarke 1993, Storey *et al.* 1993, Clarke & Lane 2003, and some 1979 DEC datasheets (J Lane).

Australasian Bittern is listed as globally Endangered in the IUCN Red List; no other species relevant to the present project is nationally or globally threatened.

Sensitive species: Australasian Bittern, Australian Little Bittern, Spotless Crake, Baillon's Crake, Australian Spotted Crake, Buff-banded Rail, Blue-billed Duck, Freckled Duck, Little Pied Cormorant (breeding); these are the only sensitive species to have been recorded at these wetlands.

There are no widely agreed international or national thresholds for importance in terms of numbers of species recorded or number of species found breeding. This is perhaps due in part to the fact that the number of species recorded at a wetland grows (due to the high mobility of waterbirds) as more surveys are undertaken (Jaensch *et al.* 1988; Halse *et al.* 1993b). However, Jaensch *et al.* (1988) considered >45 species and >15 species to indicate "very high" numbers of species and breeding species respectively, in the context of south-western Australia. Table 10 shows that those thresholds are not met by any of the six 'substantially-unchanged' wetlands although the number of species at Shark Lake (by far the most frequently surveyed of the nine wetlands: Table 6) is almost "very high".

Criterion 2 for identifying Wetlands of International Importance under the Ramsar Convention on Wetlands recommends that wetlands be considered internationally important if they support vulnerable, endangered, or critically endangered species or threatened ecological communities. The Australasian Bittern, listed as globally threatened (IUCN 2009), has been recorded at four of the six wetlands of Table 10, but probably does not occur at the other two due to sub-optimal habitat. Occurrence at BOA1, PLEA and METT has been documented on more than one occasion, including during 2008-9, and is likely to be frequent if not annual.

Sensitive species are a construct for the present project but Table 10 shows that Shark Lake supports by far the highest number (almost all of the species defined as sensitive for this project apart from colonial breeders: see above).

Migratory shorebird species, of which more than 20 regularly occur in south-western Australia, clearly are not a prominent feature of the surveyed wetlands, and have been recorded only occasionally, on the drying bed of SHAR.

The threshold set by the Ramsar Convention for international importance with respect to number of waterbirds is regular support of 20,000 individuals (Criterion 5). None of the surveyed wetlands comes near to this threshold. There are no widely used thresholds for size of breeding effort but in the context of other wetlands in south-western Australia, where breeding colonies of thousands of waterbirds occur (e.g. Chandala Swamp: Jaensch *et al.* 1988), breeding efforts at the surveyed wetlands are relatively small.

A further Ramsar measure of international importance is regular support of at least 1% of the size of a waterbird population (Criterion 6). Using the most recent estimates for population size (Wetlands International 2006), we note that the 1% level has been met at least once at two of the six wetlands:

- PLEA has supported 5 Australasian Bitterns (1% of south-western Australian population size = 5 birds) on at least two occasions: December 1981 (Jaensch *et al.* 1988) and November 1986 (Birds Australia datasheets held by DEC)
- SHAR has supported 1% of the south-western Australian population size (50 birds) of Chestnut Teal, once (70 birds, 11 May 1985, Jaensch *et al.* 1988).

Further surveys and analysis would be needed to establish that these 1% levels are met regularly.

Conclusions

Long term changes and management responses

The following are our conclusions in regard to significant changes that have occurred at five of the nine surveyed wetlands in terms of habitat and/or waterbird use, since the early 1980s and/or early 1990s:

- **Yarnup Lagoon** was formerly a significant breeding locality for Australian Little Bittern (the largest breeding aggregation in south-western Australia) and Spotless Crake and supported Australasian Bittern, but appears to have lost all of these sensitive species, as a consequence of major loss of dense emergent vegetation (tall sedgeland) and fringing vegetation (sedge-infused, live shrub thicket). This loss of habitat is predicted (R. Hearn pers. comm.) to persist due to hydrological consequences of catchment clearing and it is not known if the changes can be reversed by intervention. Another possible indicator of change is the recent first recorded breeding by Hoary-headed Grebe, coinciding with increased salinity.
- **Yellilup Lake** was formerly a fresh to brackish lake supporting herons, spoonbills, cormorants and ducks that breed in low salinity, periodically-inundated, live-wooded swamps, but has lost all live woodland habitat in its zone of seasonal inundation due to prolonged (multi-year) inundation and salinisation. Consequently these sensitive species no longer breed there, a suite of other waterbird species no longer occurs and these changes are probably irreversible, at least in the short to medium term (decades).
- **Esperance 26410** has shown a recent minor loss of habitat for sensitive waterbirds and though this is not yet manifest in major changes to waterbird use, consistent with other live-wooded swamps in the surrounding catchments it is likely that further habitat loss may occur with perhaps eventual total loss (as at the similar Coomalbidgup Swamp, 45 km to the east). It is not known if the changes can be reversed by intervention.
- **Nine Mile Lake** has lost most of its open water but gained some dense vegetation that harbours sensitive species. Some waterbird species recorded in moderate numbers in the past probably do not use the wetland in its present condition, notably Great Cormorant (prefers deep open water; up to 29 counted in 1980s) and Red-capped Plover (occurs on beaches and drying open lake beds; up to 20 counted in 1980s). Changes are probably reversible by intervention, i.e. restoring former water depths, but impacts on sensitive species now using the main lake would need to be considered.
- **Lake Davies** There are some indications of possible loss of habitat and loss of a sensitive species (Spotless Crake) and two breeding species (Spotless Crake, Australasian Grebe).

With respect to sensitive species, gains in terms of newly-listed species at BOA1, METT, ESP1 and SHAR and newly-listed breeding species at YARN, METT, and SHAR (Table 7) are considered to reflect survey methods and limitations rather than any real change over time.

These conclusions lead the authors to make the following recommendations.

Recommendation 1: *DEC to maintain its management focus on Yarnup Lagoon, with an objective of restoring breeding habitat for the Australian Little Bittern and other sensitive species.*

Recommendation 2: *DEC to further investigate Esperance 26410 to more conclusively determine its significance for waterbirds, particularly sensitive species. If its significance proves to be high, the threats posed by potential hydrological changes should be assessed and potential for mitigation considered.*

Recommendation 3: *DEC to maintain a watching brief on Davies, Boat Harbour 1, Mettler, Pleasant View and Shark Lakes, and possibly other wetlands, with the objectives of further identifying and documenting values for waterbirds, particularly sensitive species, and identifying and addressing any substantial threats, particularly hydrological.*

Recommendation 4: *DEC to more fully document the hydrological, habitat and waterbird changes at Nine Mile, Yarnup and Yellilup Lakes, and their causes, links and likely future scenarios with and without management interventions, as a case study of the major human-induced changes that have occurred at many south-western Australian wetlands in recent decades.*

Action to recognise the importance of wetlands

We conclude that, based on all survey data to the present (Tables 7 and 10), three of the surveyed wetlands (BOA1, PLEA and METT) might be considered internationally important under Criterion 2 (threatened species and communities) of the Ramsar Convention because over the past 2-3 decades and including 2008-9 they have supported Australasian Bittern, a species listed as globally endangered.

Recommendation 5: *DEC to consider undertaking further surveys to determine whether Boat Harbour 1, Pleasant View and Mettler Lakes, and possibly other wetlands, meet criteria for listing as internationally important for the Australasian Bittern under Ramsar Criterion 2.*

Two of the surveyed wetlands (PLEA and SHAR) have been shown to support at least 1% of the relevant (south-western Australian) populations of Australasian Bittern and Chestnut Teal on occasions during the past 2-3 decades. Further surveys would be needed, however, to establish continued and regular use at the ≥1% level. The authors therefore do not propose nomination of either of these wetlands for listing under Criterion 6 of the Ramsar Convention at this time. Further surveys of these two wetlands are proposed under Recommendations 3 and 5 above.

Broader implications for management of wetlands in south-western Australia

Decadal-scale change in the hydrology of numerous wetlands has occurred and continues to occur in south-western Australia; the ≤32 year record of the DEC depth and salinity monitoring program (Lane *et al.* 2004, 2009) has provided confirmation of this change. The present project provides evidence that waterbird habitats and waterbird use of at least some of these wetlands have changed accordingly. We have shown that sensitive species and their habitats have been lost from at least two (YARN, YELL) of the nine wetlands of this study and that similar changes are probably underway at others (e.g. DAVI, ESP1). Some of the wetlands that we surveyed (e.g. BOA1, METT, PLEA, SHAR) continue to provide suitable habitat for sensitive species, however these too are vulnerable to change.

The causes of these hydrological and habitat changes operate at landscape scales. In general terms they are well understood, however at the local scale only in a few instances (e.g. Toolibin and Esperance lakes) have they been investigated sufficiently to inform remedial actions (Wallace & Lloyd 2008; Walshe & Massenbauer 2008). They have been the subject of considerable research investment and management intervention. Our results and conclusions from the present project lend further weight to the need for sustaining and expanding this work.

> ***Recommendation 6:*** *DEC to use the results of the present project in support of efforts to identify and, where necessary, further investigate hydrological threats to high value waterbird habitats, particularly of sensitive waterbird species, in south-western Australia.*

In the present context, research and management should be informed by sustained and robust surveillance of use of vulnerable wetlands by sensitive waterbird species, so that negative trends in use can be detected and hopefully arrested at any early stage. Wetland management also requires an adequate understanding of the ecological requirements (e.g. home range, diet, nesting habitat, movements) of the affected waterbird species whereas to our knowledge there have been very few dedicated studies of this type specific to south-western Australia. As the Australasian Bittern is a 'top of food chain' species and is globally recognised as threatened, it would be effective and more-broadly relevant to focus surveillance and ecological study on this species. Findings may have relevance for management of this species also in eastern Australia.

> ***Recommendation 7:*** *DEC to seek and support efforts to obtain resources to establish three programs that will enhance wetland and waterbird conservation across south-western Australia: (1) identification of key habitats of the Australasian Bittern, particularly for breeding and for survival during drought; (2) a comprehensive investigation of the ecological requirements of the Australasian Bittern; and (3) regular surveillance of use of vulnerable wetlands by the Australasian Bittern and other sensitive species, particularly colonial nesting waterbirds.*

These projects would potentially benefit from collaboration between DEC scientists, other university-based zoologists, wetland and waterbird experts, volunteer ornithologists (e.g. from Birds Australia) and regional NRM organisations.

One possible approach to facilitating the conservation of a) key drought and breeding habitats of the Australasian Bittern, and b) key breeding habitats of sensitive colonial nesting waterbirds (herons, egrets, spoonbills, ibises and cormorants), could be listing as Threatened Ecological Communities (TECs) under the federal *Environment Protection and Biodiversity Conservation Act 1999*. As a Matter of National Environmental Significance under the Act, such listing would elevate these wetlands in priority for funding of investigation and management and increase their level of legal protection. In both cases current knowledge suggests that the number of key habitats is small and that a significant proportion, perhaps most, are under threat, particularly from hydrological change. Sensitive colonial nesting waterbirds are known to have quite particular requirements regarding the types of south-western Australian wetlands that are suitable for successful breeding and this is also likely to be the situation with key drought and breeding habitats of the Australasian Bittern. These birds and their key habitats may therefore be considered distinct and definable 'ecological communities', warranting threatened status.

> ***Recommendation 8:*** *DEC to further consider the suitability for listing of (1) key drought and breeding habitats of the Australasian Bittern and (2) key breeding habitats of sensitive colonial nesting waterbird species, of south-western Australia, as Threatened Ecological Communities (TECs) under the federal Environment Protection and Biodiversity Conservation Act 1999, and to initiate and support efforts to obtain the information required to progress these TEC nominations*.

References

Birds Australia 2009. Bittern Survey. Online at http://www.birdsaustralia.com.au/our-projects/bittern-survey.html

Blakers, M, Reilly, PN and Davies SJJF 1984. The Atlas of Australian Birds. Melbourne University Press, Melbourne.

Briggs, SV and Thornton, SA 1995. Management of River Red Gums for waterbird nesting. Corella 19:132-137.

Briggs, SV, Thornton, SA and Lawler, WG 1997. Relationships between hydrological control of River Red Gum wetlands and waterbird breeding. Emu 97:31-42.

Cale, DJ and Halse, SA 2006a-u. Altham, Ardath, Bennetts, Blue Gum, Bryde, Campion, Coomalbidgup, Coomelberrup, Coyrecup, Dumbleyung, Eganu, Fraser, Logue, Noobijup, Paperbark, Pleasant View, Ronnerup, Towerrinning, Walyormouring, Wheatfield and Yaalup waterbirds. A series of 21 pamphlets published by the WA Department of Environment & Conservation, Perth.

Cale, DJ, Halse, SA and Walker, CD 2004. Wetland monitoring in the wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. Conservation Science Western Australia 5(1):20–136.

Christidis, L and Boles, W 2008. Systematics and taxonomy of Australian Birds. CSIRO Publishing, Collingwood.

Clarke, AG and Lane, JAK 2003. A waterbird census of selected wetlands along the coastal margins of the Esperance District, Feb-Mar 2003. Western Australian Department of Conservation and Land Management.

DEWHA 2009. Australian Wetlands Database. Online at http://www.environment.gov.au/water/publications/environmental/wetlands/database/index.html Department of the Environment, Water, Heritage and the Arts.

Gibson, N, Keighery, GJ and Lane, JAK 2004. Five years of monitoring of the Lake Muir-Unicup wetland system, south-western Australia. J. Roy. Soc. W.A. 87:29-33.

Goodsell, JT 1990. Distribution of waterbird broods relative to wetland salinity and pH in southwestern Australia. Australian Wildlife Research 17, 219-29

Government of Western Australia 1990. Wetlands nominated by the Government of Western Australia for inclusion on the List of Wetlands of International Importance, Ramsar Convention. Nominating document prepared by WA Department of Conservation and Land Management, Perth. 43pp.

Government of Western Australia 2000. Wetlands nominated by the Government of Western Australia for inclusion on the List of Wetlands of International

Importance, Ramsar Convention. Nominating document prepared by WA Department of Conservation and Land Management, Perth. 48pp

Government of Western Australia 2002. Salinity: a new balance. Government's response to the Salinity Taskforce report of 2001 (Frost *et al.* 2001). Government of Western Australia, Perth.

Halse, SA 1987. Probable effect of increased salinity on the waterbirds of Lake Toolibin. WA Department of Conservation and Land Management Tech. Report 15. 31pp.

Halse, SA and Jaensch, RP 1989. Breeding seasons of waterbirds in south-western Australia - the importance of rainfall. Emu 89, 232-249.

Halse, SA, Jaensch, RP, Munro, DR and Pearson GB 1990. Annual waterfowl counts in south-western Australia – 1988/89. Technical Report 25. WA Department of Conservation and Land Management, Perth. 43 pp.

Halse, SA, Pearson, GB and Patrick, S 1993a. Vegetation of depth-gauged wetlands in nature reserves of south-west Western Australia. Technical Report 30. WA Department of Conservation and Land Management, Perth, 146 pp.

Halse, SA, Pearson, GB, Vervest, RM and Yung FH 1995. Annual waterfowl counts in south-west Western Australia - 1991/92. CALMScience 2:1-24.

Halse, SA, Vervest, RM, Munro, DR, Pearson, GB and Yung, FH 1992. Annual waterfowl counts in south-west Western Australia - 1989/90. Technical Report 29. Department of Conservation and Land Management, Perth, 50 pp.

Halse, SA, Vervest, RM, Pearson, GB, Yung, FH and Fuller, PJ 1994. Annual waterfowl counts in south-west Western Australia - 1990/91. CALMScience 1:107-129.

Halse, SA, Williams, MR, Jaensch, RP and Lane, JAK 1993b. Wetland characteristics and waterbird use of wetlands in south-western Australia. Wildlife Research 20:103-126.

IUCN 2009. The IUCN Red List of threatened species. Online at http://www.iucnredlist.org The International Union for Conservation of Nature

Jaensch, RP 1992. Waterbirds in wetlands on the south coast of Western Australia, summer 1991-2. Report to Western Australian Department of Conservation and Land Management, Woodvale.

Jaensch, R and Clarke, A 1993. Waterbirds breeding in spring 1992 in wetlands on the south coast of Western Australia. Report to Western Australian Department of Conservation and Land Management, Woodvale.

Jaensch, RP and Vervest, RM 1988a. Waterbirds in the Eastern Muir Wetlands, 1986-1987. RAOU Report No. 47.

Jaensch, RP and Vervest, RM 1988b. Ducks, Swans and Coots in South-Western Australia. The 1986 and 1987 counts. RAOU Report No. 31.

Jaensch, RP and Vervest, RM 1988c. Ducks, Swans and Coots in South-Western Australia. The 1988 count and recommendations. RAOU Report No. 46.

Jaensch, RP and Vervest, RM 1989. Breeding colonies of the Great Egret in Western Australia. RAOU Report No. 33.

Jaensch, RP, Vervest, RM and Hewish, MJ 1988. Waterbirds in nature reserves of south-western Australia 1981-1985: reserve accounts. RAOU Report No. 30, Royal Australasian Ornithologists Union, Canning Bridge.

Jaensch, RP, Merrifield, J and Raines, J 1993. Waterbirds of south-western Australia: highest numbers counted 1981-92. Supplement to WA Bird Notes No. 68.

Lane, JAK, Clarke, AG and Pearson, GB 2002a. Waterbirds of Peel-Harvey Estuary in 1996-97. WA Department of Conservation and Land Management, 41 pp.

Lane, JAK, Clarke, AG and Pearson, GB 2002b. Waterbirds of Peel-Harvey Estuary in 1998-99. WA Department of Conservation and Land Management, 40 pp.

Lane, JAK, Clarke, AG, Winchcombe, YC, Pearson, GB, Muir, WP, Johnson, BW and Elscot, SV (2009). South West Wetlands Monitoring Program Report 1977-2007. Western Australian Department of Conservation and Land Management. 331pp.

Lane, JAK and Pearson, GB 2002. Waterbirds of Peel-Harvey Estuary in the mid 1970s. WA Department of Conservation and Land Management, 73 pp.

Lane, JAK, Pearson, GB, Clarke, AG, Winchcombe, YC and Munro, DR 2004. Depths and salinities of wetlands in south-western Australia: 1977-2000. Western Australian Department of Conservation and Land Management.

Lyons, MN, Halse, SA, Gibson, N, Cale, DJ, Lane, JAK, Walker, CD, Mickle, DA and Froend, RH 2007. Monitoring wetlands in a salinizing landscape: case studies from the wheatbelt region of Western Australia. Hydrobiologia 591:147–164.

Marchant, S and Higgins, PJ 1990. Handbook of Australian, New Zealand and Antarctic Birds. Volume 1, ratites to ducks. Oxford University Press, Melbourne.

Robinson, CJ 1992. Survey and inventory of the wetland flora of the south coast of Western Australia. Report to WA Department of Conservation and Land Management.

State Salinity Council 2000. Natural Resource Management in Western Australia – The Salinity Strategy. Government of Western Australia.

Storey, AW, Vervest, RM, Pearson, GB and Halse SA 1993. Wetlands of the Swan Coastal Plain. Volume 7, Waterbird usage of wetlands on the Swan Coastal Plain. Water Authority of Australia and Environmental Protection Authority, Perth, 168 pp.

Wallace, KJ 2003. Toolibin Lake, working together. Pacific Conserv. Biology 9:51-57.

Wallace, K and Lloyd, C 2008. Managing salinity and water for conservation outcomes. In Proceedings, 2nd International Salinity Forum: Salinity, water and society - global issues, local action, 31 March – 3 April 2008. Adelaide, South Australia. http://www.internationalsalinityforum.org/14_final.html

Walshe, T and Massenbauer, T 2008. Decision-making under climatic uncertainty: A case study involving an Australian Ramsar-listed wetland. Ecological Management & Restoration 9(3):202-208.

Wetlands International 2006. Waterbird Population Estimates 4th Edition. Wetlands International, Wageningen, The Netherlands

Appendix 1. Scientific and English names of waterbirds mentioned in this report.

Based on Christidis and Boles (2008).

FAMILY & SCIENTIFIC NAME	ENGLISH NAME
Anatidae	
Biziura lobata	Musk Duck
Stictonetta naevosa	Freckled Duck
Cygnus atratus	Black Swan
Tadorna tadornoides	Australian Shelduck
Chenonetta jubata	Australian Wood Duck
Malacorhynchus membranaceus	Pink-eared Duck
Anas rhynchotis	Australasian Shoveler
Anas gracilis	Grey Teal
Anas castanea	Chestnut Teal
Anas superciliosa	Pacific Black Duck
Aythya australis	Hardhead
Oxyura australis	Blue-billed Duck
Podicipedidae	
Tachybaptus novaehollandiae	Australasian Grebe
Poliocephalus poliocephalus	Hoary-headed Grebe
Podiceps cristatus	Great Crested Grebe
Phalacrocoracidae	
Microcarbo melanoleucos	Little Pied Cormorant
Phalacrocorax carbo	Great Cormorant
Phalacrocorax sulcirostris	Little Black Cormorant
Ardeidae	
Botaurus poiciloptilus	Australasian Bittern
Ixobrychus dubius	Australian Little Bittern
Ardea pacifica	White-necked Heron
Ardea modesta	Eastern Great Egret
Egretta novaehollandiae	White-faced Heron
Nycticorax caledonicus	Nankeen Night-Heron
Threskiornithidae	
Platalea flavipes	Yellow-billed Spoonbill
Accipitridae	
Circus approximans	Swamp Harrier
Rallidae	
Porphyrio porphyrio	Purple Swamphen
Gallirallus philippensis	Buff-banded Rail
Porzana pusilla	Baillon's Crake

FAMILY & SCIENTIFIC NAME	ENGLISH NAME
Porzana fluminea	Australian Spotted Crake
Porzana tabuensis	Spotless Crake
Gallinula tenebrosa	Dusky Moorhen
Fulica atra	Eurasian Coot
Charadriidae	
Charadrius ruficapillus	Red-capped Plover
Acrocephalidae	
Acrocephalus australis	Australian Reed-Warbler
Megaluridae	
Megalurus gramineus	Little Grassbird

Appendix 2. Selection of target wetlands for the 2008-9 survey

Objective 1: Collect waterbird data and vegetation structure/arrangement observations to indicate changes in both that have resulted from known long-term changes in water levels and/or salinity of currently-monitored, vegetated SWWMP wetlands on or near the south coast (Augusta-Esperance).

(a) Criteria for wetland selection are:

- currently-monitored, vegetated (now and/or formerly) SWWMP wetland on/near the south coast;
- monitored long-term change in depth and/or salinity;
- known substantial change in vegetation structure/arrangement
- important wetland early in SWWMP monitoring period (i.e. in 1980s or early 1990s) for waterbirds highly-dependent upon existence of substantial emergent and/or fringing vegetation at some stage in their life cycle (e.g. bitterns, crakes, egret, spoonbill);

(b) Wetlands that meet these criteria are: YELL. Two wetlands, **NINE** and **YARN**, not on the south coast are added to this group because they are en-route (Perth-South Coast-Perth), meet other criteria above and have shown dramatic long-term trends of declining water level (Nine Mile) or increasing salinity (Yarnup).

Objective 2: Collect waterbird data and vegetation structure/arrangement observations from currently-monitored, vegetated SWWMP wetlands on or near the south coast (Augusta-Esperance).that are showing early signs of possible long term changes in water levels and/.or salinity, or with vegetation communities (particularly trees on lake bed) highly sensitive to such changes.

(a) Criteria for wetland selection are:

- currently-monitored, vegetated SWWMP wetland on/near the south coast;
- early indications of possible long-term change in water levels and/or salinity;
- vegetation structure/arrangement will be substantially-affected if long-term change in water levels and/or salinity occur
- important wetland early in SWWMP monitoring period (i.e. in 1980s or early 1990s) for waterbirds highly-dependent upon substantial emergent and/or fringing vegetation at some stage in their life cycle (e.g. bitterns, crakes, egret, spoonbill).

(b) Wetlands that meet these criteria are: METT, ESP1, DAVI, BOA1

Objective 3: Collect waterbird data and vegetation structure/arrangement observations from a currently-monitored, vegetated SWWMP wetland near Albany suitable for training DEC staff and volunteers in locating bitterns and other secretive waterbird species, and, if time permits, one other currently-monitored, vegetated SWWMP wetland on or near the south coast (Augusta-Esperance) that is of particular interest concerning secretive waterbird species (but doesn't meet criteria of objectives 1 or 2 above).

(a) Criteria for wetland selection are:

- currently-monitored, vegetated SWWMP wetlands on/near the south coast; one near Albany and suitable for training observers and one not meeting criteria of objectives 1 or 2 above but nonetheless of particular interest concerning secretive waterbird species;
- important wetland early in SWWMP monitoring period (i.e. in 1980s or early 1990s) for waterbirds highly-dependent upon emergent and/or fringing vegetation at some stage in their life cycle (e.g. bitterns, crakes, egret, spoonbill),

(b) Wetlands that meet these criteria are: <u>PLEA (training), SHAR (if time permits)</u>

Wetlnd	**Monitrd**	**2000 Trends**	**2006 Trends**	**Nov08 Depth**	**1981-85(+) WaterBirds (RPJ et al 1988)**	**Summer 91-92 SCW Report (RPJFeb92)**	**Spring 92 SCW Report (RPJ&ACMay93)**	**Directory (2nd Edn; 1996)**	**Comments**
NINE	**6/81 on**	**D -ve p=0.0001** S ns	**D –ve** S ns?	0.63	**LiBi* (1)** SsCk (8) [*20 Surveys*] 22spp 6brspp 79indiv PO: RPJ, Goodales			Not Listed	Most interest in satellite swamps?
DAVI	4/91 on	-	D ns? **S +ve**	4.51		SsCk* (1) [*Survey 2.8hrs, d&n*]	[*Survey ??hrs, d?&n?*]	Not listed	
JASP	11/85 on	-	D ns? S ns?	9.48		**LiBi* (0)** SsCk* (5) [*Survey 9.8hrs, d&n*]	**LiBi* (2)** SsCk (2) [*Survey ??hrs, d&n*]	Listed (Jingilup-Jasper System) **LiBi***	LiBi 'nests in thickets west of Lake J.'
WILS	5/91 on	-	D +ve? S ns	3.86		SsCk (2) [*Survey 6.0hrs, d&n*]		Listed (Jingilup-Jasper System)	
MARI	6/91-9/99 9/00 on	-	D ns S ns	6.32		SsCk (2) [*Survey 4.5hrs, d&n*]	SsCk (2) [*Survey ??hrs, d&n*]	Listed (Maringup Lake)	

WetInd	**Monitrd**	**2000 Trends**	**2006 Trends**	**Nov08 Depth**	**1981-85(+) WaterBirds (RPJ et al 1988)**	**Summer 91-92 SCW Report (RPJFeb92)**	**Spring 92 SCW Report (RPJ&ACMay93)**	**Directory (2nd Edn; 1996)**	**Comments**
BOYU [BB 18239; 'Kulicup']	**9/80 on**	D ns S ns	D ns S ns	0.03	[5 *Surveys*] 5spp 0brspp 7indiv			Not listed	***BMW*** Not near coast but could visit on return?
YARN	**9/80 on**	**D +ve p=0.03** **S +ve p=0.0001**	D ns? **S +ve**	0.99	**AuBi (2)** **LiBi* (7) nests (19)** SsCk (18) nests (many) [18 *Surveys*] 12spp 4brspp 32indiv PO: RPJ			Listed (Byenup Lagoon System) **LiBi***	Largest breedng 'colony' of LiBi in WA
WARR	**3/80 on**	**D +ve p=0.0004** S ns	**D +ve** S ns?	Dropr	[4 *Surveys*] 0spp 0brspp 0indiv			Not listed	Other obs?
OWIN	7/91 on	-	D –ve? S +ve?	1.33		**AuBi (5)** **SsCk* (19)** [*Survey 15.0hrs, d&n*]	SsCk (3) [*Survey ??hrs, d}*	Listed (OS System) **AuBi (5)** 40spp ≤10brspp 1457indiv	
BOA1 (RPJ's Lake 'A')	8/91 on	-	D –ve? S +ve?	0.88		SsCk (13) *Survey 2.1hrs, d&n*]	SsCk (1) [*Survey ??hrs, d?&n?*]	Listed (OS System) **AuBi (3)**	

WetInd	**Monitrd**	**2000 Trends**	**2006 Trends**	**Nov08 Depth**	**1981-85(+) WaterBirds (RPJ et al 1988)**	**Summer 91-92 SCW Report (RPJFeb92)**	**Spring 92 SCW Report (RPJ&ACMay93)**	**Directory (2nd Edn; 1996)**	**Comments**
POWE	**6/81 on**	D ns S ns		1.0	**AuBi (3)** LiBi (1) SsCk (25), AuCk (1), BaCk (1) [37 *Surveys*] 51spp 7brspp 2736indiv. PO: Lbroadhurst, WFerrell	SsCk (17) *Survey 4.3hrs, d&n*]	SsCk (1) [*Survey ??hrs, d?&n?*]	Not listed	Water levels managed
MOAT (part of RPJ's TPB NR)	**11/79 on**	D ns S ns	D ns S ns	4.46	**Au Bi (1)** **LiBi (1)** SsCk?			Listed (ML System) ***AuBi*** ≤8brspp	Angove? Gardner? (**AuBi** at both)
PLEA	**11/79 on**	D ns S ns	D –ve? S ns	0.57	**AuBi* (5)** **LiBi* (1)** SsCk (4) [*29 Surveys*] 24spp 4 brspp 119indiv PO: MNash, RPJ			Listed (Lake PV System) **AuBi (6+)**	AuBi flushed ***BMW***
ALB1 [Alb 26385; 'North Sister']	**5/81-5/85 9/98 on**	-	D +ve? S –ve?	0.56	**Au Bi (1)** SsCk (5) [13+?16 *Surveys*] 16spp 1brspp 37+?50indiv PO: MNash			Listed (Lake PV System) **AuBi**	AuBi flushed

WetInd	**Monitrd**	**2000 Trends**	**2006 Trends**	**Nov08 Depth**	**1981-85(+) WaterBirds (RPJ et al 1988)**	**Summer 91-92 SCW Report (RPJFeb92)**	**Spring 92 SCW Report (RPJ&ACMay93)**	**Directory (2nd Edn; 1996)**	**Comments**
METT	**9/82 on**	-	**D +ve** S ns	0.58	**AuBi (2)** **LiBi (1)** SsCk (3) [*19 Surveys*] 16spp 0brspp 24indiv PO: PLeighton			Not listed	AuBi flushed
YELL	11/85 on	-	**D –ve** **S +ve**	Dropr				Listed (Yellilup Yate Swamp System) FreD (2) PecS (4) LtSt (7) 40spp 8brspp 1702 indiv	
NPAR	9/00 on	-	D ns? S ns?	0.09				Not listed	
ESP1 [Esp 26410]	**11/81 on**	-	D +ve? **S +ve**	0.77	[*2 Surveys*] 7spp 2brspp 13indiv			Not listed	**See field sheets for 81-85 data**
MORT	9/00 on	-	**D –ve** **S +ve**	1.65				Listed Fred (54)	How connected to Mort. is Nambarup?

WetInd	**Monitrd**	**2000 Trends**	**2006 Trends**	**Nov08 Depth**	**1981-85(+) WaterBirds (RPJ et al 1988)**	**Summer 91-92 SCW Report (RPJFeb92)**	**Spring 92 SCW Report (RPJ&ACMay93)**	**Directory (2nd Edn; 1996)**	**Comments**
SHAR	**11/79 on**	D ns S ns	D ns? S –ve?	2.32	**AuBi (1)** BaCk (4) AuCk* (6) SsCk* (11) GaSn (1) [*37 Surveys*] 40spp 4brspp 2642indiv PO: ADaw			Not listed	AuBi flushed
MLGR	9/00 on	-	D –ve S –ve?	1.50				Not listed	
PILL	9/00 on	-	**D +ve** **S –ve**	1.04				Not listed	

* = breeding record

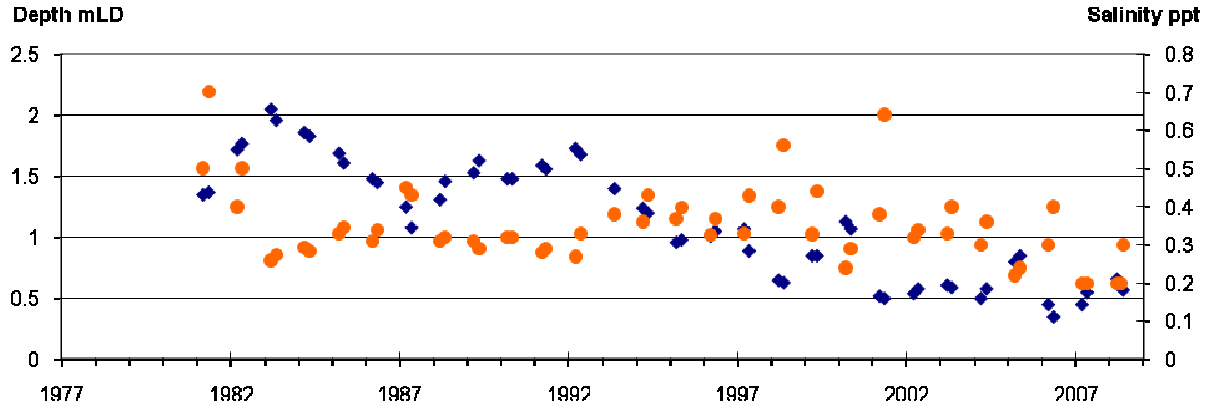
Prepared by JL Nov 2008

wetland name	***code***
Nine Mile Lake	NINE
Lake Davies	DAVI
Yarnup Lagoon	YARN
Boat Harbour Lake 1	BOA1
Lake Pleasant View	PLEA
Mettler Lake	METT
Yellilup Lake	YELL
Esperance Reserve 26410	ESP1
Shark Lake	SHAR

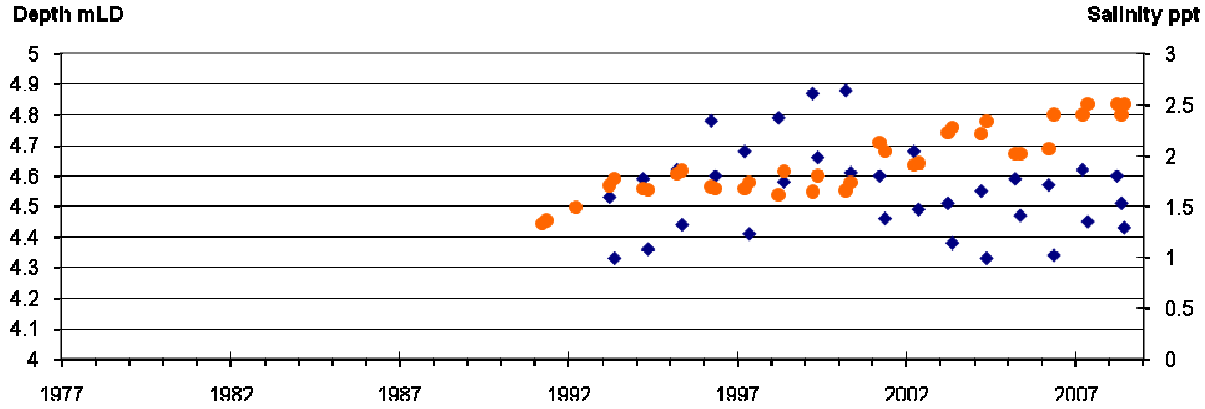
Appendix 3. Depths and salinities of the nine selected wetlands over the DEC monitoring period, to end of 2008

Blue diamonds = depth in metres, surveyed to deepest part of the wetland (mLD = metres Local Datum). Orange dots = salinity in parts per thousand.

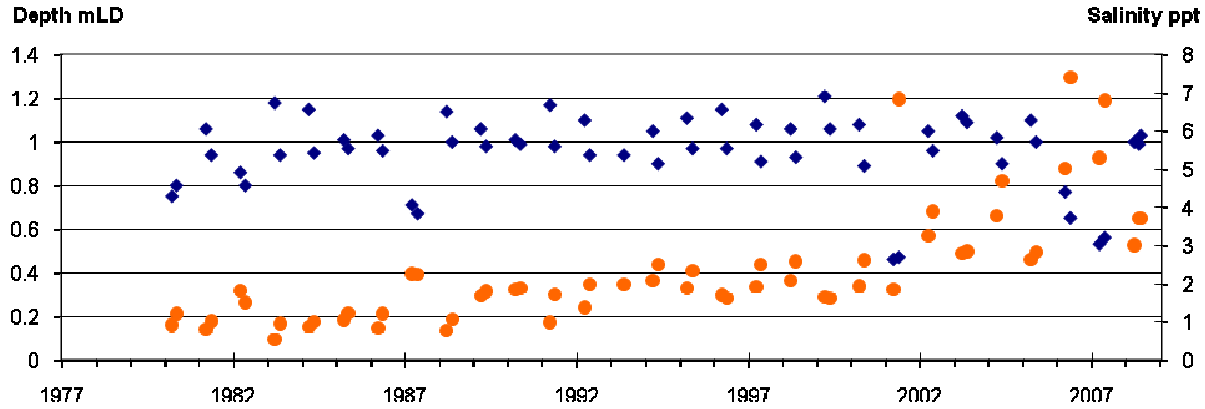
Nine Mile Lake (NINE)



Lake Davies (DAVI)

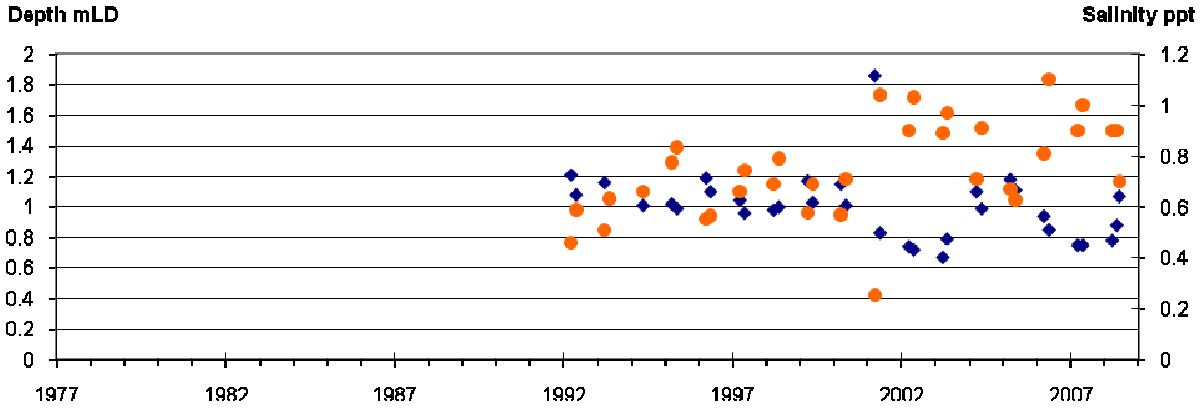


Yarnup Lagoon (YARN)

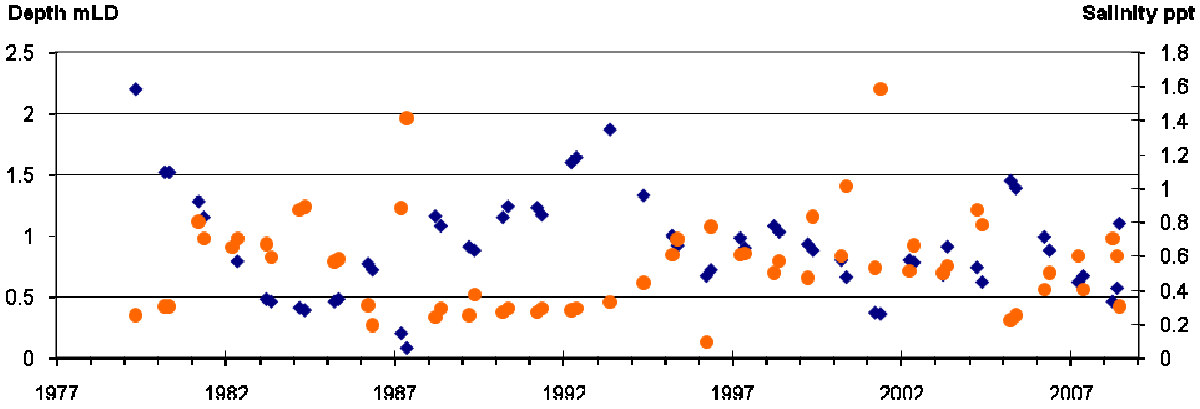


Appendix 3 continued

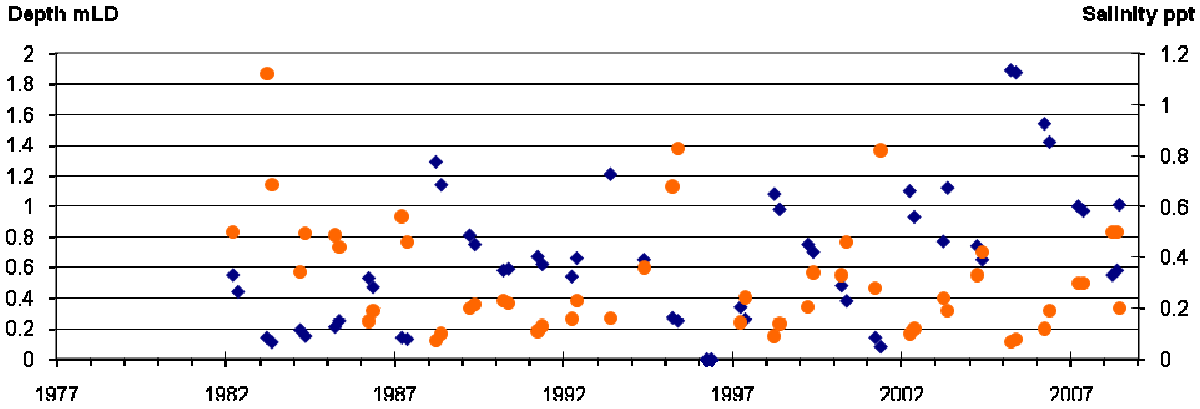
Boat Harbour Lake 1 (BOA1)



Lake Pleasant View (PLEA)

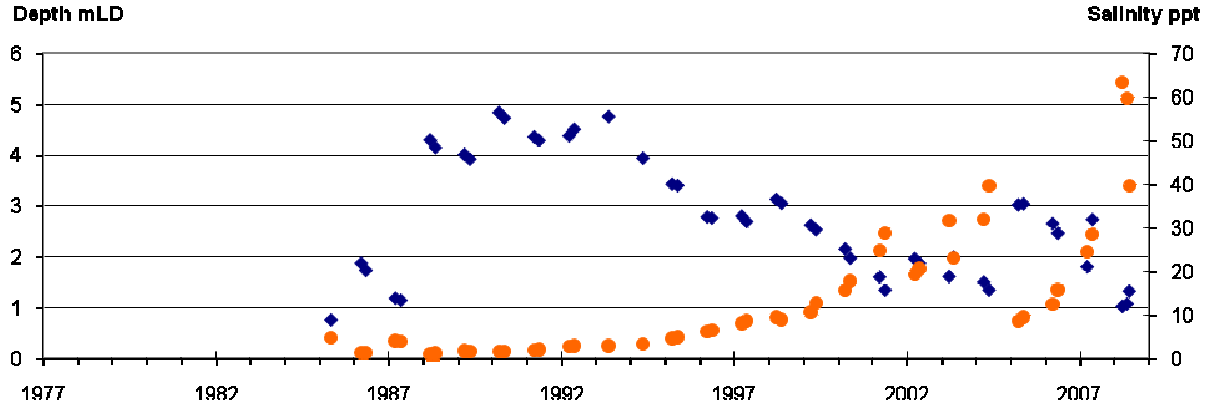


Mettler Lake (METT)

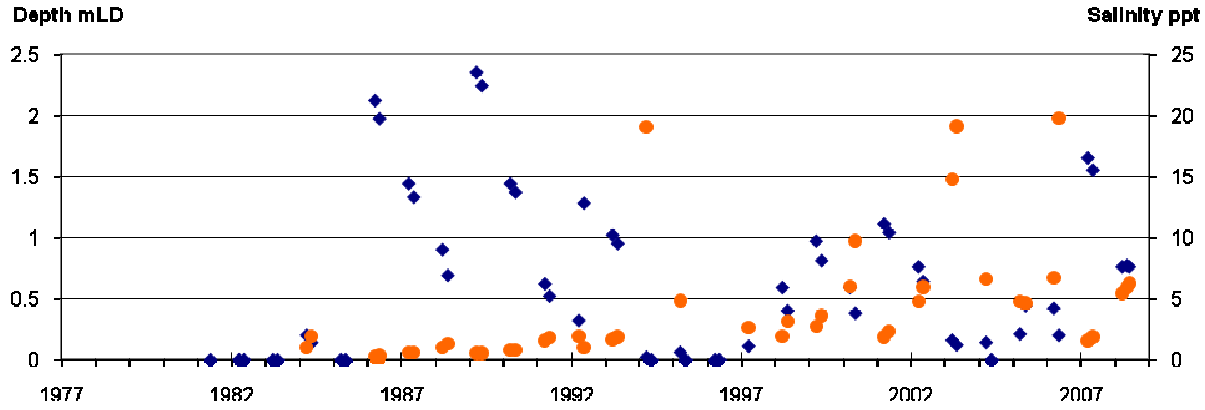


Appendix 3 continued

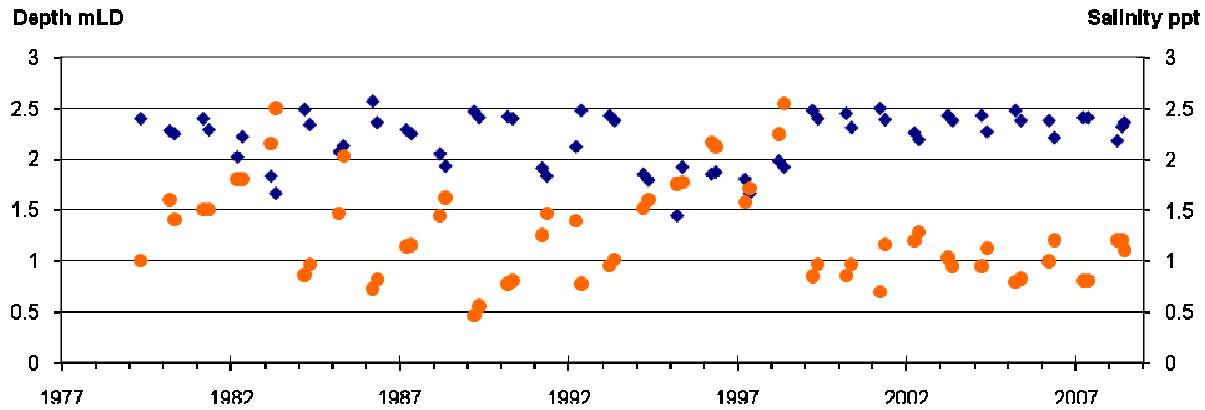
Yellilup Lake (YELL)



Esperance Reserve 26410 (ESP1)



Shark Lake (SHAR)



Appendix 4. Summary datasheets and route maps for each wetland surveyed by WIO and DEC in this project

Nine Mile Lake

Lake Davies

Yarnup Lagoon

Boat Harbour Lake 1

Lake Pleasant View

Mettler Lake

Yellilup Lake

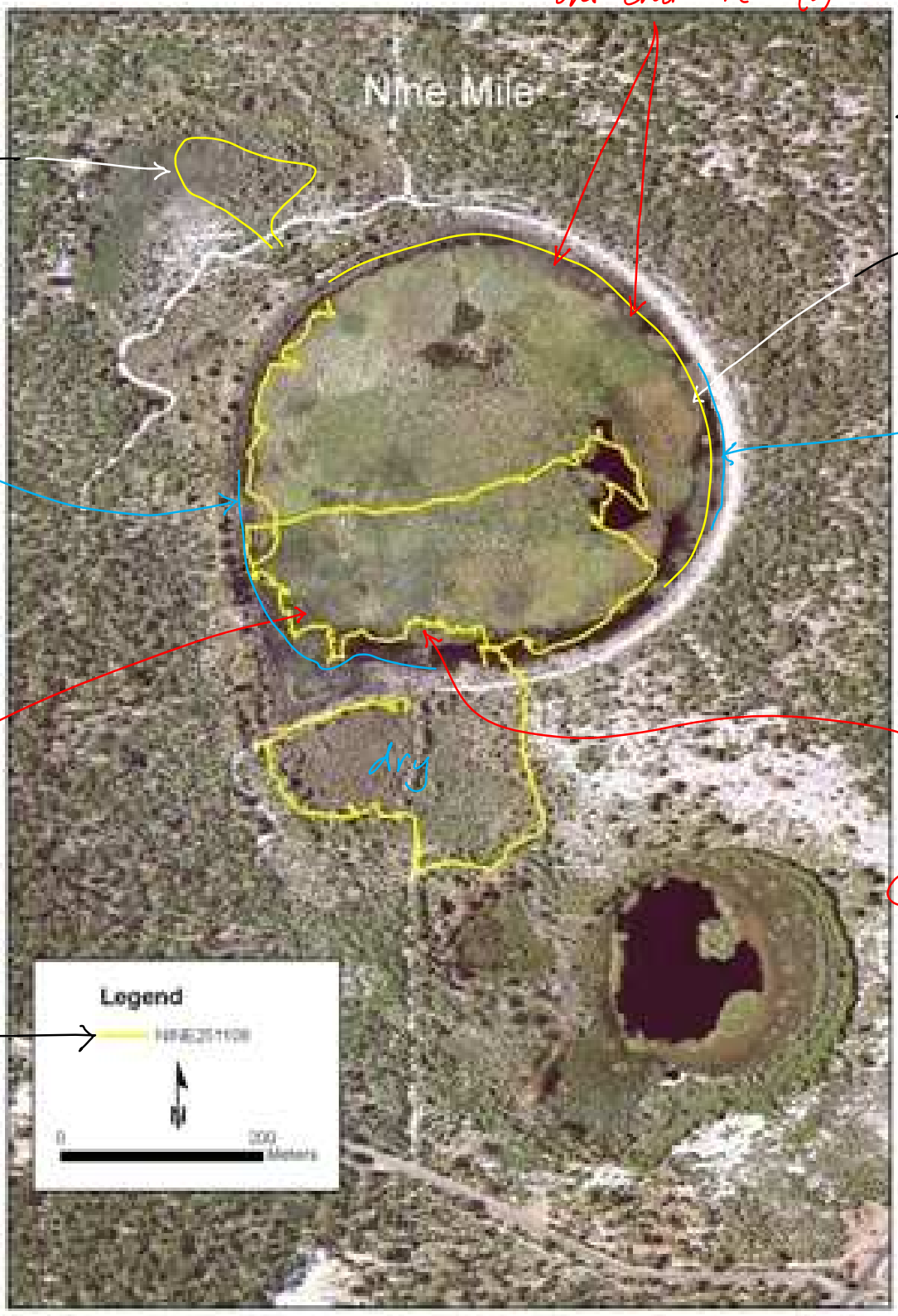
Esperance 26410

Shark Lake

Nine Mile Lake – survey data

	DATA	COMMENTS
Wetland name	Nine Mile Lake (NINE)	Within a nature reserve.
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	25 & 26 November 2008	
Start & finish time/s (Day 1)	16:10 – 21:10	One hour break taken
Start & finish time/s (Day 2)	08:20 – 10:05	
Total duration of survey	5.8 hours	Includes 0.8 hour listening at night
Weather (windy?)	Fine, hot and calm.	
% of wetland inundated	95 % (of main basin)	Both satellite swamps were dry.
% of inundated area surveyed	40 %	Satellite swamps also visited.
Water depth at gauge	0.57 m	Up to 0.75 m in open pool.
Survey methods used	Scan from shore; wading; intense nest searching.	
Habitats searched for nests	Tall sedge; *Typha* beds; shrubs with sedge.	
Change since 1980s/1990s?	Open lake invaded by *Typha* up to 2.5m tall; less water depth than 1980s. Satellite swamps apparently dry for many months.	
Other remarks	Used highest species count from either day unless for a new area. All species counts likely to be the minimum number present.	
Photos taken?	Yes: overview; habitat types; nests found.	
SPECIES	COUNT	COMMENTS
Australian Little Bittern	1 (heard only)	Apparently in tall dense *Baumea*.
Spotless Crake	10 (heard only)	Scattered; in sedge, wet margins.
Musk Duck	1	
Purple Swamphen	5	
Little Grassbird	8	
Australian Reed-Warbler	7	Minimum count.
Swamp Harrier	1	
Pacific Black Duck	5	
Eastern Great Egret	1	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Australian Reed-Warbler	3 old nests in tall Typha (NINE04N, NINE05N)	
crake sp. (Spotless?)	3 old nests in Typha with *Baumea articulata*, or in *Melaleuca teretifolia* with restionid sedge (NINE01N, NINE06N, NINE07N)	
duck sp. (Musk?)	1 old nest in *Typha* with *Baumea articulata* (50/50) (NINE02N)	

Nine Mile Lake – survey map, 25 & 26 November 2008



old crake nests (3)

Also surveyed satellite swamp (dry)

Also surveyed east & north sides

water line

water line close to base of bare sand

Aust. Little Bittern calling in S.W. corner

dry

old crake nest & old (Musk?) Duck nest

Survey route is shown in yellow

Nine Mile Lake – additional photographs

South-western edge (RJ-WI)

North-western edge (RJ-WI)

Eastern side – low sedge (RJ-WI)

Photos taken on 25-26 November 2008

Lake Davies – survey data

	DATA	COMMENTS
Wetland name	Lake Davies (DAVI)	
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	3 December 2008	
Start & finish time/s (Day 1)	16:20 – 17:40	
Total duration of survey	1.3 hours	
Weather (windy?)	Fine; light breeze.	
% of wetland inundated	At least 95 %	
% of inundated area surveyed	Close to 100%	Missed very small areas of sedge.
Water depth at gauge	4.43 m	
Survey methods used	Scan from shore; wading (full circuit); intense nest searching.	
Habitats searched for nests	Low sedge, along inundated and dry edges.	
Change since 1980s/1990s?	Low sedge was more continuous and seemed denser, lacking the separated tussock clumps noted at eastern end in Dec 91.	
Other remarks	Several tiger snakes resting atop dense collapsed sedge.	
Photos taken?	Yes: overview; habitat types; nests found.	
SPECIES	COUNT	COMMENTS
Hoary-headed Grebe	13	
Pacific Black Duck	12	
Silver Gull	2	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Hoary-headed Grebe	Current nest with 2 eggs, at inner edge of low sedge (DAVI01N); a mound of *Myriophyllum*, eggs covered.	
small grebe species	2 recent, now-empty nests at inner edge of low sedge (DAVI02N, DAVI03N); mounds of *Myriophyllum*.	

Lake Davies – survey map, 3 December 2008

Survey map omitted from this version of report in order to limit the availability of nest site information.

Lake Davies – additional photographs

North-western edge (RJ-WI)

Southern side (RJ-WI)

Photos taken on 3 December 2008

Yarnup Lagoon – survey data (first survey)

	DATA	COMMENTS
Wetland name	Yarnup Lagoon (YARN)	Within a nature reserve.
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	26 & 27 November 2008	
Start & finish time/s (Day 1)	14:45 – 21:15	1.5 hour break taken
Start & finish time/s (Day 2)	08:30 – 10:30	
Total duration of survey	7.0 hours	Includes 0.6 hour listening at night
Weather (windy?)	Calm; occasional showers.	Thundery showers, hours earlier.
% of wetland inundated	100 %	Wetland full to outer limits of basin
% of inundated area surveyed	67 %	Lake scanned & thickets searched
Water depth at gauge	1.03 m	Water flowing in off adjacent road.
Survey methods used	Scan from shore; wading; intense nest searching; listening for calling bitterns at night.	
Habitats searched for nests	Shrub thickets; tall sedge; mixed shrubs and sedge.	
Change since 1980s/1990s?	*Melaleuca laterita* thickets now dead or nearly leafless, throughout site but worst on south side. *Baumea articulata* beds now greatly reduced (>50%) in area. Some dead eucalypts in wetland at edge.	
Other remarks	Used highest species count from either day unless for a new area. Most of the species counts are the minimum number present.	
Photos taken?	Yes: overview; habitat types; habitat change; nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	5	
Musk Duck	2	
Swamp Harrier	1	
Pacific Black Duck	3	
Little Grassbird	3	
Australian Reed-Warbler	3	
Grey Teal	2	
Black Swan	2	An adult with an immature bird
Little Pied Cormorant	3	Perched near recently used nests.
White-faced Heron	1	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Hoary-headed Grebe	2 nests each with 1 cold egg, and a grebe nest with no eggs, all at inner edge of southern shrub thicket (YARN02N, 11N, 03N).	
Little Pied Cormorant	2 clusters of 5 nests, most used recently, and a single nest, all in trees/shrubs, at edge of southern thicket (YARN06N, 07N, 04N).	
Musk Duck	A recently used nest in shrub base with remnant sedge, and two duck nests, in the southern shrub thicket (YARN10N, 05N, 08N).	

Purple Swamphen	A new nest and a recently-used nest, in tall *Baumea articulata* sedge, near northern side (YARN13N, YARN14N).
Australian Reed-Warbler	An old nest in shrub thicket (YARN09N).
Little Grassbird	An old nest in shrub thicket (YARN12N).

Yarnup Lagoon – survey data (second survey)

	DATA	COMMENTS
Wetland name	Yarnup Lagoon (YARN)	Within a nature reserve.
Observers	A Clarke (DEC), J Graff (volunteer).	
Date/s	8 January 2009	
Start & finish time/s	15:00 – 22:30	2.7 hour break taken
Total duration of survey	4.8 hours	Includes 0.8 hour listening at night
Weather (windy?)	Fine; warm; night breeze.	
% of wetland inundated	95 %	
% of inundated area surveyed	50 %	Lake scan & tall sedge searched.
Water depth at gauge	0.85 m	
Survey methods used	Scan from shore; wading; intense nest searching; boat used; listening for calling bitterns at night.	
Habitats searched for nests	Mainly the tall sedge beds and clumps, accessed by boat.	
Change since 1980s/1990s?	See previous datasheet.	
Other remarks	Most of the species counts are minimum number present.	
Photos taken?	Yes: overview; nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	8	
Musk Duck	4	Two pairs
Swamp Harrier	3	Flushed off platform (~YARN27N).
Eurasian Coot	3	
Little Grassbird	2	
Australian Reed-Warbler	1	
Grey Teal	2	
Hoary-headed Grebe	2	
Little Pied Cormorant	2	
White-faced Heron	2	

NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF
Musk Duck	Nest with 3 eggs in *B. articulata* clump well into 'lake' interior; and a possible nest (YARN20N; YARN25N).
Purple Swamphen	Several old or recently used nests, in tall *B. articulata* sedge, well into 'lake' interior (e.g. YARN25N).
Little Grassbird	A recent nest; and a possible new nest, both in *B. articulata* sedge (YARN26N; YARN27N).

Yarnup Lagoon – additional photographs

Views across lagoon from north-western side (RJ-WI)

View across tall sedge from N side (RJ-WI)

Baumea articulata near N side (AC-DEC)

View from lagoon interior across *Baumea articulata* tall sedge to paperbarks, N side (AC-DEC)

Photos taken on 26-27 November 2008 (RJ) and 8 January 2009 (AC)

Yarnup Lagoon – survey map, 26-27 November 2008 and 8 January 2009

Survey map omitted from this version of report in order to limit the availability of nest site information.

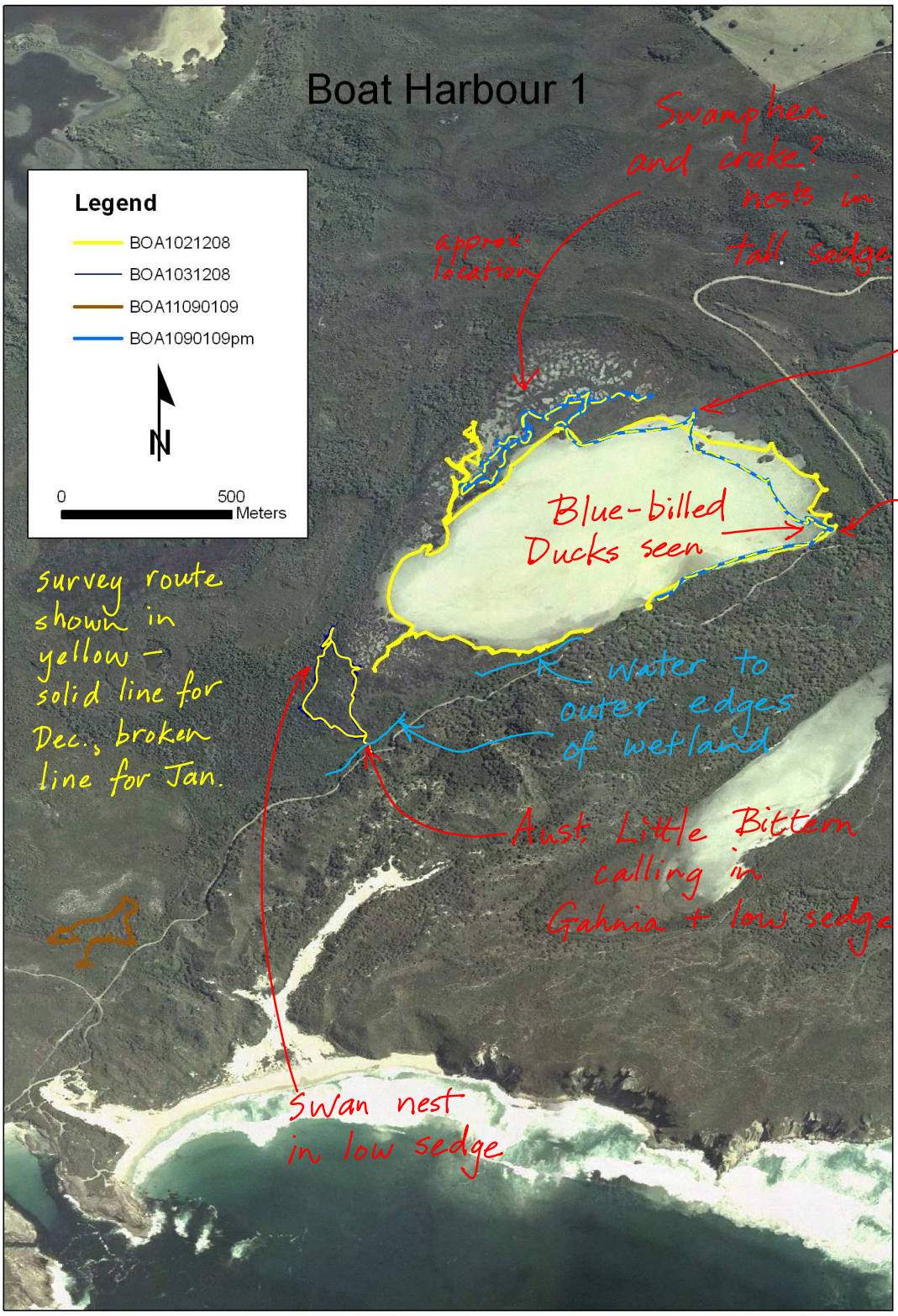
Boat Harbour Lake 1 – survey data (first survey)

	DATA	COMMENTS
Wetland name	Boat Harbour Lake 1 (BOA1)	Within a nature reserve.
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	2 & 3 December 2008	
Start & finish time/s (Day 1)	13:00 – 21:40	5 hour break taken
Start & finish time/s (Day 2)	09:25 – 11:00	
Total duration of survey	5.2 hours	Includes 0.8 hour listening at night
Weather (windy?)	Fine; light wind.	
% of wetland inundated	Probably close to 100 %	Some western edges not visited
% of inundated area surveyed	Approximately 70 %	Whole of open lake, part of swamp
Water depth at gauge	1.07 m	Water flowing in rapidly via the connecting creek from adjac. lake.
Survey methods used	Scan from shore; wading; intense nest searching; boating on lake and into sedgeland; listening for calling bitterns at night.	
Habitats searched for nests	Mixed tall sedge, low sedge and *Gahnia* tussocks; *Melaleuca* shrub/tree thickets.	
Change since 1980s/1990s?	No change evident. *Typha* not noticeably more extensive. Areas of burnt (dead?) *Agonis* trees in far NE and SE corners of wetland.	
Other remarks	Used highest species count from either day unless for a new area. Most of the species counts are the minimum number present. Also surveyed adjacent/connected southern swamps (data not shown).	
Photos taken?	Yes: overview; habitat types; nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	5	Heard only.
Swamp Harrier	1	
Pacific Black Duck	2	
Little Grassbird	3	
Spotless Crake	6	Heard only, NE and S margins.
Australasian Bittern	1	Heard only, south-west side.
Black Swan	16	12 flew in after sunset.
Little Pied Cormorant	3	
Fairy Tern	2	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Black Swan	Two young about two-thirds of adult size; and a recent nest in southern sedgeland (BOA103N).	

Boat Harbour Lake 1 – survey data (second survey)

	DATA	COMMENTS
Wetland name	Boat Harbour Lake 1 (BOA1)	Within a nature reserve.
Observers	A Clarke (DEC), J Graff (volunteer).	
Date/s	9 January 2009	
Start & finish time/s	13:30 – 22:45	1.3 hour & 2.8 hour breaks taken
Total duration of survey	5.3 hours	Includes 1.0 hour listening at night
Weather (windy?)	Fine; light wind.	
% of wetland inundated	Presumed full (100 %)	Outer limits not surveyed.
% of inundated area surveyed	Approximately 60 %	Whole of open lake, part of swamp
Water depth at gauge	1.01 m	
Survey methods used	Scan from shore; wading; intense nest searching; boating on lake and into sedgeland; listening for calling bitterns at night.	
Habitats searched for nests	Mixed tall sedge, low sedge and *Gahnia* tussocks.	
Change since 1980s/1990s?	See previous datasheet.	
Other remarks	Most of the species counts are minimum number present. Also surveyed adjacent/connected southern swamps (data not shown).	
Photos taken?	Yes: bittern habitat; nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	6	
Musk Duck	3	
Blue-billed Duck	6	In ENE corner
Pacific Black Duck	6	
Little Grassbird	4	
Australian Reed-Warbler	3	
Australasian Bittern	3	2 seen, N side; 1 calling SW side
Australian Little Bittern	3	Calling N side, ENE edge, SW side
Black Swan	104	
Little Pied Cormorant	9	
Spotless Crake	3	Heard only: far SW, and N side
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Purple Swamphen	A recently used nest (BOA105N) in tall *B. articulata*; a nest probably of swamphen (BOA106N)	
Crake species?	Nest possibly of this species, in N side *B. articulata* (BOA107N).	

Boat Harbour Lake 1 – survey map, 2-3 December 2008 and 9 January 2009



Boat Harbour Lake 1 – additional photographs

Gahnia tall tussocks, SW side (RJ-WI)

Gahnia, and *Agonis* trees, E side (RJ-WI)

Australasian Bittern sites: inundated *Gahnia* with low sedge (AC-DEC)

Aust. Bittern site: inundated *Gahnia* with low sedge (AC-DEC)

Low *Melaleuca* & *Baumea* tall sedge, (adjacent) southern swamp (RJ-WI)

Photos taken on 2-3 December 2008 (RJ) and 9 January 2009 (AC)

Lake Pleasant View – survey data (first survey)

	DATA	COMMENTS
Wetland name	Lake Pleasant View (PLEA)	Within a nature reserve.
Observers	R Jaensch (WIO), A Clarke (DEC); trainee group on 28th, some (W Zadow, R Garstone) very experienced at nest-finding.	
Date/s	27 & 28 November 2008	
Start & finish time/s (Day 1)	14:50 – 21:15	2 hour break taken
Start & finish time/s (Day 2)	10:30 – 12:30	
Total duration of survey	6.5 hours	Includes >1 hour listening at night
Weather (windy?)	Several showers; light wind.	
% of wetland inundated	At least 95 %	North-western edges not visited
% of inundated area surveyed	Approximately 75 %	Parts of open lake, parts of swamp
Water depth at gauge	1.10 m	Water flowing in via very small creeks from recent & current rain.
Survey methods used	Scan from shore; wading; intense nest searching; listening for calling bitterns at night.	
Habitats searched for nests	Mixed tall sedge and low sedge; *Melaleuca* thickets with tall and low sedge (northern side).	
Change since 1980s/1990s?	No change evident other than possible increase in extent of *Melaleuca* shrubs on outer N side. Some pampas (weed) clumps.	
Other remarks	Depth risen markedly over the past week – terrestrial weeds inundated. Used highest species count from either day unless for a new area. Most of the counts are the minimum number present.	
Photos taken?	Yes: overview; habitat types.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	4	
Swamp Harrier	2	
Pacific Black Duck	3	
Little Grassbird	1	
Musk Duck	2	
Hoary-headed Grebe	4	
Black Swan	2	
Australian Reed-Warbler	1	
Hardhead	2	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
(none recorded, this survey)	-	

Lake Pleasant View – survey data (second survey)

	DATA	COMMENTS
Wetland name	Lake Pleasant View (PLEA)	Within a nature reserve.
Observers	A Clarke (DEC) & J Graff (volunteer); 5 extra volunteers, some (W Zadow, T Bush) very experienced at nest finding.	
Date/s	10 January 2009	
Start & finish time/s	11:15 – 21:45	4 hours of breaks taken
Total duration of survey	6.5 hours	Includes 1.2 hrs listening at night
Weather (windy?)	Fine; light wind.	
% of wetland inundated	At least 95 %	
% of inundated area surveyed	Approximately 70 %	Most of open water, part of swamp
Water depth at gauge	0.96 m	
Survey methods used	Scan from shore; wading; intense nest searching; boating on lake to tall sedge clumps; listening for calling bitterns at night.	
Habitats searched for nests	Mixed tall sedge and low sedge.	
Change since 1980s/1990s?	(See previous survey)	
Other remarks	Most of the species counts are minimum number present. Listening for bitterns was done on N and E sides of the wetland.	
Photos taken?	Yes: bittern habitat; nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	8	
Swamp Harrier	1	
Pacific Black Duck	1	Flushed off nest.
Little Grassbird	8	Probably many more present.
Spotless Crake	6	On 3 sides of swamp; 1 flushed.
Australasian Bittern	2	1 flushed, West side, in low sedge; also two heard, N side.
Musk Duck	4	
Australian Reed-Warbler	6	Probably many more present.
Australian Little Bittern	2	Pair near nest in tall sedge, W side
Hardhead	6	1 on nest; also 1 dead near nest.
White-faced Heron	1	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Purple Swamphen	Nest with 3 warm eggs, in tall *Baumea articulata*, SW side.	
Australian Little Bittern	A recent or new nest, and an old nest, in tall *B. articulata* on W side (near PLEA10N); a pair of ALB flushed near the nests.	
Hardhead	A nest with 9 eggs and a nest with 10 eggs, in tall *B. articulata* on W side (PLEA10N). An adult flushed from one of the nests.	

Musk Duck	A recent nest with 2 eggs, abandoned, and another recent nest, predated, in tall *B. articulata* on W side (PLEA05N, PLEA09N).
Pacific Black Duck	A nest with 8 eggs in down, in tall *B. articulata* on W side (PLEA06N); and another possible recent nest.

Lake Pleasant View – additional photographs

Australasian Bittern site (AC-DEC)

Low sedge, NW side of lake (AC-DEC)

Inundated thistle plant indicates a very recent rise in lake level (RJ-WI)

Photos taken on 27-28 November 2008 (RJ) and 10 January 2009 (AC)

Lake Pleasant View – survey map, 27-28 November 2008 and 10 January 2009

Survey map omitted from this version of report in order to limit the availability of nest site information.

Mettler Lake – survey data (first survey)

	DATA	COMMENTS
Wetland name	Mettler Lake (METT)	Within a nature reserve.
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	28 November 2008	
Start & finish time/s	14:30 – 20:40	0.8 hour break taken
Total duration of survey	5.2 hours	Includes 0.6 hour listening at night
Weather (windy?)	Fine, slight breeze	
% of wetland inundated	Close to 100 %	Water not to 'full' depth
% of inundated area surveyed	Approx. 80 %	All open water; part of dense veg.
Water depth at gauge	1.01 m	Recent inflow had occurred.
Survey methods used	Wading; intense nest searching; listening for bitterns at night.	
Habitats searched for nests	Wooded swamp; *Gahnia* tussocks; shrub thickets; tall sedge; mixed shrubs and sedge.	
Change since 1980s/1990s?	No change evident.	
Other remarks	Some of the species counts are the minimum number present. Some trees of *Melaleuca cuticularis* in deepest water had sparse canopy foliage, and black 'smut' on upper branchlets.	
Photos taken?	Yes: overview; habitat types; nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	6	
Musk Duck	4	
Hardhead	2	
Pacific Black Duck	13	
Australasian Bittern	1	Flushed, centre south, in tall sedge
Australian Reed-Warbler	5	
Grey Teal	24	
Hoary-headed Grebe	4	
Little Pied Cormorant	34	Around central live trees
White-faced Heron	3	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Australian Little Bittern	Old nest at water level (base inundated) in tall *Baumea articulata* with *Melaleuca* sapling shrubs, centre south (METT16N).	
Little Pied Cormorant	Several nest clusters: 2, 6, 5, 8 and 6 old nests (METT01N, 09N, 11N, 12N, near 12N) and 7 new nests (METT14N); all in live *Melaleuca* saplings or small trees, most under a live yate canopy.	
Musk Duck	Old nests in *Gahnia* tussocks or tall sedge (METT06N, METT06N+15m); and a recent nest (METT15N).	
[Purple Swamphen]	Old nest at METT10N; swamphen or bittern platform at METT16N+5m.	

Australian Reed-Warbler	5 old nests in tall *B. articulata* with *Melaleuca* sapling shrubs, centre south (near METT16N).
[Eurasian Coot or duck]	Old nest under yate woodland (METT04N)
Unidentified duck species	Old nests, mainly in *Gahnia* tussocks under live yate canopy (METT05N, METT13N, and another 5 nests on W side).

Mettler Lake – survey data (second survey)

	DATA	COMMENTS
Wetland name	Mettler Lake (METT)	Within a nature reserve.
Observers	A Clarke (DEC), J Graff (volunteer).	
Date/s	11-12 January 2009	
Start & finish time/s (Day 1)	17:45 – 21:40	1 hour break taken
Start & finish time/s (Day 2)	08:45 – 11:25	
Total duration of survey	5.7 hours	Includes 1.4 hrs listening at night
Weather (windy?)	Fine; warm; night breeze.	
% of wetland inundated	90 %	
% of inundated area surveyed	40 %	Mainly west side and centre
Water depth at gauge	1.03 m	
Survey methods used	Wading; intense nest searching; listening for bitterns at night.	
Habitats searched for nests	Tall sedge; sedge and shrubs; *Gahnia* tussocks; wooded swamp.	
Change since 1980s/1990s?	See previous datasheet.	
Other remarks	Some of the species counts are the minimum number present.	
Photos taken?	Yes: nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	8	
Musk Duck	4	
Pacific Black Duck	50	Approx. number present
Australian Wood Duck	2	
Pink-eared Duck	2	
Australian Little Bittern	1	Calling, later seen: near METT16N.
Grey Teal	30	Approx. number present
Hoary-headed Grebe	2	
Little Pied Cormorant	30	Approx. number present
White-faced Heron	2	

NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF
Australian Little Bittern	New nest, nearly finished, in tall *Baumea articulata* with *Melaleuca* sapling shrubs, only 1.2 m from previous nest (METT16N).
Little Pied Cormorant	13 active nests, 12 with 4-6 eggs, one empty (previous site: METT14N); in live small *Melaleuca* trees.
Musk Duck	Nest with 1 egg, abandoned, in *Gahnia* tussock (METT20N). Other recent nests with shell pieces/down, probably this species, also in *Gahnia* (METT01N, 21N, 22N, 23N).
[Pacific Black Duck]	A recent nest, possibly this species, in *Gahnia* (METT04N).
Purple Swamphen	Nest with 3 eggs and a recent nest (N of METT16N); nest with 3 eggs, and 2 possible nests (METT27N); all in tall *B. articulata*.
Australian Reed-Warbler	Many nests of all ages in tall *B. articulata* with or near *Melaleuca* trees/shrubs, centre south (near METT16N).
[crake species?]	3 nests, unknown age, in central *B. articulata* (METT25N, 26N, 26N)

Mettler Lake – survey map, 28 November 2008 and 11-12 January 2009

Survey map omitted from this version of report in order to limit the availability of nest site information.

Mettler Lake – additional photographs

Gahnia tussock under live yates, W side

Low sedge and live yates, inner NW side

Live yates with *Baumea articulata* patch, inner N.

Paperbarks over *B. articulata*, inner NE

Live trees & shrubs over low sedge, NE side

B. articulata with shrubs, south of centre

Live paperbark showing sparse foliage, deep area, inner NE

Photos taken on 28 November 2008 by RJ-WI

Yellilup Lake – survey data

	DATA	COMMENTS
Wetland name	Yellilup Lake (YELL)	On freehold land.
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	29 November 2008	
Start & finish time/s	12:15 – 15:15	
Total duration of survey	3.0 hours	
Weather (windy?)	Fine; moderate W. wind	
% of wetland inundated	Probably 60-70 %	Outer limits on W side not seen
% of inundated area surveyed	Approx. 75 %	Open lake, part of dead tree zone
Water depth at gauge	1.32 m	Water level risen recently
Survey methods used	Scan from shore; wading; boat circuit.	
Habitats searched for nests	Open water; inundated dead trees (dead woodland).	
Change since 1980s/1990s?	Former live woodland of yate and *Melaleuca* trees occupying extensive outer zone of lake bed, now all dead; live trees now only near high water mark (Depth > ~2.5m) apart from a few live *Melaleuca* on E side just below ~2.5m; *Melaleuca* seedlings 2m high, above D=2.5m. Now samphire occurs on outer lake bed.	
Other remarks	Unable to boat into much of the shallow N and W side due to abundant fallen timber. 'Aerial roots' at >2m above present water level, on some dead *Melaleuca* trees around edge of open water, indicative of prolonged deep inundation in the past. Water salty, brown and with floating pieces of algae.	
Photos taken?	Yes: overview; habitat types; habitat change.	
SPECIES	COUNT	COMMENTS
Grey Teal	1200	
Pacific Black Duck	10	
Black Swan	45	
Australian Shelduck	3000	Many birds flightless due to moult; several intact dead birds, E shore.
Australian Wood Duck	2	
Australasian Shoveler	40	
Pink-eared Duck	300	
Hardhead	15	
Chestnut Teal	14	>half = chestnut & green males
Eurasian Coot	120	
Hoary-headed Grebe	120	
Common Greenshank	3	On large log at water level
Whiskered Tern	4	
Little Pied Cormorant	2	

Australian Darter	1	
NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF	
Chestnut Teal	A brood of 5 small young with adult pair, skulking on water in inundated dead trees, NE side	
[heron species?]	Very old nest in dead *Melaleuca* tree near edge of open water on SW side, about 3.5 m above lake bed (YELL01N)	

Yellilup Lake – additional photographs

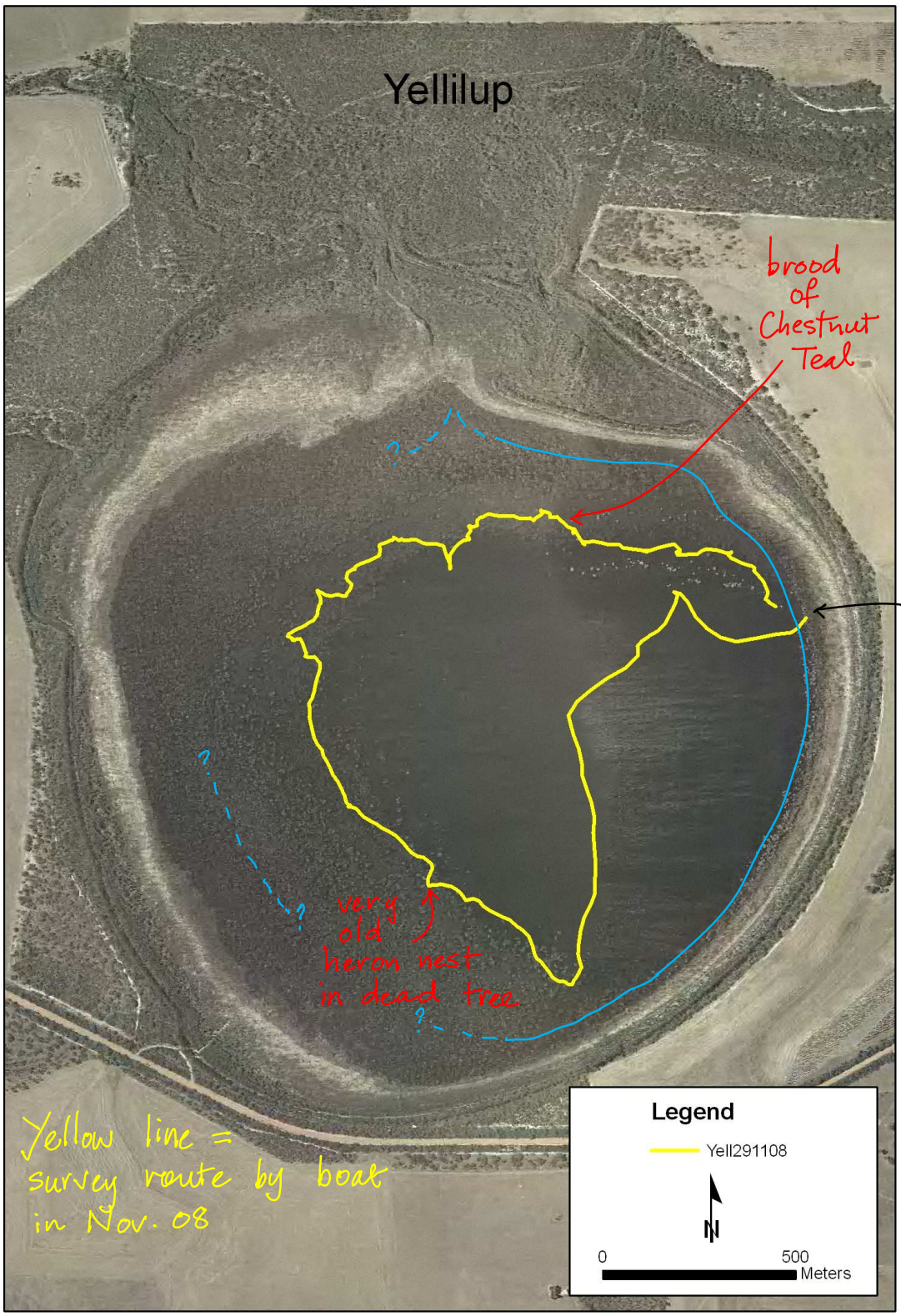
Centre south, view to east (RJ-WI)

Inner west side (RJ-WI)

Fallen dead trees obstruct boat passage, inner NE (RJ-WI

Photos taken on 29 November 2008

Yellilup Lake – survey map, 29 November 2008



Esperance 26410 – survey data

	DATA	COMMENTS
Wetland name	Esperance 26410 (ESP1)	Within a nature reserve.
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	1 December 2008	
Start & finish time/s	11:00 – 14:00	
Total duration of survey	3.0 hours	
Weather (windy?)	Fine, calm.	
% of wetland inundated	Approx. 75%	Not certain of extent when full.
% of inundated area surveyed	Almost 100 %	
Water depth at gauge	0.76 m	
Survey methods used	Scan from shore; wading; intense nest searching; boat survey of open water area.	
Habitats searched for nests	Wooded thickets; woodland; *Gahnia* tussocks.	
Change since 1980s/1990s?	Zone of dead yate trees now around edge of open water in NW to NE side of wetland, some still with fine twigs. Some yate seedlings (to 2m) in NNE just above present water line; very small yate seedlings under large live yates near boat launch site on W side.	
Other remarks	Water clear with yellow tinge. Extensive, but not dense, submerged aquatic plant (*Lepilaena* sp.?). Storm damage (fallen limbs) to some live yates at edge of open water.	
Photos taken?	Yes: overview; habitat types; habitat change; nests found.	
SPECIES	COUNT	COMMENTS
Freckled Duck	2	In/near inundated live *Melaleuca* trees on NE side; no red bills
Blue-billed Duck	1	Male in breeding plumage, displaying, *Melaleuca*, SW side.
Musk Duck	2	Male and female.
Pacific Black Duck	12	Some in wing-moult
Grey Teal	52	Many in wing-moult (in thicket)
Chestnut Teal	4	2 males and a pair
Australasian Shoveler	13	1 in wing-moult
Hardhead	2	
Australian Wood Duck	4	Some in wing-moult
Australian Shelduck	15	Several in wing-moult
Black Swan	15	
Hoary-headed Grebe	97	
Eurasian Coot	28	
Swamp Harrier	1	
White-faced Heron	5	

NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF
[Hoary-headed Grebe]	Old or recent nest of grebe species at water level in fallen trunks of *Melaleuca* tree on SW side (ESP101N).
[Eurasian Coot]	Very old nest at base of dry *Gahnia* tussock, NE side (ESP102N).
[Pacific Black Duck]	Recent (cold) egg washed on to SW shore.

Esperance 26410 – additional photographs

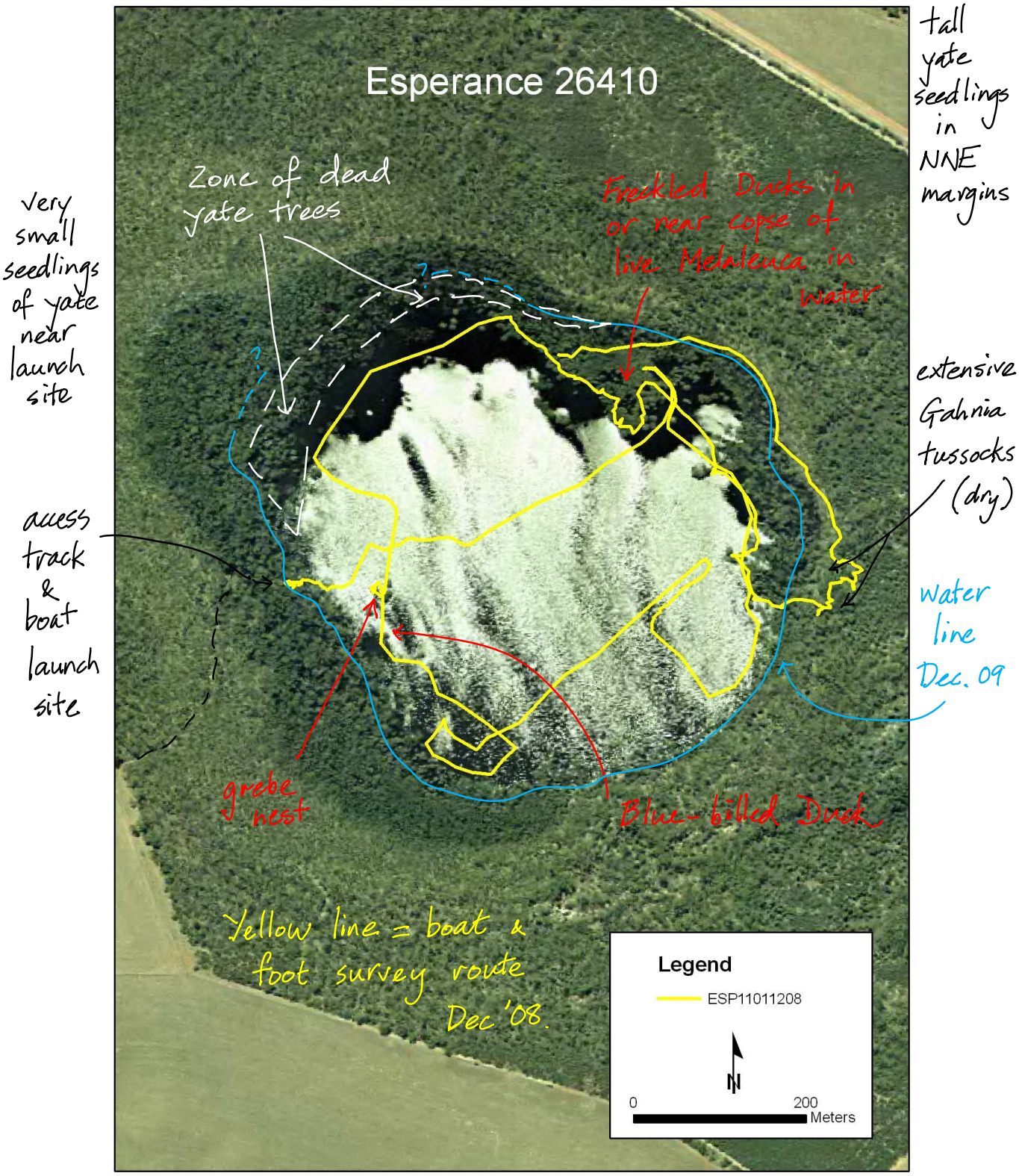
Live yates with storm damage (RJ-WI)

Dead yates on edge of open water (RJ-WI)

Yate seedlings (RJ-WI)

Photos taken on 1 December 2008

Esperance 26410 – survey map, 1 December 2008



Shark Lake – survey data

	DATA	COMMENTS
Wetland name	Shark Lake (SHAR)	Within a nature reserve.
Observers	R Jaensch (WIO), A Clarke (DEC).	
Date/s	30 November 2008	
Start & finish time/s	16:30 – 20:15	
Total duration of survey	3.8 hours	Includes 0.5 hour listening at night
Weather (windy?)	Fine; calm.	
% of wetland inundated	Close to 100 %	
% of inundated area surveyed	Over 90% (95%?)	Open water 100%; sedge 50%
Water depth at gauge	2.36 m	
Survey methods used	Scan from shore; boat access to deeper nest sites; wading; intense nest searching; listening for calling bitterns at dusk/night.	
Habitats searched for nests	Tall sedge; mixed shrubs/trees and sedge.	
Change since 1980s/1990s?	None evident.	
Other remarks	Some of the species counts are the minimum number present. A few plants of pampas grass and ?giant reed in E corners. Some *Melaleuca* low trees with sparse canopy foliage.	
Photos taken?	Yes: overview; habitat types; nests found.	
SPECIES	COUNT	COMMENTS
Purple Swamphen	3	
Musk Duck	4	
Swamp Harrier	1	
Pacific Black Duck	39	
Australian Reed-Warbler	5	
Black Swan	1	
Little Black Cormorant	3	
Blue-billed Duck	13	Some displaying by males
Australian Little Bittern	1	Male calling and seen in tall sedge
Spotless Crake	1	Heard only, in tall sedge
Hoary-headed Grebe	2	
Great Crested Grebe	4	Some birds were calling.
Hardhead	90	
Eurasian Coot	6	
Australian Darter	1	

NESTING SPECIES	NESTS, AGE & CONTENTS; HABITAT; GPS REF
[Hoary-headed Grebe]	A recent grebe nest possibly of this species, in tall *Baumea articulata* near NE edge of open water (SHAR01N+3m).
Blue-billed Duck	Nest with a fresh but broken (predated?) egg in tall *B. articulata* near NE edge of open water (SHAR01N).
[Eurasian Coot]	Recent nest possibly of this species (SHAR06N).
Spotless Crake	Old nest with eggshell of this species, in tall *B. articulata* infused with fine grass, near NNE edge of wetland (SHAR03N).
Purple Swamphen	Nest with 3 eggs and two newly-hatched young, in tall *B. articulata* near NE edge of open water (SHAR04N); recent nest with eggshell, at inner edge of tall sedge in SE corner (SHAR05N).
Australian Reed-Warbler	Two old nests in tall *B. articulata* on NNE side of lake (SHAR03N+3m); 5 old nests in tall *B. articulata* growing into *Melaleuca* low trees on SW side of lake (SHAR07N).
[Australian Little Bittern]	A new nest platform at water level in tall *B. articulata* on NNE side of lake (SHAR02N), close to where a male ALB was calling and photographed; nest apparently flooded by rising water level.

Shark Lake – additional photographs

Melaleuca thickets with tall sedge, WNW corner (RJ-WI)

Photos taken on 30 November 2008

Shark Lake – survey map, 30 November 2008

Survey map omitted from this version of report in order to limit the availability of nest site information.

Appendix 5. GPS points for nests located in surveys for the project

These coordinates are retained by DEC and are not for general distribution, at least in the short term (several years at least), in order to give current nest sites a level of protection from possible unlawful disturbance.