LAKE RICHMOND FISH SURVEY

2ND SURVEY: FEBRUARY, MARCH AND MAY 2004

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and

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Abstract

Recent surveys have confirmed the presence of two native and two introduced fish species in Lake Richmond. One species of introduced freshwater crayfish, the yabbie (*Cherax destructor*) was also collected. Beach seines, set nets and electrofishing were undertaken over three time periods in early February, March and May 2004.Visual observations of fish were also recorded during these time periods. The feral fishes in the lake include the widespread and aggressive mosquitofish (*Gambusia holbrooki*) and the goldfish (*Carassius auratus*), which was not collected during this survey period but its presence is inferred from aquaria specimens in the Naragebup Environment Centre.

A total of 520 fish were collected with the native Swan River goby (*Psuedogobius olorum*) being the most abundant fish species represented by 375 individuals in three possible size classes. The feral mosquito fish (*Gambusia holbrooki*) was the second most abundant species with 144 individuals counted and was probably represented by two size classes. One juvenile individual of the native sea mullet (*Mugil cephalus*) was also captured along with a number of feral yabbies *Cherax destrcutor* (approximately 20 individuals).

Comparisons with an earlier survey undertaken in 1998 indicated that gobies and mosquito fish still dominate the shallows of Lake Richmond. Visual observations in the Rockingham Central Main Drain indicated that western minnows (*Galaxius occidentalis*), observed in 1998, were not seen in the 2004 survey (Unfortunately visual observations could not be confirmed by dip netting or other capture techniques).

Swan River goby, mosquito fish and yabbies are likely to be breeding in the lake while the sea mullet was probably brought in by storm surge or drainage flow in the Mangles Bay drain. Freshwater land locked populations of sea mullet are unknown in the Southwest of Australia.

During electrofishing, yabbies were observed coming out of holes that they had presumably constructed, within the thrombolites. The damage that this feral species is causing to the iconic thrombolites requires urgent assessment. Long-term trapping to eliminate the population is strongly recommended, if done within the context of the management plan for the Rockingham Lakes Regional Park Management Plan. Recommendations are also made that include funding a more comprehensive spatial and temporal survey to ensure the whole fish community is characterised and that surface water and groundwater levels and water quality in the Lake are adequately and regularly monitored.

1. INTRODUCTION

Lake Richmond is a unique freshwater coastal lake close to the ocean at Mangles Bay and Point Peron (see Figure 1). It is unique because the lake has extensive areas of ancient and growing thrombolites, bottom depths of approximately 15-19m and is one of largest freshwater lakes in the metropolitan area so close to the ocean. The lake is one centrepiece of the recently gazetted CALM Park – Rockingham Lakes Regional Park (CALM 2003, Draft Management Plan).

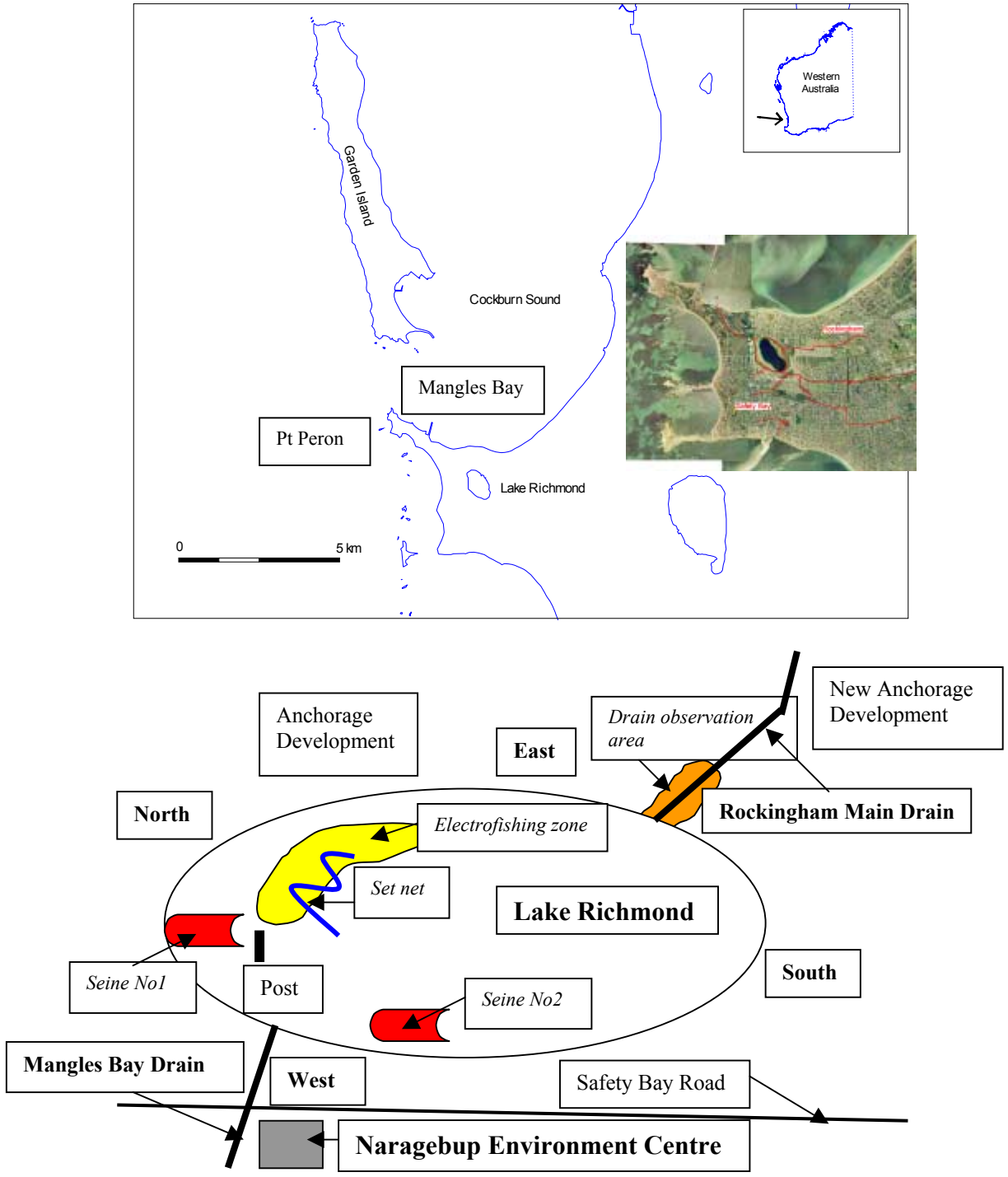


Figure 1. Locality and sampling locations in Lake Richmond, Rockingham, WA.

Historically, groundwater used to be the main source of water input to the lake. Over the years this has been superseded by surface water inflows from several main drains servicing urban areas, roads and commercial districts upstream. What role a drying climate has had on the groundwater-surface water balance is unknown. Recent planning and environmental documents relating to the Anchorage, a new urban development that will surround the lake on the southern and eastern foreshores in one or two years, estimate that approximately 3-10% of water input is from groundwater with the balance from surface inflows from surrounding stormwater main drains (DNMP by BBG, 2004).

Water quality in the lake and the Mangles Bay Drain that flows from the lake to Cockburn Sound is now measured on a regular basis since the Naragebup Environment Centre was established in 2001. The Centre is located adjacent to the lake on Safety Bay Road, Rockingham. In the last two years a blue-green algae *Microcystis aeruginosa* bloom has occurred between late spring and autumn. Observations have also been made of epiphytic growth on the thrombolites as well as a thick growth of charophytes and *Ruppia* spp in a submerged zone around the perimeter of the lake located in the shallows (<0.5 to 2m). Observations can be readily made of ducks, black swans, terns, pelicans, cormorants and gulls feeding either on this band of submerged macrophytes or on local forage fish. Although water quality analyses are taken, trends in nutrient concentrations and phytoplankton-macrophyte abundance are not known.

The fish fauna of Lake Richmond is only rudimentarily known but is reputed to have populations of introduced non-native fish. The Lake has been used as a site in a coastal PhD study (Hoddell, 2004) and the fauna is believed to have been surveyed in historical WA Museum studies. The Environment Centre has an aquarium filled with gold fish (*Crassius auratus*) that have been caught in the lake and its local drains. Otherwise, local residents and staff at the Centre have observed goldfish and other feral fish species in the lake or in feeder drains. Rose (1998) collected two species of fish in late February 1998 in the shallows of Lake Richmond with the Swan River goby, *Psuedogobius olorum*, being the most abundant fish species followed by *Gambusia*, the introduced mosquito fish.

Goldfish (*Carassius auratus*) mosquitofish (*Gambusia holbrooki*)
Photographs: D. Morgan

Plate 1. Two common and introduced (feral) fish caught in Lake Richmond.

Similar to the fish survey undertaken in 1998 for the Lake Richmond Naturalist Club, a second survey was carried out in February 2004 using a beach seine (see earlier report by Rose, 1998). Two other surveys were done in March and May using set (gill) nets and electro fishing in an attempt to survey the deeper water fish community. The survey was conducted on behalf of the Naragebup Environment Centre. Aside from the fish survey, other parties also carried out a shallow water invertebrate survey and several other surveys measuring various aspects of the Lake in February 2004.

2. OBJECTIVES

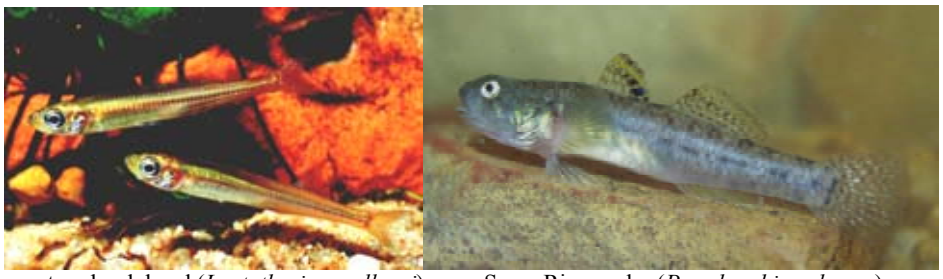
Objectives for this survey were:

1. Sample the fish community in Lake Richmond, particularly the shallow water fish community (<1.0m deep), with a small 40m-beach seine.
2. If time, equipment and assistance was available, sample the deeper water fish community.

3. Describe the fish community in terms of abundance and briefly compare results to an earlier survey done by Rose in 1998.
4. Provide recommendations based on results, for future management, fish community surveys and specifically if any adverse results were observed.

This is a short report on the second fish survey and consequently is not comprehensive in terms of a literature review and references of recent and related studies. Recent studies and a more intimate knowledge of the lake by Naragebup staff may provide better facts and figures. If so, revision of assumptions and estimates provided in this report may be necessary. Interpretations and generalisations must thus be considered carefully.

western minnow (*Galaxias occidentalis*) black bream (*Acanthopagrus butcheri*) sea mullet (*Mugil cephalus*)



western hardyhead (*Leptatherina wallacei*) Swan River goby (*Pseudogobius olorum*)

Photographs: D. Morgan (western minnow, black bream, sea mullet and goby); M. Allen (hardyhead)

Plate 2. Photographs of common freshwater inhabitants in coastal Southwest waterbodies near estuaries and the sea.

3. MATERIAL AND METHODS (with some discussion)

Fish were sampled three times. Once each on 7 February, 9 March and 4 May 2004.

A beach seine was used at two shallow sites on 7 February 2004. The seine was 1.5m deep and 40 metres long, with two 15m wings of 9mm mesh and a central panel of 10m with 6mm mesh with a two metre central bunt or pocket with 3mm mesh. Seines were taken at the two sites with semi-circle sweeps starting in water *ca* 1-1.5 metres deep and brought ashore. Each seine sampled an area of approximately 150m^2.

One site was located on the north (opposite the jetty, near the post) and the second site at the western end (slightly to right of Environment Centre, due west) of the Lake (See Figure 1). Captured fish were identified to species with the first 25-40 individuals measured for total length (TL - snout to tip of tail). Any other fauna and material collected in the nets was noted and the water tasted for saltiness at each site. A total of 67 gobies and 31 mosquito fish were measured for TL.

One set net was used on 9 March and deployed for one hour at mid-day (11:40 am) before being retrieved. It was anchored in a North-South alignment near the post off the observation jetty and rotundas at the north end of the lake, adjacent to where the first seine was carried out in February. The set net was 60m long, one meter deep and had mesh sizes ranging between 50-75 mm. A small seine was also used to corral small swimming fish seen in the shallows that looked like mullet but unfortunately both the set net and "corralling" yielded no fish.

One set net was used on 4 May and set approximately 200m east of the first set net used in March. It was deployed for 2 hours between 12 noon and 2pm. Net dimensions were the same as used in March. After setting the net, a dinghy was powered around the lake after first stopping at the junction where the

Rockingham Main Drain (MD) enters Lake Richmond on the south side. A US EPA – WA Water Corporation "drinking water reservoir approved", self-contained 2HP petrol motor, was used to power the dinghy. At the Rockingham MD, the party walked 250m upstream and made fish observations in the drain water that was approximately 5-20cm deep. Concentrated observations were also made in the area of the lake where cormorants and pelicans were seen feeding in the water and where a large flock of pelicans and birds were resting on shore, due east near the new foreshore adjacent to the Caravan Park and Anchorage developments.

After the set net was retrieved, electro fishing was conducted along approximately 300m of the foreshore facing east near where flocks of birds were resting. For this, the electro-shocker was dragged along the bow where the operator and another person netted shocked animals while another drove the boat very slowly. Once collected they were put on a measuring board, identified and their total length recorded before being returned to the water. Feral fish and yabbies were placed in an ice slurry, put in 70% alcohol and taken ashore.

The substrate in the shallows was rocky and irregular reflecting the roughness caused by young stromatolites, calcareous-rocky deposits and loose unconsolidated rocky material. During electro fishing in May, extensive epiphytic growth was observed on most thrombolites as were occasional burrow holes. Electro shocking occurred in water along the perimeter in depths where the shallow areas that are usually inundated with water were exposed and the lake bottom dropped steeply to deeper water, ie essentially along the interface between the shallow peripheral terraces and deeper water.

Seine fishing, ie. catchability, was considered poor to fair with actual fish numbers underestimated. The two times set nets were used they were deployed at one site for one time in the mid day. Quantitative fish surveys using set nets usually deploy them at a number of sites through out a lake system over various time periods. This is done to more accurately describe and estimate fish populations. Fish are usually mobile and school at different places and times in a given 24-hour period, thus repeat sampling efforts through out the study area including nightime sampling are usually required.

4. RESULTS

4.1 Species and abundance for all capture methods

A total of 520 fish from four species of fish were collected. An introduced decapod, the yabbie (*Cherax destructor*) was also captured.

Table 1. Rank based on number caught, species and their total abundance. Numbers of animals caught or counted are in brackets. No animals were caught by mid-water set net.

Rank	Species	Total Number	Size range (mm)	Capture method
1	Swan River goby – *Pseudogobius olorum*	375	14-41	Mainly seine (270) with electrofishing (5) and visual counts (100)
2	Mosquitofish – *Gambusia holbrooki*	144	14-32	Mainly seine (40) with electrofishing (4) and visual counts (100)
3	Sea mullet – *Mugil cephalus*	1	72	Electrofishing
4	Yabbie – *Cherax destructor*	20	20-30 mm OCL	Electrofishing, approximately 6-7 yabbies escaped netting due to thick epiphytic growth and attempts to not destroy thrombolite structures with net frames.
Total	**4 species**	**521**		**Seine (310), visual (200), electrofishing (11)**
Other	Oblong turtle (*Chelodina oblonga*)	1	6-10cm length	Observed electrofishing

Table 2. Catch statistics for each seine. Only one seine was taken at each site.

Species	**Site - North end Seine 1**	**Site – West end Seine 2**
	Number of fish collected	**Number of fish collected**
Swan River goby (*P. olorum*)	103	167
Mosquitofish (*G. holbrooki*)	1	39
Total	**104**	**206**

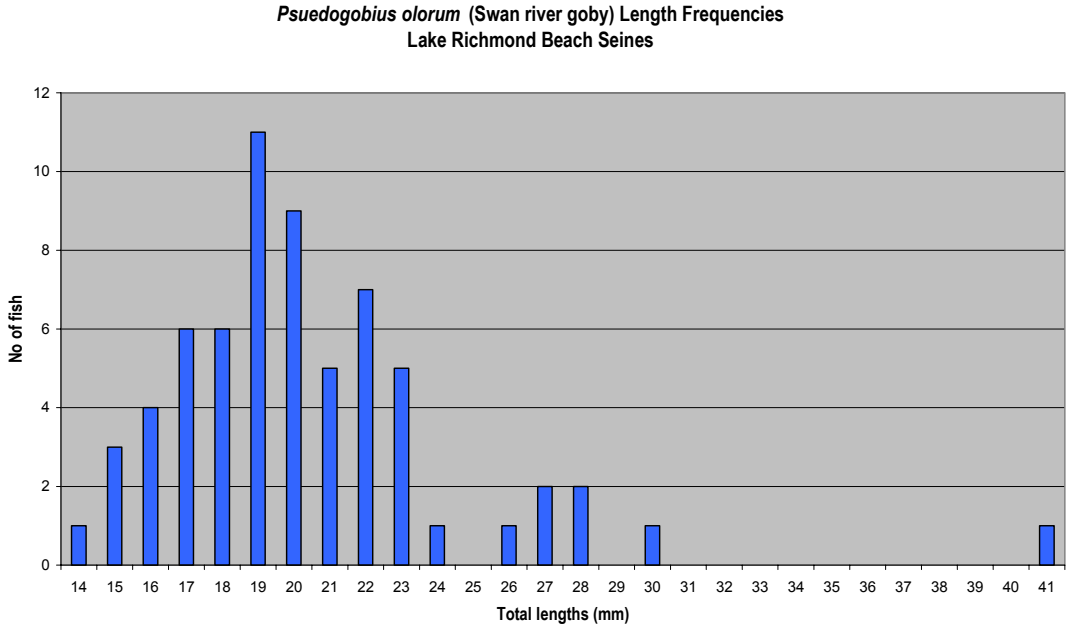
Swan River gobies ranged in size from 14 to 41mm TL, mosquitofish between 14 and 32mm TL and the single individual sea mullet was 72mm TL. Yabbies were ~20-30mm OCL (orbital carapace length) (Plate 3). Two, possibly three size classes of Swan River goby were present in the 375 captured individuals, one between 16-23mm TL and the other two between 26-40mm TL. The larger size classes numbered only 7 individuals. *Gambusia* or mosquitofish were also represented by two possible size classes, a 14-22mm TL and 24-32 mm TL group (see Fig. 2). The majority of individuals were in the smaller size class with 11 individuals in the larger category.

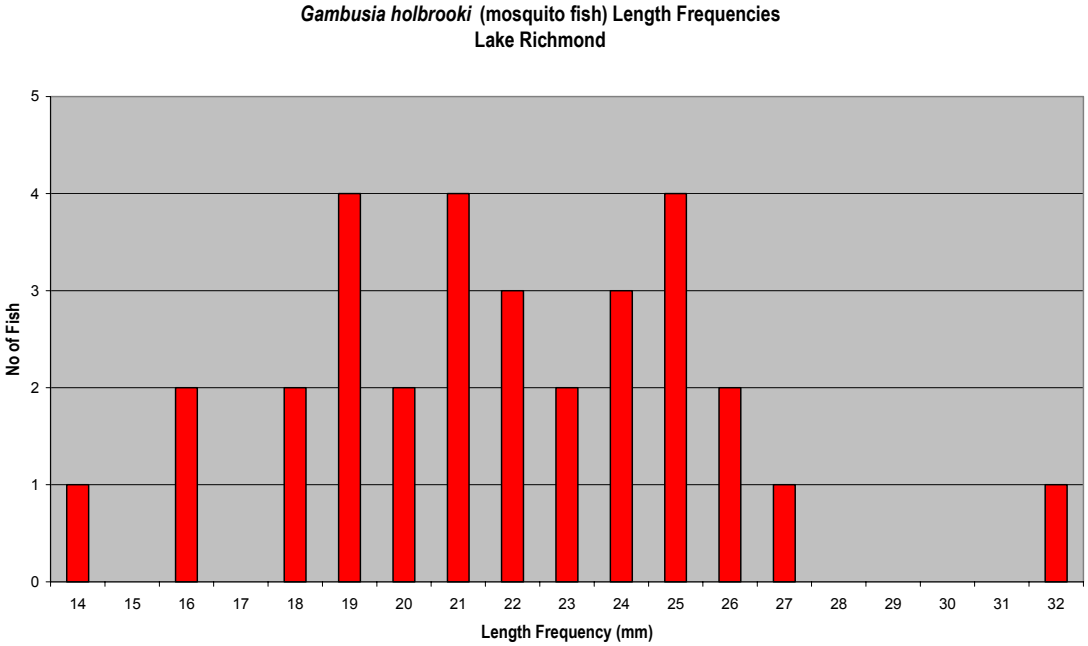
Clockwise from top left – Swan River goby, sea mullet, introduced yabbie and introduced mosquitofish (*Photographs: D. Morgan*)

Plate 3. Fish and a decapod caught sampling in Lake Richmond between February and May 2004.

The seine taken from the north side (opposite the jetty and post) contained small cobble mixed with muddy phytobenthic substrate. This clumpy mix contained charophytes and *Ruppia*, what appeared to be two species of earthworms, numerous gastropods, odonate nymph instars and tendiped chironomid larvae. The second seine, on the western side, was clean and contained several carbonaceous cobbles.

Figure 2. Length-frequencies of *Psuedogobius olorum* (Swan River goby) and *Gambusia holbrooki* (mosquitofish) caught by beach seine at Lake Richmond. Histogram groups with peaks in number of fish around a central size length usually indicate a size class or cohort born at the same time.





An estimate of standing crop of the two most abundant fish species was made (Table 3). This was based on a quick visual assessment of the area that would be occupied by the two fish species in the shallows. This estimated area and the mean number of individuals per species for the areas seined were used to extrapolate to a final number. This estimate of the area of the shallow perimeter of the lake during February may be inaccurate as it was done visually and thus population numbers are probably greater.

Table 3. Summary statistics for all capture methods. TL – Total length of fish from nose or snout to tip of tail. OCL – Orbital carapace length from eye socket to end of notch on the cephalothorax plate. * Standing crop is based on the estimated number of animals for the total estimated area of habitat. For example, it was estimated gobies occupied a 30m wide shallow perimeter around the lake. The width of seines was approximately 10m (30 x 10 = 300m^2). Thus 300m^2 blocks found in the shallow perimeter were counted around the lake using a visual estimate of the number of blocks that could be fitted around the lake. This yielded about 200 blocks, at 300m^2 x 200 = 60,000m^2. This was the estimated habitat area occupied by gobies and mosquitofish. Both species prefer shallow water and were the only species captured by seine in this shallow area. The seines covered an average size of 150m^2. Therefore standing crop = mean No per seine x 60,000m^2 ÷ 150m^2.

Rank	Species	Number	Mean No per seine	Density per 100m^2	Mean TL (mm)	Estimated standing crop*
1	Swan River goby	375	135	90	20.1	54,000
2	Mosquitofish	144	20	12	21.2	8,000
3	Yabbie (see other table for numbers)	1	-		30 CPL	-
4	Sea mullet	1	-	-	72	-
Total	**4 species**	**521**	**155**	**102**	**20.7**	**62,000**

4.2 Set nets (also known as Gill nets)

No fish were captured using fine mesh mid water set nets, ie gill nets. Set nets were used on two different days for a total of 3 hours (1hr + 2hr). Both times the net was deployed at mid-day and pulled at 1pm and 2pm respectively.

4.3 Electro-fishing

Electrofishing yielded four species of fish and a decapod as detailed in Table 1. Note the method of electrofishing used in early May can not be used to estimate population numbers since there were a number of yabbies shocked that were not collected and only a limited area was subjected to shocking. Otherwise, the method was good for capturing any species not previously collected by seine or set net, eg. yabbies and sea mullet.

4.4 Brief Comparison to 1998 Results

4.4.1 1998 Species List (based on two beach seines only)

Species	Common name	Origin
1. *Gambusia holbrooki*	Mosquito fish	Freshwater
2. *Psuedogobius olorum*	Swan River goby	Originally marine and now estuarine and is freshwater tolerant

4.4.2 Estimated Abundances 1998 (approximate numbers per 100m^2)

Species	Site - North end		Site - West end	
	Number of fish collected	Density per 100m^2	Number of fish collected	Density per 100m^2
Mosquitofish	25	17	0	0
Goby	160	107	1120	747

4.4.3 Visual Observations in 1998

Species observed	Comments
1. Yellow Tail Trumpeter (*Amniataba caudavittatus*)	A school of approximately a dozen fish looking like yellow tailed trumpeter were observed on the northern end. They are probably a freshwater tolerant strain as this species is often estuarine and can tolerate brackish conditions. Likes to eat bottom living animals. Native and maybe established when ocean water flowed into Lake. From Cockburn Sound. ***Based on aquarium specimens in Naragebup, observations may have been of gold fish.***
2. Yellow Eye Mullet (*Aldrichetta fosterii*)	One or two fish looking like this species were also observed near the school of trumpeters ***ie. now gold fish***. They eat bottom living animals, plant material and occasionally mud. Like marine embayments and are estuarine with freshwater tolerances. ***Based on the 2004 survey, they may have been gold fish.***
3. Carp (*Carpio carpio*)	2-3 fish looking like this were seen at the northern end. Difficult to confirm as the yellow eyed mullet and carp look similar at distance in the water. If carp were in the Lake they would feed on bottom muck and plant material. A feral species and probably introduced from aquarium releases. ***No carp were seen in the 2004 survey. Carp are often over-reported and these are more likely to be gold fish.***
4. Western Minnow (*Galaxis occidentalis*)	A number of schools were seen in the drain, which was flowing into the southern end of the Lake. A native and indicative of reasonable water quality in the drain. Feed on small insects and bottom creatures. ***In 2004, the drain was very shallow and putrid with lots of Typha and phytoplankton scum. No species looked like the western minnow although gobies, mosquito fish and maybe a Swan river hardyhead were present in the drain.***

5. DISCUSSION

5.1 SPECIES COMPOSITION

5.1.1 Beach seines

The same two species of fish that dominated catches in this 2004 survey are similar to what Rose (1998) also found his beach seines. The actual abundances of both the native Swan River goby and feral mosquitofish were different. A mean of 640 gobies per seine was collected in 1998 compared to 135 in 2004. This may reflect reduced habitat created by a number of drought years since 1998. It may also reflect different catch efficiencies of the seines between 1998 and 2004. In 2004, catch efficiency was very poor compared to the previous survey. Mean abundances of mosquito fish increased slightly in 2004 compared to 1998. In 1998 a mean of approximately 12 mosquito fish per seine was collected while in 2004 this increased to 20. The significance of this is uncertain as not enough seines were taken to get a better estimate of population numbers and variation between sites. A better understanding of the variation between sites would allow a more robust conclusion to be made as to whether numbers had increased compared to 1998 or merely reflected inter-site variation.

5.1.2 Visual observations of fish in the Rockingham Drain

The number of fish species found in the lower Rockingham Central Main Drain during the 2004 survey was less than the 1998 survey. In 1998 Rose observed several schools of western minnows but this was unsubstantiated by follow up catches. In 2004, the Rockingham Central MD was stagnant and drying up.

Presumably, the Anchorage development and City of Rockingham drain works were affecting downstream water volumes and quality at this site during the late summer to autumn period. De-watering and drainage works may have lowered groundwater levels or reduced discharges reaching the bottom of the drain network before it flows into Lake Richmond. Several dry years preceding this survey may have also reduced water volumes and water quality that would normally exist in the drain at this time of year. Fish sampling in the drain would have been improved if some capture techniques such as dip netting or fyke trapping had occurred in order to confirm what species were present.

5.1.3 Evidence of breeding

The observation of several size classes in the two most abundant fish species indicates that both the native Swan River goby and mosquitofish are breeding successfully in Lake Richmond. This comment is also supported by the knowledge of the breeding biology of both species where both species are known to spawn over a period of time during the year after reaching relatively small sizes. It is likely that three size classes of gobies were present in beach seine samples with individuals larger than 40mm TL being very rare. Similarly, two to three size classes of mosquitofish were probably represented with individuals over 30mm TL being rare. For both species, the size classes seem similar to sizes reached in other studies done in the Southwest (D. Morgan pers comm). Only the gobies may be slightly smaller than that recorded in other nearby studies, particularly those studied in estuarine habitats, for example, those found in the shallows of the Peel-Harvey during summer, eg. Raines and Rose (2004), or in the Swan-Canning Estuary, eg. Gill *et al*. (1996). This may reflect different water temperatures affecting size, food availability affecting growth rates, or even predation, where larger fish are consumed more frequently by lake predators.

5.1.4 Presence of other juvenile species

The presence of a juvenile sea mullet indicates that this species occupies the Lake. Sea mullet spawn in the sea, with juveniles generally temporarily recruiting into estuaries and rivers, and in the case of Lake Richmond, coastal lakes with connections to the sea. Thus the sea mullet must have gained access to the lake during flood events, ie storm surge that connect the lake to the sea, presumably up the Mangles Bay Drain, or during winter flow periods when the drain is flowing to the sea. However, other juvenile euryhaline fish including yellow eye mullet (*Aldrichetta fosterii*), whitebait (*Hyperlophus vittatus*) and western hardyhead (*Leptatherina wallacei*) could also migrate up the drain into the lake or, individuals could have escaped bird predators through pouch spills in the case of pelicans or adherence to webbed feet (mullet eggs and larvae are pelagic and are highly unlikely to get caught in mud on bird feet). Entry by other means other than by migrating up the drain during winter is very unlikely. It is possible though humans may have transferred juvenile mullet although few humans have access to juvenile mullet. Regardless, there are no recorded populations of sea mullet that can complete their life cycle in a freshwater lake and thus the presence of this species must reflect its occasional and opportunistic inhabitancy of the lake. Likewise, other juveniles of several species are likely to be present in the lake but were not collected (eg. whitebait, yellow eye mullet and hardyheads).

5.2 SAMPLING CONSTRAINTS AND INFERENCE ON LAKE RICHMOND FISH COMMUNITY COMPOSITION

Sampling methods and frequency of sampling for this survey were not quantitative. There was not enough temporal and spatial coverage of the lake to confidently define the fish community. In particular, day and night sampling in the shallows and deep water would be required. Netting would also need to be done in all areas of the lake. Sampling in this survey tended to concentrate in the northern and eastern sides of the lake and ignored southern and eastern areas. Fish populations are notoriously mobile and often display marked diel migrations mainly at night when they move from the deep to the shallows. With the number of piscivorous bird predators observed at Lake Richmond, nocturnal and spatial movements may be typical for larger individuals to avoid predation. Furthermore, the mesh sizes used in the set net may have been too large, if large species are not present during the day. This and poor temporal-spatial coverage may have meant that several fish species and their size ranges may be under-represented. Sampling efficiencies with the small beach seines was poor due to irregular bottom surfaces. This suggests that fish numbers were also underestimated.

Based on aquaria collections from the Lake and consistent shallow water beach seining over two periods (1998 and 2004), the shallow water fish community is likely to be depauperate in terms of fish species. Despite poor sampling techniques, the surveys conducted in both 1998 and 2004 have consistently collected two species of shallow water fish and confirmed opportunistic use of the lake by migratory sea mullet. Juvenile sea mullet are well known for occupying estuaries and tidal rivers while young. It is believed this strategy allows juvenile populations to exploit food resources where predation pressures or competition with other juvenile species may be reduced, compared to the ocean. Aquaria specimens indicate goldfish (*Carassius auratus*) and the common beach seine species mosquitofish are consistent introduced-feral inhabitants of the lake.

5.3 WATER QUALITY OBSERVATIONS

Water quality in the lake may be deteriorating based on observed phytoplankton scums (eg. *Microcystis* sp.) and extensive epiphytic growth on thrombolites and charophytes. Compared to 1998 when less epiphytic growth and no algal scums were observed, water quality in 2004 appeared worse than in the earlier survey. However, several drought years in the last six years have occurred, the Rockingham Central Main Drain has been closed and the summer and autumn of 2004 were very dry. What impact this would have on fish populations is unclear other than to reduce shallow water habitat as lake levels fall or slightly increase salinity through evaporation. In the short term, goby populations may increase if dissolved oxygen levels do not become critical, ie too low, frequent or extensive. This is because more individuals may be supported through increased food availability. Plant detritus and small benthic organisms associated with increased plant biomass are known to be important diet items for the Swan River goby. The effect increased plant material would have on mosquito fish populations is uncertain. Their numbers would probably remain the same if water quality changes are not too drastic. Certainly, poorer water quality in the lake, in terms of nutrient enrichment, will eventually affect thrombolites, simply through excessive epiphytic growth, smothering and changed water chemistry. Because water levels were so low and nutrient enrichment is suspected it would be wise to measure water levels and water quality in the lake, and, have a groundwater (GW) bore network established around the periphery of the lake to measure changes in GW influx and its quality. Regardless, with increased urban development around the lake, measuring surface water and groundwater quality would help identify risks to the thrombolite community.

5.4 YABBIES AND FERAL FISH: IMPLICATIONS FOR MANAGEMENT AND HEALTH OF THE LAKE

During electrofishing, yabbies were observed coming out of holes within the thrombolites that they had presumably constructed. The damage of this feral species to the iconic and biologically significant thrombolites requires urgent assessment. Borrowing animals are likely to fracture and retard thrombolite accretion and possibly alter physical and chemical microhabitat conditions conducive for microbial growth and thrombolite growth. What is also of particular concern is that yabbies are a very invasive species that can maintain extremely high population densities and thus a large potential to damage thrombolites.

The issue of feral fish and invertebrates and their management depends on the objectives of management and the Rockingham Lakes Regional Park management plan. If Lake Richmond is to be kept as pristine as possible (given changes in the source of water inputs, ie ground to surface water) then trapping strategies and neighbourhood-community education will need to be developed and implemented. This is a very urgent issue supported by this survey and needs to be addressed by CALM, the City of Rockingham and the Naragebup Environment Centre.

6. RECOMMENDATIONS

It is recommended that:

1. Further sampling be conducted using a combination of methods that adequately samples all of the lake in terms of spatial and temporal (night and day) coverage and also provides good estimates of population sizes, for eg. Determines how many yabbies exist in the lake. Murdoch University (Freshwater Fish Lab) could be hired to thoroughly survey the Lake. Without undertaking detailed cost estimates, a good survey and report would probably cost in the vicinity of $5,000 to 15,000.

2. Surface water levels and groundwater levels need to be monitored in order to measure volumes and influx patterns.
3. A surface water quality-monitoring program in the lake and from groundwater bores would help determine water quality trends and help identify possible strategies to reduce problematic water quality. A surface water monitoring program may already exist (eg. Sampling Analysis Plan prepared for the Naregebup Environment Centre by the Water and Rivers Commission in 2002/03). If so, than analyses and a possible increase in sampling frequency would need to be considered, at least on a level that could pick up rainfall and drainage inputs when drains flow after rainfall events or when water levels change.
4. Yabbies be eradicated or controlled through consistent long-term trapping. Murdoch University, CALM, Fisheries or other qualified parties need to be asked for the best advice to remove feral fish and invertebrates, if assessed as a problem.
5. Undertake a community education program to teach parties not to dump pet fish and yabbies or unwanted fish catches in drains or in the lake.

7. REFERENCES

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ACKNOWLEDGMENTS

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