WATERBIRD USE OF PEEL-HARVEY ESTUARY FOLLOWING OPENING OF THE DAWESVILLE CHANNEL IN APRIL 1994

PROGRESS REPORT

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Cover photograph of Australian Pelicans (*Pelecanus conspicillatus*) at Mandurah by A.G. Wells, AFIAP, ARPS.

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SUMMARY

Peel-Harvey estuary, 70 km south of Perth, Western Australia, is listed as a Wetland of International Importance under the Ramsar Convention. Surveys in the mid 1970s showed that at least 100 000 birds and 80 species at times made use of the estuary's extensive, shallow and highly productive waters.

During the mid to late 1900s Peel-Harvey has become increasingly eutrophic due to leaching of agricultural fertilisers from the catchment. Public objections to odours emanating from decaying macro-algae and the increasing occurrence of blue-green algae blooms have resulted in government and community action to alleviate these problems.

One component of the government's strategy has been to increase flushing of the estuary by constructing a second entrance to the ocean. This entrance - the Dawesville Channel - was completed in April 1994. A condition of government approval of the Channel was that monitoring be undertaken so that impacts could be assessed and, where desirable and practicable, managed. This report describes progress in monitoring of waterbird use of Peel-Harvey following opening of the Channel.

The waterbird program has a number of components. These include surveys of the numbers and distribution of all waterbird species; monitoring of pelican nesting activity and success and an assessment of current suitability and use of three formerly significant roost sites. Salinities in the lowest reaches of the Harvey River and the health of vegetation on the Harvey River Delta are also being monitored.

Data collection for the waterbird program began between 1994 and 1996. Previously unpublished data from waterbird surveys undertaken in the mid 1970s are being used to provide a baseline.

Some preliminary conclusions can be drawn from the data collected to date. For example, pelican nesting success appears to be sufficient at present for total pelican numbers on the estuary to be maintained. There has been no decline in the number of Eastern Curlews using the estuary. Curlew Sandpipers, however, are far less abundant. This may be due to a number of factors quite unrelated to construction of the Channel.

The health of vegetation along the lower reaches of the Harvey River Delta appears to be declining. This is probably due to increased salinity and tidal amplitude in this part of the estuary due to the Channel.

Further monitoring is needed to adequately assess post-Channel use of Peel-Harvey by waterbirds. It is proposed that field work continue until 1999.

1. BACKGROUND

Peel-Harvey estuary, 70 km south of Perth, Western Australia, is the largest estuary in south-western Australia and is popular for recreation, principally crabbing, prawning, fishing, boating and enjoyment of nature. The estuary also supports a significant commercial fishing industry.

Peel-Harvey is an internationally significant habitat for waterbirds. Tens of thousands regularly gather on the estuary. In some years the total number may exceed 100 000. More than eighty species have been recorded including many migrants from breeding grounds in northern Eurasia and Siberia. The estuary is also of great significance for species resident in Australia such as pelicans, swans, ducks, grebes, stilts, avocets and many others (ANCA 1996, pp.893-5). In recognition of its significance, Peel-Harvey has been listed, together with the Yalgorup lakes, as a Wetland of International Importance under the Ramsar Convention (Government of Western Australia 1990).

There is substantial urban development along the northern (Mandurah) and western (Dawesville) shores of the estuary. Land adjoining the eastern and southern shores is predominantly farmland or nature reserve, with some recent small holding subdivisions.

Clearing of native vegetation, drainage works and use of agricultural fertilisers has resulted in Peel-Harvey estuary becoming eutrophic. Complaints during the 1970s about the accumulation of decaying algae and the associated smell led to efforts being made to solve the problem. Following detailed and lengthy investigation it was decided that a multi-faceted approach should be taken. Key elements were to be modification of fertilizer use in the catchment and excavation of a channel - the Dawesville Channel - to provide a second connection to the sea and thereby increase tidal exchange with the ocean.

The proposal to construct a channel at Dawesville was approved in principle by the Western Australian Government in January 1989. Works began in February 1992 and the Channel was opened in April 1994.

A condition of approval of the Channel was a requirement that monitoring be undertaken so that impacts could be assessed and, where desirable and practicable, managed.

One component of the monitoring program was to be an assessment of waterbird use of the estuary following completion of the Channel. This work was to be done by the Western Australian Department of Conservation and Land Management (CALM). Funding arrangements for the Dawesville Channel monitoring program were determined by Government in February 1994. CALM was to undertake its components using existing departmental resources. Funds were to be allocated by CALM from 1994/95 onwards.

This progress report describes the waterbird monitoring work undertaken by CALM since opening of the Channel. Some preliminary findings are presented. A more comprehensive report will be prepared when data compilation and analysis have been completed.

2. STUDY AREA

The study area is the entire Peel-Harvey estuary (area c. 136 km^2, shoreline length c. 75 km) including open waters, shallows, tidal flats, shorelines and fringing marshes (Figure 1). The Harvey River Delta and the lower reaches of the Harvey River are also included.

3. DESIGN CONSIDERATION

Waterbirds are highly mobile animals and most species using Peel-Harvey and other estuaries of south-western Australia have their breeding grounds elsewhere, from vegetated swamps a few hundred metres away to the arctic tundras of northern Russia. Waterbird numbers on south-west estuaries therefore change dramatically from season to season and - depending upon breeding success, climatic conditions elsewhere

in Australia and other factors - from year to year.

These changes in numbers occur independently of any changes brought about by altered conditions on the estuaries themselves. For this reason, in order to determine whether or not a particular management action has had a significant effect on waterbird numbers, one would ideally monitor waterbird numbers on a seasonal basis for at least two years prior to the action being taken, so that a "baseline" may be established.

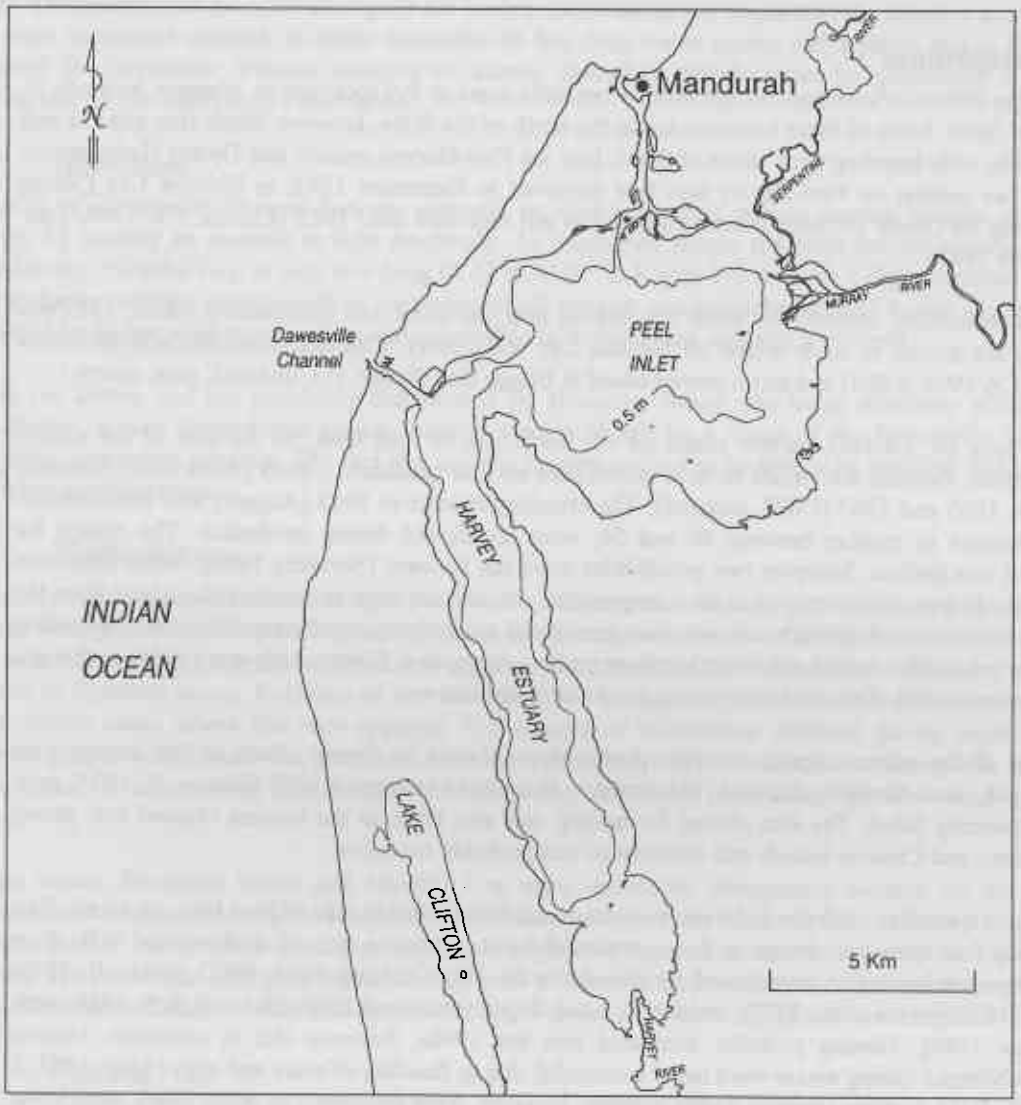

Figure 1. Peel-Harvey estuary locality map.

In the case of the Dawesville Channel, monitoring could not be commenced until after the channel was opened. It is therefore difficult to assess the extent to which the channel has or will affect waterbird use of the estuary. Nonetheless it is important to determine "post-Channel" use by waterbirds as they constitute one of the primary values of the estuary and are the basis upon which it is internationally recognised.

Urban and recreational pressures on the estuary and its margins are increasing and an up-to-date knowledge of how birds use the estuary is essential to minimise adverse impacts resulting from these

pressures. Adverse impacts resulting from the Channel may also become evident - though perhaps unproveable from a strict scientific viewpoint - as a result of ongoing post-Channel monitoring. Some of these impacts may also prove to be manageable.

The waterbird monitoring project has several components. Progress with each is described below.

4. PELICAN NESTING ACTIVITY AND SUCCESS

4.1 Background

The Australian Pelican (*Pelecanus conspicillatus)* regularly nests at 8-9 locations in Western Australia (J. Lane, unpub. data). Most of these locations are in the north of the State, between Shark Bay and the east Kimberley. The only breeding sites south of Shark Bay are Peel-Harvey estuary and Oyster Harbour near Albany. Pelican nesting on Peel-Harvey was first observed in December 1962, at Nirimba Cay (Shugg 1964). Nesting on Oyster Harbour (Green Island) was not recorded until 1985 (Collins, P.J. 1985, pers. comm.; Harris 1987).

Pelicans nest colonially, typically on small low islands near the coast and occasionally inland. On Peel-Harvey they are known to have nested on Nirimba Cay and Creery, Channel, Boodalan and Boundary Islands (ANCA 1996, p.894) and an un-named island in Boggy Bay (Fuller, P.J. undated, pers. comm.).

Creery is a long (c. 1.8 km), narrow island on the north side of Peel Inlet, to the east of the natural entrance channel. Pelicans are known to have nested here on four occasions - 1963 (Anon 1963, Serventy 1964), 1964, 1965 and 1967 (FWD, undated). The breeding attempt in 1963 (August) was unsuccessful. All nests, thought to number between 40 and 50, were abandoned during incubation. The reason for abandonment was unclear, however two possibilities were put forward (Serventy 1964). Some fishermen believed a fox *Vulpes vulpes* may have been responsible, as one was seen to swim to the island from the closely adjacent mainland. Disturbance was also considered a possible contributory factor, as the nesting site was near a boating channel. Of the other three nesting attempts at Creery, only one (1964) is thought to have been successful. The number of young produced is not known.

At least one of the pelican nesting attempts previously attributed to Creery Island in fact occurred on Channel Island, immediately to the west. This attempt, thought to be around 1967 (Easton, K. 1975, pers. comm.), apparently failed. The area chosen for nesting was also close to the boating channel that passes between Creery and Channel Islands and disturbance was probably excessive.

Nirimba Cay is a small (c. 150 m x c. 50 m), low, sand island on the south side of Peel Inlet, in Austin Bay. It is relatively free from disturbance as it is surrounded by an extensive area of shallows and is far from shore. Pelicans are known to have nested on Nirimba in the 1960s (Shugg 1964; FWD, undated), 1970s (Fuller, P.J. 1973, pers. comm.; FWD, undated; J. Lane, unpub. data) and 1980s (Jaensch, R.P. 1986, pers. comm.; Daw 1986). Nesting probably continued into the 1990s, however this is uncertain. Nesting attempts on Nirimba during winter were never successful, due to flooding of nests and eggs (Anon 1975, J. Lane, unpub. data). Nesting attempts during summer, however, *were* successful as water levels were lower and there was little disturbance. From the 1960s to the 1980s, and possibly into the early 1990s, Nirimba Cay was *the* major, successful pelican nesting site in Peel-Harvey estuary.

In September 1973, pelicans nested on a small island c. 1/2 mile (0.8 km) to the east of Nirimba Cay. This colony was deserted, probably because the island was in shallow water close to the mainland and access by predators was possible when tides were low (Fuller, P.J. 1973, pers. comm.).

Boodalan Island is a small (c. 150 m x c. 125 m) sandy island near the entrance to the canal estate at South Yunderup. It was created in 1972 with material dredged to provide a navigable channel to the estate (Serventy 1975). Pelicans are known to have nested on Boodalan in 1974 (Serventy, D.L. 1974, pers.

comm.; Anon 1975, Serventy 1975; J. Lane, unpub. data), 1975 (J. Lane, unpub. data; Bodeker 1975) and 1988 (Love, M.R. 1988, pers. comm.). Nesting success has always been low, however, due to frequent disturbance and even vandalism (Seventy, D.L. 1975, pers. comm.; Bodeker 1975).

Boundary Island is a large (c. 25 ha), sandy island at the northern end of Peel Inlet, near the main navigation channel. It was created in 1987 (Pszczola, J. 1998, pers. comm.) with material dredged from Peel-Harvey's natural outlet in order to increase tidal exchange with the ocean. Pelicans are known to have nested here in 1989 (Davis, G. 1989, pers. comm., 16 November) and might also have attempted in other years. The outcome of the 1989 attempt is not known. Disturbance is a concern as the island is adjacent to the main navigation channel, is easily accessible (it has deep water access and a jetty) and is formally reserved for recreation. Without controls on access, Boundary Island cannot be considered a secure nesting site for the pelicans of Peel-Harvey.

4.2 Rationale

Opening of Dawesville Channel had the potential to adversely affect pelican nesting success on Peel-Harvey by causing an increase in tidal amplitude. As mentioned above, the main pelican nesting site in Peel-Harvey, Nirimba Cay, is very low lying (0.22 m AHD[1] in March 1994). Even a slight increase in tide height during summer could result in drowning of all eggs or newly-hatched chicks in the colony. The potential for higher tides to make boat access possible to Nirimba Cay was also a concern.

Given the above, and the possibility that nesting on Boundary Island was being adversely affected by disturbance, it was decided that pelican nesting success should be a focus of the Dawesville Channel waterbird monitoring program. The fact that adverse impacts might also be able to be rectified was another important consideration.

4.3 Methodology

Boundary Island was visited at fortnightly intervals or thereabouts from July 1994 onwards to monitor pelican nesting activity. Whenever possible, counts or estimates were made of the number of adults in the nest area, the number on nests, nest contents (eggs or young; usually determined from a distance) and the number of flightless young. Evidence of nest area desertion or mortality was also recorded, together with the probable cause where this was apparent The amount of information obtained during visits varied depending upon how closely the nest area could be approached without causing an unacceptable level of disturbance. Great care was taken to prevent monitoring visits from prejudicing the survival of eggs or chicks.

Creery Island, Boodalan Island and Nirimba Cay were monitored infrequently because of the lower probability of nesting occurring on these islands and the need to contain costs. Ground visits were made to all three in July 1994. They were also inspected by plane at approximately two monthly intervals from October 1995 onwards during aerial censuses of total pelican numbers on the estuary. Ground inspections were also made in October 1996, December 1996 and February 1997, during general waterbird surveys.

4.4 Results

From July 1994 to July 1997 there were four periods of continuous pelican breeding activity on Boundary Island, varying in length from 4-11 months (Table 1). Thus breeding activity (any stage from adults on nests to fledging of young) occurred in 28 of 37 months.

The estimated number of young fledged during each breeding period varied from 35-45 to 150-250. The first breeding period consisted of a single nesting effort. Subsequent breeding periods each contained two or more overlapping efforts.

[1] AHD = Australian Height Datum.

The total number of chicks fledged from Boundary Island in the past 3 years is in the vicinity of 500-700. This figure is a rough estimate, rather than a precise count, because of the considerable care taken by the authors not to excessively disturb breeding birds and their young. The figure is, however, considered to be of adequate precision to meet the objectives of the monitoring program, especially when used in combination with data on total pelican numbers on Peel-Harvey (see section below).

Some disturbance occurred at Boundary Island during the monitoring period. An inspection on 7 October 1994 revealed that all 34 unfledged chicks still alive on the island at that time had deserted the nesting area and walked to the shore. Six downy chicks, all less than three weeks old, were found dead in and around the nest area. One smashed egg was found in a nest scrape. The age of the chicks, the distance moved, the presence of small dead chicks and the smashed egg, together gave a strong indication that major disturbance had occurred. The most likely cause was a careless visit by a person or people. Significantly, school holidays had begun on Friday 30 September and there were many more people on the estuary in the first week of October than there had been during the preceding two months.

Table 1. Summary of pelican nesting activity and success at Boundary Island, July 1994 - July 1997.

Period	Duration	Max # of adults in nest area	Max # of adults on nests	Max # of unfledged young observed at any one time	Estimated # of young fledged
Jul 94 - Oct 94	4 mths	100	65	67	35-45
Dec 94 - Jun 95	7 mths	300	?	235	150-200
Jan 96 - Nov 96	11 mths	250	100	216	150-250
Nov 96 - Apr 97	6 mths	300	80	240	150-200

On 16 April 1997 a family party carrying binoculars was observed to approach within 20m of a group of 23 one week to four week old pelican chicks in the nest area. They stayed for ten minutes, their presence causing the birds some distress.

On one occasion during summer 1996-97, tents were seen on the northern end of Boundary Island some distance from the nest area. Various boats, including hired house-boats, have also been seen on the beach or tying up at the jetty at the northern end of the island.

No signs of nesting activity have been found on Creery Island, Boodalan Island or Nirimba Cay during the past three years. During this period, Boodalan Island has been visited frequently by people, sometimes with dogs. Nirimba Cay has been inundated on many occasions throughout the year (DoT tidal data needed to confirm), making successful nesting impossible.

4.5 Discussion

During the past three years, disturbance has caused cessation of one pelican breeding event on Boundary Island and some associated mortality of chicks. Over most of this period, however, there has been little or no disturbance of the colony and most breeding attempts have been successful. This situation may change in the future as the number of people using the estuary and visiting Boundary Island increases. There is a growing awareness of the existence of this breeding colony and this may also result in more disturbance. Further monitoring of nesting success and disturbance levels is therefore warranted.

The lack of breeding on Creery and Boodalan Islands is neither surprising nor significant, for reasons indicated earlier in this report.

The lack of breeding activity on Nirimba Cay is not unexpected as it is now frequently inundated. The

extent to which increased inundation has been due to the small rise in sea level that has occurred in recent decades, to an increase in tide heights due to opening of the Dawesville Channel, or to erosion (if this has occurred) of the cay has yet to be determined. An examination of relevant data (to be obtained from DoT) is needed. The loss of Nirimba Cay as a breeding site now leaves Boundary Island as the only successful site on Peel-Harvey and makes monitoring of breeding success and disturbance on the latter island all the more important.

Breeding success on Boundary Island over the past three years appears to have been sufficient to maintain total pelican numbers (see section below) on Peel-Harvey. However, as disturbance levels are likely to increase, further monitoring of pelican numbers is warranted.

5. PELICAN NUMBERS AND DISTRIBUTION

5.1 Background

During the mid 1970s, numerous surveys were undertaken of total pelican numbers on Peel-Harvey estuary (J. Lane, unpub. data). The population ranged from 540 to 2100 individuals and on most occasions was in excess of 1000 (Figure 2). Since that time, waterbird surveys have been undertaken on parts of Peel-Harvey and on many other waterbodies throughout Western Australia (e.g. Jaensch, Vervest & Hewish 1988; Jaensch & Vervest 1990 a,b; Halse et al. 1992; Storey et al 1993). It is evident from these surveys that, in the mid 1970s, Peel-Harvey estuary regularly supported larger numbers of pelicans than any other waterbody in the southern half of the State. The highest ever counts from other waterbodies of this region are Vasse-Wonnerup 750, Indoon Lake 500 and Lake Guraga 120 (Jaensch, Merrifield & Raines 1993).

5.2 Rationale

Opening of the Dawesville Channel had the potential to adversely impact on pelican numbers in Peel-Harvey by reducing nesting success (see section 4.2). It was therefore considered desirable to monitor pelican numbers following Channel completion.

The numbers of pelicans frequenting the estuary in years immediately preceding opening of the Channel were not known. However, precise count data were available from the mid 1970s. These could be used to provide a baseline for comparison with results of post-Channel counts. It was therefore considered worthwhile to repeat the 1975-77 surveys, from October 1995 onwards. Counts were not undertaken in the 18 months following opening of the Channel because of other demands on personnel and the need to contain costs.

5.3 Methodology

The number and distribution of pelicans on Peel-Harvey has been determined at two month intervals since October 1995 using a single-engine, high wing aircraft (Cessna 172) with a pilot plus one observer. Each survey takes 1-1.5 hours depending upon bird numbers and flying conditions. Individuals and small groups are counted from the air. Large flocks are photographed and counted subsequently. The survey methodology, route and timing (both day of year and time of day) closely follow those of the pelican counts conducted during 1975-77.

5.4 Results

Total numbers of pelicans counted on Peel-Harvey from October 1995 to May 1997 are shown in Figure 1. Numbers counted during the period 1975-77 are also shown, for comparison.

The number inhabiting Peel-Harvey in the past two years has ranged from 268 in October 1995 to 706 in February 1996. There are two peaks in numbers; in February 1996 (706) and February 1997 (630). There is some suggestion that numbers on the estuary are rising, however it is too early to be definite about this.

Numbers from October 1995 to May 1997 are lower than in the same months from October 1975 to May 1977, when the range was 595 to 2102. Numbers since December 1995 (range 415 to 705) are similar, however, to those of February to November 1975 (range 540 to 619).

5.5 Discussion

Pelican numbers on south-west estuaries vary seasonally, with greatest numbers in summer-autumn and fewest in winter-spring. Leg-banding studies and monitoring of breeding colonies indicate that this seasonal variation is due to the departure of adults to breeding sites in northern WA in winter and the arrival of post-breeding adults and young in summer (J. Lane, unpub. data). Birds remaining in the south-west all year round are either non-breeders or, in the case of Peel-Harvey and Oyster Harbour, non-breeders plus resident breeders.

Pelican numbers on Peel-Harvey during the past nineteen months (October 1995 - May 1997) have varied in accordance with this seasonal pattern of immigration and emigration, with many resident breeding birds (and non-breeders) remaining during winter-spring 1996. Numbers counted during this period are roughly comparable with those of February 1975 to November 1975 and on this basis it could be concluded that little change has occurred. Recent numbers are, however, very much lower than those of 1976 and early months of 1977. This invites explanation.

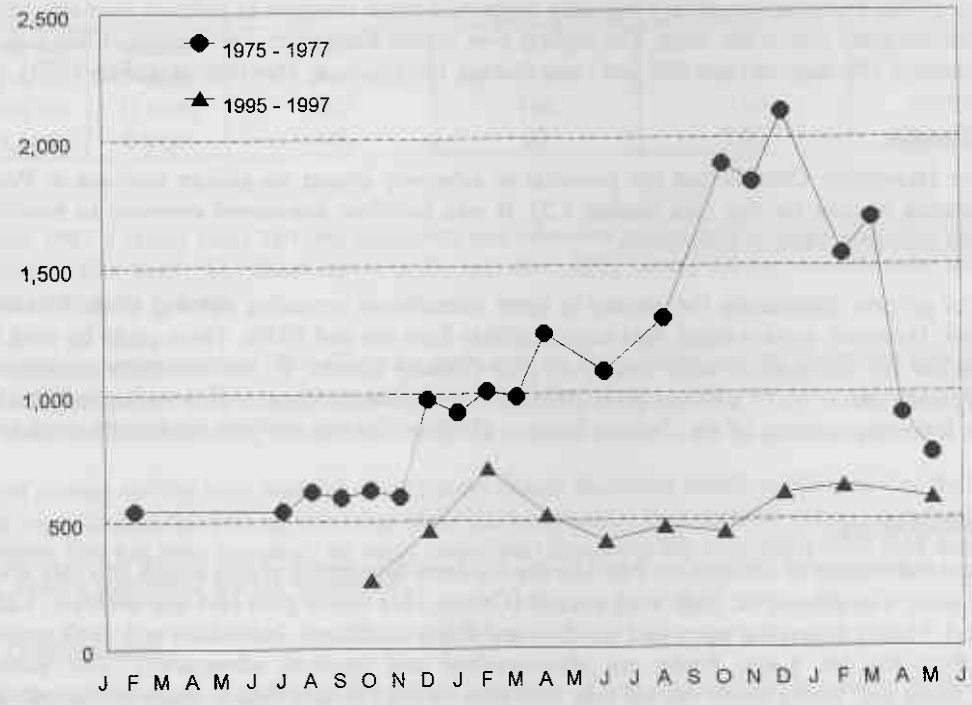

Figure 2. Numbers of Pelicans on Peel-Harvey: Feb 1975 - May 1977 and Oct 1995 - May 1997.

The dramatic increase in pelican numbers that occurred from December 1975 to December 1976 (Figure 2) might have been due in part to highly successful episodes of breeding, if these occurred, on Peel-Harvey or colonies in the north of the State. It is probable, however, that much of the increase was due to an influx of birds from eastern Australia. Lake Eyre, in South Australia, filled in 1974 and supported a large pelican breeding colony that year, and probably in 1975-76 (Blakers, Davies & Reilly 1984, p.34). As its waters receded and salinity increased, the lake's fish population died and many thousands of pelicans flew to other parts of the continent and to New Guinea in search of food (ibid.; *The Sunday Times* 20 Nov. 1977, p.67).

Some of these birds are likely to have reached waterbodies on the west coast, including Peel-Harvey. 1976 was also a drier year than average in the south west and this would have led to further concentration of birds on permanent coastal waters. Further investigation of probable sources is proposed. This work will enable Peel-Harvey's role in the maintenance of Australia's pelican population to be better understood and will assist in the interpretation of results from the current monitoring program.

There is no clear relationship between the total number of pelicans counted on Peel-Harvey between October 1995 and May 1997 and the number of young fledging from Boundary Island during the same period. This may be due to a number of factors including dispersal of recently fledged young to other waterbodies, movement of older pelicans between Peel-Harvey and other waterbodies, migration of adult pelicans to distant breeding grounds, and high natural mortality of fledglings.

6. WATERBIRD SPECIES, NUMBERS AND DISTRIBUTION

6.1 Background

Peel-Harvey estuary is recognised as one of the most important waterbird habitats in Western Australia. More than 80 species have been recorded and many are present in great abundance. In February 1977, a survey of the entire estuary revealed more 110 000 birds (J. Lane, unpub. data). In November 1982 a survey of the eastern part of Peel Inlet alone produced c. 41 000 (ANCA 1996, p.894). No other wetland in south-western Australia is known to support as many birds.

Species with highest numbers are Banded Stilt (60 000, February 1977), Grey Teal (15 400, March 1987), Eurasian Coot (15 000, October 1976), Black Swan (8100), Red-necked Stint (8100), Pied Cormorant (4000), Little Pied Cormorant (4000), Curlew Sandpiper (2800), Black-winged Stilt (2700), Sharp-tailed Sandpiper (2400), Australian Pelican (2100), Avocet (1500), Grey Plover (600) (ANCA 1996, pp.894-5).

In June 1990, Peel-Harvey estuary, together with Yalgorup National Park, was designated as a Wetland of International Importance under the Ramsar Convention. Peel-Harvey's listing was primarily on the basis of its internationally significant use by waterbirds (Government of Western Australia 1990). Many of the species using the estuary are also listed under the Japan-Australia and China-Australia Migratory Birds Agreements.

6.2 Rationale

Opening of the Dawesville Channel had the potential to affect the suitability of Peel-Harvey for use by waterbirds. The number of high tide roost sites could be reduced by an increase in tide heights. Higher tides could also cause flooding of pelican nesting grounds (see other sections of this report) and the death of some fringing vegetation used by waterbirds for feeding, refuge, roosting and breeding. Changes in the estuary's salinity regime, when combined with an increase in tide heights, could also contribute to the death of vegetation. Increased tide heights, particularly during summer, could result in an increase in disturbance, by permitting access to important waterbird feeding and loafing areas that were previously too shallow for boats. Altered water levels, salinities and circulation patterns could also have largely unpredictable effects on the food webs supporting the estuary's waterbird populations. Clearly most if not all species could be affected in some way (some perhaps positively) by creation of the Channel. For this reason it was decided that comprehensive surveys to determine use of the estuary by all species should be conducted.

As indicated in Section 3, in order to establish a baseline it would have been preferable for surveys to have been conducted for at least two years immediately prior to the Channel being opened. This, however, was not achievable. The only baseline data on waterbird use of the entire estuary come from comprehensive surveys taken by the principal author (JL), with assistance from one of the co-authors (GP), in the mid-1970s. These surveys could be repeated precisely as full details of survey methodologies, routes, times etc.

had been recorded and the same personnel were available. It was therefore decided to repeat the 1976-77 surveys during two of the five years programmed for post-Channel monitoring.

Two years of surveys have been planned in order to obtain an indication of year-to-year variability in waterbird numbers and distribution. Post-Channel years two and five (1996-97 & 1998-99) were chosen as it is likely that at least some of the effects of the Channel will take several years to be expressed. Whereas in 1976-77 six surveys were conducted at two monthly intervals from August 1976 onwards, in 1996-97 this was not possible, due to other demands on staff time. It will also not be possible in 1998-99. For this reason the 1996-97 surveys were limited, and the 1998-99 surveys will be limited, to October, December and February. These months were chosen because both total waterbird numbers and the number of species, particularly of transequatorial migrants, are expected to be greatest at this time of the year.

6.3 Methodology

Surveys of all species of waterbirds throughout the Peel-Harvey estuary were conducted in October 1996, December 1997 and February 1997. The areas surveyed, modes of transport (plane, boat and foot), equipment used (binoculars, audio cassette recorder, notebook, maps), survey routes, survey times and personnel were the same as, or very similar to, those of surveys conducted in the same months of 1976-77.

On the first day of each survey, pelican numbers and distribution on Peel-Harvey were determined by aerial census. Black Swan numbers and distribution on Harvey Estuary alone were also determined during this aerial survey. The swans of Peel Inlet were surveyed by boat.

On the second day, a survey was made (by boat) of the numbers and distribution of all waterbird species downstream from the old Mandurah Traffic Bridge. Waterbirds on the north-eastern side of Peel Inlet upstream from the same bridge to the mouth of the Serpentine River and including Creery and Channel Islands and the Creery marshes were surveyed by boat and on foot. In October 1996, the day one and day two surveys were all done in the one day, as in October 1976.

On day three, all waterbirds on the north-western side of Peel Inlet, from the old Mandurah Traffic Bridge to Ward Point, including Boundary Island and the samphire islands to the west of Channel Island, were surveyed by boat and on foot. In February 1997, a separate survey by boat of the western shoreline of Harvey Estuary from Island Point to Ward Point was also conducted.

On day four, all waterbirds on the shoreline and the inner and middle shallows of the eastern and southern side of Peel Inlet, from Yunderup Canals to the east side of Point Grey, were surveyed by foot. A separate foot survey of the east side of Point Grey and the eastern side of Harvey Estuary from Point Grey to Herron Point, was also conducted.

The shoreline and shallows between the mouths of the Serpentine and Murray Rivers, plus the middle and outer shallows on the eastern and southern sides of Peel Inlet from Yunderup Canals to Robert Bay were surveyed by boat and on foot on day five.

A survey of all waterbirds at the southern end of Harvey Estuary (from Herron Point Ford south), including the lower reaches and delta of the Harvey River, was conducted by boat and on foot on day six, the last day of the surveys.

6.4 Results and Discussion

The process of transcribing the 1996-97 survey data (17 days of recordings of the distribution and numbers of an estimated 60 species) from audio cassettes to maps and to a database has been partially completed. The information gathered during the 1975-76 surveys also need to be added to this database so that results may be compared. This work is proposed for a subsequent report.

Although survey data have yet to be assessed, some strong impressions have emerged during the 1996-97

surveys.

Little Egrets *Egretta garzetta* are undoubtedly more numerous and more widespread around the estuary now than in 1976-77. This reflects a general increase in numbers of Little Egret in south-western Australia over the past twenty years.

There has been no decline in the number of Eastern Curlews *Numenius madagascariensis* on the estuary. Though they are still rarely observed elsewhere in the southern half of Western Australia, they continue to regularly frequent the northern end of Peel Inlet in small numbers (10 or so) as before.

Curlew Sandpipers *Calidris ferruginea* were far less abundant in 1996-97 than in 1976-77. This might be due to year-to-year variations in total numbers migrating to Australia from arctic breeding grounds, to a long term decline in the abundance of this species in Australia or throughout its range, or to altered conditions on Peel-Harvey. Waterbird surveys proposed for 1998-99, plus information to be sought on trends in the abundance of this species at other sites in Australia, will assist in interpreting this observation.

7. BLACK SWAN NUMBERS AND DISTRIBUTION

7.1 Background

Peel-Harvey is one of the most significant habitats for Black Swans *Cygnus atratus* in Western Australia. Counts conducted during the mid 1970s regularly produced between 2000 and 6000 individuals and on one occasion their numbers exceeded 8000. (J. Lane & G. Pearson, unpub. data). Few other wetlands in Western Australia support so many swans.

Greatest numbers are found spread out across the extensive shallows of Peel Inlet, particularly over the seagrass (*Ruppia* sp.) beds on the eastern and southern sides of the Inlet. In some years they also congregate in large numbers at the southern end of Harvey Estuary during late summer and autumn. Here they have had access to fresh drinking water flowing all year round from the Harvey River.

Small numbers of swans breed on nearby freshwater wetlands and lead their young to the permanent waters of the estuary where they are reared. Other birds depart at the beginning of winter to breed on wetlands elsewhere on the Swan Coastal Plain or further inland, returning in summer as inland waters recede.

When gathered on open water, Black Swans are sensitive to disturbance by boats and people or dogs wading in the shallows. It is particularly important for wild swans to have large areas of undisturbed permanent open water, with assured food supplies and freshwater for drinking, when they undergo their annual moult of flight feathers. At this time they are unable to fly, and therefore very vulnerable, for a period of four to six weeks.

7.2 Rationale

Historically, Peel-Harvey has been an important habitat for the Black Swan, one of Western Australia's largest and most appealing waterbirds. Black Swans are also an important component of the estuary food web and have a significant role in the cycling of nutrients. They graze extensively on submerged aquatic plants of the system, particularly the seagrass *Ruppia* sp. (J. Lane pers. obs.). Changes in the nutrient status of the estuary, and in the species composition, distribution or productivity of aquatic plants have the potential to affect swan numbers. Increases in tide heights also had the potential to affect swan numbers, for example by allowing increased boat access to feeding, loafing and moulting areas. In the past these areas have been little disturbed.

Due to their large size and preference for open waters, swans can be readily surveyed. The total number

and distribution of swans on Peel-Harvey for a period prior to construction of the Channel (albeit the mid 1970s) were known with some precision. For these and the above reasons it was decided to institute a program of monitoring of swan numbers following opening of the Channel. Because there can be considerable year-to-year variation in numbers on Peel-Harvey (see section 7.4), it was decided that the monitoring should extend over at least two and possibly three years. In order to contain costs, and because of other work demands, the monitoring will be limited to three surveys (October, December and February) each year. These months have been chosen because swan numbers are expected to be at or near their peak in spring-summer. The swan censuses will also coincide with surveys of all other waterbird species on the estuary (see section 6.3).

7.3 Methodology

Surveys of swan numbers and distribution on Peel-Harvey were undertaken in October 1996, December 1996 and February 1997. Survey dates were chosen to coincide, within a day or so, with those of 1976-77.

The swans on Peel Inlet were surveyed by boat as they were expected to be too numerous and too dispersed for precise counts to be undertaken from an aircraft. Each survey was conducted by a single observer (GP or AC) working from a small dinghy travelling in a clockwise direction around the entire inlet. The boat was beached or anchored and short forays made on foot to survey Creery Lagoon and Boggy Bay. Binoculars and telescope plus tripod were used and data were recorded on maps and field notebooks. Each survey took several hours to complete.

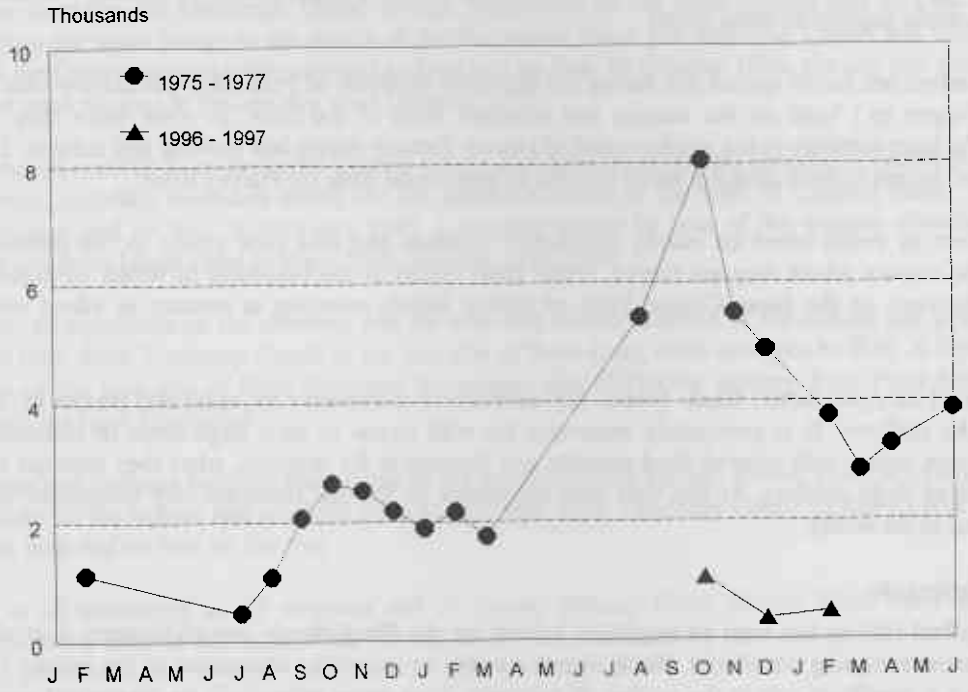

Figure 3. Numbers of Black Swans on Peel-Harvey: Feb 1975 - June 1977 and Oct 1996 - Feb 1997.

Swan numbers and distribution on Harvey Estuary were determined during the aerial survey of pelicans on Peel-Harvey (see section 5.3 for details). Individuals and small groups were counted from the air. No large flocks were encountered on Harvey Estuary so it was not necessary to take photographs. Surveys of Harvey Estuary took approximately 30 mins to complete.

The swan survey methodology, route and timing closely matched those of the swan counts conducted during 1976-77.

7.4 Results

The total numbers of swans counted on Peel-Harvey in 1975-77 and 1996-97 are shown in Figure 3.

There were many more swans on Peel-Harvey from late 1975 to mid 1977 (and possibly beyond) than in the survey months of 1996-97. There was less difference between numbers counted in the first three censuses of 1975 (February, July and August) than in the survey months of 1996-97. Note, however, that in February 1975 there were more than twice as many swans (1120) on Peel-Harvey than in February 1997 (470).

To facilitate comparison, the number of swans counted in the same months of 1975-77 and 1996-97 are provided in Table 2.

Table 2. Black Swan numbers on Peel-Harvey estuary in common survey months of 1975-77 and 1996-97.

Year	October	December	February
1975-76	2643	2188	2162
1976-77	8057	4881	3756
1996-97	1052	356	472

The numbers counted in October, December and February 1975-76 were 2.5 to 6 times greater than in the same months of 1996-97. Numbers counted in 1976-77 were 8 to 14 times greater than in 1996-97.

7.5 Discussion

The reason or reasons for the dramatic difference in swan numbers on Peel-Harvey between late 1975 to 1977 and October 1996 to February 1997 are not known. Possible causes include differences in breeding seasons in preceding years; differences in habitat availability (wetlands with water) in south-western Australia (and possibly elsewhere in the continent) in the years of survey, or differences in food availability or disturbance levels in Peel-Harvey between the two survey periods.

The fact that numbers counted during the first three surveys of 1975 were similar to those of 1996-97 suggests that the huge difference between subsequent mid 70s counts and those of 1996-97 may be due to short term factors rather than long term ones. Further surveys are needed to determine whether or not a long term change has occurred and, if so, the likely reasons for it. Some investigation of possible reasons for the dramatic variations in swan numbers observed in the mid 1970s also needs to be undertaken. Information on trends in macro-algae abundance and distribution also needs to be examined in relation to changes in swan numbers. This work is proposed to be undertaken during the next two years.

8. WATERBIRDS AND SALINITIES OF HARVEY RIVER DELTA

8.1 Background

For many years the upper (southern) end of the Harvey Estuary has been considered an important refuge area for waterfowl. Many thousands of ducks and swans have at times been observed congregated at the mouth of the Harvey River delta and on the lower reaches of the Harvey River where it passes through the delta formation (T. Riggert pers obs., J. Lane pers. obs.).

The Harvey River Delta is known as a "bird's foot" delta because of the resemblance of the river channel and its distributaries to a bird's foot when viewed from the air. The delta formation protrudes into the Harvey Estuary a distance of c. 1.5 km and has an average width of c. 0.3 km. The ground level is very low, in the vicinity of 0.5 to 1m above average water level. When the river is in flood the ground may be completely inundated. The dominant vegetation of the delta is Swamp Sheoak *Casuarina obesa* and Swamp Paperbark *Melaleuca rhaphiophylla*, with increasing numbers of Flooded Gum *Eucalyptus rudis* as one proceeds upstream. The understorey is dominated by introduced species. In places there are patches of bulrush *Typha* sp. fringing the main river channel.

The Harvey River is believed to flow all year round. Most flow occurs during winter, declining during spring. However, a small flow of freshwater - at times no more than a trickle - continues throughout summer and autumn, apparently even in dry years. This is due to discharge of "spent" water from the Harvey Irrigation area. Summer-autumn flow may also have occurred naturally before European settlement, that is, prior to clearing of natural vegetation and draining of swamps.

Although the upper Harvey Estuary has yet to be officially protected as a waterfowl refuge area, its eastern shores and the outer end of the Delta are reserved for nature conservation. There is also a narrow reserve for "drainage and conservation" on both banks of the lower River. Land to the west is privately owned and population pressures are increasing, however these have not yet had a serious impact on the river or estuary. Herron Point Ford, a sand bar extending across the estuary from Herron Point to Island Point, prevents all but the smallest boats from proceeding further south. Shallow water, sand bars, logs and submerged rocks restrict boat access to the Delta and River.

The relative seclusion of the upper Harvey Estuary and lower reaches of the River, the year-round supply of freshwater for drinking, the protection from strong winds offered by the tree-lined channel and distributaries of the Delta, the safe roost sites at the mouth of the Delta, and the close proximity of extensive shallows for feeding and loafing, all combine to make this part of Peel-Harvey a near-ideal dry season refuge for waterfowl.

8.2 Rationale

Construction of the Dawesville Channel was intended *inter alia* to increase the salinity of water in the Harvey Estuary in spring and thereby to prevent the occurrence of blue-green algae (*Nodularia*) blooms. In addition to reducing the time taken for the Harvey Estuary to become saline following cessation of winter river flows, construction of the Channel would also cause an increase in tidal amplitude in the estuary (see Appendix 1). Thus, during summer-autumn, high tides would be higher and low tides lower. These two factors in combination had the potential to significantly alter the hydrology of the upper Harvey Estuary.

The potential existed for an increase in salinities south of Herron Point Ford and up the Harvey River. This might directly affect the freshwater drinking supplies of waterfowl using this area. A combination of increased salinity and increased tide heights, particularly when strong north-westerly winds blow in autumn, also had the potential to adversely affect the Harvey River Delta, since much of its vegetation was likely to be at or near its tolerance limits. Damage to the Delta would be of concern due to both its intrinsic value and its significance for waterfowl. For these reasons it was decided that a study should be made of the salinity regime, use by waterfowl and trends in vegetation health of the upper Harvey Estuary and, in particular, the Delta and lower reaches of the River.

8.3 Methodology

The salinity of Peel-Harvey waters from several hundred metres north of Herron Point Ford to the limit of salt water intrusion up the Harvey River (from the estuary) was profiled at fortnightly intervals from mid 1994 to mid 1996, and at monthly intervals subsequently (except mid winter). Additional profiling was undertaken on the opening day of annual marron fishing seasons (see below) and during periods of strong

north-westerly winds in autumn or at the beginning of winter, before strong river flow.

Salinity was measured at 1-2 monitoring points north of Herron Point Ford, 6-7 monitoring points between the Ford and the mouth of the Delta, and at 0.5 km intervals upstream from the mouth of the Delta. The lower Harvey River is very shallow (mainly 0.5-1 m in summer), with numerous shallow sand and rock bars and spits making navigation difficult. There are, however, a number of "deep" (2-5 m) holes scattered along its length. These were also profiled routinely.

At each monitoring point salinity was measured 0.1 m and 0.2 m below the surface and at 0.2 m intervals thereafter until the bottom was reached. Water temperature was also recorded routinely. Dissolved oxygen levels were measured in the river, at several monitoring points on either side of the limit of salt water intrusion.

A Hamon salinity bridge was used until June 1995 and a TPS 90 FLMV microprocessor field analyser from June 1995 onwards. These instruments were calibrated against standard solutions at the beginning and end of profiling runs. A NATA-tested thermometer was used for calibration of water temperature readings. Water samples at both ends of the recorded salinity range were taken during profiling runs and sent to the WA Chemistry Centre for salinity and conductivity determination.

The water level in the estuary was measured at the staff gauge on the south side of Island Point at the beginning and end of each profiling run. The river level was measured at a post 4.45 km upstream from the mouth of the Delta.

Vegetation monitoring sites were established along the banks of the Delta and the River (see Gibson et al 1997). General observations of tree and shrub vigour were also made while conducting salinity profiling. Colour photographs were taken on occasions.

Waterbird species and numbers at the mouth of the Delta and on the lower reaches of the river were recorded on each visit. Additional data were collected during aerial surveys of the pelican and swan populations (October 1995 onwards; see sections 5 and 7) and during the general waterbird surveys of October 1996, December 1996 and February 1997 (see section 6).

The success or otherwise of attempts by recreational fishermen to catch marron at various points along the lower reaches of the Harvey River on marron season opening day (the first or second Saturday in January each year) was also monitored. Marron are sensitive to salinity and oxygen levels and, in the absence of comprehensive pre-Channel salinity data for the river, were considered potentially useful bio-indicators of change in water quality. Information on marron distribution and abundance in the river prior to opening of the Channel could potentially be obtained from marroners and compared with post-Channel observations.

8.4 Results and Discussion

Results of the salinity profiling are being processed. Some historical data have been located and further attempts will be made to access more. The data that have been obtained suggest a significant increase in river salinity during summer-autumn dry seasons since construction of the Dawesville Channel. This is supported by reports from recreational marroners who say that marron are no longer found in the lowest reaches of the river as they used to be prior to opening of the Channel.

Some of the trees and shrubs of the Delta are showing signs of stress. The foliage of many melaleucas has become paler and more yellowish in late summer-autumn than in other seasons, with some branches and a few individual trees having died completely. This might be a normal occurrence, but could also be due to an increase in salinity and tide height during the annual dry season. Lack of pre-Channel information on the health of the Delta's vegetation and seasonal changes in this hinders interpretation. Further monitoring is proposed to see whether the observed changes persist or worsen. Profiling of water level and salinity will also continue.

Data gathered concerning waterbird species and numbers in the vicinity of the Delta and river have yet to be analysed. Historical information needs to be collated before comparisons can be made. This work is proposed for a subsequent report.

9. BANDED STILT NUMBERS AND DISTRIBUTION

9.1 Background

During the mid 1970s, Peel-Harvey estuary supported very large numbers of waterbirds, the most abundant being the Banded Stilt *Cladorhynchus leucocephalus*. In December 1976, there were an estimated 8750 individuals of this species. By February 1976, this number had grown to c. 60 000. Numbers declined just as rapidly to 6350 in April 1977 and by June 1977 only 25 remained (J. Lane, unpub. data). Virtually all of the Banded Stilt recorded on the estuary during 1976-77 were on Peel Inlet, mainly on the eastern and southern sides, and in the Creery Marshes. Very few (15 in April 1977) were found on Harvey Estuary.

There are also published reports of 6394 Banded Stilt at Peel Inlet "east & south" sometime between 1981 and 1992, and 9000 on the Creery Marshes on another occasion during the same period (Jaensch, Merrifield & Raines 1993). Craig & Moore (1994) reported 9350 on the Creery Marshes on 28 December 1993, shortly prior to opening of the Channel.

It is very unusual to find large concentrations of Banded Stilt on tidal waters; they are more commonly found on non-tidal wetlands, particularly saline lakes of the coast or interior. A possible explanation (in part at least) for the large numbers found on Peel Inlet in 1976-77 is the exceptionally small tidal amplitude (see Appendix 1) prior to construction of the Channel, combined with the very extensive area of productive shallows available for feeding and roosting flocks. In the four years prior to opening of the Channel the average daily tidal range in Peel Inlet during summer-autumn was c. 9 cm (Maloney, B. 1998, pers. comm.). This small range was partly due to geographic location (the astronomic tide range on this part of the coast is small), but was primarily due to tidal exchange between the Inlet and the ocean being greatly restricted by the narrowness and length of the single, natural entrance channel to Peel-Harvey.

9.2 Rationale

One of the prime objectives of constructing the Dawesville Channel was to increase tidal exchange between Peel-Harvey and the ocean. An unavoidable consequence was that tidal *amplitude* within the estuary would also increase, though by how much was uncertain.

Given the general absence of Banded Stilt from tidal waters elsewhere within the species range, it was considered that an increase in tidal range might adversely impact upon stilt numbers in Peel-Harvey. It was therefore decided that Banded Stilt numbers should be monitored following construction of the Channel. Ideally they would also have been monitored for 2-3 years immediately prior to opening the Channel. However this was not possible, for reasons given elsewhere in this report.

Due to staff and budget limitations, frequent monitoring of total numbers on the entire estuary (or Peel Inlet alone) over a prolonged period could not be undertaken. It was therefore decided to restrict monitoring of total stilt numbers to the surveys of all waterbird species planned for October, December and February of 1996-97 and 1998-99.

The whole-of-estuary surveys would be supplemented by more frequent counts of stilt numbers on the Creery Marshes, an extensive area of pools, intertidal flats and samphire marsh surrounding an estuarine lagoon (Creery Lagoon) on the north side of Peel Inlet, between Creery Island and the mainland. Large numbers of Banded Stilt had previously been recorded on Creery Lagoon (see above). The Marshes were

also readily accessible and close to Boundary Island, where monitoring of pelican nesting activity was to be undertaken on a fortnightly basis (see section 4.3).

9.3 Methodology

Visits were made to the Creery Marshes at fortnightly intervals to count the total number of Banded Stilt present. Binoculars and/or telescope plus tripod were used and numbers were recorded in field notebooks. With experience it was found that two or three vantage points on the northern side were sufficient to determine numbers within the entire area. On occasions it was necessary to approach flocks more closely in order to obtain accurate figures.

9.4 Results

Results of the October 1996 and February 1997 counts of total numbers of Banded Stilt on Peel-Harvey are not yet available (the audio tapes of these surveys have yet to be fully transcribed).

Count data from the October 1996, December 1996 and February 1997 surveys of stilt numbers on the Creery Marshes and the December 1996 survey of the entire estuary are presented in Table 3, together with data from 1976-77.

Table 3. Numbers of Banded Stilt on Creery Lagoon and the whole of Peel-Harvey estuary in 1976-77 and 1996-97.

Location	Year	Aug	Oct	Dec	Feb	Apr	Jun
Creery Marshes	1976-77	760	3	240	13 000	2 600	13
	1996-97	-	0	0	6	-	-
Peel-Harvey	1976-77	800	1 500	8 800	60 000	6 400	24
	1996-97	-	?	125	?	-	-

In summer-autumn of 1976-77 there was a dramatic increase in stilt numbers (to 13 000) on the Creery Marshes. This paralleled a huge increase in total numbers on Peel-Harvey (to 60 000). A similar increase in numbers on the Marshes did not occur in 1996-97, though thousands of Banded Stilt were seen elsewhere on the estuary in February 1997 (precise numbers are not yet available).

A paper by Singor (1997) on the "waders of the Creery wetlands and adjacent mudflats" includes a discussion of the numbers of Banded Stilt he counted on the Creery Marshes during 29 visits to the area between April 1994 and October 1996. In summary, Singor said thousands (>2000) of Banded Stilt were present prior to the heavy rains which fell in inland regions in Feb-March 1994 (this should be 1995) and that following their departure (in February) only two Banded Stilt had been seen (on 11 November).

9.5 Discussion

It is premature to discuss the significance of the results presented above in relation to opening of the Channel. Data not presented here need to be transcribed and collated. All data need to be considered in the context of this species' unusual breeding cycle (Banded Stilt breed only on saline lakes of the arid interior, following exceptionally heavy, episodic rains). Tide height data from 1976-77 and 1996-97 also need to be obtained. Further monitoring of Banded Stilt numbers, preferably for two more years, is needed. This work will be reported on at a later date.

10. WATERBIRD ROOST SITES

10.1 Background

Several species of waterbirds inhabiting Peel-Harvey typically roost in very large flocks on a small number of sand bars and cays. Surveys during the mid 1970s showed that the Little Black Cormorant *Phalacrocorax sulcirostris*, for example, roosted in single flocks of several thousand birds on sand bars of Herron Point Ford (length c. 2 km), either side of Egg Island. Thousands of Pied Cormorants *Phalacrocorax varius* frequently roosted on high points of a low sand cay (c. 400 m x c. 75 m) to the north of Point Birch. Nirimba Cay (c. 150 m x c. 50m) was also a significant roost site.

10.2 Rationale

The three roost sites referred to above, and a number of other smaller roosts, had the potential to be adversely affected by an increase in tide heights brought about by construction of the Dawesville Channel (see Appendix 1). Each site was barely exposed during high tides of the mid 1970s (i.e. pre-Channel) and even a small increase in tides could have greatly diminished their suitability for roosting. Increased tide height could also have caused erosion of the sites through increased wave action.

The potential significance of a loss of preferred roost sites for the above species is unclear. Use of other, non-preferred locations such as stretches of island or estuary shoreline could result in higher energy costs due to longer distances to travel, more frequent disturbance and even an increase in mortality due to terrestrial predators such as the introduced Red Fox having access. Significant negative impacts on waterbird populations would, however, be hard to prove. On the other hand, it would not be technically difficult or particularly expensive for new cays or sand bars to be created, or old ones "topped up", should this seem desirable.

It was therefore decided that the elevation of the three existing roost sites should be measured prior to and five years after opening of the Channel. This would enable site elevations to be compared with water level records pre- and post-Channel. Any losses due to erosion could also be calculated. Post-Channel use of roost sites would also be assessed, as part of the waterbird surveys to be conducted in 1996-97 & 1998-99 (section 6). Observations from these two survey periods could then be compared with those of 1976-77.

10.3 Methodology

Surveyors from the Department of Transport (DoT) measured the elevation of the three major roost sites in March 1994, one month prior to opening of the Channel. Estuary water levels were monitored continuously (pre- and post-Channel) by DoT. The species and numbers of waterbirds roosting on these and other sites of Peel-Harvey were recorded during general waterbird surveys conducted in October 1996, December 1996 and February 1997 (see section 6.3). These data may be compared with those collected in the same manner and in the same months of 1976-77. Data from the pelican surveys conducted from 1975-77 and 1995-97 will also be examined for changes in roost site selection by this species.

10.4 Results and Discussion

Survey maps showing spot elevations of the three major roost sites in March 1994 have been prepared by DoT. The elevations of Nirimba Cay and the roost site north of Point Birch are shown in Table 4. Vertical accuracy is SE[2] 0.02m, horizontal accuracy SE 0.3m.

Large scale aerial photographs need to be examined before comparable data can be derived from the survey maps of Herron Point Ford. This work is proposed.

Pre- and post-Channel tidal data are being sought. These will enable comparisons to be made with roost site elevations.

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[2] SE = Standard Error - a statistical measure of error.

Post-Channel data concerning selection and use of roost sites by waterbirds will be compared with pre-Channel data following completion of the 1998-99 whole-of-estuary waterbird surveys.

Table 4. Elevations of Nirimba Cay and North of Point Birch roost sites, March 1994.

Roost	10 highest spot heights (m AHD)	Avge horizontal separation of spot heights (m)	Average elevation (m AHD)
Nirimba Cay	0.22, 0.22, 0.22,0.22, 0.22, 0.22, 0.22, 0.22, 0.20, 0.20	74	0.22
North of Point Birch	-0.20, -0.20, -0.21, -0.24, -0.24, -0.24,-0.24, -0.27,-0.28, -0.28	125	-0.24

Meanwhile, the waterbird monitoring program (pelican nesting success and general waterbird survey components) has already revealed that substantial use is being made of Boundary Island as a roost site by pelicans and cormorants. This large island on the northern side of Peel Inlet was created in 1987 by the dumping of material dredged from the natural entrance to the estuary. Even if some loss of mid 1970s roost sites has occurred, our observations indicate that this has been at least partly offset by construction of Boundary Island. Boodalan Island, constructed in 1972 at the entrance to Yunderup Canals on the east side of the Inlet, also provides an additional site, however this is subject to some disturbance.

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Nello Siragusa of the Department of Transport (DoT) arranged the elevational surveys of Nirimba Cay and two other waterbird roost sites. John Mullally (DoT) took a personal interest in undertaking and conveying the results of this work. Ben Maloney (DoT) was most helpful in providing tidal and other information.

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APPENDIX 1. Predicted and observed effects of Dawesville Channel on water levels and salinity in Peel-Harvey Estuary[1].

General

Water levels in Peel-Harvey Estuary are influenced by several factors including astronomical tides, river inflows, atmospheric pressure changes, wind forces, storm surges and long-term fluctuations in mean sea-level.

The Dawesville Channel was expected to cause considerable changes in the influences of astronomical tides, river inflows and storm surges on the water level regime within Peel-Harvey.

Tidal Range

The average tidal range (MHHW to MLLW[2]) in the ocean adjacent to the estuary, is c. 57.5 cm.

Prior to opening of the Dawesville Channel, the average tidal range of Peel Inlet was c. 10 cm and that of Harvey Estuary was c. 9 cm. Following opening of the Channel, the average tidal range increased to 32 cm for Peel Inlet and 45 cm for Harvey Estuary.

Prior to the Channel the average water level in Peel Inlet was -0.3 cm AHD[3], the MHHW ("spring tide") level was +5.0 cm AHD and the maximum level was +53.1 cm AHD. These may be compared with the +0.22 m AHD elevation of Nirimba Cay (see pelican nesting section of report).

Extreme Water Levels

Prior to opening of the Dawesville Channel, most of the extreme water levels in Peel-Harvey resulted from river flows. The 1 in 100 year river flood level was estimated to be 1.8 m AHD in Peel Inlet and 1.3 m AHD in Harvey Estuary. Opening of the Channel was predicted to lower the 100 year flood level to 1.1 m AHD in Peel and 1.0 m in Harvey.

The Channel was predicted to change the likely source of extreme water levels from flooding episodes (typically during winter, when salinities are low) to storm surges (which may occur at any time of the year, including summer-autumn when salinities are high).

With the Channel, ocean surges would be more readily transmitted into Peel-Harvey. A storm surge of similar magnitude to that induced by tropical cyclone Alby (April 1978) was predicted to cause the water level in the estuary to rise c. 20 cm higher than previously.

Salinity in the Harvey Estuary

Hypersaline conditions used to develop in Peel-Harvey each autumn. It was predicted that this would cease following opening of the Channel. This has not yet occurred. In autumn 1995, one year after opening, the salinity near the southern end of Harvey Estuary exceeded 46 parts per thousand (approx. 1.5 x seawater).

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[1] Much of the information presented has been extracted from the "Dawesville Channel Monitoring Programme: Two Year Technical Review. Status Report" (March 1997) prepared under contract by D.A. Lord & Associates Pty Ltd for the Water & Rivers Commission. That document quotes other, authoritative sources.

[2] MHHW = Mean High High Water (the long term average of the highest tide each month). MLLW = Mean Low Low Water (the long term average of the lowest tide each month).

[3] AHD = Australian Height Datum.