

## Fish fauna in inland waters of the Pilbara (Indian Ocean) Drainage Division of Western Australia — evidence for three subprovinces

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### Abstract

This paper describes the distribution of fishes in inland waters of the Pilbara (Indian Ocean) Drainage Division of Western Australia. 48 842 fish representing 29 species (including one undescribed plotosid catfish) were recorded from 148 of the 171 sites sampled in 21 river systems throughout the Pilbara Drainage Division, i.e. from the Irwin River in the south to the DeGrey River in the north. Of these, 26 844 were from 13 native freshwater species (this total includes the catadromous Indian short-finned eel *Anguilla bicolor* McClelland 1844 and an undescribed plotosid catfish), 3 099 were from 12 marine/estuarine species and a further 18 899 were from four introduced species. In addition, the Pilbara Drainage Division contains two endemic cave fishes in the North West Cape (Humphreys & Adams 1991; Allen *et al.* 2002). The results of this study suggest that the Pilbara Drainage Division can be divided into three subprovinces, one for the westwards flowing rivers, i.e. from the Greenough to Lyndon (Southern Pilbara Subprovince), another for the northwards flowing rivers, i.e. from the Yannarie to the DeGrey (Northern Pilbara Subprovince), and a third for the subterranean waters of North West Cape (North West Cape Subprovince).

**Key words:** Pilbara Drainage Division, Western Australia, fish fauna

### Introduction

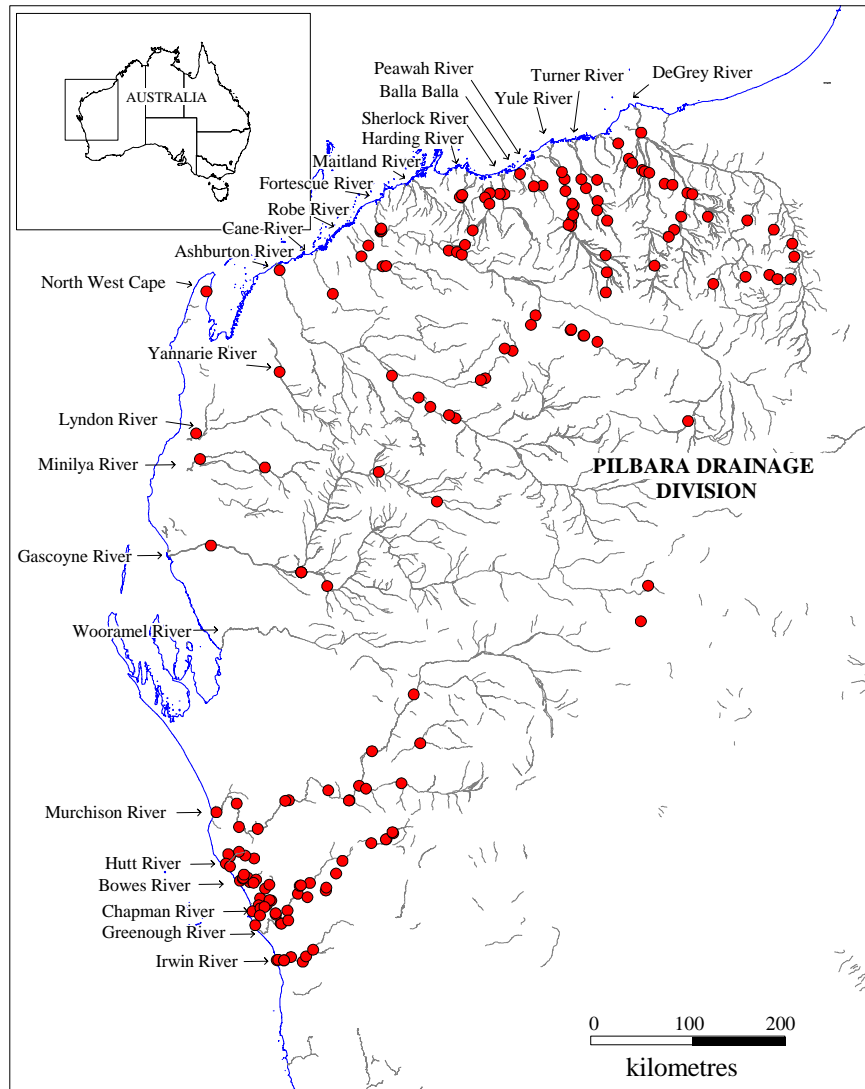
The freshwater fish fauna of Australia is depauperate but highly endemic and lacks many families found elsewhere in the world (e.g. Whitley 1947; Lake 1971; Allen 1989; Unmack 2001). Based on the prevailing freshwater fish (and molluscan) fauna (Iredale & Whitley 1938) and hydrological data (Lake 1971) of the different regions, Australia has, with only minor modifications, long been categorised into a number of biogeographical zones, bioregions or provinces (see for example, Whitley 1947; Merrick & Schmida 1984;

Allen *et al.* 2002). In the most recent discussions of these bioregions Unmack (2001), using contemporary statistical techniques, proposed that ten freshwater fish biogeographic provinces could be recognised, i.e. Southwestern, Pilbara, Kimberley, Northern, Central Australian, Eastern, Murray-Darling, Bass, Southern Tasmanian and Paleo.

The Pilbara Province extends from the Greenough River in the south to the DeGrey River in the north (Fig. 1) (Unmack 2001). It is one of the hottest regions in Australia with a mean rainfall of generally < 400 mm and in which perennial surface waters are scarce (Unmack 2001). However, a Mediterranean climate in the south, i.e. the region to the south of the Murchison River, and the effects of occasional monsoons in the north, i.e. the region to the north of the Yannarie River, ensures that whilst the region is exposed to extensive dry periods, with most of the region's rivers being intermittent for long periods, it is also subject to occasional flooding (winter in the south and summer in the north). It is worth noting that monsoonal and winter low pressure systems often extend far into the south and the north respectively, bringing with them unseasonal rainfall. As these low pressure systems rarely extend far inland, the inland sections of rivers receive even less and more erratic water than those of the coast. Furthermore, the central region between the Murchison and Ashburton rivers and the North West Cape receive even more erratic weather patterns often going several years without significant falls. However, whilst the North West Cape region is essentially desert with little, if any, perennial freshwater systems, it does have numerous caves that contain brackish waters and an associated stygo-fauna. To the north, the region is isolated from the Kimberley by the Great Sandy Desert, an extensive area with little or no surface run-off with the only records of fishes being those for the western rainbowfish *Melanotaenia australis* (Castelnau 1875) and the spangled perch *Leiopotherapon unicolor* (Günther 1859) from Sturt Creek (Unmack pers. comm.), whilst to the south there are no major catchments between the region and the first catchment of the Southwestern Division, i.e. the Arrowsmith River, ca 100 km to the south. The isolation of much of the region has resulted in only limited distributional fish faunal surveys being conducted. In 1947 Gilbert Whitley listed only three species known from the Pilbara (that he referred to as the Greyian Fluvifaunula) and stated that "We require more specimens for study, more exploration, and forbearance from introducing foreign types to the detriment of our native fauna". He did not, however, include the Murchison River hardyhead *Craterocephalus cuneiceps* Whitley 1944 in this list, which would have taken the total to four species. Since then, knowledge of the species composition of the region has been enhanced by Shipway (1950, 1953), Mees (1962, 1963), and Allen (1982). The most notable report of Pilbara fishes was that by Allen (1982) who reported on fish surveys by the Western Australian Museum in the 1970s. Masini (1998) conducted a limited fish survey of six species from between the Fortescue and DeGrey rivers, while Whitley (1945), Mees (1962), Humphreys and Adams (1991) and Humphreys (1994, 1999) provide notes on the subterranean fauna of the North West Cape. The above studies demonstrated that the Pilbara is home to five species of endemic freshwater fish

and, whilst sharing over half of it's species with the Kimberley, it shares none with the Southwestern Division (Allen *et al.* 2002).

In this paper we report on the results of a recent survey in which every major river system in the Pilbara Drainage Division was sampled for fish.



**FIGURE 1.** The sites in the Pilbara Drainage Division that were sampled for fish.

## Materials and methods

### *Sampling for fish*

Between December 2000 and November 2002 a total of 171 sites in the following rivers of the Pilbara Drainage Division were sampled for fish (see Fig. 1):

Irwin River (8 sites), Greenough River (21 sites), Chapman River (10 sites), Bowes River (8 sites), Hutt River (7 sites), Murchison River (15 sites), Gascoyne River (10 sites), Minilya River (2 sites), Lyndon River (1 site), Qualing and Charles Knife Rd pools (North West Cape) (2 sites), Yannarie River (1 site), Ashburton River (10 sites), Cane River (1 site), Robe River (4 sites), Fortescue River (16 sites), Harding River (3 sites), Sherlock River (6 sites), Balla Balla River (1 site), Peawah River (2 sites), Yule River (12 sites), Turner River (6 sites) and the DeGrey River (25 sites).

Sampling equipment included a variety of seine nets [1 m (1 mm mesh), 5, 10 and 15 m (all 3 mm mesh), 26 m (6 and 3 mm mesh) and 60 m (10 and 5 mm mesh)], gill nets (25 to 125 mm stretched mesh sizes), cast nets, masks and snorkels, and rods and lines.

#### *Environmental variables*

The salinity, temperature and pH were recorded at each sample site.

#### *Species identification and maps*

At each site, the fishes captured were identified, counted and a representative of each species photographed alive. The majority of fish were then released. However, some specimens were retained for positive identification and for the collections of the Western Australian Museum. Longitude and latitude were recorded at each site using a Global Positioning System (GPS). Species distribution maps were created using the above GPS data and MapInfo (MapInfo Corporation 1998).

#### *Classification of sample sites, ordination of rivers and Analysis of Similarity (ANOSIM)*

During the course of sampling our observations led us to propose that, based on its freshwater fish fauna, the Pilbara Drainage Division should be more appropriately considered to be comprised of three subprovinces, i.e. a southern subprovince (Southern Pilbara) extending northwards to approximately the Minilya River, a North West Cape subprovince encompassing the cave fishes that are endemic to the otherwise dry and extremely arid North West Cape, and a northern subprovince (Northern Pilbara) including all rivers between the Yannarie River and the DeGrey River. In order to test this hypothesis a similarity matrix of the freshwater fish species present at each site in each river (captured during this study and from Western Australia Museum records) employing the Bray-Curtis similarity coefficient was constructed using the PRIMER package (Clarke & Gorley 2001). In the same package a dendrogram was constructed to graphically display these data. A second analysis employing the pooled data for the sites from each river was also used to construct a similarity matrix of the freshwater fish species present in each river and an ordination plot using non-metric multidimensional scaling of these data generated. In order to test for significant differences between community structures of the proposed 'subprovinces', site and river data were subjected to one-way analysis of similarity (ANOSIM). ANOSIM is a non-parametric test that uses a permutation procedure applied to a

ranked similarity matrix, based on, in this case, a Bray-Curtis similarity matrix of species presence/absence data for sites or rivers. Firstly, the test statistic  $R$  is calculated.  $R$  is a measure of the discrimination between groups, with a value of 0 indicating no differences between groups, and a value of 1 indicating that each member within an *a priori* designated group is more similar to other members of the group than it is to members of any other group. Secondly, the samples (sites or rivers) are randomly sampled (with replacement) and assigned an arbitrary label (site or river descriptor) and the  $R$  statistic recalculated. This is performed a maximum of 999 times to produce a distribution of  $R$  values to which the original is compared and its probability of occurring by chance determined. Those rivers at which no native freshwater fish were caught were excluded from the analyses, e.g. the Irwin River was excluded as the only freshwater species caught was the introduced swordtail (*Xiphophorus hellerii* Heckel 1848).

Species presence-absence data were preferred to relative abundance data for a number of reasons; 1. Water levels, and thus sampling efficiency, varied greatly between the sample sites; 2. The level of sampling effort was governed by site characteristics, e.g. size and depth; 3. The requirement of a number of capture techniques to effectively sample the variety of species in the different sites, e.g. different meshed seine and gill nets, mask and snorkel only in clear waters, seine nets not as effective as gill nets or rod and line in capturing larger species (e.g. lesser salmon catfish); 4. Data from the Western Australian Museum gives no idea of sampling effort or total number of individuals captured. Thus, as estimates of relative abundance could not be standardised for all sites and as presence-absence data are generally more appropriate for biogeographic studies, comparisons utilising presence/absence data were employed.

## Results and Discussion

### *Environmental variables*

The conductivities of the rivers were generally low, but a number of systems in the southern part of the region were salt-affected. The salinity ranges for each species are provided in the individual species accounts. The pHs of the rivers sampled were always alkaline and ranged between 7.1 and 10.2. The water temperatures of the sites sampled ranged from 10.8 to 40.4°C. At some sites within Karijini National Park where the water temperatures were < 13°C in July all fish (*Neosilurus hyrtlii* Steindachner 1867 and *Leiopotherapon unicolor* (Günther 1859)) were dead. However, fish were found alive at nearby sites sampled during the same day where the water temperatures were >16°C. These data suggest that such low temperatures may be lethal to these tropical species.

### *Distribution of fishes in the Pilbara*

A total of 48 842 fish representing 29 species were recorded from 148 of the 171 sites sampled in 22 river systems throughout the Pilbara Drainage Division, i.e. from the Irwin

River (a small river *ca* 30 km to the south of the Greenough River) in the south to the DeGrey River in the north (Tables 1–3). Of these, 26 844 were from 12 (possibly 13) native

**TABLE 1.** The native freshwater fishes collected in the rivers of the Pilbara (Indian Ocean) Drainage Division. N.B. WAM signifies that whilst this species was not collected during the current study it is listed as present in the Western Australian Museums records.

Family Species	Common name	Total	Rivers
Anguillidae	Eels		
<i>Anguilla bicolor</i>	Indian short-finned eel	8	Fortescue, Yule, DeGrey (WAM)
Clupeidae	Herrings		
<i>Nematalosa erebi</i>	Bony bream	2 525	Ashburton, Cane, Robe, Fortescue, Maitland (WAM), Harding, Sherlock, Yule, Turner, Degrey
Ariidae	Fork-tailed catfishes		
<i>Arius graeffei</i>	Lesser salmon catfish	76	Ashburton, Fortescue, Harding, Sherlock, DeGrey
Plotosidae	Eel-tailed catfishes		
<i>Neosilurus hyrtlii</i>	Hyrtl's tandan	231	Ashburton (WAM), Fortescue, Maitland (WAM), Harding, Sherlock (WAM), Yule, DeGrey
<i>Neosilurus</i> sp.	<i>Neosilurus</i> species	1	Robe, Fortescue
Melanotaeniidae	Rainbowfishes		
<i>Melanotaenia australis</i>	Western rainbowfish	11 653	Ashburton, Robe, Fortescue, Maitland (WAM), Harding, Sherlock, Yule, Turner, DeGrey
Atherinidae	Silversides or hardyheads		
<i>Craterocephalus cuneiceps</i>	Murchison River hardyhead	8 128	Greenough, Hutt, Murchison, Wooramel (WAM), Gascoyne, DeGrey
Terapontidae	Grunters		
<i>Amniataba percoides</i>	Barred grunter	939	Ashburton, Robe, Fortescue, Maitland (WAM), Harding, Sherlock, Yule
<i>Leiopotherapon aheneus</i>	Fortescue grunter	792	Asburton, Robe, Fortescue
<i>Leiopotherapon unicolor</i>	Spangled perch	2 066	Murchison to DeGrey, Wooramel (WAM), Maitland (WAM)
Eleotridae	Gudgeons		
<i>Hypseleotris aurea</i>	Golden gudgeon	182	Murchison, Gascoyne
<i>Hypseleotris compressus</i>	Empire gudgeon	193	Chapman, Murchison, Robe (WAM), Fortescue, Harding, Sherlock, Yule, Turner, DeGrey
Gobiidae	Gobies		
<i>Glossogobius giurus</i>	Flathead goby	50	Ashburton, Fortescue, Maitland (WAM)
<b>TOTAL</b>		<b>26 844</b>	

freshwater species, 3 099 were from 12 marine/estuarine species and a further 18 899 were from four introduced species. In addition to the species captured during this study the Pilbara Drainage Division contains two endemic cave fishes in the North West Cape (Humphreys & Adams 1991; Allen *et al.* 2002). The five most abundant species were the introduced mosquitofish *Gambusia holbrooki* Girard (ex Agassiz) 1859 (16 510), and the following native species, western rainbowfish *Melanotaenia australis* (11 653), Murchison River hardyhead *Craterocephalus cuneiceps* (8 128), bony bream *Nematalosa erebi* (Günther 1868) (2 525) and spangled perch *Leiopotherapon unicolor* (2 066), which together accounted for ~85% of the total catch.

**TABLE 2.** The marine/estuarine fishes collected in the rivers of the Pilbara (Indian Ocean) Drainage Division.

Family Species	Common name	Total	Rivers
Elopidae	Tenpounders		
<i>Elops hawaiiensis</i>	Giant herring	70	Greenough, Harding, Yule
Megalopidae	Tarpon		
<i>Megalops cyprinoides</i>	Oxeye herring	102	Fortescue, Harding, Yule, DeGrey
Chanidae	Milkfish		
<i>Chanos chanos</i>	Milkfish	240	Ashburton, Fortescue, Yule, DeGrey
Mugilidae	Mulletts		
<i>Mugil cephalus</i>	Sea mullet	605	Irwin, Greenough, Chapman, Bowes, Hutt, Murchison, Ashburton, Fortescue, Turner, DeGrey
Centropomidae	Giant perches		
<i>Lates calcarifer</i>	Barramundi	35	Ashburton, Harding, Sherlock, Yule, DeGrey
Lutjanidae	Snappers		
<i>Lutjanus argentimaculatus</i>	Mangrove jack	157	Ashburton, Fortescue, Harding, Sherlock, Yule, Turner, DeGrey
Sparidae	Bream		
<i>Acanthopagrus butcheri</i>	Black bream	123	Irwin, Greenough, Chapman, Hutt, Murchison
Gerreidae	Silver biddies		
<i>Gerres filamentosus</i>	Threadfin silver biddy	4	Turner, DeGrey
<i>Gerres subfasciatus</i>	Roach	11	Ashburton, Yule
Terapontidae	Grunters		
<i>Amniataba caudavittata</i>	Yellow-tail trumpeter	1 088	Greenough, Murchison, Yule, DeGrey
Scatophagidae	Scats		
<i>Selenotoca multifasciata</i>	Striped butterfish	6	Fortescue, DeGrey
Gobiidae	Gobies		
<i>Pseudogobius olorum</i>	Swan River goby	658	Irwin, Greenough, Chapman, Bowes, Hutt, Murchison
<b>TOTAL</b>		<b>3 099</b>	

**TABLE 3.** The introduced fishes collected in the rivers of the Pilbara (Indian Ocean) Drainage Division.

Family	Common name	Total	Rivers
Species			
Poeciliidae	Livebearers		
<i>Gambusia holbrooki</i>	Mosquitofish	16 510	Greenough, Chapman, Hutt, North West Cape
<i>Poecilia reticulata</i>	Guppy	150	North West Cape
<i>Xiphophorus hellerii</i>	Swordtail	232	Irwin
Cichlidae	Cichlids		
<i>Oreochromis mossambicus</i>	Tilapia	2 007	Chapman, Gascoyne, Minilya, Lyndon
<b>TOTAL</b>		<b>18 899</b>	

The following species accounts give details on the freshwater, marine/estuarine and introduced fishes that were captured during the project. For the purposes of this paper, freshwater species are those that are either restricted to freshwater, breed in freshwater or they spend the majority of their lives in freshwater. Marine and estuarine species are those that are predominantly found in the marine or estuarine environ but may enter freshwaters during their life, but do not breed in the fresh. It should be noted that the short-finned eel *Anguilla bicolor* McClelland 1844, which breeds in the sea, was included in the freshwater category as it must spend the majority of its juvenile and adult life in freshwaters. The lesser salmon catfish *Arius graeffei* Kner and Steindachner 1867, which is found in both fresh and salt waters, has also been included in the freshwater category because they will breed in freshwater.

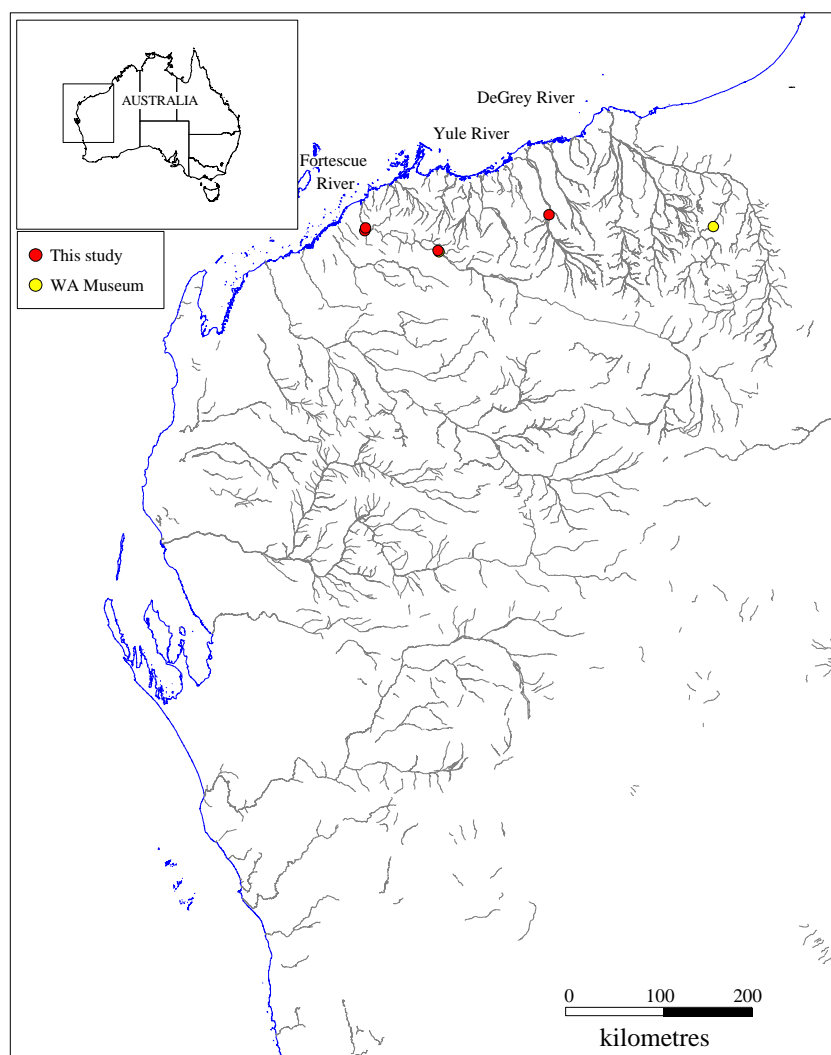
#### *Freshwater fishes of the Pilbara (Plate 1)*

##### Indian short-finned eel (Anguillidae)

##### *Anguilla bicolor* McClelland 1844

The short-finned eel was the third least abundant species caught during the course of this study (Table 1). Only eight individuals were recorded at three sites in the Fortescue River (1 individual at each site) and at one site in the Yule River (Plate 1, Table 1, Fig. 2). Western Australian Museum records also report this species from a single site in each of the Fortescue and DeGrey rivers. This species was captured in salinities of between 0.5 and 1.3 ppt. It is the only anguillid known from Western Australia. The adults, which grow to ~100 cm total length (TL), migrate to marine waters to breed, small juveniles then migrating back into freshwaters where they spend the majority of their lives before returning to the sea to breed and die (Smith 1997).





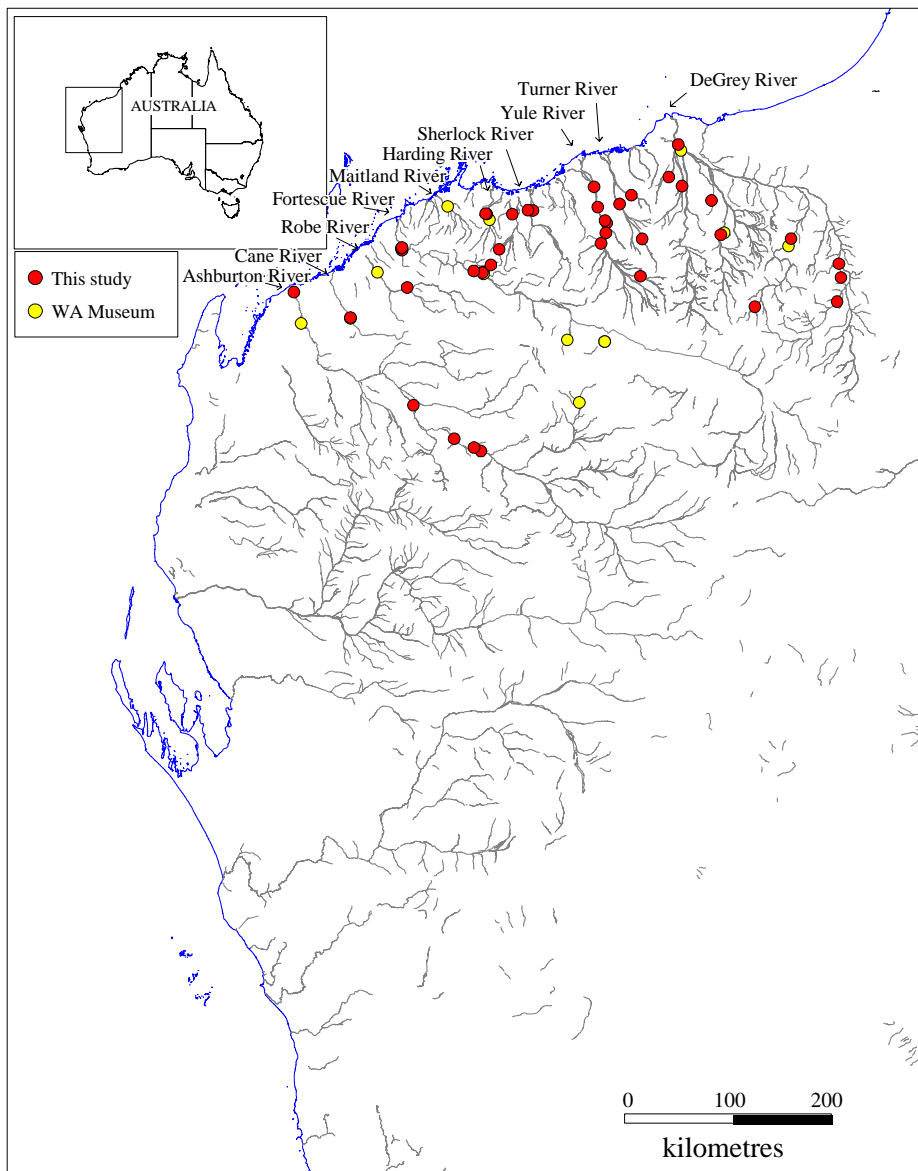
**FIGURE 2.** The sites in the Pilbara Drainage Division where the Indian short-finned eel (*Anguilla bicolor*) was captured. Also included are the Western Australian Museum records for the species.

#### Bony bream (Clupeidae)

##### *Nematalosa erebi* (Günther 1868)

The bony bream was the fourth most numerous species recorded during this study (Table 1). A total of 2 525 individuals were captured at 41 sites (at densities of up to 1.69 m<sup>-2</sup>) in the majority of rivers between the Ashburton in the south and the DeGrey in the north (Plate 1, Table 1, Fig. 3). Western Australian Museum records report this species from the Ashburton, Robe, Fortescue, Maitland, Harding and DeGrey rivers. This species was captured in salinities between 0.1 and 2.3 ppt. This is one of Australia's most widespread

freshwater species occurring throughout other parts of northern Australia, including the drainages of the Kimberley, Northern Territory, Queensland, Murray-Darling and Lake Eyre (Allen *et al.* 2002). Attains a maximum size of ~30 cm TL and is one of only two Australian freshwater herrings. *Nematalosa erebi* may have a very protracted spawning period (i.e. at least May to December) in the Pilbara. In the Murray River (South Australia) it spawns in its second or third year of life during summer when water temperatures are 21–23°C (Puckridge and Walker 1990).



**FIGURE 3.** The sites in the Pilbara Drainage Division where the bony bream (*Nematalosa erebi*) was captured. Also included are the Western Australian Museum records for the species.