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Fishes from fresh and brackish waters of islands in Torres Strait, far north Queensland

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ABSTRACT

Until recently the freshwater fish fauna of Torres Strait was virtually unknown. This paper reports on museum collections of fishes obtained in the area prior to 2005 and on several collections made in the period 2005-2011 from fresh and brackish waters on seven islands in the region: Boigu, Saibai, Mabuiag, Badu, Mua, Thursday and Horn. Eight of the fifteen freshwater fish species reported are new records for the Torres Strait Islands. Information on other aquatic fauna is presented, and the potential threats of introduced (exotic) species and sea-level rise associated with climate change, are considered. □ *Torres Strait; north Queensland; fresh and brackish water fishes; pest fish.*

The Torres Strait Islands are an archipelago located in the epicontinental seaway between Cape York Peninsula, far north Queensland and central-southern New Guinea, a north-south distance of 150 km. While the role of Torres Strait as biogeographical bridge or barrier has been the subject of considerable discussion (e.g. Mackey et al. 2001; Heinsohn & Hope 2006; Walker 1972), the islands' fauna is not well known (Strahan 1995: 444; McNiven & Hitchcock 2004).

The fresh- and brackish water (i.e. non-marine) fishes of Torres Strait are a case in point. While the species composition of Cape York is relatively well

known, and some research has been undertaken in central-southern New Guinea (e.g. Allen 1991, 2004; Herbert & Peeters 1995; Herbert *et al.* 1995; Hitchcock 2002; Pusey *et al.*, 2004), the fish fauna of aquatic systems on the Torres Strait Islands have largely been unexplored to date. Only four native freshwater fish species have been recorded from the islands: *Melanotaenia nigrans* from Muralag (Allen & Cross 1982), *M. splendida inornata* from Badu and Muralag (Prince of Wales Island) (Allen & Cross 1982), *M. rubrostriata* from Daru (Allen & Cross 1982) and Saibai (Hitchcock 2008), and *Ambassis agrammus* from Saibai

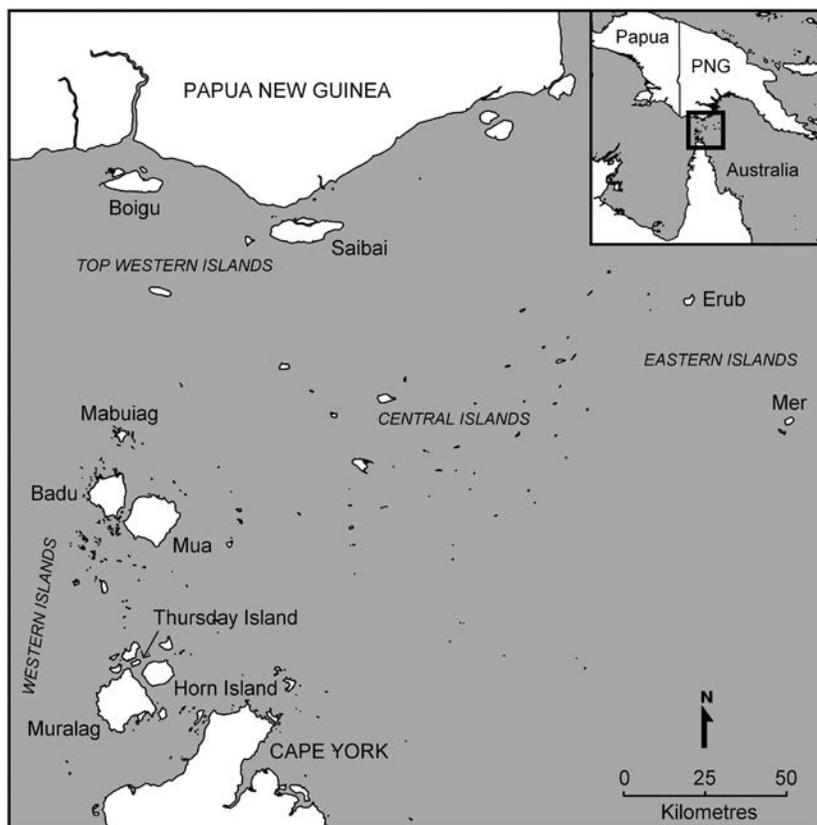


FIG. 1. Torres Strait, showing islands mentioned in the text.

(Hitchcock 2008). Among museum records, twelve species appear to have been collected from four islands in the region prior to 2005, with specimens held in the collections of the Australian Museum, Commonwealth Scientific and Industrial Research Organization and Queensland Museum. This paper reports the results of opportunistic fish collections made in freshwater and brackish streams, ponds and dams on seven islands in Torres Strait by Garrick Hitchcock (GH), Marcus Finn (MF) and Damien Burrows (DB) between 2005-2011, the collecting efforts of G. and K. Aland at Mabuiag and Mua in

March-April 2008 and a review of museum holdings in Australia.

ENVIRONMENT AND COLLECTION SITES

Torres Strait (Fig. 1) was formed by rising sea levels in the early Holocene (c. 8000-6500 years before present) that inundated the Arafura Plain, the low-lying land bridge connecting Australia and New Guinea (Barham 1999; Jennings 1972; Woodroffe *et al.* 2000). Prior to the recent formation of the Strait, southern New Guinea and northern Australia were linked during low sea level periods for much of recent geological history, accompanied by

a degree of hydrological connectivity (Allen & Hoese 1980; Heinsohn & Hope 2006). Consequently, there is a strong correlation between the freshwater fish fauna on either side of the Strait: central-southern New Guinea and northern Australia share approximately 50% of species in common (Unmack 2001; see also Allen 1991, 2004). According to Unmack (2001), the aridity of the land bridge during the Pleistocene and presence of brackish water in the vast Lake Carpentaria, which existed on the western Arafura Plain, prevented freshwater fish migrations and hence the major exchanges of Australian and New Guinea fishes occurred during the warmer and wetter late Miocene. However, a recent paper by Baker *et al.* (2008), examining the genetic relationships between northern Australia and southern New Guinea freshwater crayfish, suggests that Lake Carpentaria did provide a late Pleistocene-early Holocene connection between a considerable number of north-eastern Australian rivers and at least one river in central-southern New Guinea (see also Keenan 1994; Ride 1972).

The islands of Torres Strait can be grouped into four main geographical types. Two of these are remnants of what were once hills and elevated lands on the Arafura Plain: a group of granitic continental islands found mostly in the west and south, and a volcanic group in the east. The other two groups were formed over the last several thousand years: sandy cays on reefs in the central part of the Strait, and in the far north, alluvial or sedimentary islands, created by Holocene deposition of terrigenous muds (Barham 1999; Jennings 1972; Woodroffe *et al.* 2000).

Torres Strait has a monsoonal climate, with approximately 90% of rainfall occurring in a wet season from December to April. Average annual precipitation, based on Thursday Island records, is 1700 mm. Seasonal creeks occur on several continental islands, with rock pools and waterfalls on the largest, e.g. Muralag, Badu and Mua (Garnett & Jackes 1983; Singe 1979). Freshwater, brackish and marine swamps occur on Boigu and

Saibai, and large, anthropogenic, earth-rimmed wells were also constructed on these islands to provide a supply of potable water during the dry season (Barham 1999; Clarke 2004).

No freshwater environments exist on the sand cay islands; although small, anthropogenic, hand-dug wells were used by the local population on inhabited islands prior to the installation of water tanks and dams in the twentieth century. Several small, perennial streams occur on the eastern islands of Erub (Darnley Island) and Mer (Murray Island) (Haddon *et al.* 1894), but no freshwater fishes are known with the exception of eels, *Anguilla* sp., which have been reported from Erub. According to local people, eels formerly lived in a freshwater spring at Mogor, on the southwest side of Erub, until it was capped as a water supply measure in the twentieth century. The eels were not consumed, and are said to have kept the well 'clean' (Kapua Gutchen, Erub, pers. comm. 2008). Protection of freshwater eels, to ensure clean water sources, has also been reported from the Solomon Islands (BBC 2009).

More detailed descriptions of the collection sites appear below.

Continental Islands

Thursday Island. The administrative centre of the Torres Strait Islands, Thursday Island is approximately 3.7 km² and has the largest population (2551 at the 2006 Census). The island is relatively built up, with the exception of central and eastern lightly wooded areas in the vicinity of Milman Hill and the emergency town water supply impoundment. The indigenous name for Thursday Island is Waiben, which is said to mean 'no water'. As expected given this name, Thursday Island has no naturally permanent freshwater. There are three anthropogenic, permanent freshwater waterbodies on the island: the emergency water supply; the school irrigation supply (a smaller waterbody sitting immediately below the emergency water supply reservoir wall); and a nineteenth century dam below Green Hill.

Horn Island. Horn Island consists of approximately 54 km² of lightly wooded, low hills fringed by a narrow strip of mangrove on the northern and western sides of the island. Collecting was undertaken in Vidgen Creek, the largest freshwater stream on the island, which drains to the northern coast. This creek appears to dry out completely in the dry season. There are also two large water supply dams and an inundated former mining quarry, in which freshwater fish are known to occur (Burrows & Perna 2009).

Badu. Badu is a lightly forested, rocky granite island around 11 km in diameter, with an area of 100 km². Mangrove swamps are present on the north coast, and some areas on the east and south. Pools of water remain in the well-defined creeks that drain to the northern and western coasts throughout the dry season (Garnett & Jackes 1983). Collecting was undertaken at Sirip Koesa ('Sirip Creek'), located on the southwest side of the island.

Mabuiag. Mabuiag is a hilly, roughly triangular-shaped island of approximately 6 km², situated in the middle of the narrowest part of the Strait. Collecting was undertaken at two very small, perennial streams, Sau Koesa and Kubarau Koesa, on the northeast and southwest sides of the island respectively.

Mua. The second-largest island in the Strait, after Prince of Wales Island, Mua (formerly known as Moa) is a rocky, lightly vegetated island of about 17 km diameter, with an area of around 172 km². The island is fringed by mangroves on the south, west and north coasts. It is home to the largest freshwater creek among the islands, Koei Kussa ('Big Creek'), which drains into the narrow passage that separates Mua from Badu (Wannan 2008). Collecting here was undertaken at three locations: a small perennial creek among *Pandanus* grassland, located near the Kubin cemetery, on the southwest side of the island, at Bubu Creek, located just north of St Pauls settlement, on the eastern side of the island, and in a small tributary of Koei Kussa.

Sedimentary Islands

Saibai. Saibai Island, located just under 4 km off the south New Guinea coast, is 21 km long and up to 6 km wide, with an area of approximately 104 km². It is fringed by tidally inundated mangroves. The interior consists of seasonally inundated, permanent and semi-permanent fresh-and brackish-water sedge swamps, salt pans, and non-inundated claylands covered by *Pandanus* grasslands and open woodland. The interior swamps are connected to the sea by a system of mangrove creeks. (Barham 1999; Barham & Harris 1985; CONICS 2009; Environmental Science & Services 1994). Collection was undertaken at a sedge pool (former water supply) next to a water pump plant and several brackish, sedge-lined pools near the south-eastern end of the airstrip.

Boigu. This island is approximately 17 km long and 6 km wide, with an area of around 72 km² and lies less than 7 km south of the New Guinea mainland. It is lower and swampier than Saibai; there is much less in the way of non-inundated plains and most of the interior comprises marine swamplands: salt pans, tidal flats and mangrove forests (Clarke 2004; CONICS 2009; Stanton *et al.* 2008). Prior to the creation of modern dams, there were three wells on the island (Ingui 1991). Collecting was undertaken in an artificial lagoon, south of and adjacent to the airstrip, which was created when the earth in this location was excavated to build up the airstrip.

METHODS

Fish were caught using the following techniques: collection by hand (of fish above or near waters edge), deployment of collapsible rectangular baited traps, use of dip nets, improvised small mesh flat seine (shade cloth) and throw nets. Collecting efforts were opportunistic and often limited by the extent of available aquatic habitat at the locations and on the islands visited. The number of collecting days on each island was approximately as follows: Boigu (seven), Saibai (seven), Badu (two),

Torres Strait fresh and brackish water fishes

Mua (seven), Mabuiag (three), Thursday Island (two) and Horn Island (ten). Limited backpack electrofishing was carried out on Saibai Island to obtain species recorded by Burrows & Perna (2009).

Specimens were preserved in solutions of either 10% formalin or 90% ethanol, and forwarded

to the Queensland Museum for entry into their freshwater fish collection.

RESULTS

Thirty-one species, including two exotic introduced taxa (Eastern Gambusia, *Gambusia holbrooki* and Climbing Perch, *Anabas testudineus*), have been identified from fresh and brackish

TABLE 1. Fishes collected or recorded in fresh and brackish waters of Torres Strait Islands. Shaded rows denote strictly freshwater species; AMS = Australian Museum, Sydney; CSIRO = Commonwealth Scientific and Industrial Research Organization (Marine & Atmospheric Research), Hobart; QM = Queensland Museum, Brisbane; 1 = information sourced from Froese & Pauly (2011).

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
Megalopidae				
<i>Megalops cyprinoides</i> Oxeye herring	Boigu Saibai Badu Mua Horn Island Muralag	CSIRO H 665-3 QM I.38040 CSIRO H 664-3 - - QM I.38158 CSIRO B 723	Adults generally found in the sea, but juveniles inhabit freshwater habitats	CSIRO (1984) Hitchcock, 2008 CSIRO (1984) This study This study This study CSIRO (1959)
Anguillidae				
<i>Anguilla</i> sp. Freshwater Eel	Boigu Saibai Horn Island	- - -	Freshwater streams, lakes and swamps; adults spawn in marine waters	Burrows, 2010 Burrows & Perna, 2009 This study
Chanidae				
<i>Chanos chanos</i> Milkfish	Boigu Horn Island	CSIRO H 665-01 QM I.38160	Offshore marine waters and shallow coastal embayments; frequently enter estuaries and occasionally penetrates freshwater	CSIRO (1984) This study
Ariidae				
<i>Neoarius leptaspis</i> Boofheaded Catfish	Horn Island	QM I.38164	Lakes, rivers, muddy coastal seas and estuaries	This study
Mugilidae				
<i>Mugil cephalus</i> Sea Mullet	Horn Island	QM I.38159	Coastal species that often enter estuaries and rivers	This study
Pseudomugilidae				
<i>Pseudomugil gertrudae</i> Spotted Blue Eye	Mua	QM I.36731 QM I.38847 QM I.38850 QM I.38286 QM I.38288	Small creeks, marshes, rainforest streams, lagoons and backwaters adjacent to major water courses	This study This study This study Aland collection (2008) Aland collection (2008)

TABLE 1. Continued ...

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
<i>Pseudomugil signifer</i> Pacific Blue Eye	Mabuiag	QM I.38283	From clear, fast-flowing streams to brackish mangrove estuaries and tidal mangrove creeks	Aland collection (2008)
		QM I.38439		This study
	Mua	QM I.38285		Aland collection (2008)
		QM I.36730		This study
		QM I.38146		This study
	Horn Island	QM I.38849		This study
		QM I.38142-3		This study
		QM I.38166		This study
	Muralag	QM I.38172		This study
		QM I.6558		QM record (1938)
		CSIRO B 705		CSIRO (1959)
CSIRO B 13	CSIRO (1960)			
Melanotaenidae				
<i>Melanotaenia maccullochi</i> McCulloch's Rainbowfish	Mua	QM I.38845	Lowland swamps and small streams. Usually clear acidic waters (e.g. <i>Pandanus</i> swamps)	This study
		QM I.38290		Aland collection (2008)
<i>M. nigrans</i> Blackbanded Rainbowfish	Muralag	QM I.12830 B 639-641	Inhabits rainforest streams, lagoons and small streams	QM record (1968) CSIRO (1959)
<i>M. splendida inornata</i> Chequered Rainbowfish	Badu	QM I.38173	Freshwater streams and lakes	This study
		CSIRO B 647		CSIRO (1962)
	CSIRO B 648	CSIRO (1960)		
	Mua	QM I.38846		This study
		QM I.38287		Aland collection (2008)
Muralag	CSIRO B 4146 CSIRO B 4147	CSIRO (1959) CSIRO (1959)		
<i>M. rubrostriata</i> Redstriped Rainbowfish	Boigu	QM I.38183	Freshwater	This study
	Saibai	QM I.38037		Hitchcock, 2008
		QM I.38149		This study
Hemiramphidae				
<i>Zenarchopterus buffonis</i> Northern River Garfish	Horn Island	QM I.38165	Coastal waters, estuaries and rivers	This study
Poeciliidae (Introduced)				
<i>Gambusia holbrooki</i> Eastern Gambusia	Thursday Island	QM I.38709	Fresh and brackish water	This study
		-		Burrows & Perna, 2009
Ambassidae				
<i>Ambassis agrammus</i> Sailfin Glassfish	Saibai	QM I.38038	Freshwater streams, ponds, swamps and lakes	Hitchcock, 2008
	Horn Island	QM I.38147		This study
		QM I.38141		This study
<i>A. elongatus</i> Elongate Glassfish	Horn Island	QM I. 38144-5	Freshwater streams that frequently have moderate to high turbidity	This study
		QM I.38169		This study
		QM I.38711		This study

Torres Strait fresh and brackish water fishes

TABLE 1. Continued ...

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
<i>A. vachellii</i> Vachell's Glassfish	Horn Island	QM I.38167	Brackish waters of bays, estuaries and tidal mangrove creeks. Sometimes entering freshwater	This study
Kuhliidae				
<i>Kuhlia rupestris</i> Jungle Perch	Muralag	CSIRO C 3193 - 3201	Primarily a freshwater inhabitant but may penetrate adjacent marine habitats; estuaries and the middle reaches of rivers, usually in relatively fast-flowing, clear streams as well as in rocky pools below waterfalls	CSIRO (1959)
Lutjanidae				
<i>Lutjanus russelli</i> Moses Snapper	Horn Island	QM I.38161	Adults offshore and inshore coral and rocky reefs; juveniles mangrove estuaries and lower reaches of freshwater streams	This study
Terapontidae				
<i>Amniataba caudavittata</i> Yellowtail Grunter	Boigu Saibai Horn Island	QM I.38184 QM I.38039 QM I.38043 QM I.38174 CSIRO H 664-2 QM I.38163	Coastal marine waters, but also found in estuaries and freshwater sections of rivers	This study Hitchcock, 2008 Hitchcock, 2008 This study CSIRO (1984) This study
Eleotridae				
<i>Bostrychus zonatus</i> Sunset Gudgeon	Saibai Horn Island	QM I.38041 CSIRO H 664-1 QM I.38155	Freshwaters and estuaries	Hitchcock, 2008 CSIRO (1984) This study
<i>Hypseleotris compressa</i> Empire Gudgeon	Horn Island Muralag	QM I.38156 QM I.38710 CSIRO B 718	Usually flowing streams amongst aquatic vegetation; juveniles often found in brackish waters and adults can withstand salinities equal to seawater	This study This study CSIRO (1959)
<i>Mogurnda mogurnda</i> Northern Trout Gudgeon	Mua	QM I.38848	Rivers, creeks and billabongs, in quiet or slowly flowing sections among vegetation or rocks	This study
<i>Ophiocara porocephala</i> Spangled Gudgeon	Muralag	AMS I.34586-001	Brackish estuaries, river mouths and freshwater creeks	AMS record (1976)
<i>Oxyeleotris nullipora</i> Poreless Gudgeon	Mua	QM I.38851 QM I.38289	Backwaters of rivers, creeks, small swamps and lagoons	This study Aland collection (2008)
Gobiidae				
<i>Mugilogobius filifer</i> Threadfin Mangrovegoby	Mabuiag	QM I.38284 QM I.38438 QM I.38440	Mangrove creeks and estuaries, sometimes well into the freshwater influence	Aland collection (2008) This study This study

TABLE 1. Continued ...

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
<i>M. platystomus</i>	Horn Island	QM I.38157	Mangrove estuaries and clear rainforest streams near the sea	This study
Island Mangrovegoby		QM I.38171		This study
<i>Periophthalmus novaeguineae</i> New Guinea Mudskipper	Boigu	QM I.38185	Intertidal and amphibious air-breather; inhabits tidal estuaries and sometimes enters lower reaches of freshwater streams	This study
<i>Pseudogobius</i> cf <i>poicilosoma</i> Northern Fatnose Goby	Saibai	QM I.38148	Brackish waters	This study
	Horn Island	QM I.38168		This study
		QM I.38170		This study
<i>Pseudogobius</i> sp.1 Goby	Boigu	QM I.38182	Usually rivers and estuaries	This study
	Saibai	QM I.38175		This study
Anabantidae (Introduced)				
<i>Anabas testudineus</i> Climbing Perch	Boigu	-	Often found in turbid stagnant waters (fresh), and estuaries	Burrows, 2010 Burrows & Perna, 2009; Hitchcock, 2008
	Saibai	-		
Scatophagidae				
<i>Selenotoca multifasciata</i> Banded Scat	Saibai	QM I.38042	Mangrove creeks and the lower reaches of freshwater streams	Hitchcock, 2008 This study
	Horn Island	QM I.38162		

water habitats in the Torres Strait islands, on the basis of a review of museum specimens collected prior to 2005 and field investigations undertaken from 2005-2011 (Table 1). Eight of the fifteen species generally regarded as primarily freshwater inhabitants are new records from the Torres Strait islands: *Pseudomugil gertrudae*, *P. signifer*, *Melanotaenia maccullochi*, *Ambassis elongatus*, *Kuhlia rupestris*, *Hypseleotris compressa*, *Mogurnda mogurnda* and *Oxyeleotris nullipora*. The full list of species is shown in Table 1.

Specimens of *Megalops cyprinoides* were photographed at Mua but not collected. A specimen of *M. cyprinoides*, measuring approximately 200 mm TL, hand-collected from a small (c. 2 m diameter) pool in a perennial swamp known as Gai Gawath, located directly adjacent to the township on Badu Island, was subsequently lost. Freshwater eels, *Anguilla* sp., were observed on several occasions in Vidgen Creek, Horn Island (GH pers. obs.) and at Boigu and Saibai (Burrows 2010; Burrows & Perna 2009), but specimens were not collected and positive identification to species level was not made.

Additional aquatic fauna were collected where encountered, and deposited in the collections of the Queensland Museum. From Vidgen Creek, these were: freshwater crab *Austrothelphusa* sp. (QM W.28481); freshwater mussel *Velsunio angasi* (QM MO.78577); freshwater prawn *Macrobrachium* sp. (QM W.28482); freshwater crayfish *Cherax* sp. (QM W.28363, W.28483, W.28485); freshwater shrimp *Cardina* sp. (QM W.28284); and the aquatic insects *Dineutus (Cyclous) australis* (Coleoptera) and *Limnometra ciliodes* (Hemiptera). Specimens of *Cherax* sp. were also collected at Badu (QM W.28361) and Mua (QM W.28362). *Austrothelphusa* sp. was collected from Mabuiag (QM W.28906) and specimens were also observed on Mua and Erub but not collected. The aquatic beetle *Cybister godeffroyi* (Coleoptera) was collected at Badu. Local people state that freshwater turtles are present on Horn Island, Badu, Mua and Saibai, although none were observed or collected. Saltwater crocodiles *Crocodylus porosus* are also common in the creeks and swamps of the Torres Strait Islands.

DISCUSSION

The small size of the Torres Strait islands, lack of permanent freshwater environments of any significant size, and the region's palaeo-geography, -climate and -ecology have contributed to a freshwater fauna that is depauperate compared to the adjoining mainlands.

Twenty-two of the 31 species recorded are known to inhabit brackish or saline waters (Table 1), making them well adapted to living in small island habitats where freshwater may not be permanently available. The remaining nine species are not known to inhabit or tolerate brackish or saline waters, and were collected from Boigu, Saibai, Badu, Mua, Horn and Muralag. We suggest two possible explanations for their presence in our samples. The first is that, over a long period of time, these islands maintained at least some refugial freshwater habitats. The maintenance of non-anthropogenically spread populations of these species requires freshwater habitats that must not dry out between wet seasons. Mua, Muralag and Badu all appear to have permanent pools in their freshwater systems. The situation is less clear on other islands: the freshwater streams on Horn Island appear to dry completely most years. Saibai has extensive inland freshwater systems (Boigu much less so), some of which are permanent (Barham 1999). It may also be the case that the small wells supported fish, and that repopulation on Boigu and Saibai also occurs during periodic large flood plumes from Papua New Guinea. A fuller examination of freshwater refuges and fish species inhabiting the islands may resolve this issue.

Some traditional knowledge of local freshwater fish was obtained during the study, including vernacular names in the Western-Central Torres Strait Language. On Badu, 'yamu' was said to be the name for all small freshwater fish. The lack of specific names probably reflects the economic unimportance of these fish, to people who were highly specialised marine hunters and fishers (McNiven & Hitchcock 2004). The

1898 Cambridge Anthropological Expedition to Torres Straits recorded 'iam' as the name in this language for Oxeye Herring *Megalops cyprinoides* (Ray 1907: 100). On Saibai Island the Sunset Gudgeon *Bostrychus zonatus* is called 'kunu' (Teske 1998), and another, similar but larger, species, called 'abadam', is also said to inhabit the inland swamps. Other local language names for aquatic fauna are: 'koedal' (Saltwater Crocodile, *Crocodylus porosus*); 'kobi' (freshwater turtle); and 'koti' (freshwater crab, *Austrothelphusa augustifrons*). At Badu, *Cherax* sp. are called 'kag'.

Threats

Two introduced pest fish have now been identified in Torres Strait: Climbing Perch *Anabas testudineus* on Boigu and Saibai (Burrows 2010; Hitchcock 2008, 2007) and Eastern Gambusia *Gambusia holbrooki* on Thursday Island (Burrows & Perna 2009). Hitchcock (2008) reported on the occurrence of *Anabas testudineus* at Saibai, from a digital photograph and oral accounts by Islanders. Specimens were subsequently captured by Burrows at Saibai and Boigu in 2008 and 2010 respectively; these are held in the collection of the Australian Centre for Tropical Freshwater Research (ACTFR), James Cook University, Townsville (Burrows 2010; Burrows & Perna 2009).

Burrows and Perna (2009) identified *Gambusia* in the emergency water supply and school irrigation dam on Thursday Island, and collected a specimen which is currently held in the ACTFR collection. It was also collected (by GH) from the Green Hill dam, the island's original water supply. The fish was likely introduced during the Second World War as an anti-malaria measure, when Torres Strait was under military administration; *Gambusia* was introduced by American and Australian forces across the Pacific (including the Australian mainland) for this purpose (e.g. Ball 1996; Sholdt *et al.* 1972; Whitley 1951).

The occurrence of *Gambusia* and Climbing Perch in Torres Strait means that extra vigilance is required to keep exotic fishes out of Cape York Peninsula. *Gambusia* is widespread in Queensland but not yet known from Cape York. In addition to Climbing Perch, two other air-breathing, land-mobile species are known from catchments in the lowlands of Papua New Guinea: Snakehead *Channa striata* and Walking Catfish *Clarias batrachus* (Hitchcock 2002). The potential for introduction of these hardy species is of considerable concern, as they can survive out of water for extended periods, greatly simplifying the logistics of transporting live specimens south through Torres Strait, and into Cape York (Burrows & Perna 2009; Hitchcock 2002, 2008). If introduced to the mainland, they could invade new catchments via overland dispersal (and via flood events) and have the potential to go around or over natural barriers (e.g. waterfalls). The available evidence suggests that they would pose a considerable threat to native fish species through competition and predation (Allen 1991: 216; Lever 1996: 147,184).

While there is some monitoring of pest fish from north to south (i.e. from New Guinea into Torres Strait) as part of the region's quarantine measures (Burrows & Perna 2009; Hitchcock 2008), there are no legislative restrictions on the import of alien freshwater fishes into the Strait. A retail store on Thursday Island currently sells a range of exotic aquarium species including goldfish (*Carassius auratus*), gourami (*Trichogaster* sp.), neon tetra (*Paracheirodon innesi*), angelfish (*Pterophyllum scalare*), guppy (*Poecilia reticulata*), swordtail (*Xiphophorus helleri*), platy (*X. maculatus*) and bristlenose catfish (*Ancistrus* sp.), as well as aquatic snails and plants. Other aquarium fish are known to have been brought to the islands directly from the Australian mainland. In 2005 GH observed aquarium fish that had been purchased in Cairns by non-indigenous workers in a large, open watertank next to a house at Kubin village, Mua. Burrows and Perna (2009) also noted that red claw crayfish (*Cherax quadricarinatus*),

sourced from the mainland, have been released into a dam on Thursday Island as part of a school aquaculture project. The potential therefore exists for the unintentional or deliberate release of exotic fish, invertebrates and plants into aquatic environments of the Torres Strait Islands. Further research on the Islands will be required to identify the potential impacts of the spread of alien species.

Eustatic sea-level rise associated with climate change may also pose a threat to the native freshwater fishes of the Torres Strait region, particularly low-lying islands such as Boigu and Saibai. In January 2006 and January 2009 king tides resulted in extensive flooding of Saibai (Hitchcock 2009). If the freshwater species found on these islands are natural populations maintained in refugial freshwater habitats, sea level rise and storm surge may eventually inundate these low-lying environments, turning them brackish or saline and extinguishing local populations.

CONCLUSION

More detailed information about the fresh- and brackish water fish fauna of Torres Strait, and the aquatic environments they inhabit, await future, more detailed research. DNA analysis of specimens, comparing fish from the adjoining mainlands may also help to elucidate the connectivity of freshwater environments across northern Australia and southern New Guinea in earlier periods of low sea level (see Baker *et al.* 2008). Further work should also more fully account for the freshwater fish fauna of the Torres Strait and the possible sources of immigration of these species, both to clarify the longer-term colonisation history of freshwater fish in the Strait and allow an assessment of potential sources of pest fish species in to and out of the region.

It is recommended that surveys focus on the largest islands in the Strait: Saibai, Badu and Mua in the central cluster; and Muralag in the southwest cluster. This is all the more urgent when the potential impacts of sea-level rise on

Torres Strait fresh and brackish water fishes

freshwater environments are considered. The presence and potential spread of exotic species from the Australian and New Guinea mainlands will also require close monitoring in order to facilitate timely response by fisheries authorities.

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