The following supplement accompanies the article

The effects of shoreline armouring on estuarine fish are contingent upon the broader urbanisation context

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Table S1. List of species identified during remote underwater video station surveys, and the habitat association and functional groups to which they were assigned. Missing values in groupings columns denote species that fell into categories that were not analysed in this study. Species without categories for different groupings were from groupings that were not analysed in this study.

Species		Harvested species	Habitat association group	Functional group
Bengal sergeant	*Abudefduf bengalensis*		Structure	
Scissortail sergeant	*Abudefduf sexfasciatus*		Structure	
Indo-Pacific sergeant	*Abudefduf vaigiensis*		Structure	
Yellowfin bream	*Acanthopagrus australis*	Harvested	Mangrove	
Eyestripe surgeonfish	*Acanthurus dussumeri*		Structure	
Estuary perchlet	*Ambassis marianus*		Mangroves	Zooplanktivore
Narrow-lined pufferfish	*Arothron manilensis*		Structure	
Whitespotted pufferfish	*Arothron meleagris*		Mangroves	
Brassy trevally	*Caranx papuensis*	Harvested	Structure	Piscivore
Bigeye trevally	*Caranx sexfasciatus*	Harvested	Structure	Piscivore
Threadfin butterflyfish	*Chaetodon Auriga*		Structure	
Dusky butterflyfish	*Chaetodon flavirostris*		Structure	
Raccoon butterflyfish	*Chaetodon lunula*		Structure	
Vagabond butterflyfish	*Chaetodon vagabundus*		Structure	
Milkfish	*Chanos chanos*	Harvested		

Species		Harvested species	Habitat association group	Functional group
Crested morwong	*Cheilodactylus vestitus*		Structure	
Goldlined wrasse	*Coris aurilineata*		Structure	
Estuary stingray	*Dasyatis fluviorum*			Piscivore
Painted sweetlip	*Diagramma pictum*	Harvested		
Goldspotted rockcod	*Epinephelus coioides*		Mangroves	Piscivore
Whipfin silver-biddy	*Gerres filamentosis*			
Common silver belly	*Gerres subfasciatus*	Harvested		
Luderick	*Girella tricuspidata*	Harvested	Structure	
Golden trevally	*Gnathanodon speciosus*	Harvested	Structure	Piscivore
Goby	Gobiidae			
Pennant coralfish	*Heniochus acuminatus*		Structure	
Castelnau's herring	*Herklotsichthys castelnaui*		Mangroves	Zooplanktivore
Black-spotted goby	*Istigobius nigroocellatus*			
Silver drummer	*Kyphosus sydneyanus*	Harvested	Structure	
Common cleanerfish	*Labroides dimidiatus*		Structure	
Common ponyfish	*Leiognathus equulus*		Mangroves	
Spangled emperor	*Lethrinus nebulosus*	Harvested		Piscivore
Diamond-scale mullet	*Liza vaigienis*	Harvested		
Mangrove jack	*Lutjanus argentimaculatus*	Harvested	Mangroves	Piscivore
Dory snapper	*Lutjanus fulviflamma*	Harvested	Mangroves	Piscivore
Five-lined snapper	*Lutjanus quinquelineatus*	Harvested	Mangroves	Piscivore
Russell's snapper	*Lutjanus russelli*	Harvested	Mangroves	Piscivore
Stripey	*Microcanthis strigatus*		Structure	
Diamondfish	*Monodactylus argenteus*		Structure	
Mullet	*Mugil cephalus*	Harvested		
Fringefin trevally	*Pantolabus radiates*		Structure	Zooplanktivore
Blacksaddle goatfish	*Parupeneus spilurus*			
Six-lined trumpeter	*Pelates sexlineatus*			
Dotted sweetlips	*Plectorhinchus picus*	Harvested	Structure	Piscivore
Striped eel catfish	*Plotosus lineatus*			
Semicircle angelfish	*Pomacanthus semicirculatus*		Structure	
Gunther's wrasse	*Pseudolabrus guentheri*		Structure	

Species		Harvested species	Habitat association group	Functional group
Goldlined seabream	*Rhabdosargus sarba*	Harvested	Mangroves	
Blue-barred parrotfish	*Scarus ghobban*	Harvested	Structure	
Spotted scat	*Scatophagus argus*		Structure	
Spotbanded scat	*Selenotoca multifasciata*		Mangroves	
Mottled spinefoot	*Siganus fuscescens*	Harvested	Mangroves	
Gold-lined whiting	*Sillago analis*	Harvested		
Sand whiting	*Sillago ciliata*	Harvested		
Crescent grunter	*Terapon jarbua*		Mangroves	
Common toadfish	*Tetractenos hamiltoni*		Mangroves	
Moon wrasse	*Thalassoma lunare*		Structure	
Weeping toadfish	*Torquigener pleurogramma*		Mangroves	
Yellowtail scad	*Trachurus novaezelandiae*	Harvested	Mangroves	
Yellowfin tripodfish	*Tripodichthys angustifrons*		Mangroves	
Shadow goby	*Yongeichthys nebulosus*			
Moorish idol	*Zanclus cornutus*		Structure	

Text S1.

Establishing differences in the study seascapes

Rationale

Prior to conducting fish surveys, we quantified differences in the seascapes of our three study estuaries to ensure they provided us with appropriate, and representative, examples of low, moderately and highly urbanised systems, especially with respect to the extent of shoreline armouring and watershed urbanisation, and the extent of remaining mangroves. Previous studies in southeast Queensland have established that differences in these attributes drive differences in fish assemblages, that many of the differences in these seascapes are driven by differences in the extent of urban lands and mangroves across the estuary, and that the chosen three estuaries are likely to represent the full spectrum of these values regionally (Gilby et al. 2017b).

Methods for determining differences

We tested, using multivariate analyses replicated at the scale of individual study sites (see Figure 1), for differences in a suite of environmental metrics known to be important to estuarine fish. Details of these variables are provided in Table 1. Differences in the suite of environmental variables of sites between our three estuaries were determined using permutational multivariate analysis of variance (PERMANOVA) in PrimerE, calculated on normalised Euclidean distance measures (Clarke & Gorley 2015), and were visualised using non-metric multidimensional scaling (nMDS) ordinations (Clarke 1993). Variables driving the differences in environmental attributes of estuaries were identified using the similarity percentage (SIMPER) procedure (Clarke 1993).

Differences in estuarine seascapes

The three estuaries contained significantly different seascapes (PERMANOVA; $t>8.59$, $P=0.001$; Figure S1). These differences were primarily driven by the Extent of armoured shorelines in the lower estuary and the area of mangroves in each estuary (Table S2). The Noosa River (i.e. *low urbanisation*) had the lowest percentage of watershed urbanisation and largest extent of mangroves (Table S2). Maroochy River (i.e. *moderate urbanisation*) was characterised by moderate urbanisation and moderate mangrove extent, and the Mooloolah River (i.e. *high urbanisation*) was highly urbanised (Table S2). Although the moderately and highly urbanised estuaries had a similar percentage of watershed urbanisation (41% and 40%), these estuaries differed in the extent of urbanised shorelines in the lower estuary (10% and 51%, respectively), and mangrove extent (289 m^2/m and 62 m^2/m, respectively) (Table S2). These trends were supported by Pearson's vectors over the multivariate ordination of the suite of environmental metrics (Figure S1). Here, vectors clearly indicate the highest extent of mangroves in the least urbanised estuary, and, conversely the lowest extent of mangroves in the highly-urbanised estuary. By contract, vectors for percentage of watershed urbanisation, and extent of urbanised shorelines in the lower estuaries are clearly greater towards the most urbanised estuary. With the intermediately urbanised estuary lying clearly between the other estuaries, we can be confident that these estuaries represent the scale of estuarine urbanisation in this region.

Table S2. Similarity percentage analysis (SIMPER) outputs quantifying differences in environmental metrics between the three sampled estuaries. Only factors that contribute to a cumulative 90% of the difference between estuaries are included.

Factors	Mean values			Noosa vs Maroochy			Noosa vs Mooloolah			Maroochy vs Mooloola		
	Noosa	Maroochy	Mooloolah	Av. Sq. Dist	Sq. Dist/ SD	Contrib %	Av. Sq. Dist	Sq. Dist/ SD	Contrib %	Av. Sq. Dist	Sq. Dist/ SD	Contrib %
Estuary-scale measures												
Extent of armoured shorelines in the lower estuary	10%	10%	51%				5.38	-	20.18	5.48	-	26.76
Percentage of watershed urbanisation	8%	41%	40%	4.46	-	29.91	4.08	-	15.29			
Area of mangroves in sampled stretch (m^2/m)	47.7	28.9	6.2				6.85	-	25.69	2.04	-	9.98
Site-scale measures												
Urban land near site (m^2)	206964± 23036	187599± 32704	367649± 36782	1.58	0.7	10.57	2.23	0.83	8.38	3.06	0.95	14.93
Mangroves near site (m^2)	106030± 17861	138803± 19324	36160± 13060	2.09	0.7	14.04				2.53	0.68	12.35
Distance of site to estuary mouth	3244.59± 336.28	4593.85± 568.89	3621.10± 527.79	2.09	0.79	14.01	1.82	0.75	6.82			
Distance of site to armoured estuarine shoreline	184.74± 44.47	455.28± 100.32	386.25± 212.45	1.85	0.5	12.37	1.9	0.46	7.12	2.43	0.53	11.88
Distance of site to mangroves	332.37± 79.62	212.94± 71.69	1213.28± 262.96	1.44	0.5	9.65	2.73	0.81	10.24	2.94	0.81	14.37

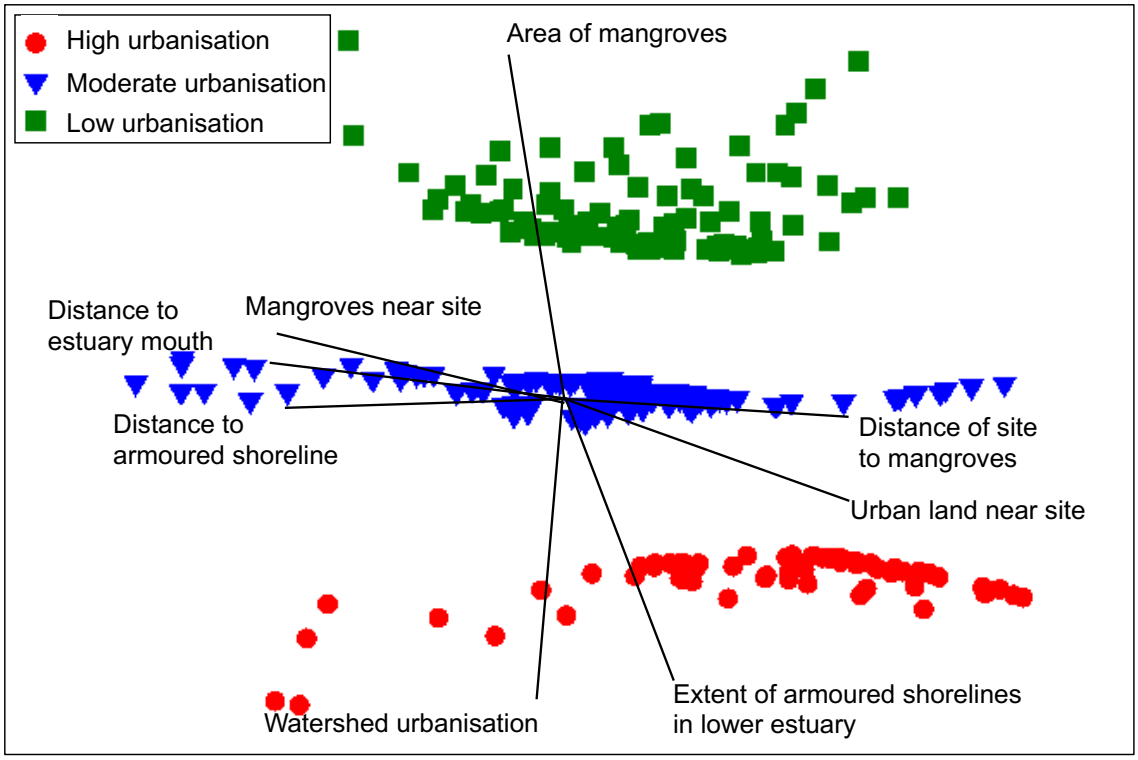

Figure S1. Multi-dimensional scaling ordination based on environmental attributes in estuaries. Vectors indicate direction of higher values of environmental metrics. 2D stress=0.11.

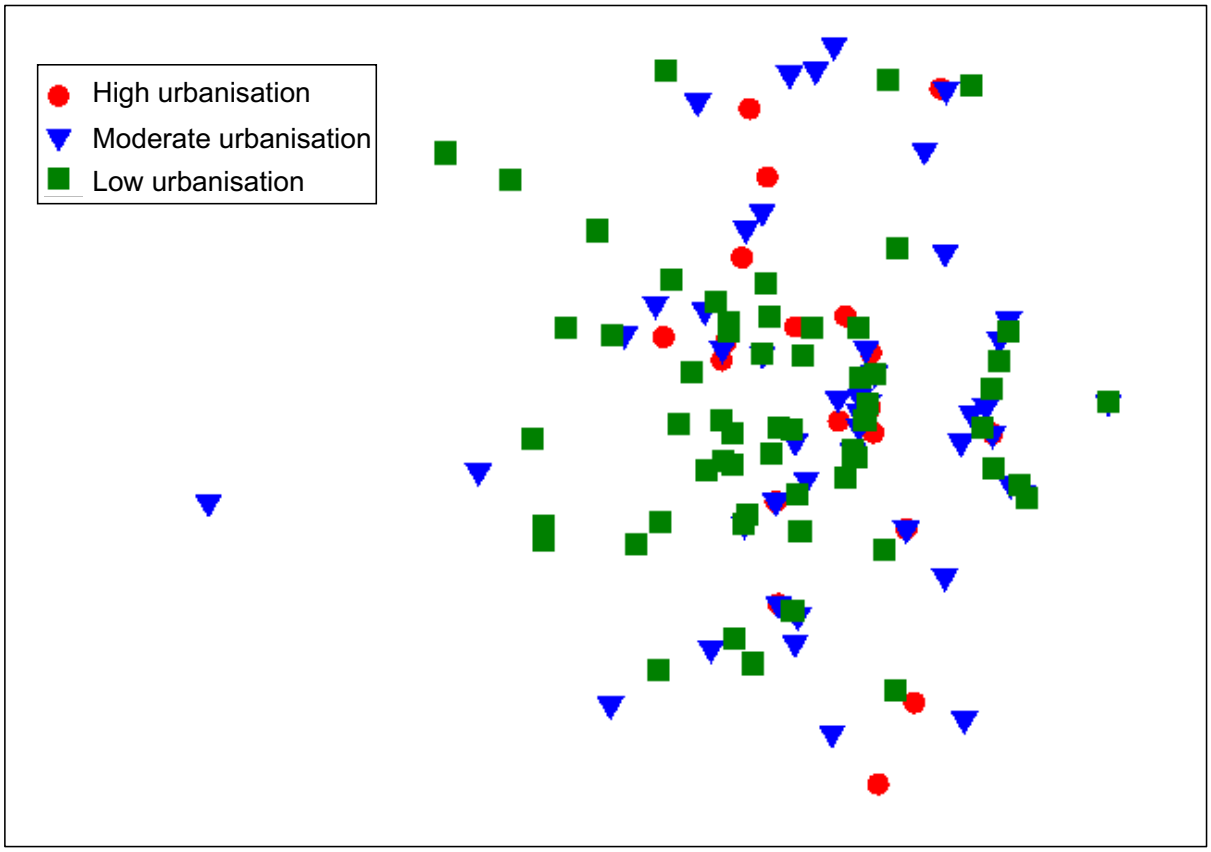

Figure S2. Multi-dimensional scaling ordination of fish assemblages across the three sampled estuaries.