

**Monitoring of fish  
communities in shallow  
lowland billabongs  
adjacent to Magela  
Creek downstream from  
Ranger uranium mine in  
2000**

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December 2000



**Monitoring of fish communities in shallow  
lowland billabongs adjacent to Magela Creek  
downstream from Ranger Uranium Mine in 2000.**

**Interim report prepared for distribution to Djabilukgu Association  
Gundjehmi Aboriginal Corporation, and Gagadju Association**

**by**

**Bob Pidgeon, James Boyden and Chris Humphrey**

## Introduction

Shallow lowland billabongs and channel billabongs downstream of Ranger Uranium Mine (RUM) potentially can receive and accumulate mine related waste substances. The shallow billabongs are technically lagoons formed by levees at the confluence of the main creek channel with side streams. They receive water from the main channel at high flows and flow back to the main stream at lower flows and hence are also termed back-flow billabongs. Some of these waterbodies are important sources of food for traditional owners of the area as well as acting as dry season refuges for fish. Consequently, there is the potential for bioaccumulation of wastes, especially metals, in these organisms and subsequent adverse effects on populations of some aquatic species. The risk of transfer of contaminants to human consumers, however, is regarded as small (Humphrey and Dostine 1994). It is likely that bioaccumulation would be a gradual process over many years and adverse effects on animal populations may occur only after harmful levels have been reached. Monitoring for detection of long-term effects on fish communities in these habitats is, therefore, important for the assurance of environmental health and management of the RUM.

Research by *eriss* (formerly ARRI) on monitoring of fish communities in lowland billabongs began in 1979. Initially gill nets and seine nets were used for sampling. However, following the removal of feral water buffalo from the area during the middle 1980's these techniques were rendered ineffective in the shallow lowland billabongs due to increases in aquatic plant density (Pidgeon & Humphrey 1991). The composition of species in the fish community was also altered by the vegetation change and some larger growing fish species were excluded from the shallow reaches of billabongs where buffalo once wallowed and fed. This situation made it necessary to develop different methods for sampling fish in dense vegetation.

A quantitative sampling technique for monitoring fish communities in shallow billabongs has been developed using a trapping device called a "pop-net". The procedure has proven to be cost effective and to provide adequate representation of fish community structure in the shallow margins of the billabongs. However, as the operation of the pop-net involves operators standing in the water attempts have been made to modify procedures to minimise the risk to operators from crocodile attack. New safety procedures were trialed in the 2000 sampling operation. This process is ongoing and a final experimental design for the monitoring program will only be determined when satisfactory OH&S standards are achieved.

Monitoring of fish communities with pop-nets in eight shallow billabongs began in 1994. These included control sites on catchments not associated with RUM, and sites potentially exposed to mining waste. Whilst the structure of fish communities changes naturally, both seasonally and from year to year, an impact of the mine would be inferred when the fish community in an exposed site changed in a different manner to control sites.

The numbers of fish of different species in each billabong are used to determine the differences in fish communities between the billabongs and the change in fish communities over time. Chemical and physical water parameters and a set of habitat structure variables are also measured as potential covariates with the fish communities to distinguish natural change from change caused by mining or other human activities. Multivariate statistical analysis is used to compare the sites over time and to identify any environmental variables that correlate with the difference between sites and with any temporal changes in community structure.

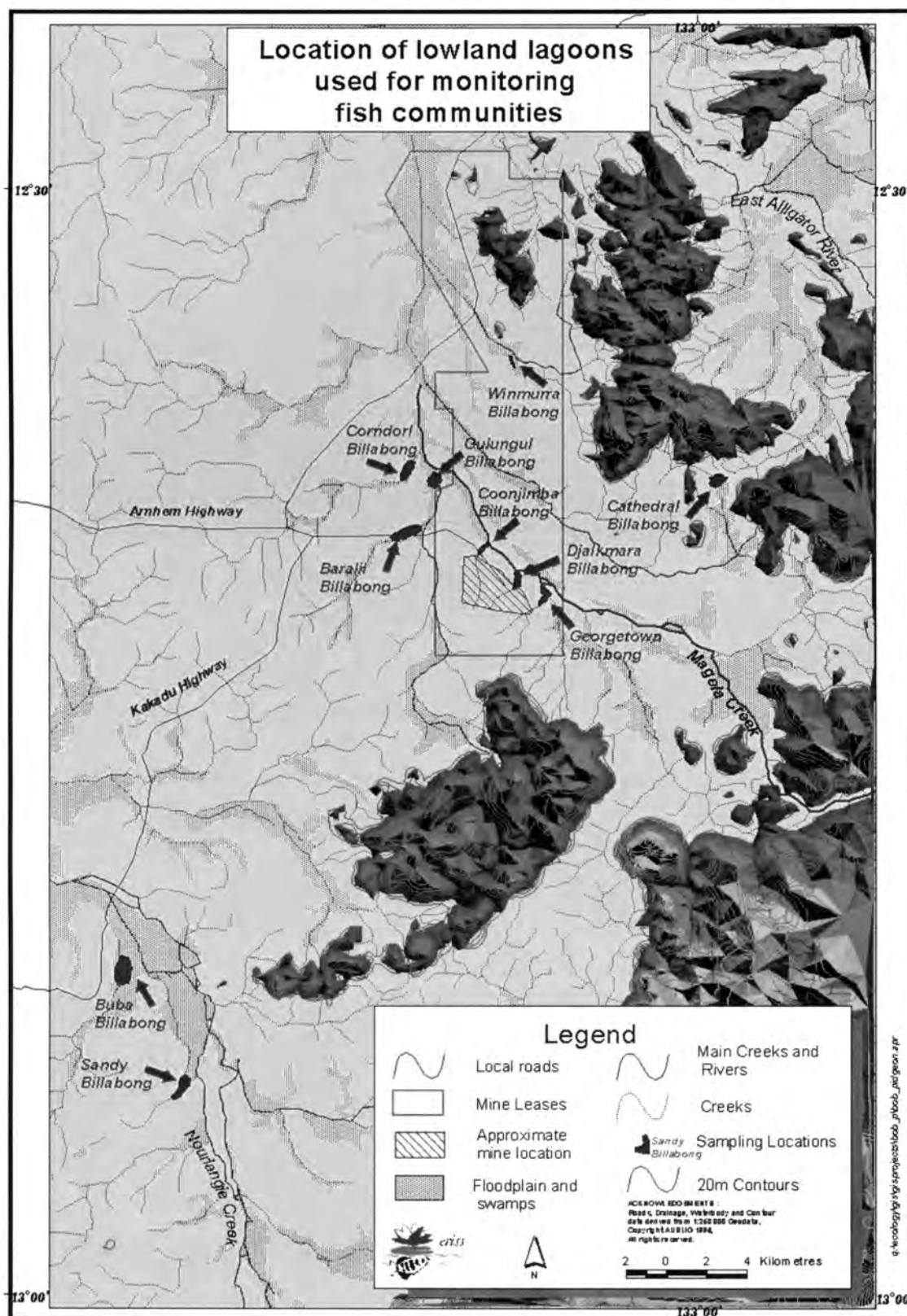


Fig. 1. Location of shallow lowland billabongs used for monitoring fish community structure.

## Monitoring design

Initially ten lowland billabongs, were chosen for the monitoring program (Table 1). Sites potentially exposed to the uranium mine in the Magela Creek catchment included Georgetown, Djalkmara, Coonjimba, Gulungul and Corndorl Billabongs. Djalkmara billabong is no longer studied as it is now isolated from Magela Creek by the operation of Ranger Pit No. 3. Gulungul Billabong, and to a much lesser extent Corndorl Billabong, may also be influenced from waste arising from the Jabiru township. Consequently, Baralil Billabong is included in the design to act as the control for effects of Jabiru town because it is exposed to the township but not to the mine. Buba and Sandy Billabongs, located in the Nourlangie Creek catchment of the South Alligator River system, act as controls, as does Winmurra billabong on the 7J Creek tributary of the Magela Creek floodplain and Cathedral Billabong on an unnamed tributary of the East Alligator River (Fig.1.).

For logistic reasons Corndorl, Sandy, Winmurra and Cathedral billabongs have been omitted from the study in some years.

Table 1. Catchment and function of different lowland billabong sites used for monitoring effects of Ranger Uranium Mine.

Function	Catchment	Site Name
Control	Nourlangie Creek	Buba Billabong
"	Nourlangie Creek	Sandy Billabong
"	East Alligator River	Cathedral Billabong
"	Magela Creek	Winmurra Billabong
Exposed to mine	Magela Creek	Georgetown Billabong
"	Magela Creek	Djalkmara Billabong
"	Magela Creek	Coonjimba Billabong
Exposed to mine and Jabiru town	Magela Creek	Gulungul Billabong
"	Magela Creek	Corndorl Billabong
Exposed to Jabiru town	Magela Creek	Baralil Billabong

## Sampling Strategy

Bishop et al (1982) demonstrated considerable seasonal variation in fish community structure in lowland billabongs so that measurements made at different seasons in the year cannot be used to obtain temporal replication for statistical inference in monitoring. Consequently, the sampling is carried out only once per year at the end of the Wet season in May when the billabongs become accessible by land. Other rationale for this timing are:

- Resident fish population abundances can be measured more effectively as emigration and immigration from Magela Creek has ceased;
- Accumulated effects of any release of mine water during recent wet season should be apparent (Humphrey et al. 1990);

- Earlier studies suggest that this time is when fish species richness and abundance is greatest (Bishop *et al* 1990);
- Environmental conditions can be more readily standardised from year to year.

At each billabong ten pop-net samples are taken in water less than 1.0 m deep. Preliminary analysis of these data indicated that ten samples are adequate to determine most of the species present and for distinguishing fish community structure differences between billabongs.

### **General fish community structure in shallow lowland billabongs**

The pop-netting procedure samples the shallow margins of billabongs that are typically densely vegetated. This habitat is characteristic of large areas of many of these billabongs and the fish community inhabiting it is dominated by smaller species. The other habitat that influences fish occurrence is the area of open water. This habitat allows larger and more active fish species to inhabit these billabongs. As the amount of open water varies enormously among billabongs and between different years, so does the relative abundance of these larger fish. The pop-net program does not attempt to sample this highly variable component of the fish assemblage in shallow billabongs.

The average composition of the fish community sampled over all sites and all years (1994-2000) is shown diagrammatically in fig. 2. This chart shows that 3 small species comprise 86% of all fish in the shallow margins. These are sailfin perchlet (na-rranggi), Pennyfish (na-rranggi) and chequered rainbowfish (Dilebang). Six other small fish make up a further 7%. Nine species of larger fish have been captured over the five-year period and together these make up only 7% of the total. The most abundant of these larger fish, Rendahl's catfish (Binjdjarrang), is not really very large (up to 25 cm long) and comprises 4% of the fish community.

A diagrammatic list of fish sampled from pop-nets and their various names (Gundjehmi, common English and scientific names) are shown in Appendix 1.

### **Fish abundance and Species diversity**

Figure 3 shows the total abundance of all fish and species richness (number of species captured) in different years in each billabong since 1994. The abundance of fish varies considerably among billabongs ranging from 5.4/m<sup>2</sup> in cathedral billabong to 37.8/m<sup>2</sup> in Winmurra Billabong. Whilst there is variation within billabongs from year to year, the differences among billabongs are quite consistent. Gulungul billabong has shown the greatest variation among years. There is no indication of fish abundance declining over time in either the control billabongs or those downstream from the Ranger mine.

By contrast, fish species richness is very similar among the billabongs with the mean number of species ranging from 8.8 in Coonjimba Billabong to 11.6 in Buba Billabong. There is very little variation from year to year and no evidence of a decline over time downstream from the Ranger mine.

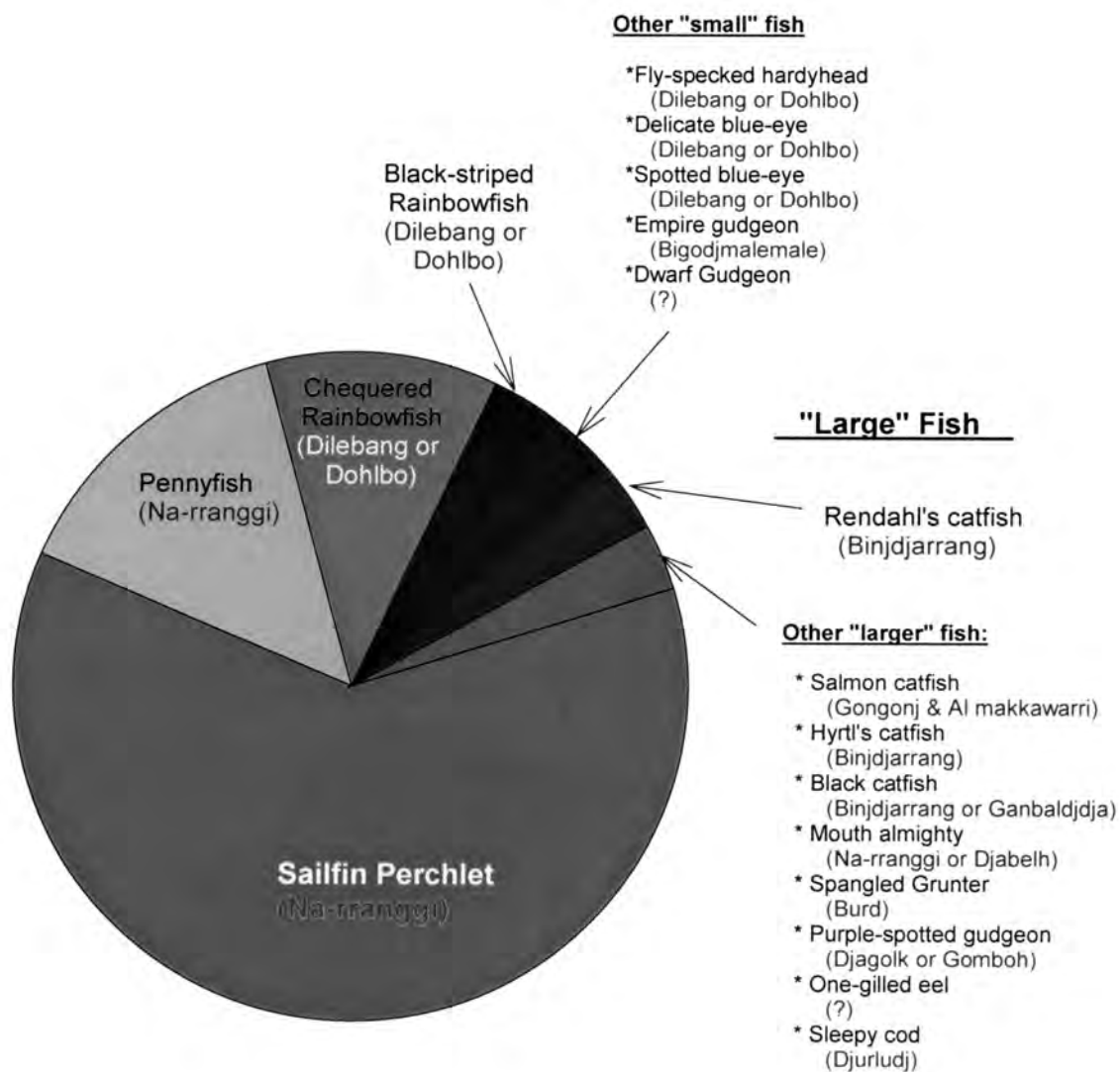


Fig 2. Average composition of fish communities in pop-net samples from shallow lowland billabongs.

Common English names and Gunjeihmi names (in red) are shown

Area of each sector indicates relative abundance (%) of different species or groups of species.

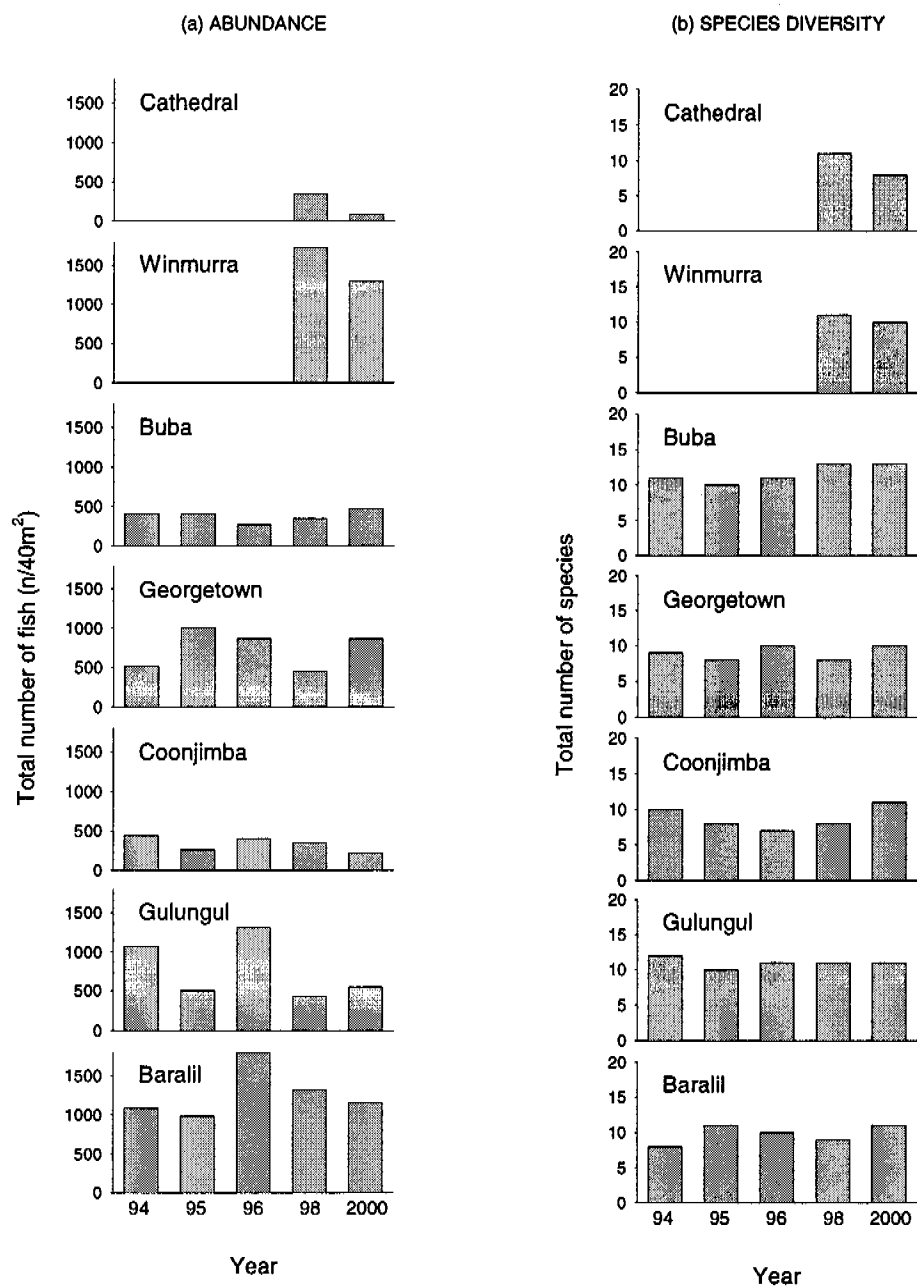


Fig. 3. Total abundance and species diversity of fish captured in pop-net traps in lowland billabongs from 1994 to 2000.

## **Fish community structure**

Impacts on community structure can occur without changing the species richness and overall abundance. This may happen in situations that cause change by depressing populations of some species and/or enhancing those of others. However, such changes can also occur naturally and the challenge for monitoring is to distinguish natural and unnatural changes of this kind.

Examples of this situation are shown in fig. 4 that compares the average structure (relative abundances of different fish species) across sampling years 1994 to 1998 with that found in 2000. Whilst most of the lowland billabongs have a similar array of species, the relative abundance of species varies between billabongs and between years. The average structure of Georgetown and Coonjimba billabongs is very similar except for larger numbers of larger fish in Coonjimba. The average structure of the control site, Buba Billabong, differed from the two Magela sites with much larger numbers of Pennyfish and Rendahl's catfish.

In each case the structure of the 2000 fish community differed from the average of earlier years. Both Buba and Georgetown had increased numbers of Pennyfish and "other small fish". In Coonjimba the main change was an increased percentage of chequered rainbowfish.

The pie charts in fig. 4 serve to indicate that there are natural differences between billabongs in the fish community structure and, as shown by the control site, large natural changes in the relative abundance of different fish species from year to year. It is assumed that the natural processes that operate to cause these changes apply equally to both control and exposed (potentially impacted) sites and changes in fish community structure should be similar. Consequently, an impact would be inferred when the control and exposed sites change in different ways. Multivariate analysis was used to test for this effect.

Multivariate pattern analysis can be used to calculate a measure of the similarity of one sample of a community with another based on the species present and their abundance. When changes occur, this measure then allows us to determine how large the change has been over time. It can also indicate whether this change is a result of natural processes, or not, by seeing if similar changes have occurred in control sites.

The measure of similarity of the fish community between pairs of sites was the Bray-Curtis index of similarity. This ranges in value from 0 (identical) to 1 (totally different). Fig. 5(a) plots changes over time in the index of similarity between the control site, Buba Billabong, and the four Magela Creek sites. This shows that the difference between the control and exposed sites has remained fairly constant. There is some departure from this trend since 1998 in Coonjimba Billabong and this could be an indication of impact.

Fig. 5 (b) plots the similarity of fish communities in the same billabong in different years. This is a measure of the size of the change between different years. It shows the inter-annual changes within a site to be much smaller (average approximately 0.2) than those between the control and exposed sites (average approximately 0.3). Also, the values have remained fairly constant over time.

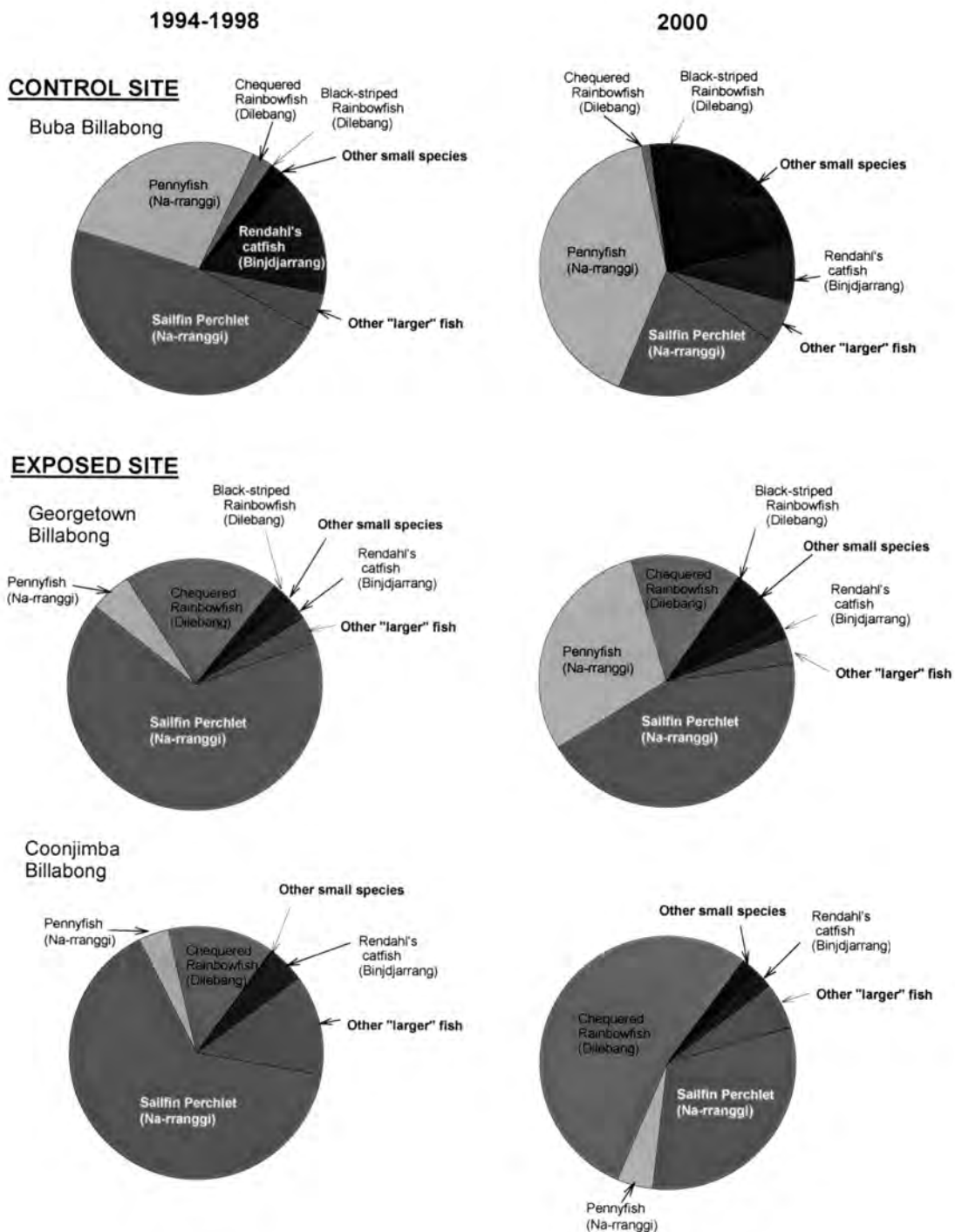


Fig. 4. Comparison of fish communities at exposed and control sites in 2000 with the average composition of fish communities for 1994-1998.

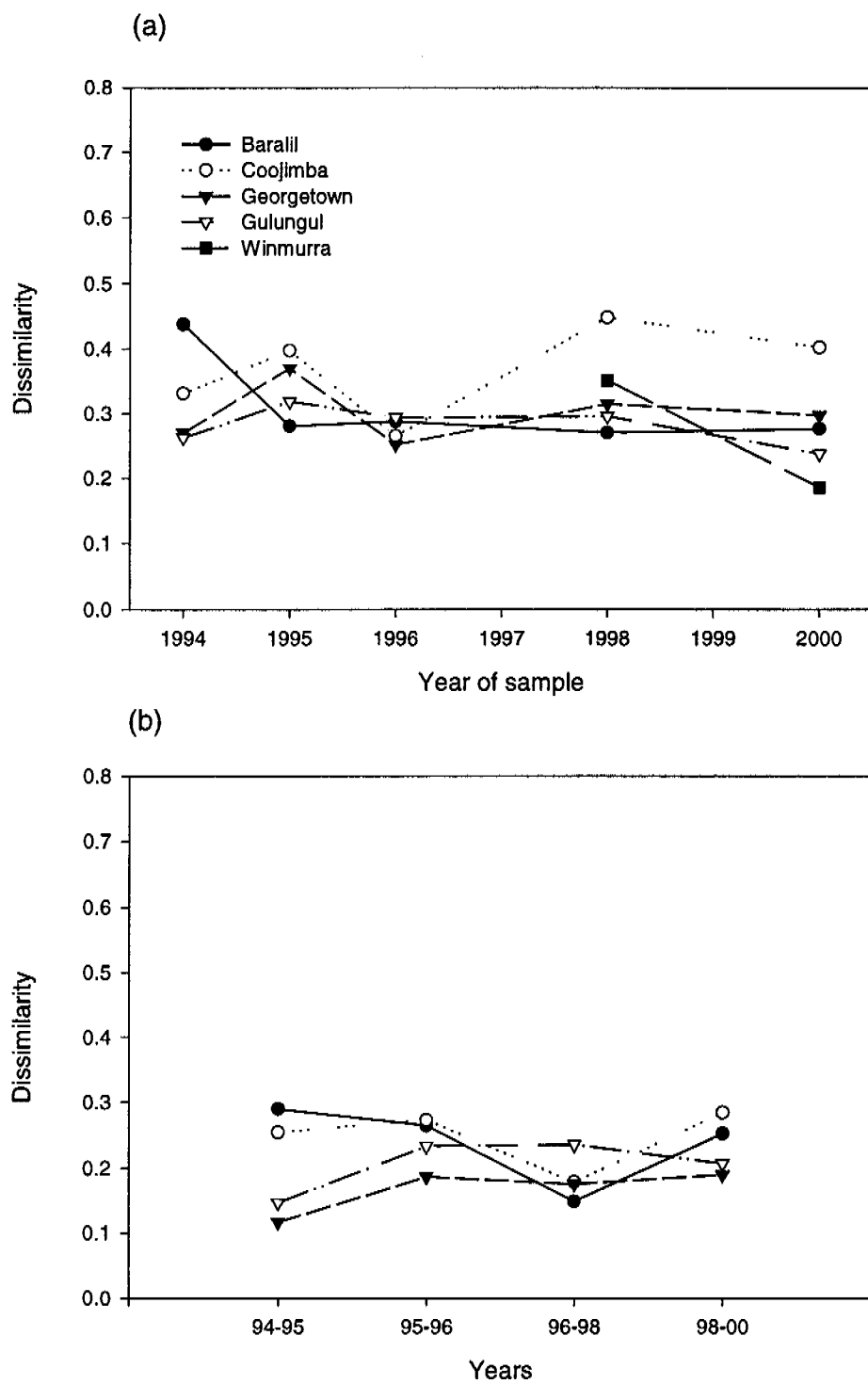


Fig. 5. Dissimilarity values for fish community structure in lowland billabongs showing (a) temporal change in dissimilarity between control site (buba) and sites exposed to Ranger, and (b) changes in dissimilarity between adjacent years at different sites.

The similarity index was also used in ordination pattern analysis to illustrate the relationships of the different fish samples to one another by their position in “multi-dimensional ordination space”. The more similar samples are the closer together they are in this space. These are shown in fig. 6 which plots the arrangement of the fish samples in two dimensions of a 3 dimensional ordination analysis. The amount of influence of a range of habitat variables and different fish species on this pattern was also determined by Principal Axis Correlation analysis. Arrows in fig. 6 also indicate the direction of influence of the significantly correlated fish and habitat parameters associated with each axis.

The pattern shows that each billabong has moved around in its own region of the ordination space with little overlap with other sites. This indicates that the natural difference between billabongs is very consistent. Also, in most sites the temporal pattern of movement has been in similar directions. In this situation an impact would be indicated by a difference in the behaviour of control and exposed sites, such as a large sustained departure of a site from the previous area occupied in the ordination space. There are no such changes by any of the billabong sites. Importantly, the Coonjimba Billabong samples are shown to have behaved in a similar pattern to other sites suggesting that the change indicated by the increase in similarity values in fig. 5(a) was most likely a reflection of natural variation for this site.

Seven habitat parameters were significantly correlated with the ordination space. The direction of influence of these helps to explain some of the natural processes that are causing differences among sites. This is shown by arrows on the axes of fig. 6. Much of the separation of sites is associated with vector 1. Four vegetation parameters were significantly correlated with the ordination pattern and also associated with vector 1. These were the surface area covered by sedges (*Eleocharis* spp.), water lilies (*Nymphaea violacea* and *Nymphoides* spp.), spiny mudgrass (*Pseudoraphis spinescens*) and the percentage by volume of submerged plants obtained when clearing vegetation from the trap site. Fish species diversity was also associated with vector 1 and this probably indicates an influence of the structure of different vegetation on different fish species. The gradient of the shoreline, as indicated by the distance to sample site from the edge, was also associated with this vector, no doubt reflecting the influence of this parameter on vegetation.

The main habitat parameter associated with vector 3 was water depth at the sample site. Fish abundance was also associated with vector 3 and this may simply reflect a larger volume of fish habitat sampled in deeper water. On the other hand, the amount of floating fern (*Azolla* sp.) was also associated with this vector and the direction indicated a negative influence on fish abundance.

Nine of the fish species were significantly correlated with the ordination pattern. Four species were associated with vector 1 and these were presumably those most influenced by vegetation structure and composition. The other five species were associated with vector 3 and were presumably more influenced by water depth and fern cover.

## Conclusions about impacts

Whilst there are no significant differences among lowland billabongs in their fish species richness, there are natural differences in their total fish abundance and the relative abundance of different species. These differences have been quite consistent over time providing a good basis for detecting adverse impacts of mining activities by Ranger uranium mine.



The comparison of univariate and multivariate measures of fish community structure in control and exposed billabongs showed no evidence of adverse effects of Ranger mine activities. In particular, the spill of tailings in the catchment of Georgetown Creek during the 2000 wet season did not result in any effects on fish community structure in either Georgetown Billabong or other billabongs further downstream along Magela Creek.

### **Future plans for the program**

The pop-net procedure continues to be an OH&S concern in relation to exposure of personnel to risk of crocodile encounter. Consequently, it is proposed to do no monitoring of these billabongs in 2001 and use the wet season to try to develop satisfactory safety procedures. This will involve the improved use of barricade nets and the use of amphibious all-terrain-vehicle for their deployment. Once safety procedures are developed, parallel testing of old and new procedures may be required to ascertain the compatibility of datasets. An inability to use the present dataset would seriously compromise the ability to detect impacts on fish communities in these billabongs.

It is anticipated that monitoring would resume in 2002.

### **Acknowledgements**























The pop-net procedure requires input in the field from a lot of people each year. *Eriss* would like to thank people who have assisted in this program in previous years. In 2000 assistance was provided by Junior Gardel, Thomas Turpin, Don McGregor, Anthony Sullivan, Barny Chong, Warren Baird, Matthew Rawlinson, Dallas Nabulwud, Ambrose Dendjel from the Djabilukgu Association, Jabiru, Otto Campion from Djelk Rangers, Maningrida, and Peter Tomlin and Honorlea Masserella from the Australian Trust for Conservation Volunteers. We are most grateful for their contribution to the work and the pleasure of their company in the field.

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# **Appendix 1. Fish in lowland billabongs of Magela Creek** **arranged in order of decreasing abundance in pop-net samples**

<i>Fish Name</i>		<i>Fish Name</i>	
	Common: <b>Sailfin Perchlet</b> Gundjeihmi: <b>Na-rranggi</b>		Common: <b>Fly-Specked hardyhead</b> Gundjeihmi: <b>Dilebang or Dolbo</b>
	Common: <b>Pennyfish</b> Gundjeihmi: <b>Na-rranggi</b>		Common: <b>Carp gudgeon</b> Gundjeihmi: <b>Bigodjmalemale</b> Scientific: <b><i>Hypseleotris compressa</i></b>
	Common: <b>Chequered rainbowfish</b> Gundjeihmi: <b>Dilebang or Dolbo</b>		Common: <b>Spotted blue-eye</b> Gundjeihmi: <b>Dilebang or Dolbo</b>
	Common: <b>Rendahl's catfish</b> Gundjeihmi: <b>Binjdjarrang</b>		Common: <b>Hyrtl's catfish</b> Gundjeihmi: <b>Binjdjarrang</b>
	Common: <b>Sleepy cod</b> Gundjeihmi: <b>Djurludj</b>		Common: <b>Spangled grunter</b> Gundjeihmi: <b>Burd</b>
	Common: <b>Black-striped rainbowfish</b> Gundjeihmi: <b>Dilebang or Dolbo</b>		Common: <b>Black catfish</b> Gundjeihmi: <b>Binjdjarrang or Ganbaldjdja</b>
	Common: <b>Delicate Blue-eye</b> Gundjeihmi: <b>Dilebang or Dolbo</b>		Common: <b>Salmon catfish</b> Gundjeihmi: <b>Gonjgonj (J), Almakkawarri</b>
	Common: <b>Dwarf gudgeon</b> Gundjeihmi: <b>?</b>		Common: <b>Saratoga</b> Gundjeihmi: <b>Yinmamarra (J), Guluibirr (A)</b>
	Common: <b>Purple-spotted gudgeon</b> Gundjeihmi: <b>Djagolk or Gomboh</b>		Common: <b>Barramundi</b> Gundjeihmi: <b>Malarlalk(J) , Na-marngorl</b>
	Common: <b>Mouth-almighty</b> Gundjeihmi: <b>Na-rranggi or Djabelh</b>		Common: <b>Ox-eye herring or Tarpon</b> Gundjeihmi: <b>Garlalba</b>
	Common: <b>Single-gilled eel</b> Gundjeihmi: <b>?</b>		Common: <b>Common archerfish</b> Gundjeihmi: <b>Njarlgan</b>

## **Appendix 2**

**An abbreviated report on pop-netting for distribution to  
traditional land owners in the Alligator Rivers Region**

**by**

**Jacqui Rovis-Hermann**

**Aboriginal Liaison Manager,  
Environmental Research Institute of the Supervising Scientist**

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# MONITORING THE ENVIRONMENT BY COUNTING FISH

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## RESULTS OF THE 2000 POP-NETTING PROGRAM

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### ***Why we count fish***

Since 1979, *eriss* has been monitoring fish that live in billabongs downstream and upstream of the Ranger mine to see if they are affected by mine related waste. Over time, it is possible for fish to absorb the waste and it can build up in their bodies and make them sick. This process is called bioaccumulation and can be a very slow process, so it is important to monitor the fish over a long period of time. Mine waste could also affect plants and little animals in billabongs that provide fish with food and shelter and this could also cause harm to fish.

There are many different types of fish living in the billabongs and by counting them every few years we can tell when there is a change in number. We also test the water for chemicals and other things so that we can tell if there has been any change.

### ***How we count them***

In 1994, *eriss* began sampling fish with a technique we call pop-netting. It is a trap made of net and is lowered into the water to trap the fish. The fish are sorted into different species and counted. This is done down stream of the mine and on other streams without mines so that if a change occurs we can tell if it was naturally occurring or if it was caused by the mine.

The town of Jabiru also has an impact on the environment (from sewage and other wastes), so it is important to take that into consideration when testing billabongs that are down stream of the town.



*The pop-net is lowered into the water, trapping the fish. They are counted, sorted into different species and then released back into the billabong.*

## ***Where we count them and why***

The Billabongs tested in 2000 were:

*Down stream of the mine:* Georgetown, Coonjimba, and Gulungul Billabongs. Gulungul was tested as it is possibly also affected by the Jabiru town.

*Possibly affected by Jabiru town, but not the mine:* Baralil Billabong.

*Not affected by the mine or town:* Buba and Sandy Billabongs (in the Nourlangie Creek catchment); Winmurra Billabong on 7J Creek, and Cathedral Billabong on an unnamed creek of the East Alligator River.

*See attached map for locations.*



*Junior Gardel pop-netting at Georgetown Billabong with James Boyden from eriss and a volunteer from the Australian Trust for Conservation Volunteers.*

## ***What we found in 2000***

Each year, the number and types of fish can vary from billabong to billabong. The important thing to look for is if there has been any change in the number and types of fish. Change can occur naturally and can be caused from things like rain fall, a change in vegetation and the availability of certain foods. A natural change will usually affect all the billabongs, whereas an unnatural change may only affect one or more billabongs downstream from the mine.

This year we found that there were no changes in the variety of different fish, but there was some difference in the number of some kinds of fish. However, these differences have been consistent among billabongs and with other years, and provided a good basis for detecting any impact caused by the Ranger mine.

In summary, we found no evidence of adverse effects of the Ranger mine. In particular, the spill of tailings water in the catchment of Georgetown Creek did not effect Georgetown Billabong or the other billabongs further down stream.



*Anthony Sullivan and Junior Gardel set a pop-net and record what type of plants are growing in the billabong.*

### ***Future plans for the program***

The increasing threat of crocodiles has meant that more safety procedures for pop-netting will need to be developed. Consequently, there will be no pop-netting done in 2001. *eriss* will develop new safety measures and trial them for their effectiveness and to see if they are compatible with collecting the data. It is anticipated that monitoring would resume in 2002.



*Anthony Sullivan records the type and number of fish with an **eriss** worker before they are released back into the billabong.*

### ***The full report***

A bigger and more detailed report is being finalised at the moment and will contain all the information about the types and quantity of fish in the billabongs in 2000 compared to previous years. This report will provide a more scientific analysis of the research.

**eriss** will forward GAC a copy of this report when it is finalised early in the new year. We would also be pleased to provide the committee with a presentation of the results and answer any questions you may have.

