Aquatic ecology and microbat surveys of Little Llangothlin and Billy Bung Lagoons

Prepared for
Glen Innes Area National Parks and Wildlife Service

15 June 2012

DOCUMENT TRACKING

ITEM	DETAIL
Project Name	Aquatic ecology and microbat surveys of Little Llangothlin and Billy Bung Lagoons
Project Number	12ARMECO-0009
File location	S:\Synergy\projects\12ARMECO\12ARMECO-0009 Little Llangotholin and Billy Bung Lagoons Aquatic Survey
Project Manager	Dr Peter Hancock Phone: 02 8081 2682 PO Box 1927, Armidale, 2350
Prepared by	Dr Peter Hancock
Approved by	Dr Paul Frazier
Status	DRAFT
Version Number	1
Last saved on	15 June 2012
Cover photo	Little Llangothlin Lagoon. Inset are several *Hydra* sp. attached to the stem of *Eleocaris sphacelata* (left) and an adult diving beetle (Dytiscidae).

This report should be cited as 'Eco Logical Australia 2012. Aquatic ecology and microbat surveys of Little Llangothlin and Billy Bung Lagoons. Prepared for Glen Innes Area National Parks and Wildlife Service.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Justin Kreis

Contents

List of Figures

List of Tables

Executive Summary

Little Llangothlin Lagoon (LLL) is a high altitude freshwater lagoon on the New England Tablelands and is part of a nature reserve that is managed by NSW National Parks and Wildlife Services. A much smaller lagoon, Billy Bung Lagoon (BBL), is connected to LLL by a shallow channel that enters LLL on the eastern shore.

A survey of the aquatic ecology and bat fauna of the Little Llangothlin Lagoon Nature Reserve was conducted between 16 and 20 May 2012. The survey confirmed that goldfish (*Carassius auratus*) and mosquitofish (*Gambusia holbrooki*) occur in BBL, and that mosquitofish and shortfinned eel (*Anguilla australis*) occur in LLL. Of these, only the shorfinned eel is native.

Eight species of microbat were recorded on-site during the survey, with four of these being listed as vulnerable under the NSW Threatened Species Conservation Act (1987). The vulnerable species were eastern bentwing (*Miniopterus schreibersii oceanensis*), eastern false pipistrelle (*Falsistrellus tasmaniensis*), large-footed myotis (*Myotis macropus*), and greater broad-nosed bat (*Scoteanax rueppellii*). Additional surveys in spring or summer are likely to indicate that more species of bat use the nature reserve.

No signs of water rat (*Hydromys chrysogaster*) were observed during the survey, although area is suitable and signs have previously been found at BBL. With the exception of having mosquitofish and goldfish, the aquatic ecology of LLL Nature Reserve is in relatively good condition and contains invertebrate species similar to other New England Lagoons. To gain a better understanding of the aquatic ecology of the lagoon, and to confirm whether goldfish occur in LLL, invertebrate and fish surveys should be conducted in warmer months.

1 Introduction

1.1 BACKGROUND

Little Llangothlin Lagoon (LLL) is a high altitude freshwater lagoon on the New England Tablelands, approximately 10 km northeast of Llangothlin (Figure 1). The lagoon forms the headwaters of the eastern flowing Oban River and covers approximately 120 hectares. LLL, and the eastern half of Billy Bung Lagoon (BBL) form the Little Lllangotholin Nature Reserve that is managed by NSW National Parks and Wildlife Services. BBL is approximately 25 ha and is connected to LLL by shallow channel that enters LLL on the south-western shore. BBL is bisected by a fence, with the western part of the lagoon in private property, and the eastern part of the lagoon falling within the Little Llangothlin Lagoon Nature Reserve.

The LLL Nature Reserve is an internationally recognised as an important habitat for water birds and is listed in the RAMSAR Convention. The lagoon is also listed as an endangered ecological community under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) as an *Upland Wetland of the New England Tablelands and Monaro Plateau*.

Voluntary bird surveys of LLL commenced in early 2011 to monitor bird communities and note the arrival of migratory species. During the summer survey, conducted on 11 February 2012, an Australian darter (*Anhinga melanogaster*) was seen in the western section of BBL with a large bronze fish speared on its' beak. The darter was observed through a spotting scope for approximately 15 minutes as it struggled with the fish. The fish was approximately 20 cm long, had large bronze scales, and appeared to be either a carp (*Cyprinus carpio*) or goldfish (*Carassius auratus*). Up until this sighting, neither species were known from either BBL or LLL, but the size of the individual observed suggests that either carp or goldfish have possibly been in BBL for a long time. Further, it is likely that the channel connecting BBL to LLL acts as a passage for migration of the fish between the two lagoons. The current survey aims to determine what fish species occur in the lagoons. As only a small number of aquatic surveys have been done on the aquatic fauna of LLL (Timms 1970, Morton 1990, NSW National Parks and Wildlife Service 1998), this survey will also document some of the aquatic vertebrates and invertebrate species present in the lagoons.

Water rats have not been observed at the lagoon, but evidence of a feeding site at on the northern shore of Billy Bung Lagoon was noted by Dudley (2011). A further objective of this survey was to look for signs of water rats at LLL and BBL.

Two species of microbat, Gould's longeared bat (*Nyctophylus gouldi*) and eastern false pipistrelle pipistrelle (*Falsistrellus tasmaniensis*) are known from the Little Llangothlin Nature Reserve (NSW National Parks and Wildlife Service 1998), but the area potentially provides habitat for several more species. Microbat communities of each lagoon were surveyed during this project.

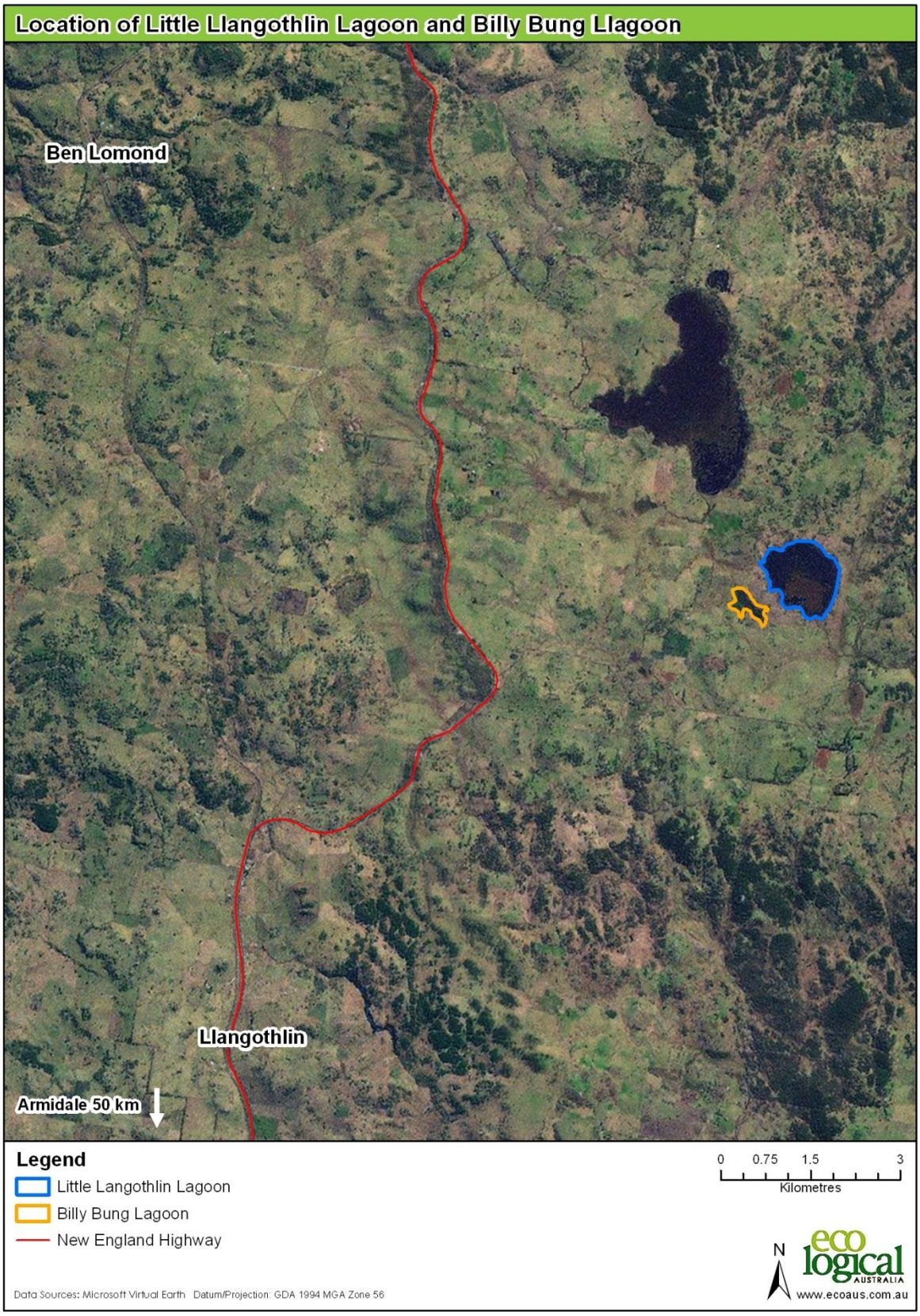

Figure 1. Location of Little Llangothlin and Billy Bung Lagoons

2 Methods

2.1 SAMPLING CONDITIONS

Weather during the survey period of 16 to 20 May 2012 was fine, with no rainfall and clear skies for all days. Maximum air temperature at Guyra, 19 km south west of LLL, ranged from 14.1 to 15.7 ^{o}C throughout the survey period, and minimum temperatures were between -1.2 and 1.2 ^{o}C (Bureau of Meteorology,Table 1).

Table 1. Air temperature and rainfall at Guyra for the period of this survey.

DATE	DAY	TEMPERATURE		RAINFALL
		Min	Max	
		°C	°C	mm
16	We	-1.2	15.7	0
17	Th	0.1	15	0
18	Fr	1.1	15.1	0
19	Sa	1.2	14.1	0
20	Su	1	15.4	0

2.2 SURVEY METHODS AND TIMING

2.2.1 Fish sampling

Two types of traps were used to survey fish. Fyke nets of 60 cm diameter and a 5 m single wing, and shrimp traps with 2.5 cm diameter entrances were deployed for two nights (16th and 19th May) at each lagoon. One Fyke net was set in each lagoon per night, with part of the net set above the water to allow a breathing space for turtles and water rats that enter the net. Six shrimp traps were set each night in LLL, and two traps per night were set in BBL. Traps were baited with tuna.

At LLL, the Fyke net was set for one night in the northern part of the lagoon (Figure 2, Figure 3), and one night in the southern part.

BBL is densely vegetated with watermilfoil (*Myriophyllum* sp.) and has very little open water in the Reserve (eastern) part of the lagoon. Cattle access to the western half creates temporary channels of open water. The Fyke net in BBL was set for one night in the reserve. The net was set on top of the watermilfoil and pushed down to the bottom. On the second night it was set on private property in a channel cleared through the watermilfoil by cattle (Figure 2).

Water temperature, dissolved oxygen concentration (DO), electrical conductivity (EC), and pH were measured at each fish sampling location on 16 May using a YSI-556 Multiparameter Meter (YSI Incorporated, Ohio). Turbidity was also measured at these sites using a Hach 2100Q Turbidimeter (Hach Company, Colorado).

Figure 2. Fyke net set in the northern section of Little Llangothlin Lagoon (upper photo) and in Billy Bung Lagoon (lower photo).

2.2.2 Snorkelling surveys

Snorkelling surveys of 15 to 20 minutes were conducted along the northern edge of the *Eleocaris* bed, and between the southern edge of the *Eleocaris sphacelata* beds and the edge of LLL (Figure 3). Surveys occurred in the early afternoon, and horizontal visibility was approximately 1.8 m. Visual assessments of different aquatic habitats were made. These included the *Eleocaris* stems, submerged logs and rocks, the open water, and soft sediment bottom of the lagoon. The objective of these surveys was to record any fish or turtles seen, and to determine the types of habitat available.

2.2.3 Aquatic invertebrates

Aquatic invertebrates were sampled at one site in LLL using a sweep net with 250 μm mesh. The survey was not meant to be comprehensive and aimed just to give an indication of what taxa are present. One sweep for of 5 m was made for zooplankton 10 m off-shore at the southern Fyke net site, and another sweep of 2 m was made against nearby *Elecoaris sphacelata*. Samples were examined rapidly under a dissecting microscope and specimens identified to Family or Order.

2.2.4 Water rat surveys

Visual searches for water rats (*Hydromys chrysogaster*) were conducted on 16th, 17th, 19th, and 20th of May 2012. These included early morning and late afternoon searches from the western, northern and southern shores of LLL, and from the north-eastern shore of BBL. The stretch of water between the eastern shore of Little Llangotholin Lagoon and central bed of tall spikerush (*Eleocaris sphacelata*), was searched using a canoe on 16 May 2012.

An active search for signs of Water Rats was made around the entire margin of LLL on 20 May. The greatest search effort focussed on rocky areas along the southern shore, and fallen timber within 30 m of the water edge. These were examined for scats and evidence of feeding tables. Stumps and fallen timber close to the north-eastern shore of BBL were also searched.

2.2.5 AnaBat surveys

Microbat surveys were conducted on the nights of 16th and 19th May 2012. On each night, a single Anabas SD2 Bat Detector (Tilley Scientific, Brisbane) was placed in woodland bordering each lagoon. Detectors were positioned in bat flyways within 50 m of the lagoon shore, and placed above the ground on stumps or fallen logs. The location of each AnaBat Detector is indicated in Figure 3.

Bat calls were analysed using the program AnalookW (Version 3.7w 31 December 2009, written by Chris Corben, www.hoarybat.com). Call identifications were made using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al. 2004), south-east Queensland and north-east New South Wales (Reinhold et al. 2001); and the accompanying reference library of over 200 calls from north-eastern NSW (http://www.forest.nsw.gov.au/research/bats/default.asp).

Bat calls are analysed using species-specific parameters of the call profile such as call shape, characteristic frequency, initial slope and time between calls (Rinehold et al. 2001). To ensure reliable and accurate results the following protocols (adapted from Lloyd et. al. 2006) were followed:

1. Recordings containing less than three pulses were not analysed (Law et al. 1999) and are labeled as short.

2. Only search phase calls were analysed (McKenzie et al. 2002).

3. Four categories of confidence in species identification were used (Mills et al. 1996):

a. definite – identity not in doubt

b. probable – low probability of confusion with species of similar calls

c. possible – medium to high probability of confusion with species with similar calls; and

d. unidentifiable – calls made by bats which cannot be identified to even a species group.

4. *Nyctophilus* spp. are difficult to identify confidently from their calls and no attempt was made to identify this genus to species level (Pennay et al. 2004).

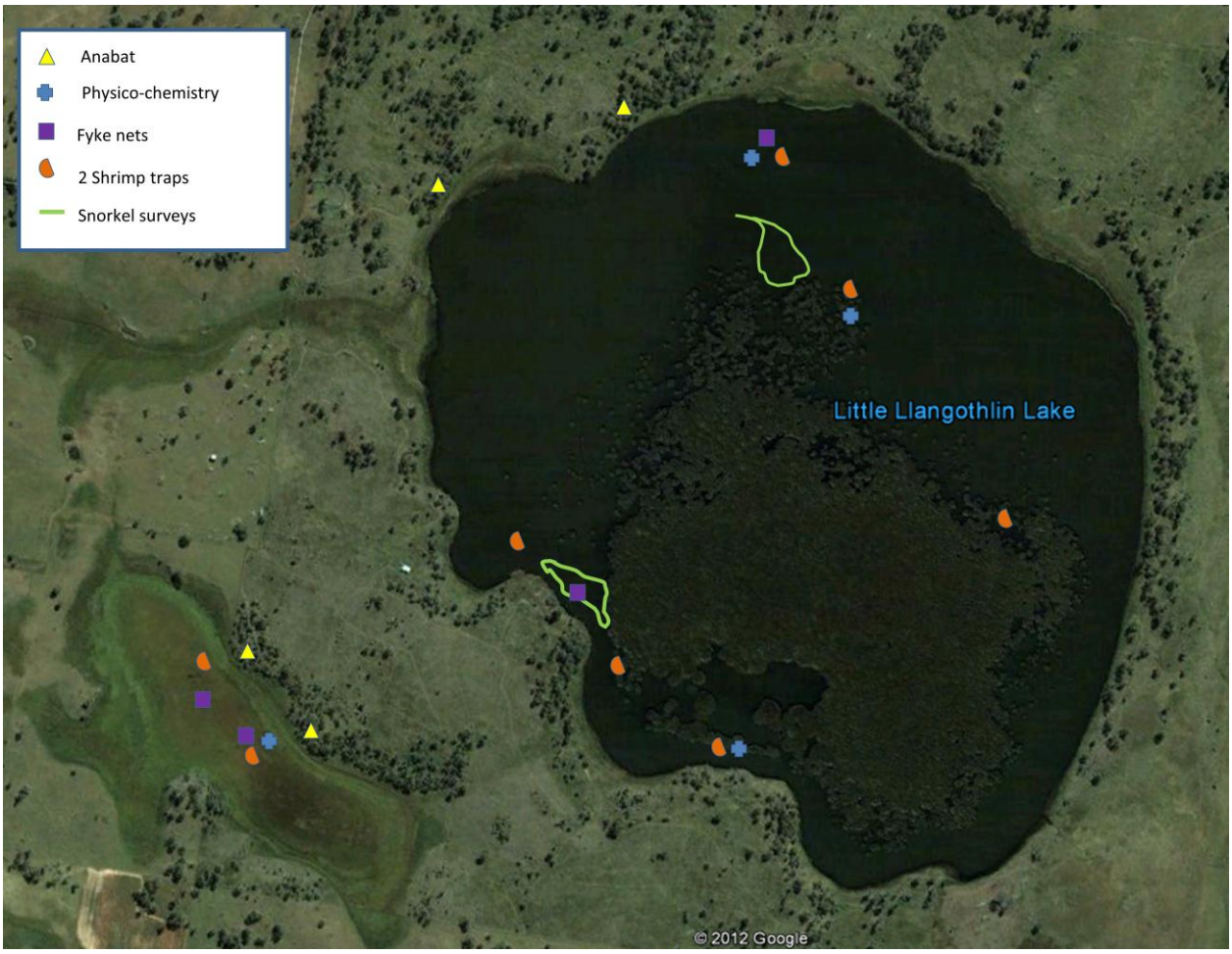

Figure 3. Location of different components of this survey at Little Llangothlin Lagoon and Billy Bung Lagoon (south west of the main lagoon).

3 Results

3.1 PHYSICOCHEMISTRY

Water depth at trapping sites in LLL was between 0.63 m and 1.15 m (Table 2). In BBL, the maximum depth measured was 0.95 m. Temperature in both lagoons was between 11.4 and 12.2 ^{o}C. Dissolved oxygen on BBL was lower than that of LLL, measuring 5.84 mg/L compared to 8.28 to 10.96 mg/L. Electrical Conductivity in LLL was consistent across all sites, ranging from 0.233 to 0.235 mS/cm. This was only slightly higher than the measurement of 0.211 mS/cm taken from BBL. At 7.43, the pH of BBL was slightly lower than the range measured in LLL (7.70 – 7.90). The turbidity of BBL was 10.7 NTU, which significantly higher than that of LLL (2.13 to 3.17 NTU).

Table 2. Physicochemistry measurements of Little Llangothlin and Billy Bung Lagoons.

LAGOON	LITTLE LLANGOTHLIN			BILLY BUNG
LOCATION	Northern Bay	Northern edge of *Eleocaris bed*	Southern edge of *Eleocaris bed*	Inside reserve
TOTAL DEPTH (m)	0.63	1.15	1.1	0.95
DO (% Sat)	100.8	91	75.3	57.4
DO (mg/l)	10.96	9.89	8.28	5.82
TEMPERATURE (ºC)	11.7	11.8	11.4	12.2
EC (mS/cm)	0.233	0.235	0.233	0.211
Ph	7.85	7.91	7.7	7.43
TURBIDITY (NTU)	2.93	3.17	2.13	10.7

3.2 FISH COMMUNITIES

Three species of fish were caught during sampling of LLL and BBL (Table 3). Shortfinned eel (*Anguilla australis*) was the only native species collected during surveys (Figure 4). Single specimens were caught in the Fyke nets in the north and south of LLL. One shortfinned eel was observed during the southern snorkelling transect. This eel was resting on soft sediments near the base of a clump of *Eleocaris* and was estimated at 50 cm long. Lengths of the two eels caught in the Fyke nets were 49 and 56 cm, and both were released unharmed (Table 4).

Mosquitofish (*Gambusia holbrookii*) were collected in both shrimp traps at BBL on both nights, but were not captured in LLL (Table 3). Mosquitofish were observed around the fringe of LLL, and were observed in shallow water (<60 cm deep) while snorkelling in the southern section. The mosquitofish captured in BBL were between 2 and 4.4 cm long.

One goldfish (*Carassius auratus*) was caught on the second night of Fyke netting in BBL (Figure 4, Table 3). This fish was 9.5 cm long and was caught in private property on the western part of the

lagoon, in a path cleared through the Watermilfoil by cattle. The goldfish was humanely euthanized and removed from the site.

Figure 4. Goldfish (*Carassius auratus*) collected from Billy Bung Lagoon (upper photo) and shortfinned eel (*Anguilla australis*) collected from Little Langothlin Lagoon (lower photo).

Table 3. Counts of fish caught in traps at Little Llangothlin and Billy Bung Lagoons.

COMMON NAME	SCIENTIFIC NAME	LLL		BBL	
		FYKE	SHRIMP	FYKE	SHRIMP
Shortfinned Eel	*Anguilla australis*	2			
Mosquitofish	*Gambusia holbrooki*				12
Goldfish	*Carassius auratus*			1	

Table 4. Length of fish captured at Llangothlin and Billy Bung Lagoons. * eel length estimated during snorkelling.

COMMON NAME	LENGTH (CM)
Shortfinned Eel	56
	49
	50 *
Goldfish	9.5

3.3 WATER RAT ASSESSMENT

No water rats (*Hydromys chrysogaster*) were observed during surveys, nor were any signs seen of water rat activity. The southern shore of LLL had many structures suitable for use by water rats as 'tables'. These included fallen logs near or emergent from the water, standing stumps, and rocks. There were no water rat scats or feeding scraps on or around these tables.

3.4 OTHER AQUATIC FAUNA

One eastern longneck turtle (*Chelodina longicollis*) was caught in the Fyke net at the southern trapping site in LLL (Figure 5. A predatory diving beetle (upper left) and eastern longnecked turtle (*Chelodina longicollis,* upper right), and a small colony of 1 cm long *Hydra* attached to stems in the southern part of Little Llangothlin Lagoon.Figure 5). The turtle was released at the point of capture and swam away.

Calanoid copepods dominated the zooplankton community, constituting 82.4 % of all individuals in the sample. The water flea genus *Daphnia* was the second dominant taxa, making up 16.0 % of the zooplankton community. Water mites represented 1.2 % of the community, while hydra made up the remaining 0.4 %.

The invertebrate community living along the edge of the *Eleocaris* bed consisted of 15 taxa (Table 5). Hydra (Figure 5) was the most abundant taxon, followed by midge larvae and flatworms.

Figure 5. A predatory diving beetle (upper left) and eastern longnecked turtle (*Chelodina longicollis,* upper right), and a small colony of 1 cm long *Hydra* attached to stems in the southern part of Little Llangothlin Lagoon.

3.5 MICROBATS

AnaBat results varied between the two nights of survey effort. First night for both sites contained medium levels of bat activity through the evening until approximately 3 am, with the second night 19th of May recording bat activity until approximately 10 pm.

AnaBat surveys over two nights recorded eight species of microbat at the two lagoons (Table 6). Four of these species are listed as vulnerable under the NSW Threatened Species Conservation Act (1987), all of which were recorded at both lagoons (Table 6). The vulnerable species were eastern bentwing

(*Miniopterus schreibersii oceanensis*), eastern false pipistrelle (*Falsistrellus tasmaniensis*), large-footed myotis (*Myotis macropus*), and greater broad-nosed bat (*Scoteanax rueppellii*). The most common species were the eastern bentwing bat followed by Gould's wattled bat (*Chalinolobus gouldii*).

Call profiles for the species recorded are included in Appendix A.

Table 5. Aquatic invertebrate taxa collected in two samples in Little Llangothlin Lagoon.

PHYLUM/ CLASS	ORDER	FAMILY	GENUS	COMMON NAME	OPEN WATER	EDGE MACROPHYTE
Cnidaria	Anthomedusae	Hydridae	*Hydra* sp.	Hydra		
Turbellaria	Tricladida	Dugesiidae	*Spathula* sp.	Flatworms		
Oligochaeta				Segmented worms		
Aracnida	Acarina			Water mites		
Crustacea	Copepoda, Calanoida			Copepods		
	Cladocera	Daphniidae	*Daphnia* sp	Water fleas		
	Amphipoda			Scuds		
Insecta	Diptera	Chironomidae		Midges		
	Trichoptera	Hydroptillidae	*Hellyethira* sp.	Caddis flies		
		Ecnomidae	*Ecnomus* sp.	Caddis flies		
	Hemiptera	Corixidae	*Micronecta* sp.	Waterboatmen		
		Belostomatidae	*Diplonycus* sp.	Giant water bugs		
		Notonectidae	*Enithares* sp.	Back swimmers		
		Dytiscidae	*Onchohydrus scutellaris*	Diving beetle		
	Odonata	Coenagrionidae		Damselfly		

Table 6. Microbat species recorded at Little Llangothlin and Billy Bung Lagoons. Only definite identifications are included. See Appendix A for probable and possible identifications. * denotes vulnerable species.

COMMON NAME	SCIENTIFIC NAME	LLL		BBL	
		16/05/2012	19/05/2012	16/05/2012	19/05/2012
Gould's wattled bat	*Chalinolobus gouldii*	2		19	3
Eastern false pipistrelle	*Falsistrellus tasmaniensis**	3			2
Eastern bentwing	*Miniopterus schreibersii oceanensis**	99	14	12	
	Myotis macropus / Nyctophilus sp			1	
Large-footed myotis	*Myotis macropus**	8		1	
White-striped free-tailed bat	*Tadarida australis*	1		1	
Large forest bat	*Vespadelus darlingtoni*	5	33	7	2
Southern forest bat	*Vespadelus regulus*	1			
Greater broad-nosed bat	*Scoteanax rueppellii**	1			

4 Discussion

4.1 EXOTIC FISH SPECIES

This survey confirmed that there are Goldfish (*Carassius auratus*) present in Billy Bung Lagoon (BBL). The shallow channel connecting BBL to Little Llangothlin Lagoon suggests that they may be present there as well, although none were captured. Goldfish are native to eastern Asia and were initially imported to Australia in the 1860s as an ornamental fish, and subsequent accidental or deliberate releases mean that it now occurs in nearly all parts of NSW (McDowall 1996). Goldfish generally obtain a bronze colour one or two generations after their release from captivity, although some individuals can be orange or black, resembling aquaria specimens. Goldfish tolerate a wide range of environmental conditions, including low dissolved oxygen concentration and high water temperatures (Allen *et al* 2002). Fish mature at around 100 to 150 mm, and lay several thousand small eggs among aquatic plants. The specimen collected in BBL was probably mature, or close to maturity and its bronze colour suggest it was a wild, rather than a captive bred specimen released to the wild.

Goldfish are benthic herbivores, and where there are between 15 000 and 17 000 individuals per hectare, can significantly increase turbidity and decrease benthic vegetation density (Richardson et al. 1995). Goldfish densities in BBL are unlikely to be this high yet, since only one specimen was captured over two nights of trapping. In BBL, near the boundary of the Nature Reserve and private property, turbidity was 3.45 to 5 times higher than it was in LLL. Goldfish may have partially contributed to this, but it is important to keep these impacts in context. A more significant contribution to turbidity levels in the lagoon will come from cattle, which have access to the entire lagoon outside of the Nature Reserve, and regularly walk through the water. Cattle also potentially have a more significant impact on aquatic vegetation density in BBL than Goldfish. While cattle access to the Nature Reserve can be prevented by adequate fencing, Goldfish will have access to the entire lagoon and to LLL.

Apart from increasing turbidity and reducing vegetation density when Goldfish occur in high numbers, their overall environmental impact appears to be relatively benign compared to that of Carp (Riccardi and Cohen 2007). The large bronze fish observed on 11 February 2012 was probably a Goldfish, although may still have been a Carp (*Cyprinus carpio*), since the two species can co-occur. As Carp can grow larger (up to 120 cm, though mostly 30-40 cm) than Goldfish (up to 40 cm, but seldom exceeding 20 cm) and aggregate in larger numbers, they generally have a more significant impact on aquatic ecology (Moffatt and Voller 2002).

The other exotic fish occurring in the Nature Reserve are Mosquitofish (*Gambusia holbrooki*). Mosquitofish occur around the shallow edges of both lagoons. Mosquitofish are native to Mexico and the southern USA and were a popular aquarium species before being introduced worldwide to control mosquito populations and as an aquarium species (Allen et al. 2002). The species is extremely hardy and can survive in water under ice and up to 44 ^{o}C, and tolerate salinities from fresh to marine concentrations (McDowall 1996). Mosquitofish bear up to 9 broods of 50-100 live young per year, and grow to maturity in less than 2 months (McDowall 1996).Their high fecundity and hardiness make them a pest species in many parts of the world, with negative impacts on a wide range of aquatic animals, including invertebrates, fish, and amphibians (Pyke 2008). Gambusia eat aquatic and terrestrial invertebrates and can be aggressive towards other fish and tadpoles, repeatedly nipping their fins. Mosquitofish have been blamed for the decline in range of the Ornate Rainbowfish (*Rhadinocentrus*

ornatus) in Queensland (McDowall 1996) and are very aggressive towards tadpoles (Anstis 2002, Komak and Crossland 2000).

No small native fish are known from LLL or BBL, but Mosquitofish have the potential to impact on frog and invertebrate populations. Field observations and laboratory experiments have found that tadpole survival, rate of development, and size at metamorphosis are all lower in areas populated by Mosquitofish (Pyke 2008). Nine frog species are known from the Little Llangothlin Nature Reserve (Dudley 2011), despite high numbers of Gambusia in the shallow margins, where many species lay their eggs or occur as tadpoles. Tadpole survival rate is improved by dense aquatic vegetation, since Mosquitofish forage mostly in open water (Pyke 2008). Dudley (2011) also suggests that the frogs use seeps, which are free from Mosquitofish. Another strategy that allows amphibians to survive Mosquitofish is to lay their eggs in distasteful or toxic foam masses (Pyke 2008). The three species of Limnodynastidae known from the reserves employ this tactic, laying eggs in floating foam masses amongst vegetation.

4.2 NATIVE FISH SPECIES

Only one species of native fish was collected or observed during this survey. Shortfinned Eels (*Anguilla australis*) were collected from LLL and observed while snorkelling. Shortfinned Eels occur in coastal catchments between the Richmond River (NSW) and Mount Gambier (SA) and are widespread throughout the western Pacific (Allen *et al.*2002). Adults migrate to the ocean to spawn, before returning to freshwaters where potential barriers are overcome. Shortfinned Eels can climb or go around waterfalls, dams, or weirs, and are able to move short distances over saturated ground (McDowall 1996). The species can live to 30 years, although at 50 cm long are likely to be between 10 to 20 years old (Chisnall and Hayes 1991).

4.3 WATER RATS AND OTHER AQUATIC FAUNA

No evidence of water rats (*Hydromys chrysogaster*) was seen at either lagoon during the survey, although one feeding site was found on the northern shore of Billy Bung Lagoon by Dudley (2011). One possible explanation of this is that water rat activity may have declined in the period approaching winter There are fallen logs, rocks, and stumps around LLL that are likely to be suitable for feeding tables, but the highest concentration of these is on the southern shore. However, scats and evidence of bird predation from foxes (*Vulpes vulpes*) was also evident around the lagoon, and this species poses a potential threat to water rats while they are feeding.

One eastern longnecked turtle (*Chelodina longicollis*) was captured in the fyke net along the southern shore of LLL. This species is one of the most commonly encountered freshwater turtles in eastern Australia and is able to travel long distances between water bodies. Longnecked turtles eat a range of aquatic invertebrates, small fish, frogs and tadpoles, and carrion.

The invertebrate fauna collected during this survey are typical of the New England lagoons. *Hydra* were abundant on plant stalks, submerged logs, and rocks. *Hydra* grow up to 1 cm long and use their stinging tentacles to catch microcrustacea such as cladocerans and copepods (Gooderham and Tsyrlin 2002). The zooplankton consisted almost entirely of copepods and cladocerans. Both of these groups of microcrustaceans feed on phytoplankton and detritus and have egg stages that are able to survive in sediments for periods of several years when water bodies dry completely (Williams 1980).

4.4 MICROBATS

Eight species of microbat were recorded from LLL Nature Reserve. One species known from the reserve, Gould's longeared bat (*Nyctophylus gouldi*), was not detected. However this species hibernates from April until September (Churchill 2008), so was unlikely to have been actively calling. Considering that many species of microbat are inactive during cooler months (Strahan 1995), the AnaBat surveys at LLL and BBL were very successful. A surprising amount of bat activity was recorded, particularly on the first night of the survey. Surveys in late spring or summer would likely detect several more species.

Four of the species detected are listed as vulnerable under the NSW Threatened Species Conservation Act. The eastern false pipistrelle (*Falsistrellus tasmaniensis*) is previously known from the LLL Nature Reserve (NSW National Parks and Wildlife Service 1998). This species generally lives in dry sclerophyll forests and roosts in hollow eucalypt trunks in colonies of up to 36 individuals (Churchill 2008).

Eastern bentwing bats (*Miniopterus schreibersii oceanensis*) roost mostly in caves, but also use man-made structures such as road culverts, stormwater drains, mines, and tunnels. This species forms discrete populations around a maternity cave where reproduction occurs. Bats then disperse in February/March to other caves throughout the year, but remain within about 300 km of the maternity cave before returning to it in spring (Strahan 1998).

The large-footed myotis (*Myotis macropus*) roost in small colonies (10-15 individuals) in caves and tree hollows, but seldom occur far from water (Churchill 2008). They feed on flying and aquatic insects, as well as small fish. To gather aquatic prey they fly low over the water and rake the surface with their large (10-14 mm long) feet.

Greater broadnosed bats (*Scoteanax rueppellii*) roost in small colonies in tree hollows. They occur in a variety of habitats from open woodland and swamps, to coastal rainforests and occur at altitudes up to 1200 m. Greater broadnosed bats eat insects such as beetles, flies and moths, as well as spiders. This species also eats other small bats, including little forest bats (*Vespadelus vulturnus*), and eastern blossom bats (*Syconycteris australis*) (Churchill 2008)

4.5 TIMING OF SURVEY

Both bat activity, and the activity of aquatic animals slows down during cooler months (Churchill 2008, McDowall 1996), making the chance of capture or recording lower for surveys conducted near winter. The current survey recorded eight species of bat in the reserve. Surveys in spring or summer will probably add to these numbers, and surveys in warmer periods are recommended if a more comprehensive knowledge of the bat fauna is required.

The three species of fish collected during the survey included two exotic species and one native species. It is possible that additional surveys will find more species, although this is unlikely given that the relative isolation of the lagoon from other water bodies and the fact that the lagoons dry out periodically. It can be assumed that Goldfish occur in Little Llangotholin Lagoon, but if confirmation of this is needed, then sampling in spring or early summer is recommended.

5 References

Allen, G.R., Midgley, S.H., and Allen, M. 2002. Field guide to the freshwater fishes of Australia. Western Australian Museum, Perth.

Anstis, M. 2002. Tadpoles of South-eastern Australia: a guide with keys. Reed New Holland, Sydney.

Chisnall, B.J. and Hayes, J.W. 1991. Age and growth of shortfinned eels (Anguilla australis) in the lower Waikato basin, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research*. 25: 71-80.

Churchill, S. 2008. *Australian Bats*. Second Edition. Allen and Unwin, Sydney.

Komak, S. and Crossland, M.R. 2000. An assessment of the introduced mosquitofish (*Gambusia affinis holbrooki*) as a predator of eggs, hatchlings and tadpoles of native and non-native anurans. *Wildlife Research*, 27: 185-189.

Law, B. S., Anderson, J., and Chidel, M. (1999). Bat communities in a fragmented forest landscape on the south-west slopes of New South Wales, Australia. Biological Conservation 88, 333-345.

Lloyd, A.M., Law, B.S., and Goldingay, R. (2006) Bat activity on riparian zones and upper slopes in Australian timber production forests and the effectiveness of riparian buffers. Biological Conservation 129, 207-220.

McDowall, R. 1996. *Freshwater fishes of southeastern Australia.* Reed Books. Sydney.

McKenzie, N. L., Stuart, A. N., and Bullen, R. D. (2002). Foraging ecology and organisation of a desert bat fauna. Australian Journal of Zoology 50, 529-548.

Mills, D. J., Norton, T. W., Parnaby, H. E., Cunningham, R. B., and Nix, H. A. (1996). Designing surveys for microchiropteran bats in complex forest landscapes - a pilot study from south-east Australia. Special issue: Conservation of biological diversity in temperate and boreal forest ecosystems 85, 149-161.

Moffatt, D. and Voller, J. 2002. Fish and fish habitat of the Queensland Murray-Darling Basin. Department of Primary Industries, Queensland, Brisbane.

Morton, D.W. 1990. Revision of the Australian Cyclopoidae (Copepoda: Cyclopoida). II. *Eucyclops* Claus and *Ectocyclops* Brady. *Australian Journal of Marine and Freshwater Research*, 41: 657-675.

NSW National Parks and Wildlife Service 1998

Parnaby, H. (1992). An interim guide to identification of insectivorous bats of south-eastern Australia. Technical Reports of the Australian Museum Number 8.

Pennay, M., Law, B., and Rhinhold, L. (2004). Bat calls of New South Wales: Region based guide to echolocation calls of Microchiropteran bats. NSW Department of Environment and Conservation, Hurstville.

Pyke, G.H. 2008. Plague minnow or mosquitofish? A review of the biology and impacts of introduced *Gambusia* species. *Annual Reviews of Ecology, Evolution, and Systematics*, 39:171-191.

Reinhold, L., Law, B., Ford, G., and Pennay, M. Key to the bat calls of south-east Queensland and north-east New South Wales. 2001. Queensland, DNR

Swanson, S. 2007. *Field Guide to Australian Reptiles*. Steve Parish Publishing.

Appendix A: Anabat analyses

Anabat results for 2 sites Billy Bung and Little Llangotholin Lagoons, Little Llangotholin Nature Reserve. Shaded cells indicate TSC listed species.

Billy Bung					
Night	**Label**	**Number**	**Definite**	**Probable**	**Possible**
16/05/2012	*Chalinolobus gouldii*	20	19	1	0
16/05/2012	*Falsistrellus tasmaniensis*	3	0	0	3
16/05/2012	*Miniopterus schreibersii oceanensis*	23	12	5	6
16/05/2012	*Myotis macropus / Nyctophilus sp*	1	1	0	0
16/05/2012	*Myotis macropus*	3	1	2	0
16/05/2012	*Tadarida australis*	1	1	0	0
16/05/2012	*Vespadelus darlingtoni*	11	7	0	4
16/05/2012	low	11			
16/05/2012	short	24			
	Non-bat noise	218			
19/05/2012	*Chalinolobus gouldii*	3	3	0	0
19/05/2012	*Miniopterus schreibersii oceanensis*	5	2	1	2
19/05/2012	*Vespadelus darlingtoni*	2	2	0	0
19/05/2012	low	1			
19/05/2012	short	9			
	Non-bat noise	7			
Llangotholin					
Night	**Label**	**Number**	**Definite**	**Probable**	**Possible**
16/05/2012	*Chalinolobus gouldii*	2	2	0	0
16/05/2012	*Falsistrellus tasmaniensis*	4	3	1	0
16/05/2012	*Miniopterus schreibersii oceanensis*	106	99	3	4
16/05/2012	*Myotis macropus*	8	8	0	0
16/05/2012	*Scoteanax rueppellii*	1	1	0	0
16/05/2012	*Tadarida australis*	1	1	0	0
16/05/2012	*Vespadelus darlingtoni*	9	5	1	3
16/05/2012	*Vespadelus regulus*	1	1	0	0
16/05/2012	low	15			
16/05/2012	short	26			
	Non-bat noise	350			
19/05/2012	Miniopterus schreibersii oceanensis	14	14	0	0
19/05/2012	Vespadelus darlingtoni	33	33	0	0
19/05/2012	low	2			
19/05/2012	short	2			
	Non-bat noise	9			

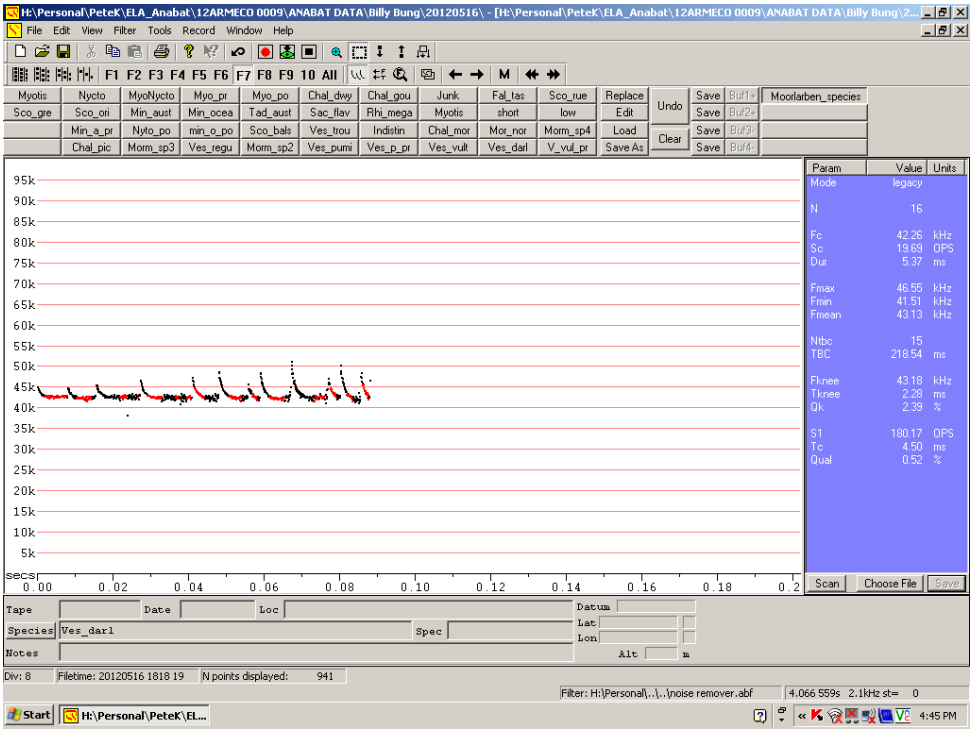

Figure 6: Call profile for *Vespadelus darlingtoni* recorded at Little Llangotholin Nature Reserve at 18:18 on 16 May 2012.

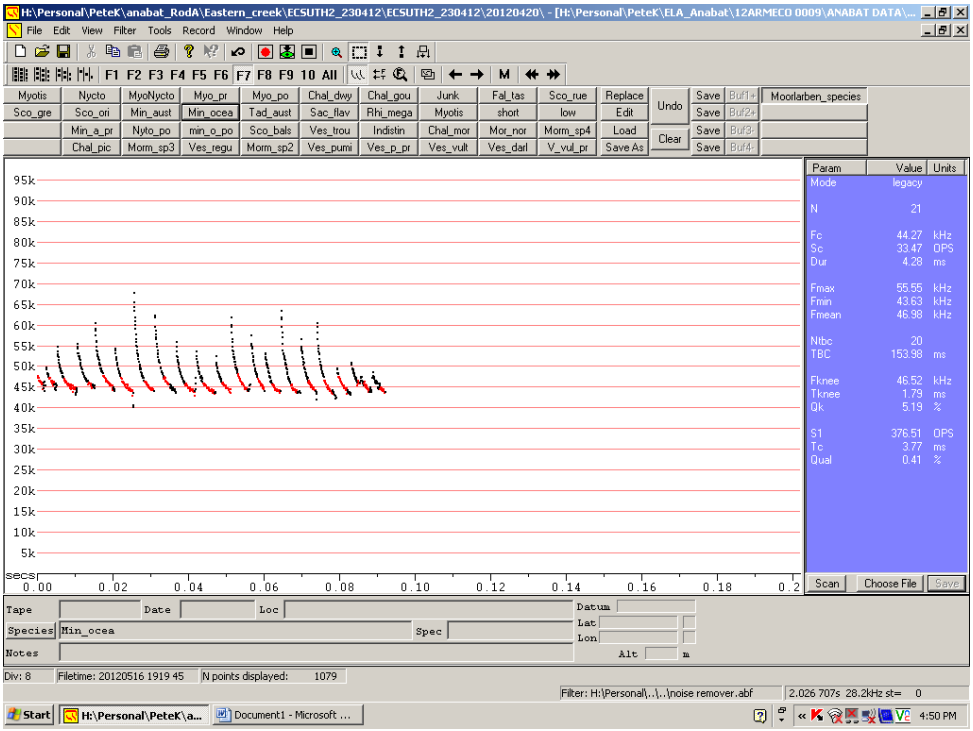

Figure 7: Call profile for *Miniopterus schreibersii oceanensis* recorded at Little Llangotholin Nature Reserve at 19:19 on 16 May 2012.

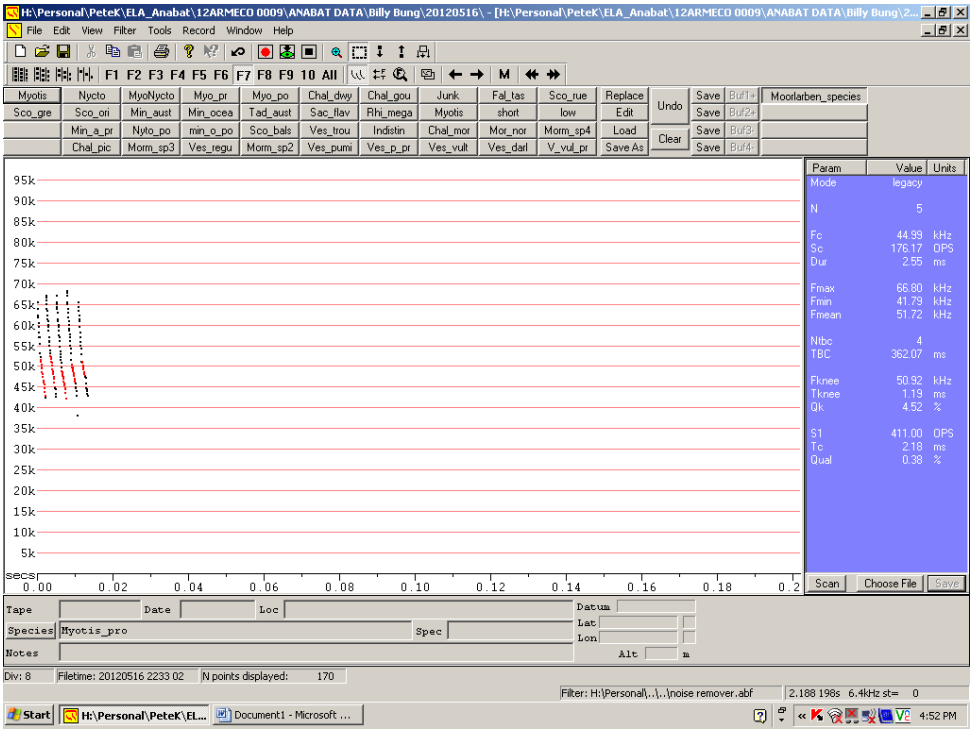

Figure 8: Call profile for *Myotis macropus* recorded at Little Llangotholin Nature Reserve at 22:33 on 16 May 2012.

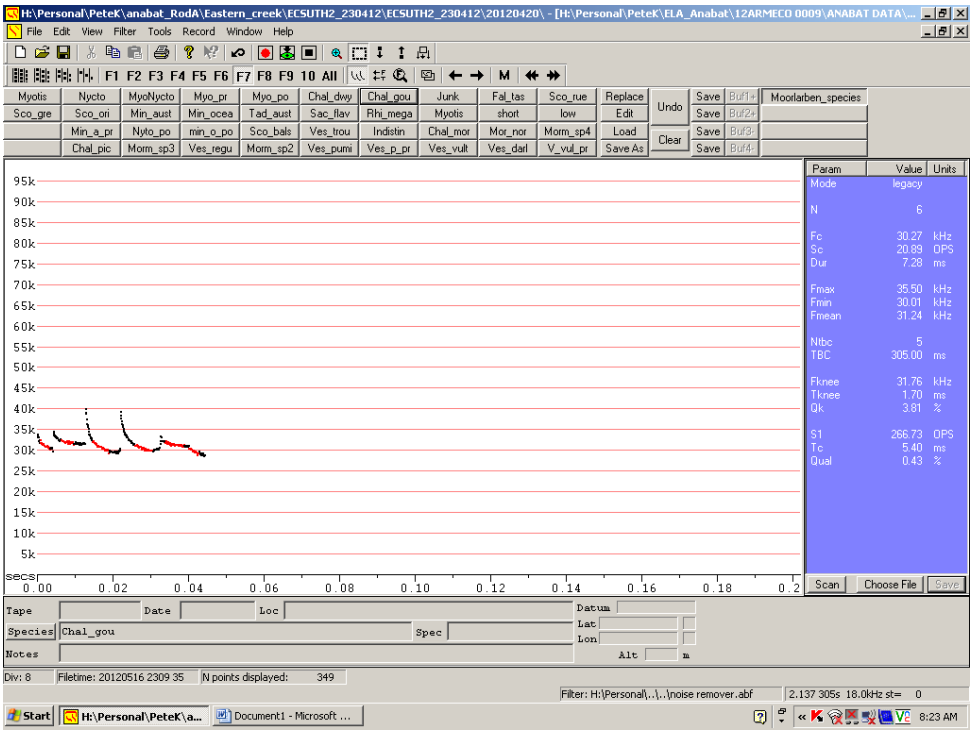

Figure 9: Call profile for *Chalinolobus gouldii* recorded at Little Llangotholin Nature Reserve at 23:09 on 16 May 2012.

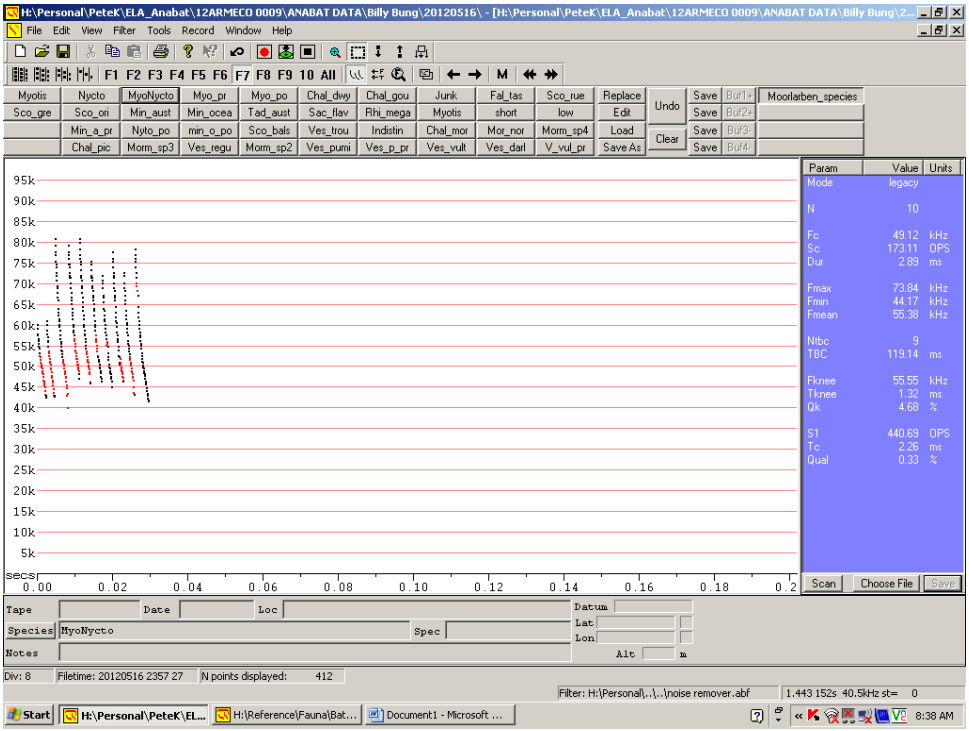

Figure 10: Call profile for *Myotis macropus / Nyctophilus* sp recorded at Little Llangotholin Nature Reserve at 23:57 on 16 May 2012.

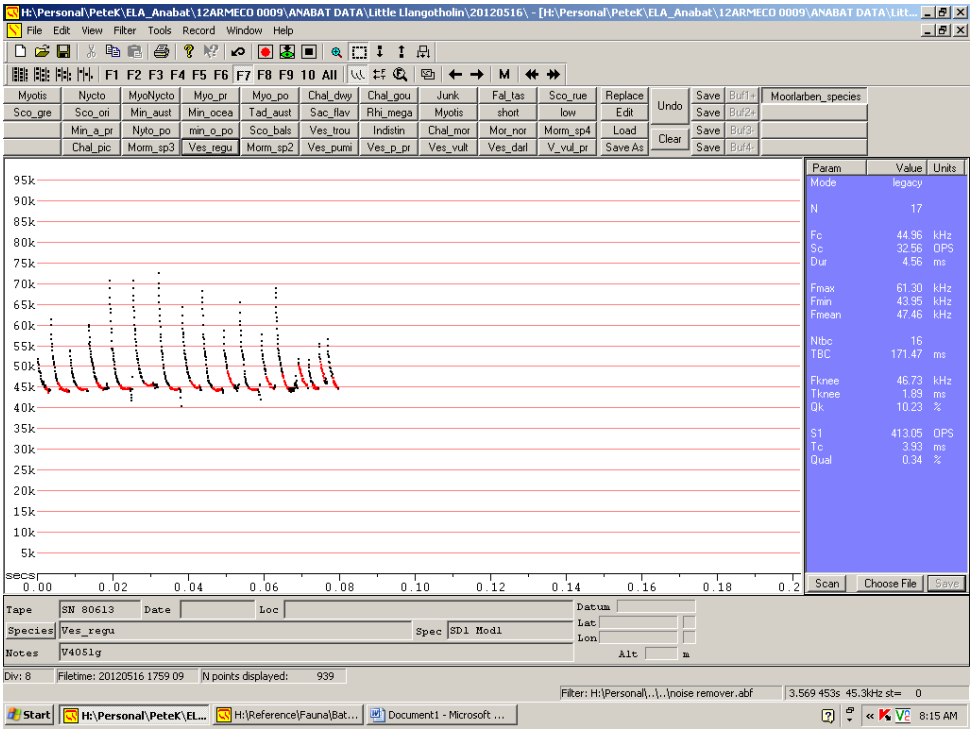

Figure 11: Call profile for *Vespadelus regulus* recorded at Little Llangotholin Nature Reserve at 17:59 on 16 May 2012.

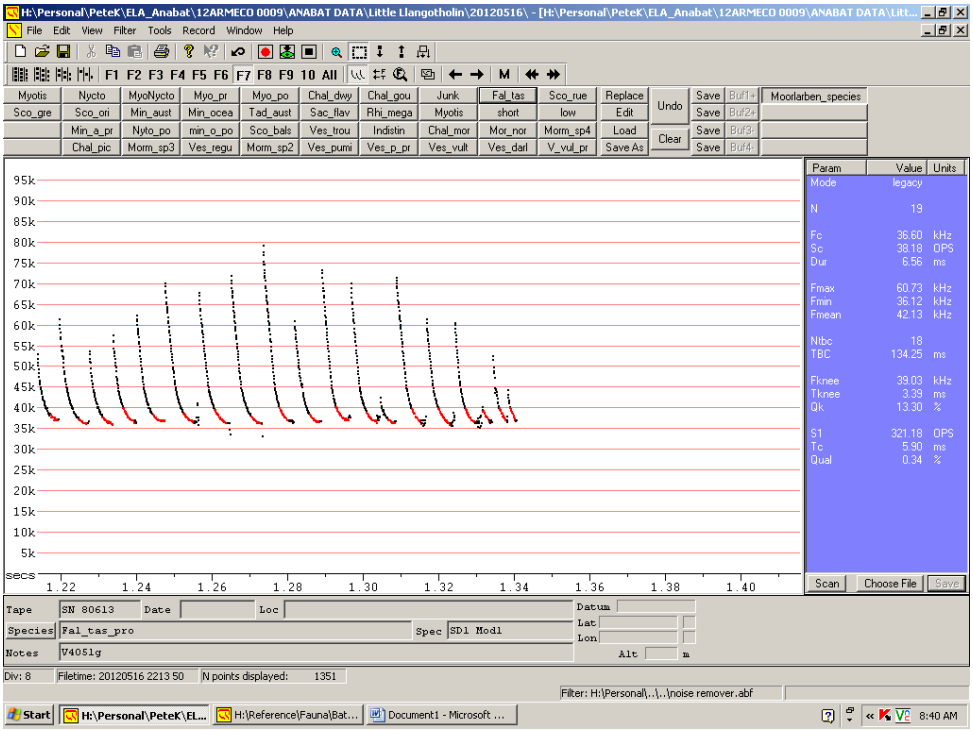

Figure 12: Call profile for *Falsistrellus tasmaniensis* recorded at Little Llangotholin Nature Reserve at 23:09 on 16 May 2012.

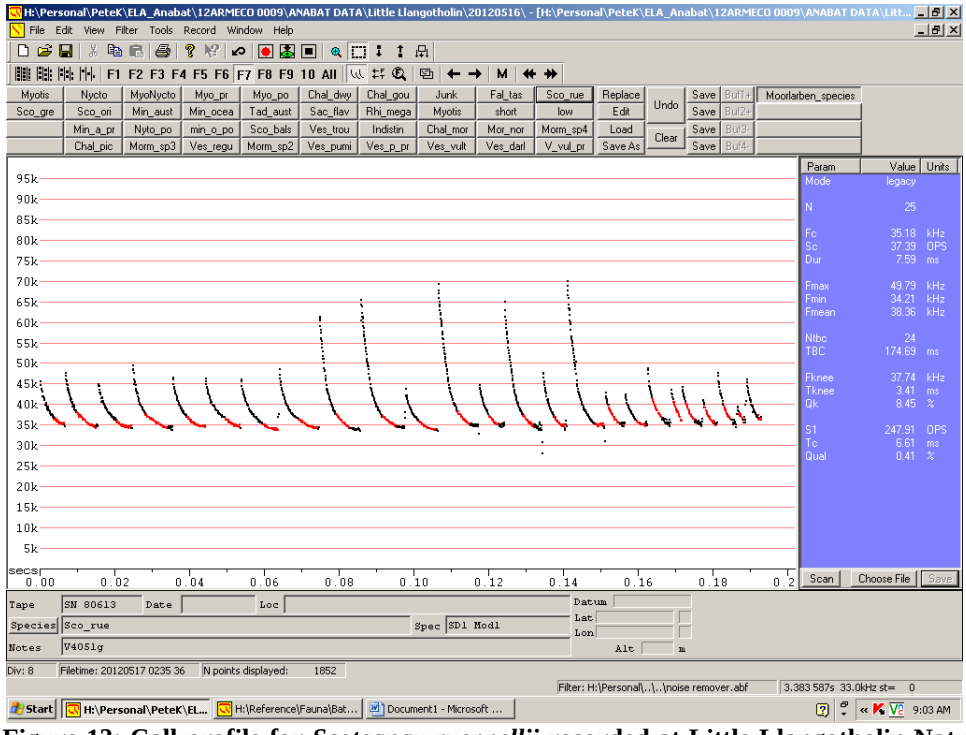

Figure 13: Call profile for *Scoteanax rueppellii* recorded at Little Llangotholin Nature Reserve at 02:35 on 17 May 2012.

HEAD OFFICE
Suite 4, Level 1
2-4 Merton Street
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

SYDNEY
Level 6
299 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9264 0717

ST GEORGES BASIN
8/128 Island Point Road
St Georges Basin NSW 2540
T 02 4443 5555
F 02 4443 6655

CANBERRA
Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 6103 0148

NEWCASTLE
Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 4910 0126

NAROOMA
5/20 Canty Street
Narooma NSW 2546
T 02 4476 1151
F 02 4476 1161

COFFS HARBOUR
35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

ARMIDALE
92 Taylor Street
Armidale NSW 2350
T 02 8081 2681
F 02 6772 1279

MUDGEE
Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1230
F 02 6372 9230

PERTH
Suite 1 & 2
49 Ord Street
West Perth WA 6005
T 08 9227 1070
F 08 9322 1358

WOLLONGONG
Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 4268 4361

GOSFORD
Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1220
F 02 4322 2897

DARWIN
16/56 Marina Boulevard
Cullen Bay NT 0820
T 08 8989 5601

BRISBANE
PO Box 1422
Fortitude Valley QLD 4006
T 0400 494 366