What Factors Explain Reduced Fishing Power With Increased Mesh Size of Antillean Fish Traps?

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ABSTRACT

Experimental fishing with commercial traps (maximum mesh aperture 4.1 cm) and large mesh traps (maximum mesh aperture 5.5 cm) was conducted on west coast reefs in Barbados to test a visual image hypothesis and a squeezability hypothesis as explanations for the observation that large mesh traps have lower fishing power. The lower fishing power resulted primarily from lower catch rates of fish of body depth 5.5 - 6.0 cm; (i.e. the size class which might be expected to squeeze through the 5.5 cm aperture of large mesh traps). This strongly supports the squeezability hypothesis for the lower fishing power of large mesh traps. Differences in the visual images of traps created by structural differences (differences in trap design) and biotic differences (i.e. the number of fish already in the trap) did not produce definitive differences in ingress rates to traps, suggesting that the visual image hypothesis is an inadequate explanation for the lower fishing power of large mesh traps.

KEY WORDS: Antillean fish traps, Barbados, fishing power, mesh size selectivity, squeezability, visual image

THE STATUS OF REEF FISH STOCKS

Coral reefs support many fish species which are commercially important, especially to Caribbean islands (Caribbean Fishery Management Council, 1985). Since trawl net and hook- and-line fishing are difficult in areas of extensive coral cover due to damage caused to the fishing gear and to the reef, demersal traps are the predominant gear used for exploitation of reef fish in the Caribbean (Dammann, 1980). Since fish traps are relatively inexpensive to build and use, many Caribbean countries rely on the harvest of coral reef fishes as an inexpensive source of protein (Sylvester and Dammann, 1972). However, since the reef fish resource is so accessible, and the fishery largely unregulated, reef fish have been overexploited at many locations, especially around islands with narrow shelves (Appeldoorn *et al.*, 1987).

Overfishing has been attributed to the combined effects of excess fishing effort (i.e. too many traps per reef area) and of trap mesh sizes that are too small and thus capture too many immature fish (Stevenson, 1978; Stevenson and Stuart-Sharkey, 1980; Lee and Al-Baz 1989; Sary *et al.*, 1991; Beliaeff *et al.*, 1992), resulting in a loss of potential yield (Bohnsack *et al.*, 1989; Rosario and Sadovy, 1991; Hunte and Mahon, 1994). Given the latter effect, many Caribbean governments are considering imposing an increase in the legal minimum mesh size (Aiken and Haughton, 1987; Burnett-Herkes *et al.*, 1988; Rosario and Sadovy, 1991; McConney, 1996).

CHANGES IN CATCH RATES AND FISHING POWER WITH INCREASES IN MESH SIZE

One constraint on the imposition of larger minimum mesh sizes in Caribbean reef fisheries is that there are likely to be significant reductions in catch rates in the short term, since some portion of fish retained by traps of smaller mesh will be too small to be retained by traps of larger mesh (see Munro, 1983 for the assumption that the size of fish caught in a trap, specifically body-depth, is a direct function of trap mesh size). This effect has been reported in several studies in which traps of different mesh sizes have been simultaneously fished (e.g. Olsen *et al.*, 1978; Stevenson and Stuart-Sharkey, 1980; Ward, 1988; Bohnsack *et al.*, 1989; Hunte *et al.* in prep). A further constraint to the imposition of larger minimum mesh sizes is that the fishing power of traps may decrease with increasing mesh size (Moran and Jenke, 1990); i.e., the relative vulnerability of fish with body depths large enough to be retained by both mesh sizes may be greater for commercial traps than for large mesh traps (see Hunte *et al.* in prep. for confirmation of this in the Barbados trap fishery).

Two hypotheses have been proposed to explain why large mesh traps may have reduced fishing power. The first is the squeezability hypothesis (Hartsuijker, 1982) which suggests that fish whose body depths are slightly larger than the maximum aperture of the mesh can squeeze through it, and that this causes the estimated fishing power of large mesh traps to be lower than that of small mesh traps. The squeezability hypothesis can be tested by comparing, for commercial and large mesh traps, the catch rate of different size classes of fish with body depths larger than the maximum aperture of the large mesh. The prediction is that, if squeezability is an important factor, the greatest difference in catch rates should occur in size classes immediately larger than the maximum aperture of the large mesh, with the catch rate difference becoming negligible at larger fish sizes.

The second hypothesis for reduced fishing power of large mesh traps, proposed by several authors (e.g. Ward, 1986; Luckhurst and Ward, 1987; Bohnsack *et al.*, 1989; Moran and Jenke, 1990), is the visual image hypothesis.

The hypothesis assumes that fish are attracted to solid structures on the reef (Samples and Sproul, 1985; Bohnsack, 1989) out of curiosity, for food, for sleeping sites or for refuge from predators (Randall, 1963, Stone et al., 1979; Matthews, 1985; Hixon and Beets, 1989). Small mesh traps may offer a more solid visual image since they have more wire per unit area of trap surface. The visual image hypothesis therefore suggests that small mesh traps have higher fishing power than large mesh traps because ingress rates to small mesh traps are higher. If this hypothesis is correct, any large mesh traps designed to have a similar visual image as commercial (small mesh) traps should have similar catch rates as the commercial traps on fish large enough to be retained by both mesh sizes. It is important to note that visual image can be affected by factors other than structural trap design. For example, early aggregation of small fish in commercial traps may increase the visual image of the trap, thereby resulting in higher subsequent ingress rates, for fish of all sizes, than occurs in large mesh traps. Such factors potentially affecting the visual image of traps are subsequently referred to as "biotic factors"; aspects of trap design that may affect the visual image of traps are referred to as "structural factors". We can therefore identify two distinct visual image hypotheses: the "structural visual image hypothesis" and "the biotic visual image hypothesis".

In two separate field studies, described in detail in Hunte *et al.* (in prep) and in Robichaud and Hunte (in prep), the squeezability and the visual image hypotheses for reduced fishing power of large mesh traps were tested using Antillean fish traps (described in Munro *et al.*, 1971) on west coast fringing reefs in Barbados.

TESTING THE SQUEEZABILITY AND VISUAL IMAGE HYPOTHESES

Robichaud and Hunte (in prep) tested the squeezability hypothesis by comparing the catch rates of commercial (maximum mesh aperture 4.1 cm) and large mesh traps (maximum mesh aperture 5.5 cm) for fish of different size classes. Their data indicate that the higher fishing power of commercial traps is generated primarily by a difference in catch rates on fish in the 5.5 cm - 6.0 cm body depth size class, and secondarily by a catch rate difference in the 6.0 cm - 6.5 cm body depth size class; i.e., in the size classes which might be expected to squeeze through the 5.5 cm maximum aperture of the large mesh traps. Catch rate differences between traps were negligible for fish with body depths larger than 6.5 cm. These results are strongly supportive of the squeezability hypothesis for the higher fishing power of small mesh traps. The visual image hypothesis would predict higher catch rates, through higher ingress rates, for small mesh traps across all fish size classes.

Robichaud and Hunte (in prep) tested the structural visual image hypothesis for the increased fishing power of small mesh traps by comparing the ingress rates and catch rates of fish to commercial, large mesh and "experimental" traps. The experimental traps were designed to have a similar visual image as the commercial traps (by having similar mesh size over most of the trap area) but similar size-specific retention capacity as the large mesh traps (by having a panel of similar mesh size as the large mesh traps). If visual image effects were the principal reason for the higher fishing power of small mesh traps, through increased ingress rates, one would expect ingress rates, and hence catch rates on fish large enough to be retained by all mesh sizes (subsequently referred to as "large fish") to be similar for commercial and experimental traps, but higher for these trap types than for large mesh traps. Ingress rates of large fish to the different trap types did not differ (Robichaud and Hunte, in prep.). Moreover, the catch rate of large fish by experimental traps was closer to that of the large mesh traps than to that of commercial traps (Robichaud and Hunte, in prep.). These results are inconsistent with the visual image hypothesis.

The biotic visual image hypothesis was investigated by examining the effect of the number of fish in a trap on the ingress of large fish in the subsequent 24-hour period (Robichaud and Hunte, in prep). The subsequent ingress of large fish increased significantly with the number of fish of all sizes in a trap for all trap types, but the model explained a negligible proportion of the variance in all cases, and the slopes were shallow. This indicates that the effect of number of fish in a trap on subsequent ingress is very small, and can not explain the large differences in fishing power observed between commercial and large mesh traps (Hunte *et al.*, in prep). It is important to note that the effect could be a consequence of social aggregation or schooling tendencies of reef fish species, rather than simply an increase in the perceived solidness of the trap resulting from the presence of trapped fish.

Our results provide strong support for the hypothesis that the higher fishing power of small mesh traps arises through higher squeezing escape rates from large mesh traps of fish expected to be retained by both trap types on the basis of their body depths (the squeezability hypothesis). We found no definitive evidence indicating that the higher fishing power of small mesh traps arises through an enhanced visual image effect resulting in higher ingress rates to the traps. A more detailed description of the experimental design of this study, and a further treatment of the experimental results, are provided in Hunte *et al.* (in prep.) and Robichaud and Hunte (in prep.).

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