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FISHES OF THE MARINA BASIN, SINGAPORE, BEFORE THE ERECTION OF THE MARINA BARRAGE

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ABSTRACT. – A survey of the fish diversity in the Marina Basin was conducted from March to October 2005 for the Public Utilities Board (PUB) to establish the pre-barrage baseline condition so that post-barrage changes in the ecosystem can be monitored and managed. A total of 139 fish species from 57 families is recorded. A critical assessment of the potential occupants of the Marina basin was carried out, in anticipation of the change in salinity that will be caused by the erection of the Marina Barrage. The likely species loss and possible new ones to be settled in the new reservoir created by the barrage building are examined.

KEY WORDS. – Marina Bay, Singapore, Fish, pre-Barrage, biodiversity.

INTRODUCTION

The coastal areas of Singapore have been heavily modified due to land reclamation and the damming of rivers to construct reservoirs (Chia et al., 1988). Despite these activities, patches of mature secondary mangroves still remain along the northern coast, i.e. Sungei Buloh Wetland Reserve (Bird et al., 2004) and the Mandai mangroves near the Woodlands causeway (Ng & Sivasothi, 1999). The Johor Straits still serve as a vital nursery ground for fishes despite being heavily impacted (Hajisamae & Chou, 2003; Jaafar et al., 2004). Less is known of the southern coast, although much of it has been heavily modified for port facilities and reclaimed for land expansion.

The Marina Bay area, which consists of reclaimed land and the estuaries of several natural drainage systems (namely the Singapore River, Geylang River and Kallang River) is currently being converted into a freshwater reservoir by the erection of the Marina Barrage at the mouth of Marina Bay (Fig. 1). The following reports on a recent survey in the Marina Basin, conducted over 8 months in 2005 for the Public Utilities Board (PUB), as part of the biodiversity baseline data collation, done in partnership with the Tropical Marine Science Institute (TMSI).

MATERIALS AND METHODS

The extent of the present survey covers the boat accessible areas of the Marina Basin, which includes visual surveys covering the open drain areas up to tidal influence. Fish

specimens were obtained by several methods: custom-made bubu/fish traps (about one metre in length, mesh 4 cm), gill nets (mesh size 3” and 4”), cast net (10, 12 and 14 feet diameter), scoop net, hand net, 25 metre seine net (15 mm mesh size) and angling. Due to heavy boating traffic, the fish traps were placed near the concrete or rock embankments and bridge foundations. Gill nets were set parallel to shore and constantly monitored for three to four hours before retrieval (with written permission from the Maritime and Port Authority of Singapore, MPA). Cast netting was only used along concrete or rock embankments, and sandy areas. Seining was carried out parallel to shore only in areas with sandy or silty bottom (e.g. Kallang Riverside Park). Visual census was conducted during both low and high tides, using binoculars (8× magnification power). Visual census was carried out mostly along banks of canals and drains within the survey area.

Fish specimens obtained were euthanized in ice (a protocol approved by the Institutional Animal Care and Use Committee, IACUC, of the National University of Singapore, NUS) and fixed in 10% formalin solution for one to two weeks. They were subsequently placed in tap water to leach for one to two days before transfer to permanent storage in 75% ethanol. The specimens were catalogued and deposited in the Zoological Reference Collection of the Raffles Museum of Biodiversity Research (RMBR), NUS. Fish species were identified with reference to the following: Tan et al. (1982), Lim & Ng (1990), Kottelat et al. (1993), Carpenter & Niem (1998, 1999a, 1999b, 1999c, 1999d), Lim & Low (1998), Kimura & Matsuura (2003) and Larson & Lim (2005).

Fish of local conservation status. – The conservation status of the various species encountered follow those presented in the second edition of The Singapore Red Data Book (Davison et al., 2008). Three categories are relevant: Critically Endangered (CR), Endangered (EN) and Vulnerable (VU).

RESULTS

A total of 138 fish species from 57 families is obtained from the present survey (see Table 1). A search through museum catalogue records and the collection at the RMBR turned up an additional 44 fish species (of which 16 are confined to freshwater) and an additional 6 families.

DISCUSSION

The abundance of each fish trap was not noted, as the use of the traps were not standardized nor were the locations of the traps fixed. Each fish trap method targeted different groups of fish. The fish traps/bubus were not baited and usually placed near a man-made structure (e.g. bridge foundation) and these normally attracted species attracted to hard structures, i.e. *Etrophus suratensis*, *Siganus javus*, *Epinephalus* spp., *Monacanthus chinensis*. Cast netting usually yielded pelagic species (e.g. *Ambassis* spp., clupeids and engraulids, *Atherinomorus duodecimalis*, mugilids, gerrids and leiognathids) and benthic species (e.g. gobiids, platycephalids and synodontids). Seine netting yielded the highest diversity as the net is swept and dragged along a water column and substratum, usually with a mix of pelagic and benthic fauna, including invertebrates, e.g. crustaceans, echinoderms, mollusks. Gill netting produced the least yield, as the net placement was restricted to being placed parallel to shore, whereas the maximal output would have been perpendicular to the shore. Nonetheless, a single specimen of wolf herring (*Chirocentrus dorab*) was obtained via this method. Usually, seine and scoop netting obtained the small species and juvenile specimens, as the mesh size is smaller.

The location of the fishing site also plays a role in the yield. Sampling at the confluence of two river systems or canals yields a larger catch. Sampling at the Marina channel yielded more marine species than at the estuarine areas (e.g. species from Pomacanthidae, Chaetodontidae, Ehippidae, Labriidae and Pempheridae).

The current results indicate that estuarine elements still exist in the modified habitats such as Kallang and Geylang Rivers, but only in remnant populations. The Marina channel is more reminiscent of a rocky shore marine habitat, because of the rock bunds.

CONCLUSIONS

A list of possible fishes that will survive in freshwater without access to the sea is as follows: Anabantidae – *Anabas testudineus*, Channidae – *Channa striata*, Cichlidae – *Etrophus suratensis*, *Geophagus altifrons*, *Oreochromis mossambicus*, Clariidae – *Clarias batrachus*, *C. gariepinis*, Cyprinidae – *Carassius auratus*, *Cyclocheilichthys apogon*, *Puntius banksi*, *P. lateristriga*, *P. semifasciolatus*, *Rasbora elegans*, *Rasborinus lineatus*, Gobiidae – except *Rhinogobius*, *Glossogobius giuris*, *Gobiopterus* and *Oxyeleotris marmorata*, Hemiramphidae – *Dermogenys collettei*, *Hemirhamphodon pogonognathus*, Mastacembelidae – *Macrognathus maculatus*, Osphronemidae – *Betta splendens*, *Trichopodus pectoralis*, *T. trichopterus*, *Trichopsis vittata*, Poeciliidae – *Poecilia sphenops*, *Xiphorus maculatus*, Siluridae – *Silurichthys hasseltii*.

This next list of fishes may survive but not breed if access to the marine environment is restricted, is as follows: Adrianichthyidae – *Oryzias javanicus*, Ariidae – *Arius sagor*, Batrachiodidae – *Batrachomoeus trispinosus*, Centropomidae – *Lates calcarifer*, Eleotrididae – *Butis humeralis*, *Ophiocara porocephala*, Gobiidae – all species listed (except those mentioned above), Lutjanidae – *Lutjanus johnii*, *L. russellii*, Megalopidae – *Megalops cyprinoides*, Muraenidae – *Gymnothorax tile*, Plotosidae – *Paraplotosus albilabrus*, *Plotosus canius*, Scatophagidae – *Scatophagus argus*, *S. cf. argus*, Terapontidae – *Terapon jarbua*, Tetraodontidae – *Tetraodon nigroviridis*, Toxotidae – *Toxotes chatareus*, *T. jaculator*.

As there had been no previous studies or research into freshwater adaptation of existing fish fauna of riverine habitats being converted in freshwater reservoirs in Singapore, this study would serve as a good basis and baseline for future studies and surveys. The postulations of the potential occupants of the Marina Barrage can be tested and should prove to be an excellent case study for similar scenarios that may occur in Asia and the region in the future.

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Table 1. Distribution of coastal fish from the Marina Bay and Channel area. Legend: (CR), critically endangered; (EN), endangered; (VU), vulnerable. °, denotes wholly freshwater species; *, denotes introduced species. Conservation status information are from Davison et al., 2008.

FAMILY SPECIES	DISTRIBUTION				
	Singapore River	Rochor Canal	Kallang River	Geylang River	Marina Channel
Adrianichthyidae					
<i>Oryzias javanicus</i>		+	+	+	
Ambassidae					
<i>Ambassis interrupta</i>			+		
<i>Ambassis kopsii</i>	+	+	+	+	+
<i>Ambassis nalua</i>					+
<i>Ambassis vachellii</i>				+	+
Anabantidae					
<i>Anabas testudineus</i> °			+		
Apogonidae					
<i>Apogon fraenatus</i>	+				
<i>Apogon hyalosoma</i>				+	+
<i>Apogon melas</i>					+
<i>Apogon quadrfasciatus</i>					+
<i>Chilodipterus singapurensis</i>					+
<i>Lepidamia kalosoma</i>					+
Ariidae					
<i>Arius nella</i>					+
<i>Arius sagor</i>			+		+
Atherinidae					
<i>Atherinomorus duodecimalis</i>				+	
Batrachoididae					
<i>Batrachomoeus trispinosus</i>	+			+	+
Blennidae					
<i>Omobranchus ferox</i>				+	+
Carangidae					
<i>Alectis indicus</i>					+
<i>Alepes djedaba</i>					+
<i>Gnathanodon speciosus</i>					+
<i>Scomberoides commersonianus</i>					+
Centropomidae					
<i>Lates calcarifer</i>	+				+
<i>Psammoperca waigiensis</i>					+
Chaetodontidae					
<i>Chaetodon octofasciatus</i>					+
<i>Chelmon rostratus</i>					+
<i>Parachaetodon ocellatus</i>	+				
Chanidae					
<i>Chanos chanos</i>		+			
Channidae					
<i>Channa striata</i> °			+		
Chirocentridae					
<i>Chirocentrus dorab</i>					+
Cichlidae					
<i>Etroplus suratensis</i> *	+	+	+	+	+
<i>Geophagus surinamensis</i> *			+		
<i>Oreochromis mossambicus</i> *	+	+	+	+	

Table 1. Cont'd.

FAMILY	SPECIES	DISTRIBUTION				
		Singapore River	Rochor Canal	Kallang River	Geylang River	Marina Channel
Clariidae						
	<i>Clarias batrachus</i> [°]			+		
	<i>Clarias gariepinus</i> ^{°*}		+			
Clupeidae						
	<i>Anodontostoma chacunda</i>	+				+
	<i>Dussumieria acuta</i>					+
	<i>Escualosa thoracata</i>				+	+
	<i>Herklotsichthys dispilonotus</i>					+
	<i>Hilsa keele</i>	+				+
	<i>Sardinella albella</i>	+			+	+
	<i>Sardinella fimbriata</i>	+				+
Cyprinidae						
	<i>Carassius auratus</i> ^{°*}			+		
	<i>Cyclocheilichthys apogon</i> ^{° (EN)}			+		
	<i>Metzia lineatus</i> ^{°*}			+		
	<i>Puntius banksi</i> [°]			+		
	<i>Puntius lateristriga</i> [°]			+		
	<i>Puntius semifasciolatus</i> ^{°*}			+		
	<i>Rasbora elegans</i> [°]			+		
Dasyatidae						
	<i>Dasyatis zugei</i>					+
	<i>Himantura gerrardi</i>					+
Drepaneidae						
	<i>Drepane punctata</i>					+
Eleotrididae						
	<i>Butis humeralis</i>				+	
	<i>Ophiocara porocephala</i>		+	+	+	+
Engraulididae						
	<i>Stolephorus indicus</i>			+		+
	<i>Stoelphorus</i> sp.				+	+
	<i>Thryssa hamiltonii</i>					+
	<i>Thryssa setirostris</i>					+
Ephippidae						
	<i>Platax orbicularis</i>					+
Gerreidae						
	<i>Gerres erythrourus</i>					+
	<i>Gerres filamentosus</i>	+				+
	<i>Gerres kapas</i>	+			+	+
	<i>Gerres macracanthus</i>				+	+
	<i>Gerres oyena</i>	+				+
Gobiidae						
	<i>Acentrogobius caninus</i>	+	+			+
	<i>Acentrogobius janthinopterus</i>					+
	<i>Acentrogobius nebulosus</i>					+
	<i>Acentrogobius viridipunctatus</i>					+
	<i>Arcygobius baliurus</i>	+				+
	<i>Brachyamblyopus brachysoma</i>					+
	<i>Callamiana illota</i>			+		
	<i>Drombus globiceps</i>	+	+			+
	<i>Drombus ocyurus</i>	+				
	<i>Exyrias puntang</i>		+			+
	<i>Favonigobius reichei</i>					+

Table 1. Cont'd.

FAMILY	SPECIES	DISTRIBUTION				
		Singapore River	Rochor Canal	Kallang River	Geylang River	Marina Channel
	<i>Glossogobius aureus</i>	+				
	<i>Glossogobius circumspectus</i>					+
	<i>Gobiopsis macrostoma</i>					+
	<i>Hemigobius hoeveni</i>	+		+		
	<i>Istigobius dianema</i>					+
	<i>Mugilogobius chulae</i>			+		
	<i>Oxyurichthys uronema</i>	+				
	<i>Periophthalmodon schlosseri</i>		+	+	+	
	<i>Periophthalmus argentilineatus</i>			+	+	+
	<i>Periophthalmus variabilis</i>			+	+	
	<i>Periophthalmus walailakae</i>		+			
	<i>Psammogobius biocellatus</i>	+				
	<i>Pseudogobiopsis oligactis</i>			+		
	<i>Pseudogobius javanicus</i>	+	+	+		+
	<i>Stigmatogobius pleurostigma</i>		+	+		
	<i>Stigmatogobius sadanundio</i>		+			
	<i>Taenioides gracilis</i>	+				
	<i>Trypauchen vagina</i>					+
	Haemulidae					
	<i>Diagramma pictum</i>					+
	<i>Plectorhinchus gibbosus</i>					+
	<i>Pomadasys argenteus</i>					+
	<i>Pomadasys kaakan</i>					+
	<i>Pomadasys maculatum</i>				+	+
	Hemiramphidae					
	<i>Dermogenys collettei</i> ^o			+		
	<i>Hemirhamphodon pogonognathus</i> ^o			+		
	<i>Zenarchopterus buffonis</i>		+			+
	<i>Zenarchopterus gilli</i>		+	+	+	+
	Labridae					
	<i>Choerodon anchorago</i>					+
	<i>Choerodon oligocanthus</i>					+
	<i>Choerodon schoenleinii</i>				+	
	Leiognathidae					
	<i>Deveximentum ruconis</i>	+				
	<i>Gazza minuta</i>					+
	<i>Leiognathus equulus</i>	+	+	+		+
	<i>Nuchequula blochii</i>		+	+		+
	Lethrinidae					
	<i>Lethrinus lentjan</i>					+
	Lutjanidae					
	<i>Lutjanus carponotatus</i>					+
	<i>Lutjanus erythropterus</i>					+
	<i>Lutjanus fulviflamma</i>					+
	<i>Lutjanus johnii</i>					+
	<i>Lutjanus monostigma</i>	+				
	<i>Lutjanus russellii</i>	+	+			+
	Mastacembelidae					
	<i>Macrognathus maculatus</i> ^o (CR)			+		
	Megalopidae					
	<i>Megalops cyprinoides</i>			+		

Table 1. Cont'd.

FAMILY SPECIES	DISTRIBUTION				
	Singapore River	Rochor Canal	Kallang River	Geylang River	Marina Channel
Monacanthidae					
<i>Acreichthys tomentosum</i>					+
<i>Monacanthus chinensis</i>				+	+
Mugilidae					
<i>Ellochelon vaigiensis</i>					+
<i>Liza</i> sp. 1	+	+	+	+	+
<i>Liza</i> sp. 2		+	+		+
Mulidae					
<i>Paruepeneus cyclostomus</i>					+
Muraenidae					
<i>Gymnothorax reevesi</i>					+
<i>Gymnothorax tile</i>					+
Nemipteridae					
<i>Scolopsis vosmeri</i>					+
Ophichthidae					
<i>Pisodonophis cancrivorus</i>					+
Osphronemidae					
<i>Betta splendens</i> ^{o*}			+		
<i>Trichopodus pectoralis</i> ^{o*}			+		
<i>Trichopodus trichopterus</i> ^o			+		
<i>Trichopsis vittata</i> ^o			+		
Ostraciidae					
<i>Ostracion nasus</i>					+
Paralichthyidae					
<i>Pseudorhombus malayanus</i>					+
Pempheridae					
<i>Pempheris oualensis</i>					+
Platycephalidae					
<i>Cymbacephalus nematophthalmus</i>					+
<i>Eurycephalus carbunculus</i>					+
<i>Grammoplites knappi</i>	+				
<i>Inegocia japonica</i>					+
<i>Platycephalus indicus</i>	+				+
Plotosidae					
<i>Paraplotosus albilabris</i>					+
<i>Plotosus canius</i>	+				+
<i>Plotosus lineatus</i>	+				+
Poeciliidae					
<i>Poecilia sphenops</i> *	+	+	+	+	+
<i>Xiphophorus maculatus</i> *			+		
Pomacanthidae					
<i>Chaetodontoplus mesoleucus</i>					+
<i>Pomacanthus imperator</i>					+
Scatophagidae					
<i>Scatophagus argus</i>	+	+	+	+	+
<i>Scatophagus</i> cf. <i>argus</i>					+
Sciaenidae					
<i>Dendrophysa russelli</i>					+

Table 1. Cont'd.

FAMILY SPECIES	DISTRIBUTION				
	Singapore River	Rochor Canal	Kallang River	Geylang River	Marina Channel
Scorpaenidae					
<i>Minous monodactylus</i>			+		
<i>Scorpaeniopsis oxycephala</i>					+
<i>Synanceia horrida</i>					+
Serranidae					
<i>Diploprion bifasciatum</i>					+
<i>Epinephelus coioides</i>					+
<i>Epinephelus fuscoguttatus</i>					+
<i>Epinephelus malabaricus</i>	+				+
<i>Plectropomus leopardus</i>					+
Siganidae					
<i>Siganus canaliculatus</i>				+	+
<i>Siganus guttatus</i>	+			+	+
<i>Siganus javus</i>	+	+		+	+
Sillaginidae					
<i>Sillago sihama</i>			+		
Siluridae					
<i>Silurichthys hasseltii</i> ^o		+			
Soleidae					
<i>Pardachirus pavoninus</i>					+
Sphyraenidae					
<i>Sphyraena jello</i>	+				
Synbranchidae					
<i>Opisternon bengalense</i>	+				
Syngnathidae					
<i>Hippichthys cyanospilos</i>					+
<i>Hippocampus comes</i> (VU)					+
<i>Hippocampus kuda</i> (VU)	+				
Synodontidae					
<i>Saurida tumbil</i>					+
Terapontidae					
<i>Terapon jarbua</i>		+		+	
<i>Terapon puta</i>					+
<i>Terapon theraps</i>	+				
Tetraodontidae					
<i>Arothron immaculatus</i>	+				+
<i>Arothron mappa</i>					+
<i>Arothron reticularis</i>	+				+
<i>Lagocephalus lunaris</i>					+
<i>Takifugu oblongus</i>					+
<i>Tetraodon nigroviridis</i>	+				+
Toxotidae					
<i>Toxotes chatareus</i>	+	+			
<i>Toxotes jaculator</i>	+	+		+	+
Triacanthidae					
<i>Tripodichthys blochi</i>		+			+
Trichiuridae					
<i>Trichiurus lepturus</i>					+
TOTAL NUMBER OF SPECIES	49	30	47	30	123

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