Biodisparity in fish communities in the Coorong, and Lakes Alexandrina and Albert Ramsar Site

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Background

The Coorong, and Lakes Alexandrina and Albert site was listed as a 'Wetland of International Importance' under the Ramsar Convention in 1985. As a signatory to the Ramsar Convention, the Australian government is obligated to retain the 'Ecological Character' of the site. The site comprises a diverse range of habitats with differing hydrological, physical and physico-chemical attributes, thus harbouring highly diverse fish assemblages unique within the Murray-Darling Basin. This includes species of national and state conservation.

Important components of ecological character are measures of 'biodiversity' and 'biodisparity', whereby biodiversity relates to species richness and biodisparity relates to measures of uniqueness in morphology, life-history, function and/or genetics within a community (Gould 1989; DeVaney 2010). The biodisparity of a wetland community will be determined by the diversity and predictability of its habitats in time and space, i.e. the more heterogeneous and unpredictable the habitats, the greater the biodisparity of the fish fauna. Measures of both biodiversity and biodisparity should therefore be used to assess the international importance of a wetland.

There is a need for clearly articulated rationale for interpreting and applying the current Ramsar criteria within the context of the new ECD framework. Quantitative data and appropriate justification (i.e. using expert opinion, comparison with global biodiversity in similar climatic zones) to support the meeting of Ramsar criteria, including Criteria 7 and 8 for fish communities is required. The listing of a wetland under the Ramsar convention should be selected on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology and indicates that in the first instance, wetlands of international importance to waterfowl at any season should be included (Ramsar Convention Article 2.2). Listing may be based upon several different criteria, some of which are specific to different biotic groups, including fish. Indeed the following criteria specifically relate to fish-based parameters in regards to Ramsar listing

- Criteria 7: ' *a wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity*.'
- Criteria 8: '*a wetland should be considered internationally important if it is an important source for food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere depend*'.

(Criteria taken from Appendix 4 Department of the Environment, Water, Heritage and the Arts (2008).

The specific objectives of the current report are,

1. To assess whether the Coorong, and Lakes Alexandrina and Albert site meets Ramsar criteria 7 and 8 based on available literature and fish data (including a comparison of global biodiversity in similar climatic zones).
2. Comment on the potential to identify changes in ecological character at the site (based on available fish data).

3. Provide a summary of knowledge gaps.
4. Provide recommendations for future monitoring and research based on knowledge gaps.

Assessment of the Coorong, and Lakes Alexandrina and Albert site against Ramsar criteria 7 and 8

The Ramsar convention provides a series of points to guide determination of concordance with criteria. To determine if the Coorong, and Lakes Alexandrina and Albert site meets Criteria 7, the site should:

- Support a high diversity of fishes and shellfishes related to several factors: number of taxa, different life-history stages, species interactions, and the complexity of interactions between the taxa and the external environment
- Support significant numbers (at least 10%) of endemic species or genetically distinct intraspecific categories such as geographical races
- Support a community that demonstrates high biodisparity (i.e. large range of morphologies and reproductive styles).

To determine if the Coorong, and Lakes Alexandrina and Albert site meets Criteria 8, the Site should:

- Support nursery, breeding and/or feeding grounds for fish species

The following provides support for the listing the Coorong, and Lakes Alexandrina and Albert site under the Ramsar convention in concordance with Criteria 7 and 8 and guiding points above.

Numerous studies, investigating various aspects of fish ecology, have been undertaken in the Coorong, and Lakes Alexandrina and Albert site and this literature indicates that 90 individual fish species have been recorded from the site, representing 47 different families (Tables 1). Nonetheless, large proportions of these species (45) are of marine origin and are irregularly sampled within the site. Recent monitoring supports this, indicating that the site regularly supports 34 fish species, representing 22 families (Table 2). The total number of taxa observed and regularly recorded at the site seems low by international standards but this is misleading. In regards to freshwater fish species, Australia is often considered to have a depauperate fauna, with just 300 native species, 46 of which are native to the Murray-Darling Basin. Of these, over 30 have been recorded in the Lower Lakes, suggesting it harbours arguably the most diverse freshwater fish assemblage in the MDB. Additionally, species richness in the Murray Mouth Estuary (see Zampatti *et al* 2010) is typically similar to that observed in other temperate estuaries in Southern Australia (Humphries et al 1992; Potter and Hyndes 1999 and references therein) and South Africa (Whitfield 1999; Lamberth *et al* 2008).

The Coorong, and Lakes Alexandrina and Albert site harbours a diverse fish community, in regards to species richness, but perhaps more notably, the fish community of the region exhibits high levels of biodisparity in regards to morphology and life history strategy. Fishes of the region range in size (adult length) from 40 mm to > 1 m possess contrasting morphologies, from benthic flatfishes (i.e. Pleuronectidae) to fusiform pelagic species (e.g. Arripidae) and represent a wide range of different life history strategies. Elliott *et al* (2007) present a guild approach to classify the life history strategies of fishes based upon their use of estuaries and suggest eight disparate life history guilds globally; namely marine migrant, marine straggler, estuarine resident, estuarine migrant, freshwater migrant, freshwater straggler, anadromous and catadromous. These guilds differ based upon their dependence upon estuaries (i.e. dependent v independent), the environment within which spawning occurs (freshwater, estuarine or marine), the life stages that utilise estuaries

(i.e. all, juvenile, adult) and the conditions under which estuaries are utilised (e.g. high freshwater input v low freshwater input). All eight guilds suggested by Elliott *et al* (2007) are represented by species regularly sampled within the Coorong, and Lakes Alexandrina and Albert site (Table 2).

The Coorong, and Lakes Alexandrina and Albert site is also home to a number of genetically distinct populations for species within South Australia and the Murray-Darling Basin (Hammer *et al*, 2009). However, due to the fact that populations of these species are found in other areas of Australia, it is thought that this site does not meet this particular point.

The Coorong, and Lakes Alexandrina and Albert site, by virtue of the diversity of habitats present, the influence of hydrology within the MDB and interaction with river regulation, typically exhibits highly variable physical (e.g. water level, connectivity), chemical (e.g. salinity)and biological (e.g. productivity) characteristics at a range of temporal and spatial scales. Accordingly, patterns of fish assemblage structure (i.e. species composition and abundance) are highly variable (Zampatti *et al* 2010; Wedderburn *et al* 2012) and influenced by complex interactions between taxa and the external environment. Whilst interactions between taxa and the external environment are species-specific, Bice (2010a) suggests that the flow regime and resulting physico-chemical environment, and connectivity, are broadly important to fish communities of the Coorong, and Lakes Alexandrina and Albert site and affect the general functioning of the system.

This is supported by numerous studies investigating the effects of flow, connectivity, and physico-chemical conditions either separately or in combination within the Coorong, and Lakes Alexandrina and Albert site and in broader estuarine and coastal ecosystems.

- On-going lack of freshwater inflows into the Coorong/Murray Mouth had a negative impact on Greenback flounder, Mulloway, Black bream and Congolli. Noell *et al* 2009.
- On-going lack of freshwater inflows into the Coorong/Murray Mouth and therefore lack of connectivity between freshwater, estuarine and marine environments lead to failed recruitment of catadromous and anadromous species between 2002 and 2010. Zampatti *et al* 2010.
- On-going lack of freshwater inflows into the Coorong/Murray Mouth and subsequent increases in salinity have influence the composition of fish assemblages and limited distributions. Noell *et al* 2009.
- There has been a clear shift in fish assemblage composition in the Coorong from assemblages dominated by marine/estuarine species in 2006/07 during drought (Noell *et al*. 2009), to assemblages dominated primarily by freshwater/estuarine species during years of high flow (2010-2012) (Ye *et al*. 2012a).
- Similar to previous studies in the Coorong, a general decline in species richness and diversity with increasing distance from the Murray Mouth is likely a response to the strong salinity gradient. Certain fish taxa probably forced out of the more saline areas due to the increasing osmoregulatory stress and/or diminishing food resources (Whitfield, 1999) (Noell, *et al* 2009) (Ye *et al* 2012).
- The effects of reduced or no freshwater inflows on fish in estuarine and coastal ecosystems include: impediment to migration of diadromous species without attractant flows, particularly when there are physical barriers (e.g. barrages); lack of stimulus for spawning; indirect impact on spawning and recruitment success as a result of modified water temperature and salinity; alteration of

nursery habitat with changes in food, temperature, turbidity and salinity; reduction in primary production and trophic structure of ecosystem; and changes in fish assemblages (see Drinkwater & Frank (1994) and Gillanders & Kingsford (2002) for thorough reviews of these effects). Noell *et al* 2009.

- Freshwater flows can influence fish species that inhabit estuaries directly through changes in physico-chemical conditions (e.g. turbulence, water quality variables), or indirectly through modifying primary and secondary productivity, habitat availability and quality, thereby influencing fish growth and recruitment (and subsequent abundance) (Whitfield 2005; Robins and Ye 2007) (Ye *et al* 2012a).

In summary, several studies indicate that The Coorong, and Lakes Alexandrina and Albert site support a high diversity of fishes in relation to species richness, as well as high level of biodisparity in relation to species with differing morphologies and life-histories, and there is a high level of complexity of interactions between taxa and the external environment. The information outlined above indicates that the site could meet the requirements of this particular point under Criteria 7.

Estuarine resident species are those that utilise estuaries for their entire life cycle (Elliott *et al* 2007) (There are numerous estuarine resident species commonly monitored in the Ramsar site (Ye *et al* 2012a), including but small-mouthed hardyhead, Tamar River goby, greenback flounder, and black bream, , that utilise the CLLMM site as a spawning ground, nursery and as adult habitat. Furthermore the Ramsar site represents migratory pathway, and potentially a nursery, for several diadromous fish species, including common galaxias, congolli and lamprey species, which require move between freshwater (Lakes Alexandrina) and marine environments (Coorong/Murray Mouth) in order to complete their life cycle (Bice 2010a).

The Ramsar site is also important for 'marine migrants' species, such as mulloway, which tend to utilise the Coorong estuary during the juvenile life stage. Ferguson *et al* 2008 suggest that the population of mulloway (*Argyrosomus japonicus*) located about the Murray River system are estuarine dependent and that the estuary provides important refuge for juveniles. Furthermore, Ferguson et al (2008) present evidence that year class strength in mulloway is positively correlated with freshwater flow to the Coorong and may influence population dynamics more broadly across Australia's southern coast. In support of this supposition, recent evidence suggests there is some level of movement of mulloway between the Coorong and the Glenelg River estuary in south-western Victoria, a movement of ~400 km (Jason Lieschke Pers comm.)

The Coorong has been highlighted as an important nursery ground and habitat for the marine migrant sandy sprat (*Hyperlophus vittatus*) (Rogers and Ward, 2007). The sandy sprat is small-bodied (<100 mm in length) schooling, pelagic clupeid, which has been shown to be a significant prey item of piscivorous fishes (Hoedt and Dimmlich 1994) and piscivorous birds, including little penguins (Klomp and Wooler 1995) and little terns (Taylor and Roe 2004). It has been suggested that this species may be important for trophic dynamics within the CLLMM Ramsar site, particularly within the Coorong estuary (Bice *et al* 2012).

In summary the Ramsar site provides a range of fish species with sources of food, spawning grounds and nurseries, and acts as a migration path on which diadromous fishes of the region depend.

1. ***Comment on the potential to identify changes in ecological character at the site (based on available fish data).***

There is extensive fish data available for the Coorong, and Lakes Alexandrina and Albert site for small-bodied fish abundance and distribution in the Lakes, as well as Coorong fish abundance and distribution.

Available fish data for the Ramsar site includes:

- Coorong fish monitoring – Assemblage structure, abundance and distribution 2009/2013.
- Small-bodied threatened fish - Assemblage structure, abundance/population dynamics threatened. 2008 – 2013
- Fishway monitoring - Assemblage structure, abundance/population dynamics threatened, spawning/recruitment, movement. 2006 – 2012
- Fishway assessments and monitoring movements of black bream within the Coorong - Fishway effectiveness, movement. 2004/5 and 2009 – 2012
- Monitoring movements of adult female congollis – Movement 2009-2010
- Wetland monitoring – Assemblage structure, abundance/population dynamics, influence of management interventions. 2009 – 2011

The summary of data above suggests that there is potential to identify changes in certain aspects of the ecological character at the site (e.g. population status of threatened small-bodied fish). There are however many knowledge gaps surrounding the fish communities and interactions within the site, which may limit the ability to identify changes (e.g. population status of threatened large-bodied fish and habitat and food requirements that contribute to recruitment).

2. ***Provide a summary of knowledge gaps.***

- The degree of movement of different species between Lake Alexandrina and the River Murray and between Lake Alexandrina and Lake Albert remains largely unknown (Bice 2010a).
- Bice 2010a outlines more knowledge gaps that can be further discussed here, also the latest monitoring reports may be able to help.
- Large bodied native fish (Murray cod, Golden perch, etc) status/distribution in Lakes Alexandrina and Albert
- Critical habitat requirements and food resources that contribute to recruitment success (within the Coorong)
- Diadromous species response to different freshwater flows (i.e. linkages between spawning/migration to flow regimes in terms of timing and duration)
- Specific habitat associations of fishes in the Lower Lakes
- Influence of the Coorong on populations of marine migrant species more broadly along the southern coastline. Does the Coorong estuary produce significant proportions of recruits to populations outside the site?

3. ***Provide recommendations for future monitoring and research based on knowledge gaps.***

- Further targeted research is required to determine the mechanisms involved in fish assemblage and recruitment responses, and how they are linked to flow regimes (e.g. magnitude, timing and duration)
- Critical habitat requirements and food resources that contribute to recruitment success for key estuarine fish species
- Connectivity requirements for assemblages

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Appendix 1.

Table 1. Fish species found in Lower Lakes and Coorong

	Common Name	**Scientific Name**	**Family**	**Functional Group**	**Reference:**
1	Australian smelt	*Retropinna semoni*	Retropinnidae	Freshwater migrant	Zampatti, *et al* 2011
2	Flat-headed gudgeon	*Philypnodon grandiceps*	Eleotridae	Freshwater migrant	Zampatti, *et al* 2011
3	Bony herring (bream)	*Nematalosa erebi*	Clupeidae	Freshwater straggler	Zampatti, *et al* 2011
4	Dwarf flat-headed gudgeon	*Philypnodon macrostomus*	Eleotridae	Freshwater straggler	Zampatti, *et al* 2011
5	Common carp	*Cyprinus carpio*	Cyprinidae	Freshwater straggler	Zampatti, *et al* 2011
6	Redfin perch	*Perca fluviatilis*	Percidae	Freshwater straggler	Zampatti, *et al* 2011
7	Eastern Gambusia	*Gambusia holbrooki*	Poecilidae	Freshwater straggler	Zampatti, *et al* 2011
8	Carp gudgeon complex	*Hypseleotris spp.*	Eleotridae	Freshwater straggler	Higham, *et al* 2002
9	Silver perch	*Bidyanus Bidyanus*	Terapontidae	Freshwater straggler	Higham, *et al* 2002
10	Goldfish	*Carassius auratus*	Cyprinidae	Freshwater straggler	Higham, *et al* 2002
11	Murray hardyhead	*Craterocephalus fluviatilis*	Atherinidae	Freshwater straggler	Higham, *et al* 2002
12	Unspecked hardyhead	*Craterocephalus stercusmuscarum fulvus*	Atherinidae	Freshwater straggler	Higham, *et al* 2002
13	River blackfish	*Gadopsis marmoratus*	Gadopsidae	Freshwater straggler	Higham, *et al* 2002
14	Mountain galaxias	*Galaxias olidus*	Galaxiidae	Freshwater straggler	Higham, *et al* 2002
15	Spangled perch	*Leiopatherapon unicolour*	Terapontidae	Freshwater straggler	Higham, *et al* 2002
16	Murray cod	*Maccullochella peeli*	Percichthyidae	Freshwater straggler	Higham, *et al* 2002
17	Golden perch	*Macquaria ambigua*	Percichthyidae	Freshwater straggler	Higham, *et al* 2002
18	Murray-Darling rainbowfish	*Melanotaenia fluviatilis*	Melanotaeniidae	Freshwater straggler	Higham, *et al* 2002
19	Southern purple spotted gudgeon	*Mogurnda adspersa*	Eleotridae	Freshwater straggler	Higham, *et al* 2002
20	Southern pygmy perch	*Nannoperca australis*	Nannopercidae	Freshwater straggler	Higham, *et al* 2002
21	Yarra pygmy perch	*Nannoperca obscura*	Nannopercidae	Freshwater straggler	Hammer *et al* 2002.
23	Rainbow trout	*Oncorhynchus mykiss*	Salmonidae	Freshwater straggler	Higham, *et al* 2002
24	Brown trout	*Salmo trutta*	Salmonidae	Freshwater straggler	Higham, *et al* 2002
25	Freshwater (eel-tailed) catfish	*Tandanus tandanus*	Plotosidae	Freshwater straggler	Higham, *et al* 2002
26	Tench	*Tinca tinca*	Cyprinidae	Freshwater straggler	Higham, *et al* 2002
27	Common galaxias	*Galaxias maculatus*	Galaxiidae	Anadromous	Higham, *et al* 2002

28	Congolli	*Pseudaphritis urvillii*	Bovichtidae	Catadromous/Estuarine Resident	Zampatti, *et al* 2011
29	Short-finned eel	*Anguilla australis*	Anguillidae	Catadromous	Higham, *et al* 2002
30	Estuary Perch	*Macquaria colonorum*	Percichthyidae	Catadromous	Higham, *et al* 2002
31	Climbing galaxias	*Galaxias brevipinnis*	Galaxiidae	Anadromous	Higham, *et al* 2002
32	Short-headed lamprey	*Mordacia mordax*	Mordaciidae	Anadromous	Zampatti, *et al* 2011
33	Pouched lamprey	*Geotria australis*	Geotriidae	Anadromous	Zampatti, *et al* 2011
34	River garfish	*Hyporhamphus regularis*	Hemiramphidae	Estuarine migrant/resident	Higham, *et al* 2002
35	Small-mouthed hardyhead	*Atherinosoma micostoma*	Atherinidae	Estuarine resident	Higham, *et al* 2002
36	Tamar River goby	*Afurcagobius tamarensis*	Gobiidae	Estuarine resident	Higham, *et al* 2002
37	Blue-spot goby	*Pseudogobius olorum*	Gobiidae	Estuarine resident	Higham, *et al* 2002
38	Lagoon goby	*Tasmanogobius lasti*	Gobiidae	Estuarine resident	Higham, *et al* 2002
39	Bridled goby	*Arenogobius bifrenatus*	Gobiidae	Estuarine resident	Higham, *et al* 2002
40	Greenback flounder	*Rhombosolea tapirina*	Pleuronectidae	Estuarine resident	Higham, *et al* 2002
41	Long-snouted flounder	*Ammotretis rostratus*	Pleuronectidae	Estuarine resident	Higham, *et al* 2002
42	Estuary catfish/cobbler	*Cnidoglanis macrocephalus*	Plotosidae	Estuarine resident	Higham, *et al* 2002
43	Black bream	*Acanthopagrus butcheri*	Sparidae	Estuarine resident	Higham, *et al* 2002
44	Yellow-eyed mullet	*Aldrichetta forsteri*	Mugilidae	Estuarine migrant/resident	Higham, *et al* 2002
45	Flat-tailed mullet/Jumping mullet/etc	*Liza argentea*	Mugilidae	Estuarine migrant	Zampatti, *et al* 2011
46	Sea mullet	*Mugil cephalus*	Mugilidae	Marine migrant	Higham, *et al* 2002
47	Mulloway	*Argyrosomus japonicus*	Sciaenidae	Marine migrant	Zampatti, *et al* 2011
48	Soldier fish	*Gymnapistes marmoratus*	Tetrarogidae	Marine migrant	Zampatti, *et al* 2011
49	Smooth toadfish	*Tetractenos glaber*	Tetraodontidae	Marine migrant	Zampatti, *et al* 2011
50	Prickly toadfish	*Contusus brevicaudus*	Tetraodontidae	Marine migrant	Zampatti, *et al* 2011
51	King George whiting	*Sillaginodes punctatus*	Sillaginidae	Marine migrant	Zampatti, *et al* 2011
52	Yellowfin whiting	*Sillago schomburgkii*	Sillaginidae	Marine migrant	Zampatti, *et al* 2011
53	Australian herring	*Arripis georgianus*	Arripidae	Marine migrant	Zampatti, *et al* 2011
54	Australian salmon	*Arripis truttacea*	Arripidae	Marine migrant	Zampatti, *et al* 2011
55	Sandy sprat	*Hyperlophus vittatus*	Clupeidae	Marine migrant	Zampatti, *et al* 2011
56	Southern garfish	*Hyporhamphus melanchir*	Hemiramphidae	Marine migrant	Zampatti, *et al* 2011

57	Gummy shark	*Mustelus antarcticus*	Triakidae	Marine migrant	Zampatti, *et al* 2011
58	Southern eagle ray	*Myliobatis australis*	Myliobatidae	Marine migrant	Zampatti, *et al* 2011
59	Blue sprat	*Spratelloides robustus*	Clupeidae	Marine straggler	Zampatti, *et al* 2011
60	Australian anchovy	*Engraulis australis*	Engraulidae	Marine straggler	Zampatti, *et al* 2011
61	Australian pilchard	*Sardinops sagax*	Clupeidae	Marine straggler	Zampatti, *et al* 2011
62	Pugnose pipefish	*Pugnaso curtirostris*	Syngnathidae	Marine straggler	Zampatti, *et al* 2011
63	Tuckers pipefish	*Mitotichthys tuckeri*	Syngnathidae	Marine straggler	Zampatti, *et al* 2011
64	Big belly seahorse	*Hippocampus abdominalis*	Syngnathidae	Marine straggler	Zampatti, *et al* 2011
65	Zebra fish	*Girella zebra*	Kyphosidae	Marine straggler	Zampatti, *et al* 2011
66	Tasmanian blenny	*Parablennius tasmanianus*	Blenniidae	Marine straggler	Zampatti, *et al* 2011
67	Silver spot (kelpfish)	*Threpterius maculosus*	Chironemidae	Marine straggler	Zampatti, *et al* 2011
68	Bridled leatherjacket	*Acanthaluteres spilomelanurus*	Monacanthidae	Marine straggler	Zampatti, *et al* 2011
69	Sea sweep	*Scorpis aequipinnis*	Kyphosidae	Marine straggler	Zampatti, *et al* 2011
70	Blue grouper	*Achoerodus gouldii*	Labridae	Marine straggler	Higham, *et al* 2002
71	Ornate cowfish	*Aracana ornate*	Aracanidae	Marine straggler	Higham, *et al* 2002
72	Red gurnard	*Chelidonichthys kumu*	Triglidae	Marine straggler	Higham, *et al* 2002
73	Sand fish	*Lesueurina platycephala*	Leptoscopidae	Marine straggler	Higham, *et al* 2002
74	Southern crested weedfish	*Cristiceps australis*	Clinidae	Marine straggler	Higham, *et al* 2002
75	Old wife	*Enoplosus armatus*	Enoplosidae	Marine straggler	Higham, *et al* 2002
76	Gunn's leatherjacket	*Eubalichthys gunnii*	Monacanthidae	Marine straggler	Higham, *et al* 2002
78	Red Gurnard Perch	*Heliocolenus percoides*	Sebastidae	Marine straggler	Higham, *et al* 2002
79	Striped perch	*Helotes sexilineatus*	Terapontidae	Marine straggler	Higham, *et al* 2002
80	Longnose weedfish	*Heteroclinus tristis*	Clinidae	Marine straggler	Higham, *et al* 2002
81	Six-spined leatherjacket	*Meuschenia freycineti*	Monacanthidae	Marine straggler	Higham, *et al* 2002
82	Goblin shark	*Mitsukurina owstoni*	Mitsukurinidae	Marine straggler	Higham, *et al* 2002
83	Black spotted gurnard perch	*Neosebastes nigropunctatus*	Neosebastidae	Marine straggler	Higham, *et al* 2002
84	Common gurnard perch	*Neosebastes scorpaenoides*	Neosebastidae	Marine straggler	Higham, *et al* 2002
85	Snapper	*Pagrus auratus*	Sparidae	Marine straggler	Higham, *et al* 2002

86	Velvet leatherjacket	*Parika scaber*	Monacanthidae	Marine straggler	Higham, *et al* 2002
87	Common seadragon	*Phyllopteryx taeniolatus*	Syngnathidae	Marine straggler	Higham, *et al* 2002
88	Southern saw shark	*Pristiophorus nudipinnis*	Pristiophoriformes	Marine straggler	Higham, *et al* 2002
89	Trevally	*Pseudocaranx dentex*	Carangidae	Marine straggler	Higham, *et al* 2002
90	Rough leatherjacket	*Scobinichthys granulatus*	Monacanthidae	Marine straggler	Higham, *et al* 2002
92	Richardson's toadfish	*Tetractenos hamlitoni*	Tetraodontidae	Marine straggler	Higham, *et al* 2002
93	Southern longfin goby	*Favonigobius lateralis*	Gobiidae	Marine straggler	Ye, *et al* 2011

Table 2. Spawning information on fish found in CLLMM site

	Common Name	Scientific Name	Spawning mode	Egg type	Literature source
	Large-bodied native freshwater species				
9	Silver perch	*Bidyanus Bidyanus*	2	P	5,11,26
17	Golden perch	*Macquaria ambigua*	2	P	5,11,26
16	Murray cod	*Maccullochella peeli*	1	N	5,11,16,24,26
3	Bony herring	*Nematalosa erebi*	3b	P	6,26
25	Freshwater (eel-tailed) catfish	*Tandanus Tandanus*	1	N	5,11,26
	Common small-bodied native freshwater species				
8	Carp gudgeon complex	*Hypseleotris spp.*	3a	N	5,11,26
2	Flat-headed gudgeon	*Philypnodon grandiceps*	3a	N	5,11,26
4	Dwarf flat-headed gudgeon	*Philypnodon macrostomus*	3a?	N	5,11,26
1	Australian smelt	*Retropinna semoni*	3a	R	5,11,26
18	Crimson spotted (Murray) rainbowfish	*Melanotaenia fluviatilis*	3b	A	5,11,26
12	Fly specked (Unspecked) hardyhead	*Craterocephalus stercusmuscarum fulvus*	3a?	A	5,11,26
	Rare or endangered small-bodied freshwater species				
11	Murray hardyhead	*Craterocephalus fluviatilis*	3a	A	5,11,20,23,26
19	Southern purple-spotted gudgeon	*Mogurnda adspersa*	3a	N	5,11,25,26
20	Southern pygmy perch	*Nannoperca australis*	3b	A	5,11,26
21	Yarra pygmy perch	*Nannoperca obscura*	3b	A	26,27
	Alien freshwater species				
10	Goldfish	*Carassius auratus*	3a	A	26
5	Common carp	*Cyprinus carpio*	3a	A	18,26
7	Eastern Gambusia	*Gambusia holbrooki*	Live bearer	L	26
6	Redfish perch	*Perca fluviatilis*	3a	A	26,28
	Diadromous species (anadromous and catadromous)				
33	Pouched lamprey	*Geotria australis*	3b?	R	5,11,26
32	Short-headed lamprey	*Mordacia mordax*	3b?	R	5,11,26
27	Common galaxias	*Galaxias maculatus*	3b	A	5,11,26
29	Short-finned eel	*Anguilla australis*	?	P?	5,11,26
30	Estuary perch	*Macquaria colonorum*	2?	P	5,11,26
28	Congolli	*Pseudaphritis urvillii*	3b?	R?	2,26,29

	Estuarine species				
44	Yellow-eyed mullet	*Aldrichetta forsteri*	3b	P	21
43	Black bream	*Acanthopagrus butcheri*	3a	P	4,12,13,15,17
39	Bridled goby	*Arenogobius bifrenatus*	3a	N	3,11,12
36	Tamar goby	*Afurcagobius tamarensis*	3a	N?	12,26
37	Bluespot goby	*Pseudogobius olorum*	3a	N	9,26
38	Lagoon goby	*Tasmanogobius lasti*	3a	N?	26
40	Greenback flounder	*Rhombosolea tapirina*	3a	P	1,14
35	Small-mouthed hardyhead	*Atherinosoma micostoma*	3a	A	8
	Marine species				
47	Mulloway	*Argyrosomus japonicus*	?	P?	18

Egg Type: N – eggs guarded or laid in nest, A – adhesive eggs attached to structure/vegetation with no parental care, R – demersal eggs distributed randomly, P – surface drifting pelagic eggs, L – bear live young, ? – signifies uncertainty in classification
Spawning mode as described by Humphries *et al* (1999)

Literature sources are coded as follows: 1-(Kurth 1957), 2-(Hortle 1978), 3-(Cadwallader and Backhouse 1983), 4-(Hall 1984), 5-(Koehn and O'Connor 1990), 6-(Puckridge and Walker 1990), 8-(Molsher *et al*. 1994), 9-(Neira and Potter 1994), 11-(McDowall 1996), 12-(Newton 1996), 13-(Haddy and Pankhurst 1998), 14-(Barnett and Pankhurst 1999), 15-(Sarre and Potter 1999), 16-(Ye *et al*. 2000), 17-(Norriss *et al*. 2002), 18-(Ferguson and Ward 2003), 20-(Ellis 2005), 21-(Higham *et al*. 2005), 23-(Bice and Ye 2006), 24-(Koehn and Harrington 2006), 25-(Llewellyn 2006), 26-(Lintermans 2007), 27-(McNeil and Hammer 2007), 28-(Nunn *et al*. 2007), 29-(Jennings *et al*. 2008)