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Differences in Catch Composition among Types of Commercial Penaeid-Seining Operations in an Australian Estuary

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Abstract

Three variants of commercial penaeid prawn (or shrimp) seining are done in the Wallis Lake estuarine system in New South Wales (NSW), Australia (day-time river, and day- and night-time lagoon), which are operated differently according to the type of habitat and time of day in which they are used. A large-scale observer study was done during the 1998-1999 and 2001-2002 prawn seining seasons to quantify penaeid-seine catches in this estuary. These data were used to compare the species composition of penaeid catches and non-penaeid bycatches across the three types of seining. Catch compositions varied considerably – mostly according to the specific habitat being fished (i.e. riverine vs. coastal lagoon) and time of day. Currently, the codends of all NSW seines are restricted to a legal stretched-mesh opening of between 30 and 36 mm and are constructed of diamond-shaped mesh throughout. Recent research with some NSW penaeid seines (including Wallis Lake night-time lagoon seines) has, however, demonstrated the utility of codends made from square-shaped mesh (i.e. hung on the bar) for reducing the bycatch of unwanted small fauna. Consequently, the compulsory use of square-mesh codends in most penaeid seines throughout NSW is being considered as a management strategy for reducing bycatch. We discuss the differences in catches among the three seining variants in terms of the implementation of square-mesh codends, and recommend that appropriate rigorous trials with such codends be conducted for each seining variant in each NSW estuary prior to mandating their use.

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Introduction

Trawl fisheries that target penaeid prawns (or shrimps) are typically characterized by large bycatches of small organisms, including juvenile penaeids (Andrew & Pepperell 1992; Broadhurst 2000). Consequently, there have been extensive efforts to improve size and species selection in such gears during the past decade or so (e.g. Broadhurst 2000; Broadhurst et al. 2004; Courtney et al. 2006; Macbeth et al. 2007). In contrast, considerably fewer bycatch-reduction studies have been done with other types of towed penaeid-catching gears such as seines (Macbeth et al. 2005a; 2005b), despite their widespread use throughout the temperate and tropical regions world-wide (Vendeville 1990; Gray 2001; Gray et al. 2003).

In New South Wales (NSW), Australia, seining for penaeid prawns is permitted in 15 estuaries using gears configured and operated differently according to the type of habitat and time of day in which they are used. River seines, which are restricted to a headline length of < 40 m, are used to target school prawns (*Metapenaeus macleayi*) in river channels during the day (Gray et al. 2003; Gray & Kennelly 2004; Macbeth et al. 2005a; 2005b). In contrast, lagoon seines (restricted to a headline length of < 140 m) are used to target school, greasyback (*M. bennettae*) and eastern king prawns (*Penaeus plebejus*) in coastal lagoons during the day and at night (Gray 2001; Macbeth et al. 2005a; 2005b). Both of these methods involve deployment and retrieval of the seine using small dories (i.e. < 5 m long) and are generally used during the spring, summer and autumn months (i.e. September through May) (Gray 2001; Gray & Kennelly 2004; Macbeth et al. 2005a; 2005b).

In any given estuary, generally only one of the three variants (i.e. day-time river, day-time and night-time lagoon) is used, although, uniquely, all three are regularly employed in the Wallis Lake estuarine system (Fig. 1). Wallis Lake is a barrier estuary of ~ 86 km^2 in area and has three major tributaries (Fig. 1; Macbeth et al. 2005b). Along with the seine fishery, an important stow-net fishery for penaeids is also supported in the estuary, which is the third largest producer of wild penaeids in NSW (Macbeth et al. 2005b).

All penaeid seines used in NSW are currently restricted to a legal mesh size of between 30- and 36-mm stretched-mesh opening (SMO) (Ferro & Xu 1996), and are conventionally constructed of diamond-shaped mesh (Robertson & Stewart 1988) throughout. Nevertheless, recent research has demonstrated the utility of codends made from 25- to 29-mm square-shaped mesh (i.e. hung on the bar) for reducing the capture of small, juvenile penaeids and other non-penaeid bycatch in a range of fisheries, including the night-time lagoon-seine fishery of Wallis Lake (Macbeth et al. 2005b). In contrast, and despite improvements in size selectivity reported for a similar seine in another NSW river (Macbeth et al. 2005a), the use of square-mesh codends with a Wallamba River (a tributary of Wallis Lake; Fig. 1) seine did not significantly improve its selectivity (Macbeth et al. 2005b).

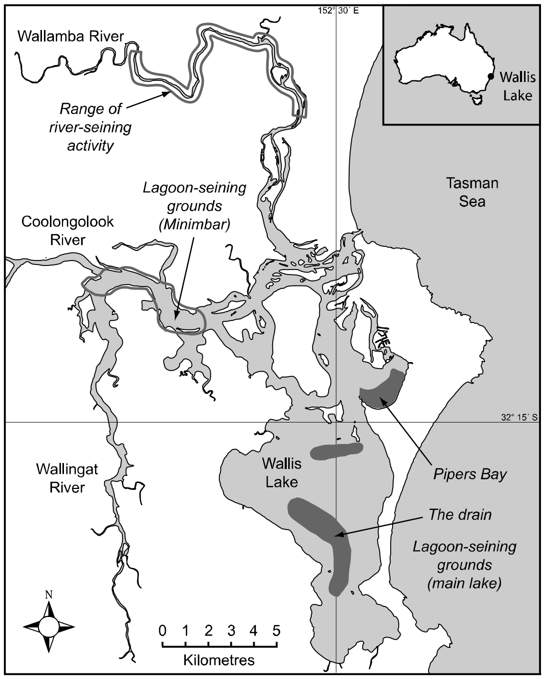

Fig. 1. River-seine, and night- and day-time lagoon-seine fishing grounds in the Wallis Lake estuary that were fished during the observer sampling periods (i.e. the 1998 - 1999 and 2000 - 2001 seasons)

Variability in the selectivity of square-mesh codends within gear types has also been found for trawls (Campos et al. 2002; Macbeth et al. 2007) and stow nets (Macbeth et al. 2005b; 2005c), and has been attributed to a range of factors including operational, biological and environmental factors unique to each fishing operation. Although the selectivities of conventional diamond- and square-mesh codends were determined for two of the three Wallis Lake seining variants (see above), little is known about the operations, typical catch compositions or selectivity of day-time lagoon seines. Despite day- and night-time lagoon seining involving the use of almost identical seines and methods of operation, the composition of their catches, and therefore their selectivities, may differ considerably owing to different times and/or areas in which fishing is done. Although the selectivity of lagoon seines during day-time use has not been assessed, the potential for differences in the selectivity of these seines when used at night should not be ignored, particularly when considering the implementation of gear-based strategies, such as square-mesh codends, as tools for improving selectivity.

The objective of the present study was to determine and compare the composition of penaeid catches and non-penaeid bycatches for day-time river, and day- and night-time lagoon seines used in the Wallis Lake estuary. Differences in catches among the three prawn-seining variants will be discussed in terms of the implementation of square-mesh codends as a measure for improving the size and species selectivity in penaeid-seine fisheries throughout NSW.

Materials and Methods

Data were collected in the Wallis Lake estuary (32º 15´ S, 152º 30´ E) for each of the three types of seining (river, and day- and night-time lagoon) as part of a large-scale observer survey, which was designed to quantify the catches and bycatches associated with prawn seining in NSW estuaries (Gray 2001; Gray et al. 2003). Detailed descriptions of Wallis Lake prawn seines and their methods of operation can be found in Gray et al. (2003) and Macbeth et al. (2005b).

All sampling was done between September 1998 and February 2001. Observers accompanied commercial seining crews on up to seven randomly chosen trips (fisher days) in each month during the 1998-1999 (river and limited lagoon seining) and 2000-2001 (lagoon seining only) fishing seasons (Table 1). Given the limited sampling resources available, observer effort during these two seasons was generally concentrated in the river- and lagoon-seine fisheries, respectively, in an attempt to maximise accuracy and precision of the bycatch estimates generated for each of the methods (Table 1). Sampling was done opportunistically so that during any given month the number of trips completed for each of the three methods was dependent on the overall fishing effort expended. As a consequence of these temporal inconsistencies among and within methods, the number of observer trips completed and the quantity of data recorded for each type of seining varied considerably (Table 1).

After each haul or tow was completed during each observed trip, the fishers sorted the contents of the codend into penaeid catch (retained) and non-penaeid bycatch (to be discarded). The observer weighed these components, then further identified and sorted each according to individual taxa, recording the total weight and number of individuals for each (where necessary, the total number was estimated by scaling up a weighed sub-sample). In addition, for some catches (where time permitted) the carapace length (CL) of each prawn in subsamples of up to 100 penaeids was measured to the nearest mm (Table 1).

Table 1. Number of trips (fisher days) during which detailed bycatch and/or prawn data were collected. Data are for river seining, and day- and night-time lagoon seining in each month during which sampling was done

Year	Month	River Seining		Lagoon Seining			
				Day		Night	
		Bycatch	Prawns	Bycatch	Prawns	Bycatch	Prawns
1998	September	3	2	2	0	1	0
	October	3	1	0	0	1	0
	November	4	2	0	0	0	0
	December	4	3	0	0	0	0
1999	January	0	0	0	0	0	0
	February	2	2	0	0	1	0
	March	6	1	0	0	0	0
	April	2	0	0	0	0	0
	May	5	3	0	0	0	0
	June	1	1	0	0	0	0
2000	October	0	0	0	0	6	2
	November	0	0	0	0	4	4
	December	0	0	3	0	4	2
2001	January	0	0	7	3	5	4
	February	0	0	0	0	2	2
Total trips		30	15	12	3	24	14

Data analysis

Two-sample Kolmogorov-Smirnov (KS) tests were used to detect differences in the size-frequency distributions of penaeids in catches among the three different fishing methods. Non-metric multivariate analyses were used to test for differences in the composition of bycatch among the three fishing methods. Day-time lagoon seining was further separated into two groups according to the different locations fished (see Results for an explanation), giving a total of four groupings. Similarity matrices for untransformed counts of all bycatch species were constructed using the Bray-Curtis similarity measure. Counts were standardised prior to all analyses to account for any dissimilarities in bycatch composition arising from differences in abundance owing to: (i) gear-related factors such as swept area; and (ii) temporal factors such as different fishing seasons. Patterns of catch composition were explored visually using non-metric multidimensional scaling (MDS). One-way analysis-of-similarities

(ANOSIM) was used to test for significant differences among groupings. Where significant differences were detected by ANOSIM, the species or groups primarily responsible for these dissimilarities were determined using similarity-percentages (SIMPER) analysis. All multivariate analyses were done using PRIMER 5 (Clarke and Gorley 2001).

Results

All river-seining trips were to sites in the Wallamba River, while all but one night-time lagoon-seining trip (to Pipers Bay) were to 'The drain' (Fig. 1; Table 1). Day-time lagoon-seining trips were to night-time lagoon-seining sites in the Wallis Lake, or to sites at Minimbar (Fig. 1), or to both during the same trip (treated as separate trips). Bycatch data were collected for a total of 30 river-seining trips (all during the 1998-1999 season), 12 day-time lagoon-seining (two trips during 1998-1999 and 10 during the 2000-2001 season), and 24 night-time lagoon-seining trips (three trips during 1998-1999 and 21 during 2000-2001) (Table 1). Size-frequency data for prawns were collected during 15, 3 and 14 of these trips, respectively (Table 1). The mean number of codend-lifts·trip^{-1} (±SE) were 5.2 (± 0.7), 3.0 (± 0.2) and 2.0 (± 0.2), respectively.

The mean catch rates of prawns for river, and night-time and day-time lagoon seining were 14.6 (± 1.1), 9.1 (± 0.9) and 6.9 (± 0.8) kg·codend-lift^{-1}, respectively, while the mean bycatch rates were 2.0 (± 0.2), 3.1 (± 0.4) and 2.1 (± 0.4) kg·codend-lift^{-1}, respectively. The mean ratio of non-penaeid bycatch to prawn catch·codend-lift^{-1} (by weight) for river-seining trips was 0.270:1 (± 0.063); night-time lagoon-seining trips was 0.502:1 (± 0.073); and day-time lagoon-seining trips was 0.435:1 (± 0.108).

Composition of penaeid catches

School prawns ranging in size from 5- to 25-mm CL were the only penaeids recorded during river-seining trips (Fig. 2a). In contrast, penaeid catches from night-time lagoon-seining trips comprised of greasyback (74 ± 4% by number; from 11- to 28-mm CL), school (17 ± 4%; from 6- to 28-mm CL) and eastern king prawns (9 ± 3%; from 9- to 25-mm CL) (Fig. 2b). One brown tiger prawn (*Penaeus esculentus*; 24-mm CL) was also recorded. The species composition of penaeid catches from the three day-time lagoon-seining trips during which prawn data were collected varied

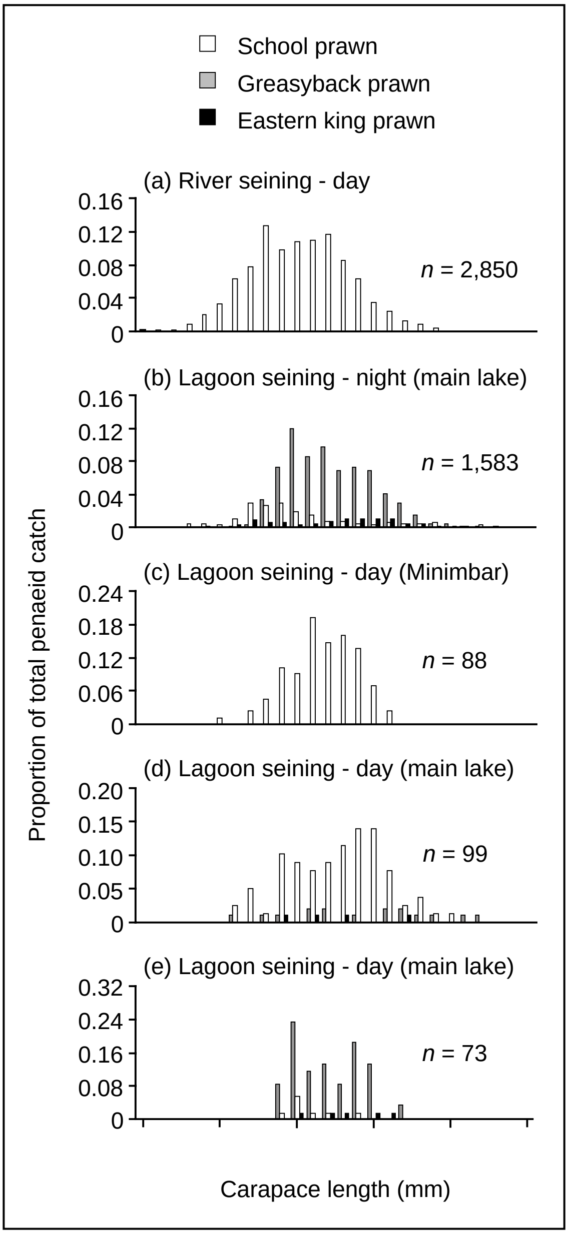

Fig. 2. Size-frequency distributions of school, greasyback and eastern king prawns in sampled catches from (a) river-seining trips; (b) night-time lagoon-seining trips; (c) a day-time lagoon-seining trip to Minimbar; and, (d) and (e) two day-time lagoon-seining trips to night-time lagoon-seining sites in the main lake

considerably (Fig. 2c – e). School prawns ranging in size from 10- to 21-mm CL were the only penaeids caught at Minimbar (Fig. 2c), while the proportions of greasyback, school and eastern king prawns in catches from the two trips to the sites in the main lake were 16, 80 and 4%, respectively, and 82, 11 and 7%, respectively (Fig. 2d and e). The size-frequency distribution of school prawns caught in the river seines differed significantly from those for the lagoon seine used at night in the main lake and during the day at Minimbar and in the main lake, which all differed significantly from each other (KS tests, $P < 0.05$; Fig. 2a – d). In contrast, the size-frequency distributions of greasyback prawns caught in lagoon seines in the main lake at night and for one of the trips done during the day were not significantly different (KS tests, $P > 0.05$; Fig. 2b and e).

Non-penaeid bycatches

More than 51 species of finfish and 5 species of non-penaeid invertebrates were recorded in catches during the study (Table 2). A total of 30, 47 and 36 species or groups were present in river-seine, and night- and day-time lagoon-seine catches, respectively. Overall, the most abundant species in bycatches for all three methods was *Gerres subfasciatus* – a species of minor commercial value locally (Table 3a).

Table 2. List of all non-penaeid bycatch species recorded in river- (RS); and night- (NS) and day-time (DS) lagoon-seine catches

Family	Scientific name	Common name	RS	NS	DS
Crustaceans					
Portunidae	*Portunus pelagicus*	Blue-swimmer crab#		*	*
	Scylla serrata	Mud crab #	*		
Squillidae	(unidentified)	Mantis shrimp		*	*
Finfish					
Ambassidae	*Ambassis* spp.	Glassy perchlet	*	*	*
Antennariidae	*Antennarius* spp.	Anglerfish		*	*
Apogonidae	*Siphamia* spp.	Siphonfish	*	*	*
Arripidae	*Arripis trutta*	Australian salmon #	*		
Atherinidae	*Atherinomorus ogilbyi*	Ogilby’s hardyhead		*	
Batrachoididae	*Batrachomoeus dubius*	Eastern frogfish		*	*
Bothidae	*Pseudorhombus arsius*	Large-toothed flounder #	*	*	*
	Pseudorhombus jenynsii	Small-toothed flounder #		*	*
Callionymidae	*Foetorepus calauropomus*	Common stinkfish	*	*	*
Carangidae	*Trachurus novaezelandiae*	Yellowtail scad #		*	*
Carcharhinidae	*Carcharhinus leucas*	Bull shark	*		
Chaetodontidae	*Selenotoca multifasciata*	Striped butterfish	*		
Clupeidae	*Herklotsichthys castelnaui*	Southern herring #	*	*	*
	Hyperlophus vittatus	Sandy sprat		*	*
Dasyatididae	*Dasyatis* spp.	Estuary stingray	*		*
Dinolestidae	*Dinolestes lewini*	Longfin pike		*	*
Diodontidae	*Dicotylichthys punctulatus*	Three-bar porcupinefish		*	
Engraulididae	*Engraulis australis*	Australian anchovy		*	*
Gerreidae	*Gerres subfaciatus*	Silver biddy #	*	*	*
Girellidae	*Girella tricuspidata*	Luderick #	*	*	
Gobiidae	(unidentified)	Various species	*	*	*
	Arenigobius bifrenatus	Bridled goby		*	
	Arenigobius frenatus	Half-bridled goby		*	
	Cristatogobius gobioides	Oyster goby		*	
	Favonigobius exquisites	Sand goby		*	*
	Favonigobius lateralis	Longfin goby		*	
	Philypnodon grandiceps	Flathead gudgeon	*		
Hemiramphidae	*Hyporhamphus regularis*	River garfish #	*	*	
Monocanthidae	*Monacanthus chinensis*	Fan-belly leatherjacket #		*	
	Meushenia trachylepus	Yellow-finned leatherjacket #		*	
Monodactylidae	*Monodactylus argenteus*	Diamond fish	*		*
Mullidae	*Upeneus tragula*	Bar-tail goatfish		*	*
Mugilidae	*Mugil cephalus*	Sea mullet #	*		
	Valamugil georgii	Fan-tail mullet #	*		
Platycephalidae	*Platycephalus fuscus*	Dusky flathead #	*	*	*
Plotosidae	*Cnidoglanis macrocephalus*	Estuary catfish #	*	*	*
	Plotosis lineatus	Striped catfish	*	*	*
Pomatomidae	*Pomatomus saltatrix*	Tailor #	*	*	*
Priacanthidae	*Priacanthus macracanthus*	Red bigeye		*	*
Sciaenidae	*Argyrosomus japonicus*	Mulloway #	*	*	*
Scorpaenidae	*Centropogon australis*	Fortescue	*	*	

Table 2. List of all non-penaeid bycatch species recorded in river- (RS); and night- (NS) and day-time (DS) lagoon-seine catches (continued)

Family	Scientific name	Common name	RS	NS	DS
Sillaginidae	*Sillago ciliata*	Sand whiting #	*	*	*
	Sillago maculata	Trumpeter whiting #		*	*
Soleidae	*Synaptura nigra*	Black sole	*	*	
Sparidae	*Acanthopagrus australis*	Yellowfin bream #	*	*	*
	Chrysophrys auratus	Snapper #		*	*
	Rhabdosargus sarba	Tarwhine #	*	*	*
Terapontidae	*Pelates sexlineatus*	Eastern striped trumpeter	*	*	*
Tetraodontidae	*Tetractenos* spp.	Toadfish	*	*	*
Triglidae	*Chelidonichthys kumu*	Red gurnard		*	
Urolophidae	*Trigonoptera testacea*	Common stingaree		*	*
Cephalopods					
Loliginidae	*Loliolus noctiluca*	Bottle squid		*	*
	Photololigo sp.	Estuary squid		*	*

# denotes species of economic importance

Herklotsichthys castelnaui, also of minor commercial importance, was caught in large quantities in river seines at times (Table 3a). Most other species caught in large quantities were small, demersal species of little or no economic value, such as *Ambassis* spp., *Siphamia* spp., *Batrachomoeus dubius*, *Foetorepus calauropomus* and *Loliolus noctiluca* (Table 3a).

A number of species of considerable economic importance were present in catches, but in relatively small quantities. *Portunus pelagicus* was regularly caught in lagoon seines (4.7 ± 0.6 and 1.0 ± 0.4 individuals·codend-lift^{-1} during the night and day, respectively), as was *Pomatomus saltatrix* (2.6 ± 0.7 and 4.3 ± 0.9 individuals·codend-lift^{-1}, respectively). Some *Rhabdosargus sarba* (1.6 ± 0.5 individuals·codend-lift^{-1}) and *Pseudorhombus arsius* (1.2 ± 0.6 individuals·codend-lift^{-1}) were caught in day-time lagoon seines, while 1.4 ± 0.5 *Monacanthus chinensis*·codend-lift^{-1} were caught in night-time lagoon seines. Other economically important species, including *Platycephalus fuscus*, *Sillago ciliata* and *Chrysophrys auratus* were caught at rates of less than one fish·codend-lift^{-1} (Table 2).

Four method/location groupings were defined for non-metric, multivariate analysis of bycatch composition: (i) river seining; (ii) night-time lagoon seining; and day-time lagoon seining (iii) at Minimbar; and (iv) in the main lake (Fig. 3; Table 3). The latter two groupings were made due to the distance between those two fishing grounds (Fig. 1). The analysis demonstrated that there were significant differences in bycatch composition among the four groupings (ANOSIM, global R = 0.37, P < 0.001; Fig. 3). The stress value associated with the MDS ordination was 0.18 (Fig. 3), indicating that it is reliable enough to be useful for discerning general differences among groupings (Clarke & Warwick 1994). Pairwise comparisons indicated that there were no significant differences in bycatch composition between the river-seining and Minimbar day-time lagoon-seining groupings (R = 0.017). Both of these groupings were, however, significantly different to the night-time lagoon-seining (R > 0.355) and main-lake, day-time lagoon-seining groupings (R > 0.170), which were also significantly different from each other (R = 0.179) (Fig. 3; Table 3b). Dissimilarity between groupings was found to be primarily driven by patterns in the abundance of the more numerically-dominant bycatch species in catches (Table 3). *Gerres subfasciatus* made the greatest contribution to dissimilarity for all pairwise comparisons, while *H. castelnaui*, *L. noctiluca* and *B. dubius* also provided substantial contributions (Table 3b).

Table 3. Summary of ANOSIM and SIMPER analyses: (a) mean abundances of the non-penaeid bycatch species or groups in catches in river seines (RS), night-time lagoon seines (NS), and day-time lagoon seines used at Minimbar (DS-M) and in the main lake (DS-L) that contributed the most to dissimilarity (i.e. > 5%) in pairwise comparisons among these four groupings; (b) results of pairwise comparisons among catch compositions for the four groupings (ANOSIM – significance level for *R*-value shown) and the species or groups primarily responsible for overall dissimilarities in composition of non-penaeid bycatch.

(a)	Bycatch species or group	Mean abundance			
		RS	NS	DS-M	DS-L
	G. subfaciatus	47.11	37.21	164.83	56.70
	H. castelnaui	44.91	1.21	15.72	2.50
	Ambassis spp.	12.71	0.60	12.00	2.10
	Siphamia spp.	2.49	14.12	0.61	4.70
	F. calauropomus	0.16	0.90	14.94	0.80
	H. vittatus	0	14.88	1.28	0.50
	B. dubius	0	21.29	0	0.50
	L. noctiluca	0	4.49	1.61	50.60

(b)	Pairwise test	*P*-value	Top three species or groups contributing to dissimilarity (%)
	RS vs. NS	0.001	*G. subfaciatus* (20.3), *H. castelnaui* (15.5), *B. dubius* (11.3)
	RS vs. DS-M	0.391	*G. subfaciatus* (28.6), *H. castelnaui* (21.5), *Ambassis* spp. (12.8)
	RS vs. DS-L	0.002	*G. subfaciatus* (21.5), *H. castelnaui* (17.5), *L. noctiluca* (15.8)
	NS vs. DS-M	0.001	*G. subfaciatus* (22.9), *B. dubius* (12.2), *Ambassis* spp. (9.4)
	NS vs. DS-L	0.012	*G. subfaciatus* (20.1), *L. noctiluca* (15.9), *B. dubius* (12.7)
	DS vs. DS	0.035	*G. subfaciatus* (23.0), *L. noctiluca* (18.0), *Ambassis* spp. (11.2)

Discussion

The species composition of penaeid catches and bycatches in prawn seines used in the Wallis Lake estuary varied considerably according to the specific habitat being fished (i.e. riverine vs. coastal lagoon). School prawns were the only prawns caught in river seines, as has been the case for other studies done with river-based prawn seines in NSW (Gray et al. 2003; Macbeth et al. 2005a; 2005b).

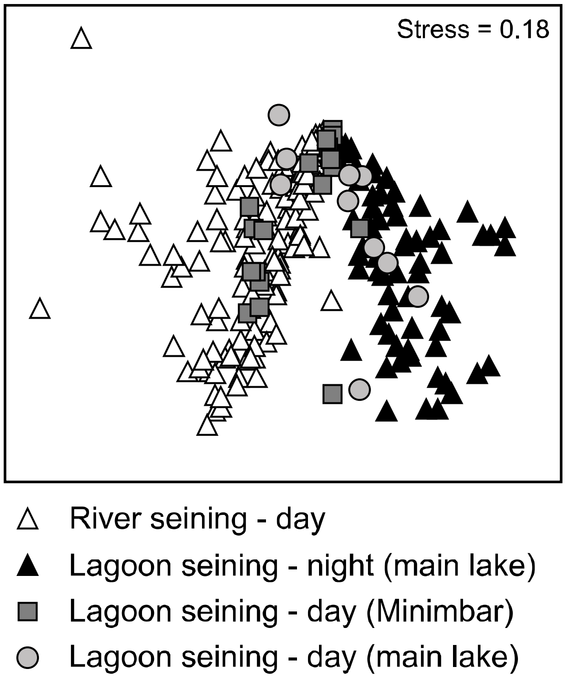

Fig. 3. Non-metric MDS ordination plot of bycatch compositions among four groupings: river seining; night-time lagoon seining; and day-time lagoon seining at Minimbar, and in the main lake

In contrast, school, greasyback and eastern king prawns were all present in lagoon-seine catches in proportions varying according to the grounds being fished, as is the case for other NSW estuaries in which lagoon-based penaeid seining takes place (e.g. Gray 2001; Macbeth et al. 2005b). The composition of bycatch also varied among lagoon-seining grounds, and there were also differences between day- and night-time catches on the same grounds. Bycatches in river seines and lagoon seines when used at night were very similar in composition to those recorded during other studies done in the Wallis Lake estuary (Gray et al. 2003; Macbeth et al. 2005b).

There were distinct differences in catch composition between lagoon-seine catches from near the mouth of one of the tributaries (i.e. Minimbar) and catches from the main lake. In fact, catches from Minimbar more closely resembled river-seine catches than those from the main lake, with school prawns being the only penaeids caught, and no significant difference in bycatch composition. These similarities suggest that differences in the specific design or operational characteristics of the two types of gears (Macbeth et al. 2005a) have a secondary influence on the composition of catches compared to the influence of differences in the ecologies associated with the different fishing grounds. Interestingly, multivariate analysis detected a significant difference in bycatch composition between river seining and day-time lagoon seining at Minimbar when untransformed data was analysed without being standardised (ANOSIM, $P < 0.05$, detailed results not presented). Standardising the data reduces the influence that differing quantities of catch (i.e. total number of individuals irrespective of species) has on the analysis, therefore increasing the emphasis of any differences in species composition and the ability of the analysis to detect such differences. This is an important consideration in this case because of the differences in the designs and operational characteristics of the two types of seines (Macbeth et al. 2005b), and the aggregated distribution of some of the species caught in large quantities. Furthermore, *G. subfasciatus* and *H. castelnaui* generally exist demersally in dense schools (Kuiter 1996) and, as a consequence, are usually captured in large numbers when caught in small-mesh prawn gears (e.g. Andrew et al. 1995; Liggins & Kennelly 1996; Gray 2001; Gray et al. 2003; Macbeth et al. 2005b; 2005c), further justifying standardising of the data prior to analysis.

Comparisons between catches from night- and day-time lagoon-seine catches must be made with caution due to a lack of data for the latter. Nevertheless, some interesting observations were made. First, the composition of the penaeid catches from the three day-time lagoon-seining trips differed considerably, with the species composition from one trip to the main lake (i.e. Fig. 2e) strongly resembling that from the night-time trips to that area. In contrast, the catch from the other day-time trip to the main lake (i.e. Fig. 2d) was more similar in penaeid species composition to catches from the day-time lagoon-seining trip to Minimbar and the river seining. This may have been a result of lagoon seining being done after prolonged, heavy precipitation in the catchment, which, according to anecdotal evidence, tends to correlate with the subsequent presence of large quantities and dense aggregations of school prawns in the main lake (possibly after being washed out of the tributaries). In any case, these differences, along with clear diurnal differences in bycatch composition in catches from the main lake, are likely to have been due to differences in the diurnal activity levels and/or patterns of spatial distribution among species.

Except for *G. subfasciatus* and *H. castelnaui*, relatively few individuals of species of economic importance were recorded in lagoon-seine catches (i.e. < 5 individuals·codend-lift^{-1}). This is in contrast to results from an observer-type study done in another day-time lagoon-seine fishery in NSW (Tuggerah Lakes). Gray (2001) found that bycatches were dominated by quite large quantities of *G. subfasciatus*, *R. sarba*, *Acanthopagrus australis* and *Girella tricuspidata*, which are all of at least some economic importance. The lagoon-seining grounds in Tuggerah Lakes include many beds of seagrass (*Zostera capricornii*), which act as nursery grounds for juveniles of economically important species (Gray 2001). By comparison, the Wallis Lake lagoon-seining grounds do not include large areas of seagrass. This may account for differences between the two fisheries in the quantities of those species present in bycatches.

Macbeth et al. (2005b) demonstrated that increasing the lateral mesh openings in Wallis Lake lagoon-seine codends via the utility of square-shaped meshes between 25 and 29 mm drastically improved the size and species selectivity of the seines (compared with the conventional diamond-mesh codends) when they are used at night in the main lake. More specifically, it was concluded that by using these square-mesh codends, large proportions of small, unwanted, juvenile penaeids (i.e. < 15-mm CL) are able to escape from the gear during towing without significantly reducing catches of target-sized prawns. The success of this gear modification was attributed in part to the hypothesis that greasyback prawns are distributed more evenly throughout the muddy basin in the main lake, and so enter the codend at a more-or-less constant rate during the tow (Macbeth et al. 2005b). Furthermore, the square-mesh codends yielded significant reductions in the retention of non-penaeid bycatch individuals (i.e. by up to 95%) (Macbeth et al. 2005b). Given those results, it would seem appropriate to mandate the compulsory use of such codends in lagoon-seine fisheries throughout NSW. Square-mesh codends did not, however, improve the size selection of school prawns in the Wallamba River seine during the same study, with slow hauling speeds suggested as the most likely reason for this (Macbeth et al. 2005b). Another contributing factor might have been the large quantities of densely concentrated prawns being funnelled into the codend and lifted onboard the boat in a relatively short period of time. This is characteristic of river seining in NSW and may also explain why catch sizes have been shown to be relatively variable in these gears at times (Gray et al. 2003; Macbeth et al. 2005a). Under these conditions small prawns and fish near the centre of the concentration have almost no chance of encountering an open mesh (i.e. 'blinding' of meshes, Casey et al. 1992), reducing the overall selectivity of the gear.

Although previous research has emphasised the necessity for gear-based strategies to improve size and species selectivity of penaeid seines (e.g. square-mesh codends) to be investigated on a fishery-specific basis (Macbeth et al. 2005a; 2005b), results from the current study indicate that appropriately rigorous scientific trials should be done within many of these fisheries as well. In the case of Wallis Lake penaeid seining, the variability in the composition of catches from day-time lagoon-seine fishing grounds requires particular attention with respect to assessing the suitability of square-mesh codends as a selectivity-improving gear modification. The effectiveness of square-mesh codends when used with lagoon seines in the main lake at night should not be assumed to translate to similar effectiveness at other lagoon-seining grounds and/or at other times of day. This is clearly illustrated by the combination of: (i) previous recommendations championing the use of such codends in Wallis Lake lagoon seines (Macbeth et al. 2005b); (ii) the apparent ineffectiveness of that strategy in Wallamba River seines; and (iii) the similarities in catch composition, and probably also in the patterns of dispersion (i.e. degree of aggregation) of the targeted school prawns, between Wallamba River seine and Minimbar lagoon-seine catches. This issue should be addressed prior to any formal mandating of the use of square-mesh codends throughout the Wallis Lake lagoon-seine fishery. Furthermore, strategies to improve size and species selectivity in any fishery that uses these sorts of gears should be thoroughly tested under a range of representative fishing conditions to ensure their suitability for widespread use throughout that fishery.

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