Effects of Fish Trap Mesh Size on Species and Size Selectivity in the Australian North West Shelf Trap Fishery

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Abstract

Trap-introduced fishing mortality of juvenile fish was seen as a potential problem in the developing fish trap fishery on the Australian North West Shelf. Line fishermen are concerned that traps are unselective. Research to investigate the reality of the problem and to assess large-mesh traps as a solution found that:

(i) Standard 5 x 5 cm mesh traps do catch many small fish;
(ii) 10 x 10 and 15 x 5 cm mesh traps catch few small fish;
(iii) Large-mesh traps are less efficient for big fish;
(iv) The small fish caught tend to be small-bodied species, not juveniles of more valuable large-bodied species;
(v) Mesh size appears to have effects on trap efficiency independent of simple escapement through the mesh.

Since juvenile mortality is not yet considered a problem, continued use of standard mesh traps is recommended. Future research aimed at identifying nursery areas for valuable species is suggested to enable protective area closures to be used by management.

Introduction

The North West Shelf Trap Fishery

Trap fishing on the Australian North West Shelf began only in 1984. Until then, exploitation of the multispecies demersal fish stocks was mainly by the Taiwanese pair trawl fishery, though vessels of other nations had also fished these stocks. Australian finfish fishing in the region was conducted by a small number of line fishing boats, working close to the mainland and offshore islands. The Australian market is for larger, higher-valued fish compared with a broad range of species retained by the Taiwanese. These larger species have been shown to be most vulnerable to depletion by the foreign trawlers (Sainsbury 1988).

Fish trapping for pink snapper (*Chrysophrys auratus*) on the Australian west coast near Shark Bay has occurred since 1959 and has always been opposed by line fishermen (Moran and Jenke 1989). A group of pink snapper fishermen introduced traps to the NW Shelf in 1984 following the June-July snapper season. The local NW Shelf line fishermen opposed the trapping, mainly on the grounds that it was more efficient than line fishing and would lead to over-exploitation of the stocks. There was also concern that traps would be less selective than lines and would catch juveniles of the largest, most valuable species, contributing further to depletion.

Fish trapping has been confined mainly to areas of hard bottom which were not worked by the Taiwanese trawl fishery. The depths worked mainly are 50 to 100 m so it is not a coral reef fishery as described for the Caribbean by Munro (1973). Rather, it is similar to the exploratory fishing of the outer Caribbean banks and continental shelf described by Wolf and Chislett (1974) where traps were set around ridges, steep slopes and outcrops. The type of trap used is the Australian O-trap with a single entrance of vertical parallel bars 10 cm apart (Wolf and Chislett 1974; Moran and Jenke 1989). Traps are baited with pilchards (*Sardinops neopilchardus*) or trash-fish, and soak-times vary from 30 minutes to 12 hours. Boats carry two to 20 traps, depending on the size of the vessel.

The dominant family taken by the trap fishery is the Lethrinidae (approximately 40% of the catch), with the main species being the spangled emperor (*Lethrinus nebulosus*). The other major families are the Lutjanidae and Serranidae, with main species being red emperor (*Lutjanus sebae*) and rankin cod (*Epinephelus multinotatus*). Overall, catch rates average around 200 kg/boat day, but the most efficient boats average up to 500 kg per day (Moran et al. 1988).

The catch is marketed in Western Australia, where large fish command high prices. Fishermen are often offered such low prices for small fish (less than 30 cm length to caudal fork) that it is not worth the cost of catching them. Line fishermen were concerned that traps would be unselective, catching many small fish which would then be wasted. The assumption was made that the small fish would be juveniles of the valuable large-bodied species. The catch of small fish would then not contribute to the yield from the fishery, but would increase fishing mortality.

Aims of this Research

The standard mesh size of traps in the fishery is 5 x 5 cm, either chain-link or weld-mesh. The purpose of this study was to determine:

1. Whether standard mesh traps do catch small fish;
2. Whether the number of small fish caught could be reduced by using larger mesh while maintaining the catch of large fish;
3. Whether the small fish are juveniles of large-bodied species.

The approach taken was to fish large-mesh traps alongside standard traps, and identifying and measuring all fish caught.

While selectivity studies of trawl and gillnet mesh sizes are common, e.g., Hamley (1975), Liu et al. (1985), comparisons of trap meshes such as that in Wolf and Chislett (1974) and Ward (1988) are rare. Most trap selectivity studies have related to the effectiveness of escape gaps in single-species fisheries for retaining legal size and releasing undersize crustaceans, e.g., Brown and Caputi (1986).

Methods

Trap Design

The traps used were based on the standard traps used by industry: circular, 1.5 m diameter and 1.0 m high, with a frame made from 12 mm steel rod, covered with steel mesh, then galvanized. There was a single entrance of two parallel vertical rods, 10 cm apart; a bait box of small mesh wire; and a door for removing fish after capture. A rope lifting-bridle was attached at two points on the top of the trap and the rope for retrieving the trap was tied to the middle of the bridle. Six plastic foam floats at the other end of this rope marked the position of the trap in the water. For trap retrieval, the floating rope was grappled and pulled in on a hydraulic pot winch. The mesh sizes used to cover the trap frame were the standard 5 cm mesh used by industry and two commercially available weld-mesh sizes of 10 x 10 cm and 15 x 5 cm. The 15 x 5 cm mesh was used with the long side of the mesh rectangle vertical because most of the fish species of interest are a laterally compressed body shape and small fish could thus swim out in normal upright position.

There were two groups of trap sets. In the first group, the three traps were set 44 times. In the second group, the 10 x 10 cm mesh was covered with chicken wire. The 15 x 5 cm trap was lost and the chicken wire trap was set with the standard trap 44 times.

Fishing Procedure

The experimental traps were deployed from the research vessel "Flinders" on the trap fishing grounds of the Australian NW Shelf, 114°E to 116°R. Fishing locations were chosen to give the widest possible coverage of the main commercially fished grounds in the time available. Traps were set on fish schools located with the echo-sounder, with all three traps being used in each set. Setting all together was necessary to enable valid comparisons with location and time. In day time fishing from the research vessel, traps remained set for one hour; in the evening, traps remained set overnight.

Data Recording and Analysis

For all fish caught, data recorded were: species name, identified using Sainsbury et al. (1985); length measured from snout to caudal fork (LF); set identifier and trap mesh type. These data were later combined to produce length-frequency distributions for each species for each trap type. Analysis of variance of the number of fish per trap, transformed to log (number +1), was used for tests of significance, with the Student-Neuman-Keuls test used to determine significant differences between means.

Results

To simplify analysis and interpretation of results, species have been divided into large-bodied and small-bodied species. Small-bodied species are defined as those which do not grow longer than 40 cm in this region. For some analyses, species have been grouped into families. The species caught in the first group of 44 sets are listed in Fig. 1 by family and body size category. For each trap type, the

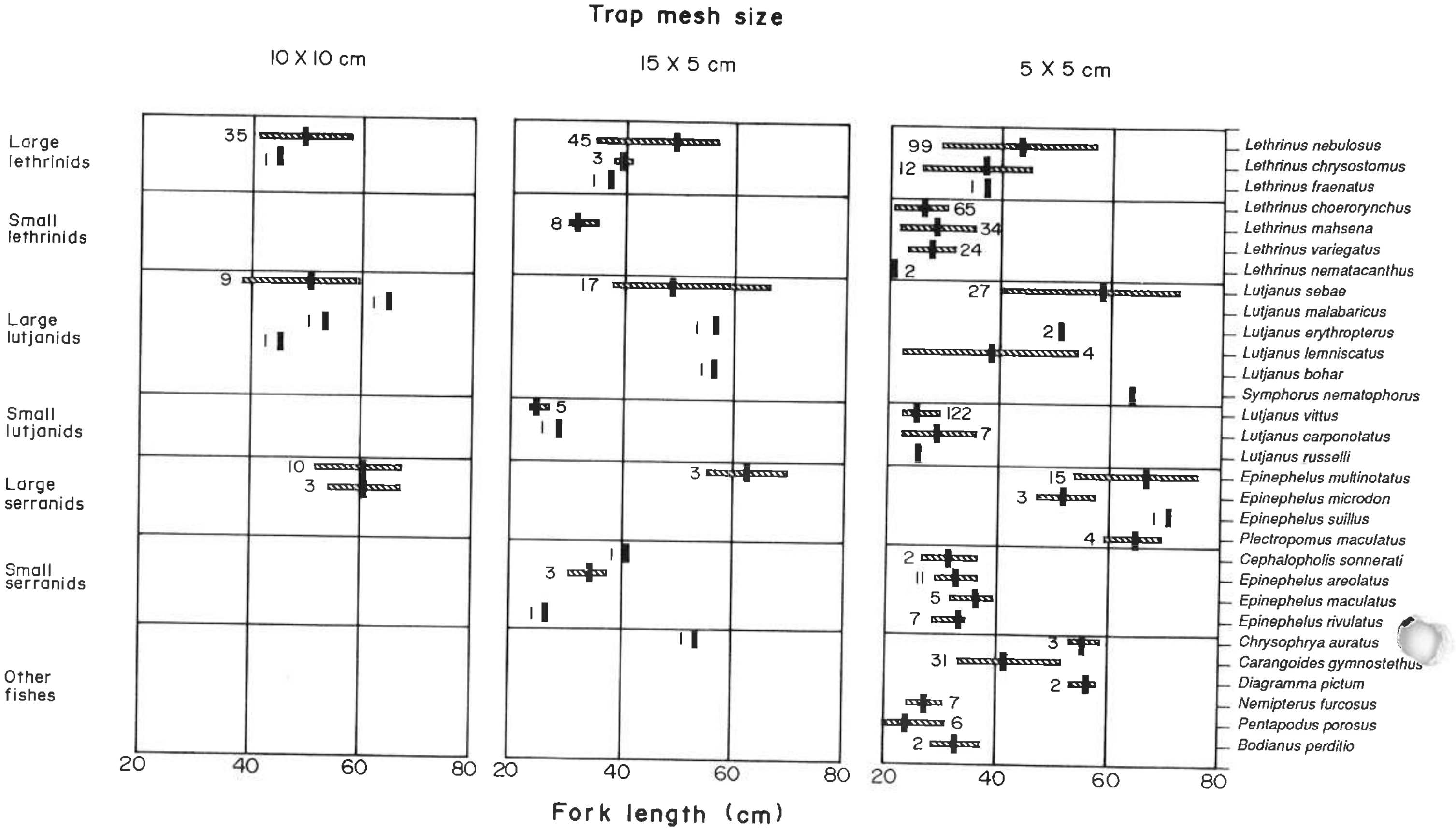

Fig. 1. The number, mean length and range of lengths of the fish species caught by traps of three mesh sizes.

number fish of each species caught, the mean length and the range of lengths are also shown. Six hundred and fifty-two individuals of 30 species were caught, compared with 91 species observed in two years of monitoring the commercial fishery (Moran et al. 1988). Most of the common species taken by the trap fishery were represented; *Lethrinus nebulosus, Lutjanus sebae* and *Epinephelus multinotatus* were dominant by weight.

Because tropical fish communities are so speciose, patterns in small data sets such as this can be more clearly and briefly shown at the family level. The differences between trap types in the length-frequency distributions of the catch can be seen in Fig. 2 for the three major families. For lethrinids and lutjanids, while fish less than 30 cm are much better represented in the 5 x 5 cm mesh trap than the 15 x 5 cm, they are completely absent from the 10 x 10 cm trap.

The pattern for the serranids is different. While the 5 x 5 cm is still most efficient, the 5 x 5 cm trap and the 15 x 5 cm trap are quite similar to each other in serranid size composition, but again there were no small fish caught by the 10 x 10 cm mesh trap. The difference is very likely due to the laterally compressed lutjanids and lethrinids being able to escape through the high, narrow 15 x 5 cm mesh while the wide-bodied serranids cannot. The other point that is apparent from Fig. 2 is that almost all of the fish less than 30 cm caught belonged to small-bodied species, rather than being the young of large-bodied species.

The efficiency of the large-mesh traps, relative to the standard 5 x 5 cm mesh trap, is very low, as expected, for small fish. More surprising is the reduced efficiency of the traps even for the fish sizes they catch best, above 40 cm (Fig. 3). Catches of large (> 40 cm) and small (< 40 cm) fish, transformed to log (number +1) from 44 trap sets using the three trap types were subjected to analysis of variance. This analysis showed a significant interaction between trap type and fish size ($F = 52.27$; 2, 258 df; $P < 0.01$). The basis for this interaction can be seen from Table 1. While the mean for the standard trap was higher than that of the large-mesh traps for both large and small fish, the difference among traps was not significant at $P = 0.05$ for large fish. The standard trap caught significantly more small fish than the two large mesh traps. There were no significant differences between the two large mesh traps for any size fish.

The greater efficiency of the standard trap than the large-mesh traps in catching small fish was expected and can be readily explained on the basis

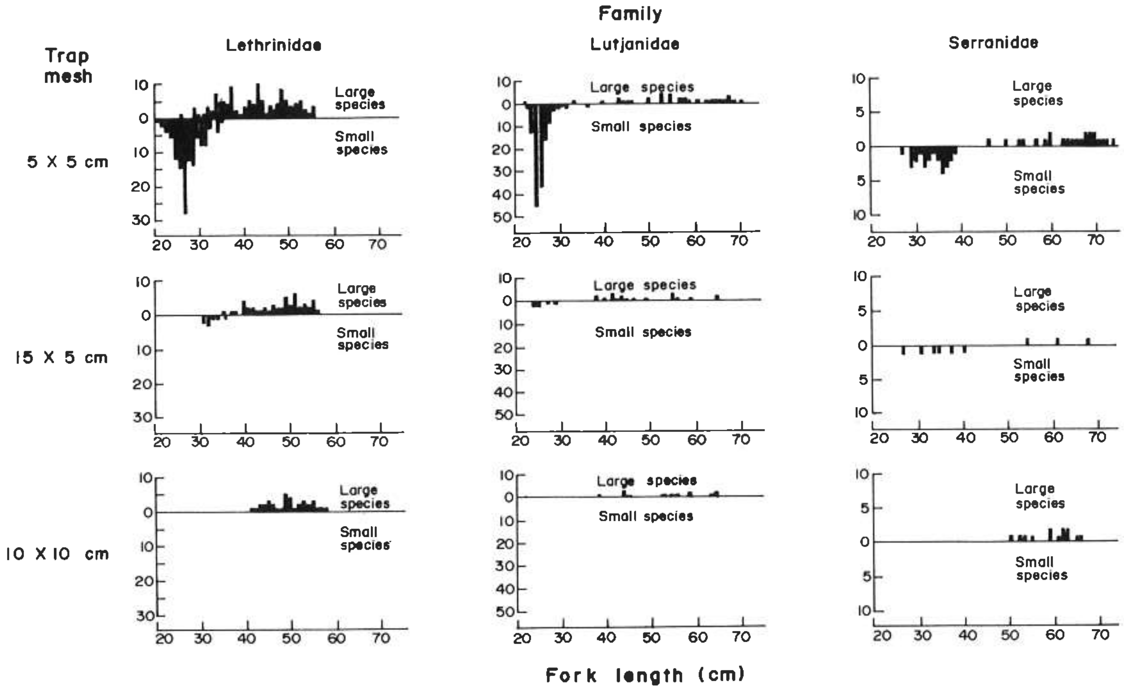

Fig. 2. Length-frequencies of large and small species of fish belonging to the three main familes caught using traps of three mesh sizes.

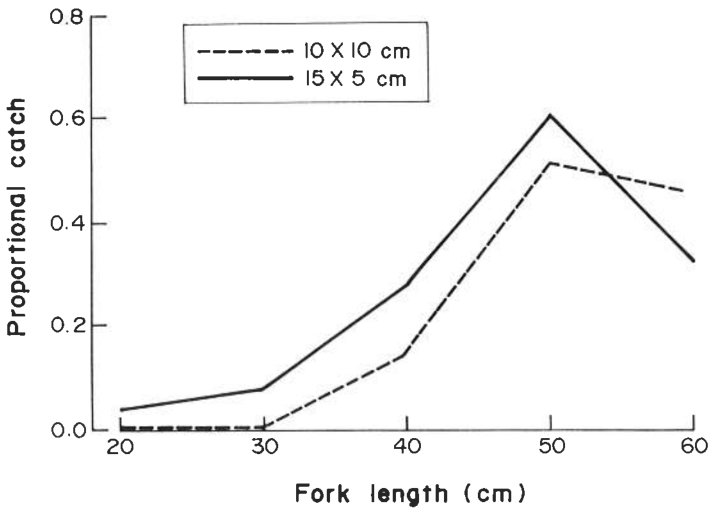

Fig. 3. Catch-rates, by 10 cm length-goups, of all commercial species of fish taken by traps of 10 x 10 cm and 15 x 5 cm mesh sizes, expressed as a proportion of the catch-rate of a standard 5 x 5 cm mesh trap.

Table 1. Comparison of catch-per-haul (transformed to log number of fish + 1) by the three trap mesh types for large fish (> 40 cm FL) and small fish. Means of 44 hauls are shown with standard errors in brackets.

	Large fish		Small fish	
Trap mesh (cm)	Mean	(s.e.)	Mean	(s.e.)
5 x 5	0.443	(0.061)	0.563	(0.078)
15 x 5	0.240	(0.050)	0.085	(0.034)
10 x 10	0.254	(0.049)	0.000	(0.000)

Analysis of variance

Source	SS	DF	MS	F
Fish size	0.18857	1	0.18857	
Trap mesh	6.99594	2	3.49797	
Size x trap	9.20611	2	4.60305	52.27
Residual	22.72047	258	0.08806	

of escapement through the mesh. The poorer performance of the large-mesh traps in catching large fish is not so readily understood. To determine whether it was really the mesh size that made the 10 x 10 cm trap so inefficient at catching large fish, we covered the large mesh with chicken wire (4 cm wide, 5.4 cm high hexagonal mesh) and fished it alongside the standard trap. Catches of large fish in 44 trap sets of the two traps in a trial following the addition of chicken wire were analyzed with 44 sets of a trial conducted before covering with chicken wire (analysis of variance on log (number +1)). The standard trap is included in the before and after comparison as a control. The inherent variability in catch rates due to changes in abundance of fish and environmental factors affecting catchability would make a simple before and after chicken wire comparison on the 10 x 10 cm trap alone suspect.

While the standard trap caught remarkably similar mean numbers of large fish in the first and second trials, the improvement in mean catch by the large-mesh trap following covering with chicken wire was dramatic ($F = 14.3$ for the interaction of trial x trap; 1, 172 df; $P < 0.01$; Table 2).

Mean catch rates of large fish, back-transformed from the logarithms, are plotted in Fig. 4 to illustrate the apparent relationship between catch rate and closeness of the mesh expressed as the inverse of the area of a single mesh. We did not set out to test such a relationship and include the figure simply to point out that effects of mesh size on efficiency, independent of simple mesh retention, may be worth investigating in future studies.

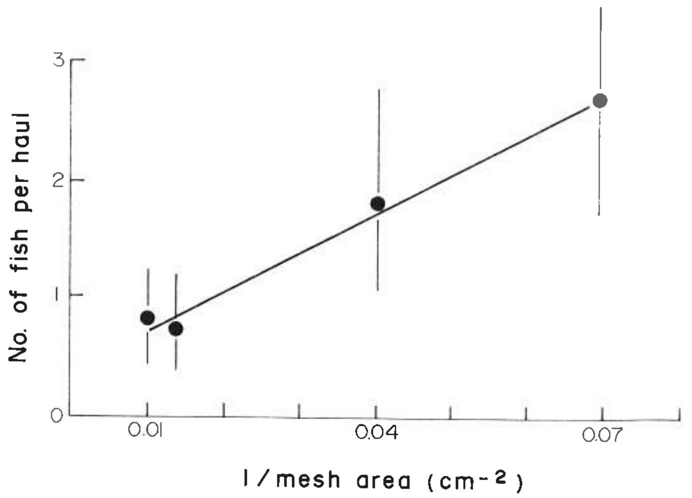

Fig. 4. The mean catch-rate of large fish (> 40 cm FL) by four mesh-sizes, plotted against the inverse of the area of a single mesh. Means and 95% confidence limits are back-transformed from the logarithms.

Discussion

Clearly the standard traps do catch small fish when deployed on the main trap fishing grounds of the North West Shelf. The number of small fish caught could be very effectively reduced by using traps of larger mesh, but the costs in terms of overall efficiency would not be acceptable. The large mesh traps could have a role if the price premium for fish in the 40-70 cm size range was sufficiently high.

Ward (1988) found that in the Caribbean a 5.1 cm wide x 7 cm high hexagonal mesh trap was more efficient than a 3.8 x 5.4 cm mesh, above the size range of fish which escaped through the 7 cm mesh. An 8.3 x 10.5 cm mesh trap caught few fish, but it appeared that fish of a size large enough to be retained by that mesh were rare in Ward's study area. His conclusion for the two smaller meshes used appears to contradict our results.

We speculate that the reason the large-mesh traps are less efficient than the small-mesh is that the entrance is less visible to the fish against the more

Table 2. Comparison of catch-per-haul, transformed to log (number of fish + 1) by the standard 5 x 5 cm mesh trap and the 10 x 10 cm mesh trap in two trials. The large-mesh trap was covered with chicken wire for the second trial. Means of 44 hauls are shown with standard errors in brackets.

Trial	Standard trap		Large-mesh trap	
	Mean	(s.e.)	Mean	(s.e.)
Trial 1	0.443	(0.061)	0.254	(0.049)
Trial 2	0.442	(0.066)	0.566	(0.066)

Analysis of variance

Source	SS	DF	MS	F
Trap	0.04644	1	0.04644	
Trial	1.07236	1	1.07236	
Trap x trial	2.19367	1	2.19367	14.28
Residual	26.41490	172	0.15358	

open background of the large-mesh. Seeking a 10 cm wide entrance in a trap of 10 x 10 cm mesh may be very difficult for a fish. Ward (1988) thought it likely that funnels of small mesh provide a more distinct image to fish than those of larger mesh, thereby making it easier for trapped fish to find their way out. The Australian NW Shelf trap fishery differs from the Caribbean fishery in that baited traps and short soak-times are used. While visibility of the entrance may be important in both cases, in short soak-time fisheries the rate of entry may be the most important factor and rates of egress may be more important in long soak-time fisheries. Studies of effects of mesh size on trap efficiency should therefore take soak-time into account, and, if possible should measure rates of ingress and egress.

The potential usefulness of large-mesh traps was seen as minimizing capture of young fish of the valuable large-bodied species, thus increasing the yield-per-recruit of the fishery. This is usually the reason for setting minimum mesh sizes in trawl fisheries, e.g., Sainsbury (1984) for the NW Shelf pair trawl fishery. There appears to be no need for concern in this regard on the grounds presently fished by the trap fishery since the small fish caught are adults of small-bodied species, not juveniles of large species. Thus, either the juveniles of large species are in different areas or are not catchable by traps. Juveniles of the main species in the fishery, *Lethrinus nebulosus*, are common in the shallow waters of coral reef lagoons in this region. It is not known whether the juveniles also occur on the grounds where the adults are trapped.

As the fishermen get to know their grounds, they are able to avoid areas dominated by small species such as *Lethrinus choeroryrchus*. At present, they are able to maintain a catch composition with an acceptably low proportion of small fish, though some discarding of small species does occur. In future, if difficulties are encountered in maintaining a suitable size composition, a trap of small mesh with some panels of the 15 x 5 cm mesh may provide the answer. We consider it more likely, however, that the market will adapt to an abundant supply of the smaller species.

Conclusions

On the basis of this work, the capture of large numbers of juvenile fish is not currently an issue. There is thus no need for management of this trap fishery to focus on regulating trap mesh size. The solution to any potential future problem of capture of juvenile fish probably lies in the direction of identifying and protecting nursery grounds of the more valuable species. Among many factors which affect the efficiency of fish traps, mesh size may be important in ways other than simple escapement through the mesh; such as visibility of the entrance. This should be investigated together with length of soak-time, with measurements of fish ingress and egress rates.

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