COMPARISONS OF FISH CATCHES USING FYKE NETS AND BUOYANT POP NETS IN A VEGETATED SHALLOW WATER SALTMARSH FLAT AT TOWRA POINT, NSW

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ABSTRACT

The selection of appropriate sampling methods is a prerequisite for the design of any survey detailing nekton assemblages. In the present study two commonly used saltmarsh fish sampling methods, the fyke net and the buoyant pop net, were used to compare the assemblages of fish caught in a saltmarsh flat during monthly spring tides over a twelve month period. Both nets were made of 2mm mesh. A total of 3514 fish and crustaceans of 21 species were captured by 48 fyke net sets and 818 fish of 16 species were captured by 48 pop net releases. Fyke and pop nets recorded significantly different (ANOSIM: $P<0.001$) assemblages, with higher proportions of *Pseudomugil signifer* caught in the fyke nets and *Ambassis jacksoniensis* in the pop nets. Five species, *Sillago cilliata, Rhabdosargus sarba, Redigobius macrostoma, Taeniodes mordax* and *Metapenaeus macleayi,* were caught in the fyke nets only. Significant differences in the size of fish caught were recorded for two species, *Gobiopterus semivestitus* and *Gerres subfasciatus,* with larger fish on average caught in the pop nets. The result suggested that pop nets are less efficient at catching smaller fish.

INTRODUCTION

The development of suitable methods for the sampling of nekton in saltmarsh is complicated by the infrequent and relatively short periods of inundation. Further, conventional methods of sampling such as trawling are often not practicable due to shallowness of water. In the Sydney region, spring tides heights of greater than 1.6m are required for the flooding of a saltmarsh (Clarke & Hannon 1969), where the maximum spring tidal height is approximately 2.0 metres. The exact extent of tidal inundation at any given saltmarsh will depend on local topography and climatic conditions.

Studies conducted to date in Australia and overseas have used hand trawling (Gibbs 1986), fyke nets (Morton *et al.* 1987, Williams *et al.* 1996), block nets (Hettler 1989), lift nets (Rozas 1992), pop nets (Michel *et al.* 1989, Connolly *et al.* 1994), traps (Smith & Able 1994) and poisoning (Gibbs 1986) to collect fish from saltmarsh. The multiplicity of methods used makes regional and local comparisons difficult. Analogous studies in seagrass habitat suggest that contrasting results can be achieved using to different of methods. Sometimes fish assemblages collected from the same meadow of seagrass using two different methods (such as poisoning and trawling) can be more different than assemblages collected from different meadows with the same method (Gray and Bell 1986). Connolly (1994) found pop nets caught more fish than seine nets in a shallow seagrass habitat.

The present study employed two commonly used saltmarsh fish sampling methods, fyke nets (Morton *et al.* 1987, Williams *et al*. 1996) and buoyant pop nets (Michel *et al*. 1989, Connolly *et al*. 1994) simultaneously over the course of 12 months to allow comparisons of the assemblages caught. The aim of the study was to determine whether fyke and pop nets employed in the same environment yielded comparable results.

STUDY SITE AND METHODS

The study was conducted on saltmarsh flats of Towra Point, within Botany Bay (Figure 1). The saltmarsh of Towra Point consists of two vegetation communities, with the lower saltmarsh dominated by *Sarcocornia quinqueflora* with *Sporobolus virginicus, Triglochin striata*, and *Suaeda australis* also present. At higher elevations, *Juncus krausii* is the dominant species (Clarke & Hannon 1967, Adam *et al*. 1988). The saltmarsh is flooded by spring tides through breaks in a levee bank which forms a boundary between the mangrove and saltmarsh habitats along most of the Woolooware Bay side of the wetland.

Fyke net design and installation

The fyke net (Morton *et al.* 1987, Williams *et al*. 1996) consists of a 4 metre long funnel-shaped net with one central and two lateral wings and a 400mm wide and 250mm high entrance. Mesh size throughout was 2mm. The net was secured in place by six large wooden stakes at its extremities; a metal plate kept the base of the entrance flush with the substrate. Where needed, small metal pegs were also placed to keep the entrance funnel and wings tight against the substrate. The wings had floats and leads along their tops and bottoms respectively, to keep them upright (Figure 2). Four fyke nets were placed randomly in the lower saltmarsh zone, with openings facing the saltmarsh. Nets were positioned immediately before the flooding of the saltmarsh. Fish were collected from the fyke nets immediately after tide water had fully receded.

Pop net design and installation

The pop net (after Michel *et al*. 1989, and Connolly *et al*. 1994) was made of 2mm nylon mesh and was 5.5 x 5.5m square, elevating when fully extended to a maximum height of 1.5 metres. The top of the mesh was attached to 20mm diameter PVC pipe, sealed for flotation. The base of the net was secured tightly to the marsh surface with tent pegs, with the nets hidden prior to release inside shallow trenches, which were dug two months prior to the beginning of the experiment. Nets were weighed down with four concrete blocks attached by a nylon rope to a remote point 100 metres from the nets (Figure 3), and released from this remote point at the peak of the tide. Nekton trapped inside were collected using a large sweeping hand net. Four replicate pop nets were placed randomly in the lower (*Sporobolus/Sarcocornia* dominated) segment of the saltmarsh.

Fyke and pop nets were deployed simultaneously during spring high tides (>1.8m) from March 2001 to February 2002 every month when saltmarsh flats were inundated by tidal water. Captured individuals were preserved with 10% formaldehyde solution for species identification, enumeration and length measurement. Total length (point of snout to the end of the tail) of fish and crustaceans was measured for *Ambassis jacksoniensis*, *Pseudomugil signifer*, *Gobiopterus semivestitus*, *Mugilogobius stigmaticus*, *Gerres subfasciatus*, *Acanthopagrus australis* and *Macrobrachium intermedium* the most common species caught.

Data analysis

Differences in composition of fish captured by fyke and pop nets were examined using Bray-Curtis measures of dissimilarity (Bray & Curtis 1957) with square root transformed data. Nonmetric multidimensional scaling (nMDS) plots were constructed to demonstrate the patterns of fish community in different nets (Clarke & Warrick 2001). Multivariate techniques such as ANOSIM (Clarke & Warrick 2001) were used to test the statistical significance of differences between the fish community in fyke and pop nets. Univariate analysis (ANOVA) and *post-hoc* Student-Newmans-Kuels (SNK) tests were performed using GMAV5 (Underwood & Chapman 1989) to determine the significance of differences between net types for the numbers of individuals caught and the size of individuals for the most commonly caught species.

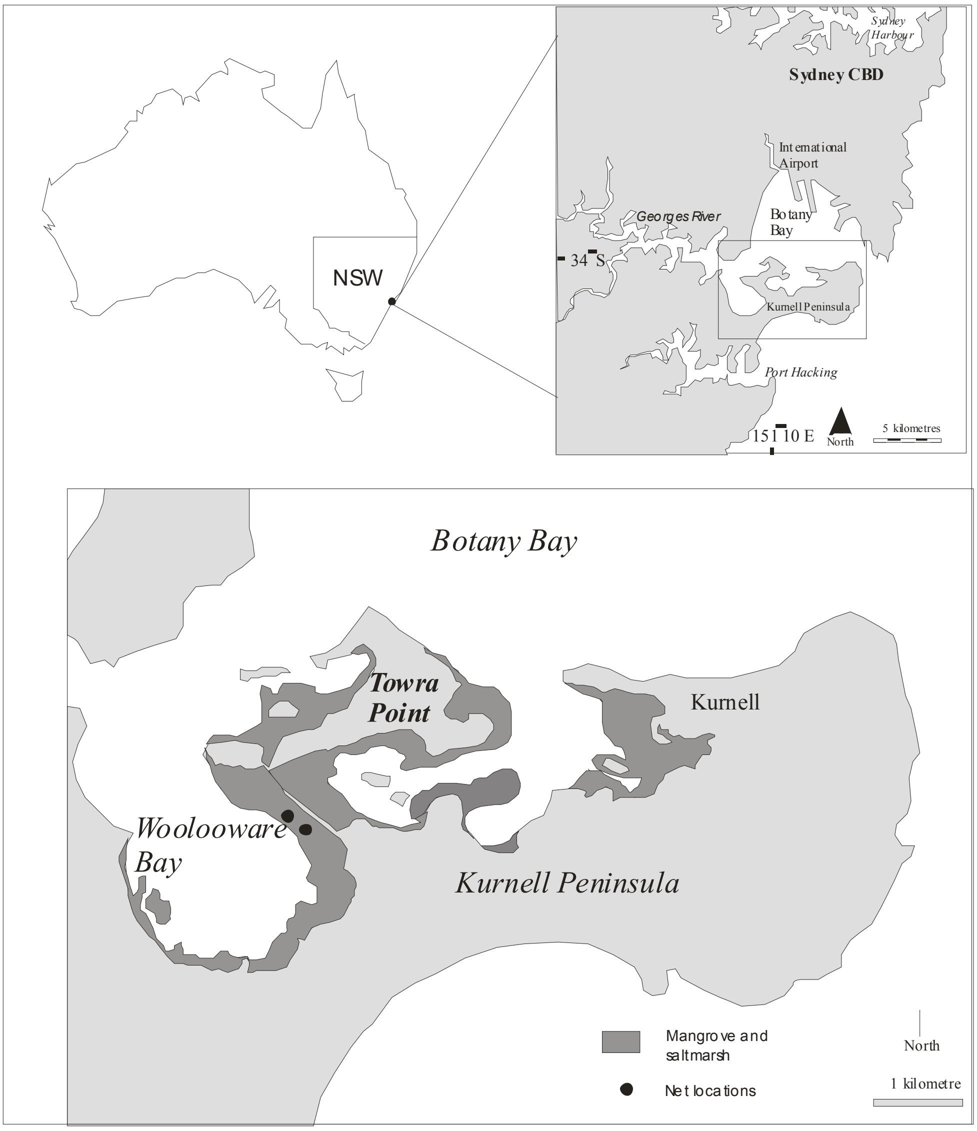

Figure 1: Location of Towra Point, Botany Bay showing the distribution of mangrove and saltmarsh.

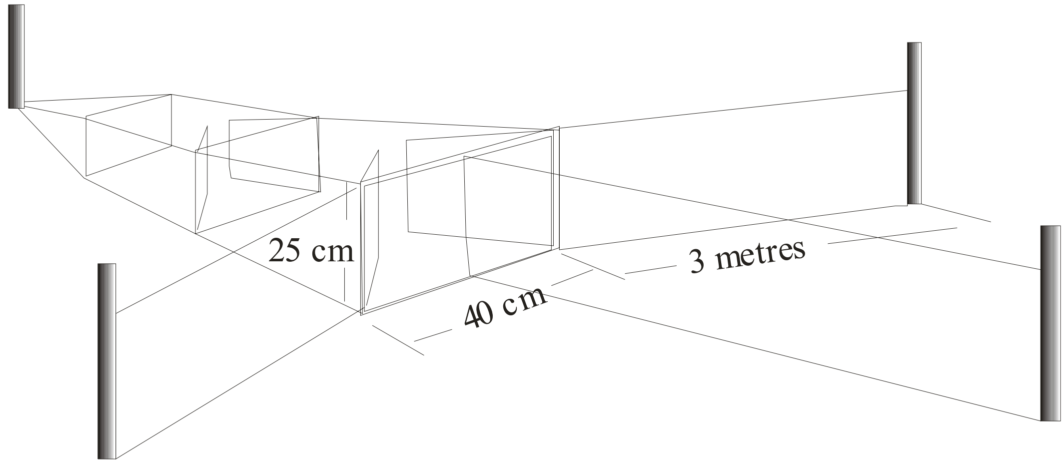

Figure 2. Design of the fyke net.

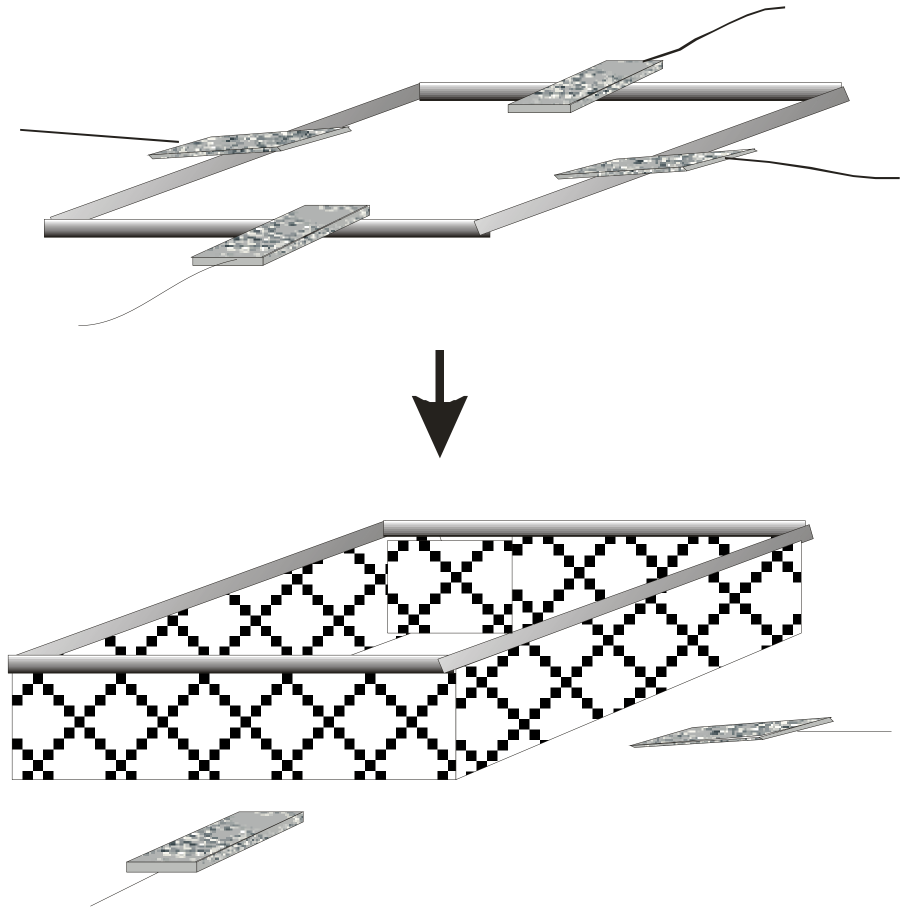

Figure 3. Design of the bouyant pop net.

RESULTS

A total of 3512 fish and crustaceans comprising 21 species were caught by fyke nets, of which *Pseudomugil signifer* was most abundant (25.2%), followed by *Macrobrachium intermedium* (23.6%), *Ambassis jacksoniensis* (10.8%), *Gobiopterus semivestitus* (8.9%) and *Mugilogobius stigmaticus* (8.9%). Of the 818 fish of 16 species caught by pop nets, *A. jacksoniensis* was most abundant (43.03%), followed by *G. semivestitus* (18.7%) and *P. signifer* (9.3%) (Table1). Five species were caught by fyke nets only, these being *Sillago cilliata*, *Rhabdosargus sarba*, *Redigobius macrostoma*, *Taenioides mordax*, and *Metapenaeus macleayi*. No species were caught in the pop nets that were not also caught in the fyke nets.

Non-metric multidimensional scaling (nMDS) ordinations showed different assemblages of fish caught in fyke and pop nets in all months except May 2001 (ANOSIM: P= 0.067), July 2001 (ANOSIM: P=0.1), August 2001 (ANOSIM: P=0.229) and January 2002 (ANOSIM: P=0.114) where assemblages of fish captured by fyke nets and pop nets were similar (Figure 4). Overall analysis of similarities suggested a significant difference (ANOSIM: P<0.001) between fyke and pop nets assemblages of catch.

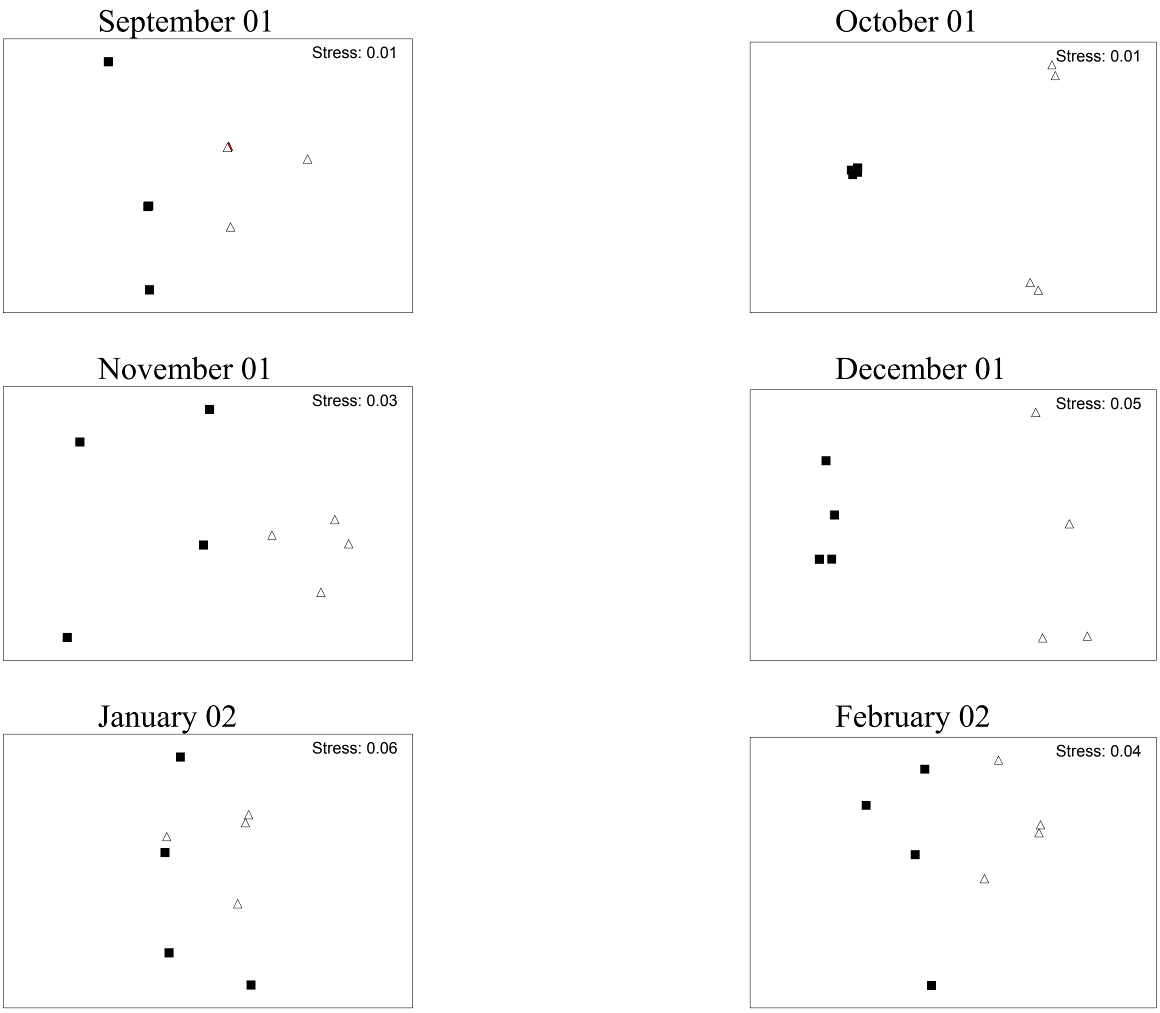

Figure 4: Selected nMDS ordinations showing assemblages of fish caught in fyke and pop nets monthly, at Towra Point saltmarsh 2001-2002.

Table 1: Species caught from saltmarsh with fyke and pop nets at Towra Point, 2001–2002. The asterisk (*) designates species of commercial and or recreational fisheries significance.

Family	*Genus/species*	*Common name*	*Fyke net*		*Pop net*	
			No. of fish	% of total	No. of fish	% of total
Fish						
Platy-cephalidae	Platycephalus fuscus	Dusky flathead *	80	2.28	9	1.10
Chandidae	Ambassis jacksoniensis	Glassfish	378	10.76	352	43.03
Sillaginidae	Sillago clliata	Sand whiting *	11	0.31	0	0.00
Gerreidae	Gerres subfasciatus	Silver biddy *	153	4.35	54	6.60
Sparidae	Acanthopagrus australis	Yellow fin bream *	103	2.93	21	2.57
Sparidae	Rhabdosargus sarba	Tarwhine *	1	0.03	0	0.00
Mugilidae	Liza argenta	Flat tail mullet *	32	0.91	5	0.61
Mugilidae	Myxus elongatus	Sand mullet *	54	1.54	5	0.61
Mugilidae	Mugil cephalus	Sea mullet *	14	0.04	3	0.37
Atherinidae	Pseudomugil signifer	Blue eye	887	25.24	76	9.29
Poeciliidae	Gambusia holbrooki	Mosquito fish	68	1.94	1	0.12
Gobiidae	Gobiopterus semivestitus	Glass goby	316	8.99	153	18.70
Gobiidae	Mugilogobius paludis	Mangrove goby	58	1.65	14	1.71
Gobiidae	Mugilogobius stigmaticus	Checkered mangrove goby	315	8.96	10	1.22
Gobiidae	Pseudogobius olorum	Blue spot goby	87	2.48	49	5.99
Gobiidae	Redigobius macrostoma	Largemouth goby	12	0.34	0	0.00
Gobiidae	Taenioides mordax	Snake head goby	6	0.17	0	0.00
		Unidentified fish	26	0.74	8	0.98
Tetraodontidae	Tetractenos hamiltoni	Common toad	30	0.85	6	0.73
Crustacean						
Atyidae	Macrobrachium intermedium	Grass shrimp	828	23.56	52	6.36
Penaeidae	Metapenaeus macleayi	School prawn *	55	1.57	0	0.00
Total no. of fish and crustacean			3514		818	
Total no. of species			21		16	
Total no. of species of commercial/recreational significance			9		6	

Comparison of abundances

In general, analysis of variance (ANOVA) results for all species showed that number of fish captured by fyke net (73.21 fish per fyke net) was significantly ($P<0.0001$) higher than pop net (17.04 fish per pop net) (Table 2, Figure 4). Catch performance based on the most common species in both net types showed fyke net catch was significantly higher than pop net for *A. jacksoniensis*, ($P = 0.0105$), *P.signifer* ($P = 0.0002$), *M. stigmaticus* ($P = 0.0056$), *A. australis* ($P = 0.0153$) and *M. intermedium* ($P = 0.0010$). No significant difference was observed between fyke and pop nets for numbers of *M. semivestitus* ($P = 0.1080$) and *G. subfasciatus* ($P = 0.0971$).

Fish density determined by pop net was 0.56 fish m^{-2} of saltmarsh flat. It was not possible to calculate fish densities from using the fyke nets.

Fish size effect

Seven species, *A. jacksoniensis*, *P. signifer*, *G. semivestitus*, *M. stigmaticus*, *G. subfasciatus*, *A. australis* and *M. intermedium* contributed 85% of the total catch in fyke nets, and 88% of the total catch in pop nets respectively (Table 1). Analysis of variance (ANOVA) comparing the lengths of individuals of these species between net types demonstrated that significantly larger individuals of *G. semivestitus* (P = 0.04) and *G. subfasciatus* (P = 0.03) were retrieved from pop nets when compared with fyke nets (Figure 6). No significant size differences were observed between fyke and pop nets for individuals of *A. jacksoniensis*, *P. signifer, M. intermedium*, *M. stigmaticus* and *Acanthopagrus australis* (Figure 6)

For the two species which showed differences in size between net types, *G. semivestitus* and *G. subfasciatus,* pop nets captured relatively higher number of *G. semivestitus* in the larger size range of 21-25mm (Figure 7). Similarly, catches of *G. subfasciatus* were weighted toward the larger size categories in pop nets and the smaller size categories in the fyke nets (Figure 8).

Table 2: ANOVA comparison of catch of number of fish and crustaceans from fyke and pop nets in saltmarsh flats at Towra Point, Botany Bay, NSW.

Source of variation	DF	MS	F	P
Net	1	75712.666	27.69	0.0001
Residual	94	2734.764		
Total	95			

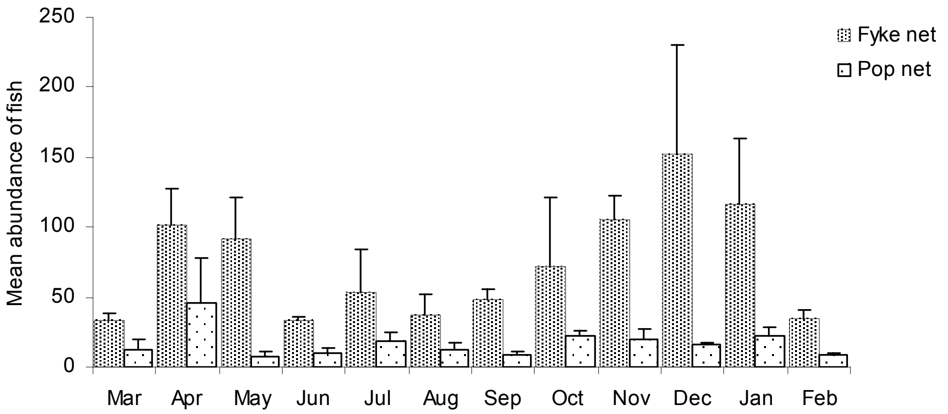

Figure 5: Mean number (+SE) of fish captured by fyke and pop nets through the year in saltmarsh flats at Towra Point, 2001-2002: n= 96.

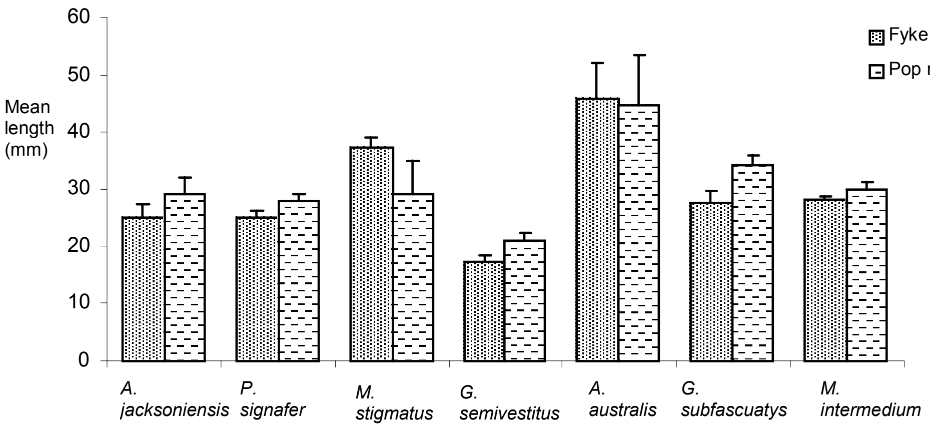

Figure 6: Mean length and standard errors (+SE) for most contributing species captured by fyke and pop nets at Towra Point saltmarsh, 2001-2002.

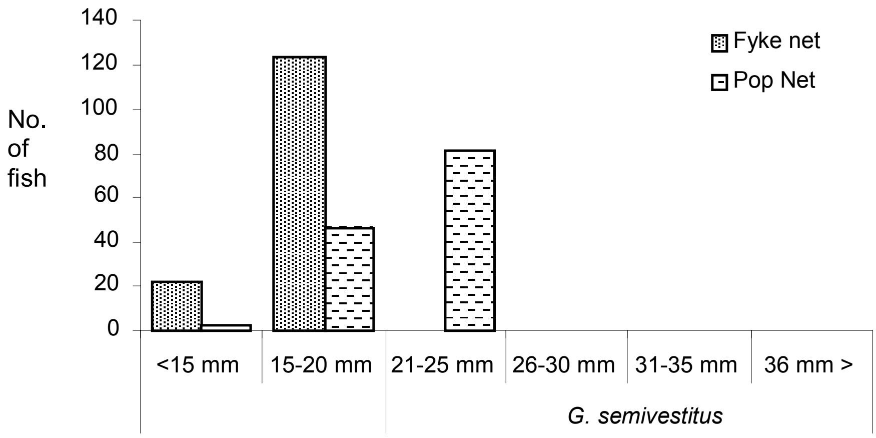

Figure 7: Size categories of glass goby (*Gobiopterus semivestus*) captured by fyke and pop nets at Towra Point saltmarsh, 2001-2002.

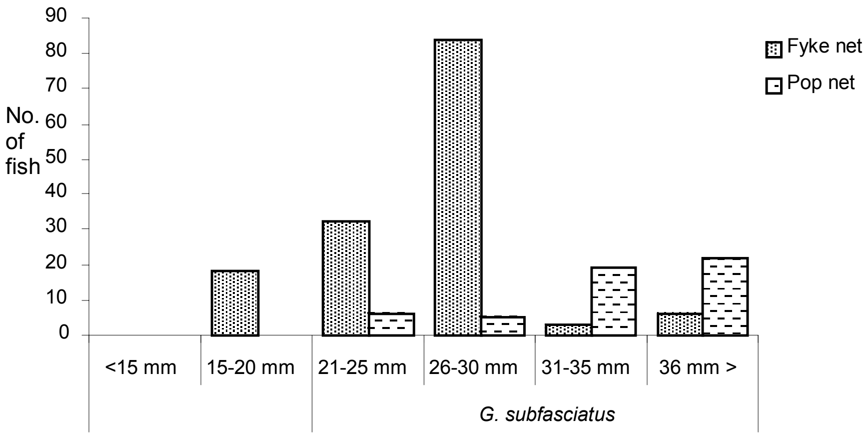

Figure 8: Size categories of silver biddy (*Gerres subfasciatus*) captured by fyke and pop nets at Towra Point saltmarsh, 2001-2002.

DISCUSSION

Clearly, the two nets did not perform similarly. Differences were found relating to cost, ease of setting, the number of species captured and the efficiency of capturing smaller fish. Pop nets had two advantages over fyke nets. Firstly, the catch of the pop net can be represented as a density on the basis of area, or volume of water if the height of the tide at the time of release is measured. This facilitates comparisons between nets and localities in a way not possible for the fyke nets.

One limitation of the fyke nets employed in this study is that fish density could not be calculated from the catch data, because the volume of water having moved through the net opening was not known, nor was the relationship between water volume passing the net and catch efficiency. Fish may be attracted to the net or diverted from the net in a way not consistent with water flow volume, even were it known.

However, there are a number of observations arising from the study that suggest fyke nets are more efficient than pop nets in the survey of fish abundance and diversity in the saltmarsh. Firstly, in no case did the pop net capture a species not taken by the fyke net. Conversely, five species caught by the fyke nets *(Sillago clliata*, *Rhabdosargus sarba*, *Redigobius macrostoma*, *Taenioides mordax* and *Metapenaeus macleayi)* were not caught by the pop nets.

More telling is the differences between net types in the size of individuals caught for at least two species, *G. semivestitus* and *G. subfasciatus.* The average size of fish retrieved from the pop nets was consistently larger than from the fyke nets. Presuming the nets are sampling the same population, the result could suggest that smaller fish caught in the pop net were not retrieved. Analysis of size class distributions confirms this suggestion, with fyke net size classes skewed toward the smaller size categories, and pop-net catches toward the larger categories.

Fyke nets were easier to install than pop nets and fish were more readily retrieved from inside the net. Installation of the pop nets was time consuming because of the necessity of preparing shallow trenches within which to hide the net. If ground disturbance during this process increased food availability, one might assume that numbers of fish taken by this method would be greater than the passive application of the fyke net. We would suggest that limitations in pop-net catch efficiency might be countered if the net was allowed a base, or a base inserted after release. The design of the fyke net might be improved with the installation of a flow meter which would allow standardisation of catch against water volume passing through the net. This might provide some opportunity for the comparison of catches between different nets and settings.

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REFERENCES

Adam P, Wilson NC and Huntley B (1988) The phytosociology of coastal saltmarsh vegetation in New South Wales, *Wetlands (Australia)* **7:**35-84.

Bray JR and Curtis JT (1957) An ordination of the upland forest communities of southern Wisconsin, *Ecological Monographs* **27:**325-349.

Clark LD and Hannon NJ (1967) The mangrove swamp and saltmarsh communities of the Sydney district. I. Vegetation, soil and climate *Journal of Ecology* **55:**753-771.

Clark LD and Hannon NJ (1969) The mangrove swamp and saltmarsh communities of the Sydney district: II. The holocoenotic complex with particular reference to physiography *Journal of Ecology* **57:**213-244.

Clarke KR and Warwick RM (2001) *Changes in marine communities: An approach to statistical analysis and interpretation*, 2nd edition, PRIMER-E; Plymouth.

Connolly MR (1994) Comparison of fish catches from a buoyant pop net and beach seine net in a shallow seagrass habitat, *Marine Ecology Progress Series* **109:**305-309.

Connolly RM, Dalton A, and Bass DA (1997) Fish use of an inundated saltmarsh flat in a temperate Australian estuary, *Australian Journal of Ecology* **22:**222-226.

Gibbs PJ (1986) The fauna and fishery of Wallis Lake. In: *Wallis Lake: Present and Future,* Occasional papers of the Australian Marine Science Association, Sydney, NSW, pp.1-7.

Gray CA and Bell JD (1986) Consequences of two common techniques for sampling fragile macrofauna associated with the seagrass *Zostera capricornia, Marine Ecology Progress Series* **28:**43-48.

Hettler WF (1989) Nekton use of regularly-flooded saltmarsh cordgrass habitat in North Carolina, USA; *Marine Ecology Progress Series* **56:**111-118.

Michael RD, Holland EL and Zigler JS (1989) Comparison of fish catches with buoyant pop nets and seines in vegetated and non-vegetated habitats; *North American Journal of Fisheries Management* **9:**249-253.

Morton RM, Pollock BR and Beumer JP (1987) The occurrence and diet of fishes in a tidal inlet to a saltmarsh in southern Moreton Bay, Queensland; *Australian Journal of Ecology* **12:**217-237.

Rozas LP (1992) Bottomless lift net for quantitative sampling nekton on intertidal marshes, *Marine Ecology Progress Series* **89:**287-292.

Smith KJ and Able KW (1994) Salt-marsh tide pools as winter refuges for the mummichog, *Fundulus heteroclitus*, in New Jersey, *Estuaries* **17:**226-234.

Underwood AJ and Chapman MG (1989) *GMAV5 for Windows,* Institute of Marine Ecology, University of Sydney, Australia.

Williams RJ, Hannan J, Balashov V and Watford FA (1996) The changing estuarine fish and decapod crustacean community of western Kooragang Island, NSW, Australia. In: *Wetlands for the future, INTECOL'S V international wetlands conference*, Conference programme and book of abstracts, Encore Productions, WA, Australia, pp.118-119.