# Selecting Biodegradable Fasteners and Testing the Effects of Escape Panels on Catch Rates of Fish Traps

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## ABSTRACT

The 1998 Fisheries (Management) Regulations of Barbados require that all fish traps be fitted with an escape panel and carry an identification marker. The first part of the study tests various biodegradable escape panel fasteners to find one that will open in no less than three weeks and no more than five weeks. Fasteners were made of materials which were low cost and readily available, and included: cane lily, coconut bark, caulking, no. 6 cotton, cane trash, paper ribbon, and hemp twine. The second part of this study compares the catch rates of conventional fish traps with identical traps fitted with escape panels and identification markers (regulation traps). This was done using three commercial trap fishers over a 5-month period (January - May 1999), each fishing a different reef habitat using an equal number of conventional traps and regulation traps fished side-by-side. All trap hauls were recorded by number, size and species of fish taken. Hemp twine was found to be the most suitable fastener for the escape panel. Catch rates and taxonomic composition of catches were generally unaffected by the regulation specifications, suggesting that they will be readily accepted by fishers as a tool to reduce ghost fishing by lost traps.

KEY WORDS: Catch rates, fish traps, management measures.

## INTRODUCTION

The trap fishery in Barbados, which targets nearshore coral reef fish species, using mainly wire mesh z-shaped and arrowhead Antillean traps fished from small open boats (moses) with outboard engines, is of significant cultural and economic importance, despite the relatively low landings (annual catch represents an average (1994 - 1998) of 0.4% of total fish landings).

The fishery has a long tradition in Barbados, with fishers reporting at least three generations of trap fishers. The trap fishery is particularly important in providing employment and food fish during the summer (July - October) which represents the pelagic fishery off-season. There are approximately 50 trap fisher captains and at least 50 additional crew members who engage in trap fishing during the summer and 15 - 20 of these trap fish year-round (Selliah in press).

Trap fish landings during the pelagic off-season average (1994 - 1998) 6.5 mt which represents 3% of total landings during this period. However, at some of the island's 31 landing sites (e.g. Pile Bay) trap fish landings represent as much as 36.6% of summer fish landings and 12.6% of total annual fish landings. The fishery also has important links with the tourism industry, providing an exotic array of food fish in the markets and for the restaurant trade.

The trap fishery resource in Barbados, like many other countries in the Caribbean, is believed to be over-exploited, particularly along the south and west coasts where trap fishers are concentrated (Mahon and Drayton 1990, Fisheries Division 1997, Selliah in press). The recent Fisheries Act 1993 - 1996 with accompanying Fisheries (Management) Regulations 1998, and the first ever 1997 Fisheries Management Plan for Barbados have attempted to address this problem by the introduction of a number of new management measures to control fishing mortality in the trap fishery. These include *inter alia* the introduction of a minimum legal mesh size regulation of 3.18 cm (1.25") and a plan to increase that to 3.80 cm (1.5") within the next two years, and perhaps incrementally to 5.1 cm (2.0") at some future time if deemed necessary to further reduce fish mortality, particularly on immature fish (Fisheries Division 1997). A second regulation states that every fish trap shall be fitted with an escape panel of a size and design approved by the Chief Fisheries Officer. This is to reduce the incidence of continued fishing mortality when traps are lost (ghost fishing). A third regulation states that all traps should be marked for identification in a manner approved by the Chief Fisheries Officer. This is to assist in the enforcement of other regulations related to the trap fishery.

Several studies have examined the effects of increasing mesh size in various Caribbean trap fisheries including Jamaica (Munro 1983, Nicholson and Hartsuijker 1983, Sary et al. 1997), Southern Florida (Bohnsack et al. 1989), Saba Bank (Wolf and Chislett 1974), St. Thomas (Olsen et al. 1978), Puerto Rico (Stevenson and Stuart-Sharkey 1980, Rosario and Sadovy 1991), Guadeloupe (Beliaeff et al. 1992), and Barbados (Robichaud et al. 1999). However, there have been few, if any, studies on the potential effects of using escape panels and or identification marks on the catch rates of fish traps, and none in the Barbados trap fishery. Furthermore, biodegradable panel designs have not been tested for approval by the Chief Fisheries Officer of Barbados.

This study attempts to test various biodegradable fasteners on a sprung mesh door (the Modified Dowridge Design proposed by the Fisheries Division) for suitability in providing fish traps with an effective escape panel. This study also investigates the effects of the chosen fasteners and escape panel design and the approved identification marks on the catch rates of trap fishers in Barbados.

## METHODS

### Escape Panel Design

The design of the escape panel (the Modified Dowridge Design) was developed by the Fisheries Division in Barbados and consisted of a sprung mesh door held closed by biodegradable fasteners, and designed to spring open into the trap (thereby avoiding any damage to adjacent coral) when the fasteners degrade (Figure 1). The door consisted of a square wooden frame covered by 1.25" mesh wire. It was set against a wooden frame measuring approximately 14 x 14", but specifically 2" larger all around than the diameter of the entry funnel, built into the side panel of the trap. The door was hinged at the bottom with strapping wire, weighted at the top with a small lead strip, and fastened at the top with two strips of biodegradable material (Figure 1). The springing mechanism comprised a 2 cm wide strip of tyre inner tubing tied to the top of the door and to the bottom of the trap at a 45 degree angle and pulled taut when closed (Figure1).

### Selecting and Testing Biodegradable Fasteners

The criteria for selecting the biodegradable fasteners followed those of Kumpf (1980) in that the material should be relatively inexpensive, readily available locally, simple to replace, and have some predictable durability. In this case, we were looking for a durability of no less than three weeks and no more than five weeks. Seven different fastening materials were selected (dried cane lily, coconut bark, cane trash, caulking, no. 6 cotton, hemp twine, and paper ribbon) for *in situ* durability testing.

*In situ* tests were conducted over a four month period (June-October 1998), using two z-shaped fish traps which were modified to carry six escape panels each. Up to four different biodegradable fasteners were tested simultaneously and these were randomly allocated to the 12 escape panels so that each fastener was tested in triplicate. The two traps were set side-by-side in a shallow (6.5 - 7.5 m depth), relatively calm area, approximately 0.5 km from shore in Carlisle Bay on the west coast of Barbados (Figure 2). They were hauled and checked every five to six days. Fasteners that had not biodegraded after five weeks were deemed unsuitable and replaced with new materials for testing.

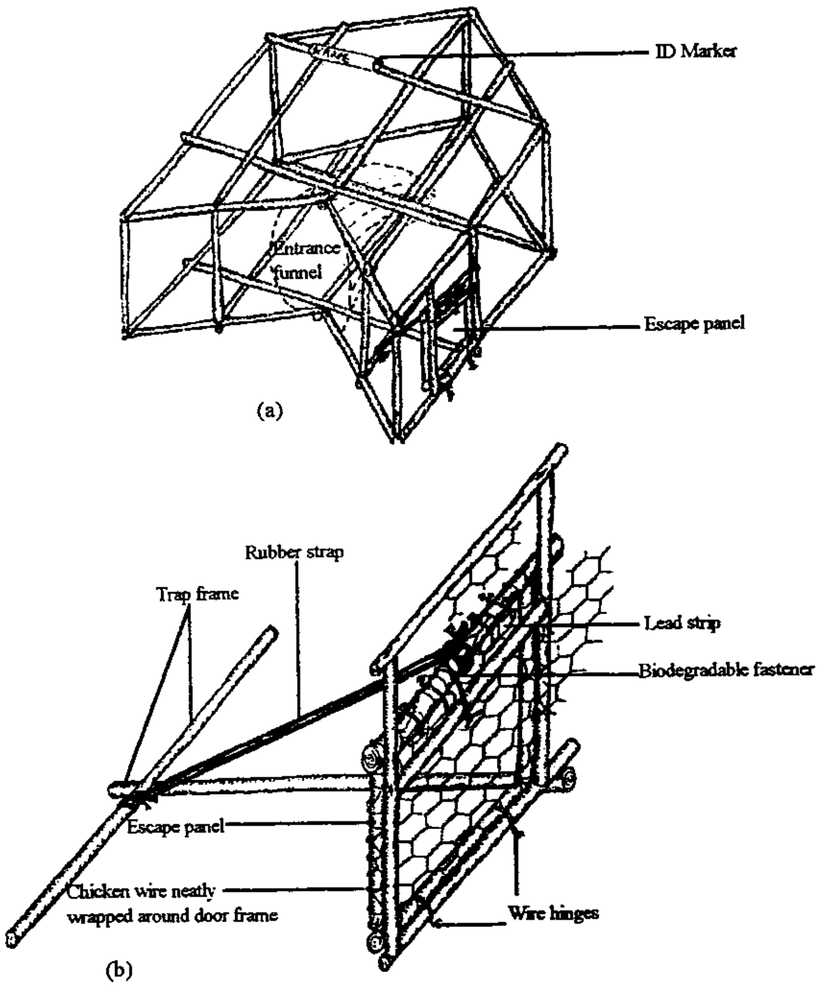


**Figure 1.** Diagram of a regulation fish trap showing: (a) positions of the identification marker and escape panel; and (b) details of the Modified Dowridge Design escape panel.

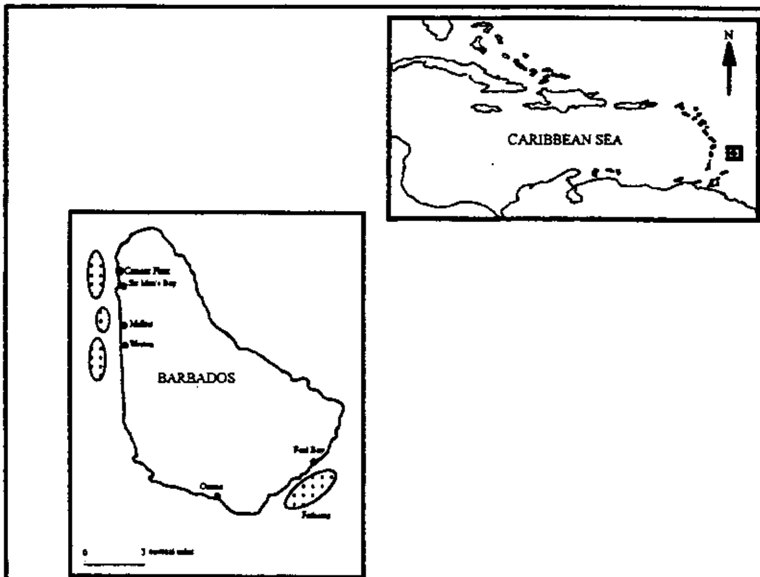


Figure 2. Locations of the fishing grounds and reefs used in the study to compare the catch rates between regulation and conventional traps.

**Figure 2.** Map of Barbados showing the location of study sites and fishing grounds.

## Comparison of Catches between Experimental Regulation Traps and Conventional Traps

*Site selection* — Three sites (Six Men's, Weston, Oistins; Figure 2) were chosen along the west and south coasts of Barbados where trap fishing activity is concentrated. These three sites provide a good representation of the different sea conditions and types of coral reef habitat used by trap fishers in Barbados.

Six Men's, at the north end of the west coast, is characterised by calm seas (leeward shore). Nearshore to the south (off Mullins) there are fringing reefs extending up to 200 m from shore and interspersed by sandy areas, and to the north (off the Arawak Cement Plant) there is a flat rock reef platform dominated by a mixture of soft and hard corals. Offshore (at about 1 km) is a continuous coral-rich bank reef at 18 - 50 m depth.

Weston, in the centre of the west coast, is also calm and characterised to the north and south by shallow fringing reefs extending up to 200m from shore and interspersed by sandy bays, offshore deep (15 - 40 m) patch reefs dominated by rubble, hard corals and sponges, and a deep (18 - 50 m) coral-rich bank reef approximately 1 km from shore.

The fishing grounds off Oistins extend along the southeast (windward) coast and are characterised by choppy seas and a coral-rich relatively shallow bank-barrier reef system located 0.5 - 1 km from shore.

*Fishing gear and methods* — One full-time (year-round) trap fisher from each site was invited to assist in the study, and asked to build a replicate set of traps (identical to their own conventional traps) to which the regulation escape panel with biodegradable (hemp twine) fasteners and the approved identification marker were then added (subsequently referred to as 'regulation traps').

Since the primary aim was to investigate possible effects of the new trap regulations on the catch rates, the fishers were instructed to continue fishing exactly as they normally would (but with the assistance of a researcher). This meant that trap design, soak times, depths and habitats fished were not standardised within or between fishers, but traps were fished side-by-side in pairs comprising one regulation and one conventional trap of the same design. This allowed paired-comparisons of catches by the two trap types, to be made. Fishing continued to the fishers' own schedules for a period of five months (January - May, 1999).

Specifically, six pairs of traps (arrowhead and z-shaped traps all measuring 2' deep x 4' wide x 8' long) were fished from Six Men's. The traps were set and hauled once or twice a week, from January to February and from April to May, 1999. Two distinct fishing grounds were used, one off the Arawak Cement Plant between 0.5 - 1 km from shore at a depth of approximately 25 m, the other was on the bank reef off Mullins Beach about 1 km from shore and at a depth of approximately 40 - 50 m (Figure 2).

At Weston, five pairs of arrowhead traps (measuring 2' deep x 5' wide x 4' long) were set and hauled once or twice a week, from January to April, 1999. The traps were set adjacent to fringing reefs less than 0.3 km from shore at a depth of approximately 6-8 m.

Eight pairs of z-shaped traps (measuring 2' deep x 5' wide x 10' long) were fished from Oistins. These traps were set and hauled twice a week, from January to April, 1999. Two distinct fishing grounds on the bank-barrier reef system were used, one off South Point lighthouse known as the Fathom located about 0.5 - 1 km from shore and at a depth of 19 - 20 m, the other was off Foul Bay, 0.5 km from shore and at a depth of 26 m (Figure 2).

## Data Collection and Analyses

For every fishing day, the commercially valuable catch from each trap pair was collected as the traps were hauled, and was stored in separate marked buckets.

Fish of no commercial value were thrown back by the fisher. On landing, all finfish were identified to species and measured for wet weight to the nearest 1 g and for fork length (FL) to the nearest 0.5 cm. Crustaceans were noted, but not measured and not included in any analyses. Moray eels (which were generally used only for bait), scorpionfish (which were generally left untouched in the traps), and nurse sharks (which were thrown back by the fisher) were also noted but not measured and were not included in any analyses.

All catch data were stored in spreadsheets. The few missing weights for individuals were either filled on the basis of their length (by examination of other individuals in the data base of the same species and size) or on the basis of the mean size of that species landed at the given site. Non-parametric statistical analyses were performed throughout since not all of the data sets were normally distributed. Catch rates (kg/trap haul and no. fish/trap haul) were compared between regulation and conventional traps using Wilcoxon paired-sample tests, and in one instance, where some traps were not strictly paired, a Mann-Whitney test was used. Species composition of catches by weight were compared between regulation and conventional traps using Chi-square contingency tests to examine the top ten families taken. Mean individual fish weights were compared between regulation and conventional traps using Mann-Whitney tests.

## RESULTS

### Durability of Fasteners

The material deemed the most suitable for use as fasteners on the escape panel door was hemp twine, which degraded sufficiently to allow the door to open in all three replicates in 22 - 26 days. Other materials which showed some potential included two stranded caulking (fasteners on two out of the three doors degraded in 22 - 26 days; one door remained closed beyond five weeks), strips of cane trash (fasteners on one door degraded in 16 days, a second door opened after 22 - 26 days, the third door remained closed beyond five weeks), and paper ribbon (fasteners on one door degraded in 22 - 26 days, while two doors remained closed beyond five weeks). Materials deemed unsuitable as fasteners were dried cane lily, coconut bark, five stranded caulking and no. 6 cotton since all of these remained intact for five weeks or more.

Hemp twine was therefore chosen for use in the experimental regulation traps that were used to investigate the effects of the new regulation trap specifications on catch rates. The effectiveness of hemp twine as a biodegradable fastener was subsequently reconfirmed during the investigation when regulation traps were left in the water (on one occasion at Oistins) for a little over three weeks, and all doors were found to have opened when they were hauled.

### Description of Catches

Altogether 28 fishing trips were taken over a period of five months (January to May, 1999). A total of 182 traps were hauled and 3,747 commercially valuable finfish weighing 663.13 kg were taken. The catch composition is summarised by species, by trap type and by site in Table 1. An additional 38 crustaceans including four species of crab, two species of lobster and a mollusc were also taken in the traps but were not considered further in this study (Table 1).

The commercially valuable finfish catch comprised 73 species from 26 families. The most common species (by weight) in the catches overall were princess parrotfish (*Scarus taeniopterus*), redband parrotfish (*Sparisoma aurofrenatum*), and whitespotted filefish which represented 11%, 10% and 9% of the total catch respectively (Table 1). The most common species by number of fish were princess and redband parrotfish and ocean surgeon (*Acanthurus bahianus*) which each accounted for 12% of the total number of finfish caught.

The catch composition is further summarised by family, trap type and site in Table 2. The most common family in the catches overall was Scaridae which accounted for 24% by weight and 26% by number of the total catch (Table 2).

The key characteristics and catch performance of the two trap types at each of the three sites is summarised in Table 3. Overall, the mean catch per trap haul was 3.31 kg (19 fish) for regulation traps and 4.00 kg (22 fish) for conventional traps. The mean individual size of fish taken was 173 g for regulation traps and 181 kg for conventional traps and did not differ between them (Mann-Whitney Test: U = 1.011, n = 1800+1947, P = 0.312; Table 3).

### Comparison of Catch Rates between Regulation and Conventional Traps

As a result of obvious differences among sites in gear and habitats, analyses were initially done separately for each site.

*Six Men's* — Since two different trap designs were used by the Six Men's fisher, an initial comparison of their catch performance was undertaken using regulation traps. There was no significant difference between arrowhead and z-shaped traps in either the weight or number of fish per trap haul (Mann-Whitney test; for weight: U = 0.995, n = 15+15, P = 0.320; for numbers: U = 0.613, n= 15+15, P = 0.540). Therefore, all data including mixed design pairs were pooled for comparative analyses of regulation versus conventional traps.

**Table 1.** Catch composition of regulation and conventional traps sampled at three sites in Barbados between January and May 1999, shown by total weight (kg) and number of fish for each species.

| GROUP | | SIX MEN'S | | | | WESTON | | | | OISTINS | | | | ALL SITES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Reg. traps | | Con. traps | | Reg. traps | | Con. traps | | Reg. traps | | Con. traps | | All traps | |
| Family | Species | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish |
| FINFISH | | | | | | | | | | | | | | | |
| Acanthuridae | *Acanthurus coeruleus* | 0.51 | 6 | 0.22 | 4 | 1.84 | 15 | 0.21 | 1 | 6.26 | 59 | 22.74 | 146 | **31.78** | **231** |
| | *Acanthurus chirurgus* | 0 | 0 | 0 | 0 | 0.36 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | **0.36** | **2** |
| | *Acanthurus bahianus* | 2.16 | 29 | 1.79 | 21 | 1.45 | 18 | 2.30 | 27 | 15.93 | 155 | 21.45 | 197 | **45.08** | **447** |
| Aloustomidae | *Aulostomus maculatus* | 0.48 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.48** | **2** |
| Balistidae | *Melichthys niger* | 0.28 | 3 | 0.14 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.43** | **5** |
| | *Balistes vetula* | 2.39 | 2 | 7.23 | 7 | 0 | 0 | 0.73 | 1 | 2.41 | 3 | 3.04 | 4 | **15.80** | **17** |
| | *Xanthichthys ringens* | 12.68 | 101 | 10.94 | 93 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **23.63** | **194** |
| Bothidae | *Bothus lunatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.41 | 1 | 3.07 | 2 | **3.48** | **3** |
| Carangidae | *Caranx ruber* | 0.6 | 5 | 1.03 | 9 | 0 | 0 | 0 | 0 | 0.23 | 3 | 4.13 | 27 | **5.99** | **44** |
| | *Caranx crysos* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.08 | 1 | **4.08** | **1** |
| Chaetodontidae | *Chaetodon striatus* | 0.33 | 6 | 0.48 | 8 | 0 | 0 | 0 | 0 | 0.81 | 17 | 1.34 | 28 | **2.96** | **59** |
| | *Chaetodon capistratus* | 0.15 | 3 | 0.13 | 5 | 0 | 0 | 0 | 0 | 0.3 | 6 | 0 | 0 | **0.58** | **14** |
| | *Chaetodon sedentarius* | 0.04 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.04** | **1** |
| | *Chaetodon ocellatus* | 0.03 | 1 | 0.05 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.09 | 1 | **0.17** | **4** |
| Diodontidae | *Diodon holocanthus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.16 | 2 | 0.56 | 2 | **2.72** | **4** |
| | *Diodon hystrix* | 1.13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1.13** | **1** |
| | *Chilomycterus schoepfi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.31 | 2 | **0.31** | **2** |
| | *Chilomycterus antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.16 | 1 | 0 | 0 | **0.16** | **1** |
| Echeneididae | *Echeneis naucrates* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.41 | 1 | 0 | 0 | **0.41** | **1** |
| Grammistidae | *Rypticus saponaceus* | 0.69 | 5 | 0.74 | 4 | 0 | 0 | 0 | 0 | 0.64 | 3 | 0.50 | 3 | **2.57** | **15** |
| Haemulidae | *Haemulon carbonarium* | 0 | 0 | 0.33 | 3 | 0.27 | 2 | 0.64 | 4 | 5.17 | 44 | 3.38 | 23 | **9.78** | **76** |
| | *Haemulon flavolineatum* | 1.95 | 18 | 2.20 | 19 | 3.27 | 37 | 5.33 | 61 | 7.22 | 69 | 2.48 | 21 | **22.45** | **225** |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Table 1. continued | *Haemulon chrysargyreum* | 0.86 | 10 | 0.54 | 5 | 0.15 | 2 | 0.09 | 1 | 0.46 | 6 | 3.43 | 32 | 5.54 | 56 |
| | *Haemulon aurolineatum* | 0.22 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.22 | 2 |
| | *Haemulon plumieri* | 2.05 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.05 | 3 |
| Holocentridae | *Myripristis jacobus* | 1.58 | 19 | 3.02 | 32 | 1.91 | 20 | 1.77 | 20 | 6.15 | 58 | 2.73 | 30 | 17.16 | 179 |
| | *Holocentrus marianus* | 0.13 | 2 | 0.30 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.43 | 3 |
| | *Holocentrus rufus* | 9.57 | 93 | 10.44 | 89 | 3.82 | 36 | 2.16 | 21 | 6.87 | 52 | 4.60 | 35 | 37.46 | 326 |
| | *Holocentrus adscensionis* | 0.47 | 2 | 5.54 | 21 | 0 | 0 | 0 | 0 | 3.56 | 17 | 3.27 | 14 | 12.84 | 54 |
| Kyphosidae | *Kyphosus sectatrix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.68 | 2 | 0.55 | 1 | 1.24 | 3 |
| Labridae | *Clepticus parrai* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.22 | 1 | 0.47 | 3 | 0.68 | 4 |
| | *Bodianus rufus* | 0 | 0 | 0 | 0 | 0.28 | 1 | 0 | 0 | 3.43 | 8 | 0.81 | 2 | 4.52 | 11 |
| Lutjanidae | *Lutjanus buccanella* | 0.36 | 3 | 1.12 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.48 | 11 |
| | *Lutjanus joco* | 0 | 0 | 1.1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.10 | 2 |
| | *Lutjanus griseus* | 0 | 0 | 5.25 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5.25 | 3 |
| | *Lutjanus mahogoni* | 2.09 | 6 | 1.64 | 7 | 1.14 | 4 | 0 | 0 | 1.58 | 11 | 1.38 | 7 | 7.83 | 35 |
| | *Ocyurus chrysurus* | 0.24 | 2 | 0.8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1.45 | 1 | 2.49 | 4 |
| Malacanthidae | *Malancanthus plumieri* | 0.62 | 2 | 1.09 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.71 | 6 |
| Monacanthidae | *Cantherhines pullus* | 0 | 0 | 0.57 | 6 | 0 | 0 | 0 | 0 | 0.54 | 6 | 0.42 | 5 | 1.53 | 17 |
| | *Aluterus scriptus* | 1.85 | 5 | 1.37 | 2 | 3.11 | 5 | 5.58 | 8 | 2 | 5 | 3.58 | 2 | 17.49 | 27 |
| | *Cantherhines macroceros* | 8.72 | 17 | 8.94 | 17 | 1.55 | 2 | 0.95 | 7 | 27.15 | 69 | 13.98 | 34 | 61.29 | 146 |
| Mullidae | *Pseudupeneus maculatus* | 0.73 | 4 | 0.24 | 4 | 0 | 0 | 0 | 0 | 1.42 | 10 | 2.08 | 14 | 4.47 | 32 |
| | *Mulloidichthys martinicus* | 2.82 | 19 | 2.04 | 13 | 0.88 | 5 | 0.11 | 1 | 11.10 | 65 | 11.99 | 72 | 28.95 | 175 |
| Ostraciidae | *Lactophrys polygonia* | 2.77 | 7 | 3.61 | 10 | 0 | 0 | 0 | 0 | 1.79 | 5 | 3.75 | 12 | 11.93 | 34 |
| | *Lactophrys quadricornis* | 0.75 | 1 | 0.59 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.34 | 2 |
| | *Lactophrys triqueter* | 0.30 | 1 | 0.14 | 2 | 0 | 0 | 0 | 0 | 0.58 | 8 | 1.24 | 7 | 2.25 | 18 |
| | *Lactophrys bicaudalis* | 0 | 0 | 0.81 | 4 | 0 | 0 | 0 | 0 | 0.64 | 1 | 0 | 0 | 1.44 | 5 |
| | *Lactophrys trigonus* | 0.15 | 3 | 0.13 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.29 | 2 | 0.56 | 7 |
| Pomacanthidae | *Pomacanthus paru* | 0.39 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1.00 | 1 | 0.06 | 1 | 1.45 | 3 |

| Table 1. continued | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Holacanthus ciliaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.46 | 1 | 1.65 | 2 | **2.11** | **3** |
| | *Holacanthus tricolor* | 0.05 | 1 | 0.54 | 4 | 0 | 0 | 0 | 0 | 2.60 | 13 | 10.87 | 9 | **14.05** | **27** |
| Pomacentridae | *Stegastes variabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.12 | 2 | **0.12** | **2** |
| | *Abudefduf saxatilis* | 0 | 0 | 0.12 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.10 | 1 | **0.22** | **2** |
| | *Microspathodon chrysurus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.24 | 3 | **0.24** | **3** |
| Priacanthidae | *Priacanthus cruentatus* | 0.45 | 5 | 0.15 | 2 | 0 | 0 | 0 | 0 | 1.05 | 2 | 0.48 | 1 | **2.14** | **10** |
| Scaridae | *Scarus taeniopterus* | 23.26 | 154 | 36.59 | 232 | 0.53 | 4 | 0.59 | 5 | 4.30 | 19 | 10.13 | 46 | **75.40** | **460** |
| | *Sparisoma aurofrenatum* | 4.75 | 38 | 7.60 | 62 | 0.57 | 6 | 0.56 | 6 | 26.23 | 169 | 27.61 | 176 | **67.32** | **457** |
| | *Sparisoma rubripinne* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.15 | 1 | 0.32 | 1 | **0.48** | **2** |
| | *Sparisoma chrysopterum* | 0.16 | 2 | 0.14 | 1 | 1.08 | 6 | 0.42 | 3 | 4.68 | 12 | 2.01 | 4 | **8.47** | **28** |
| | *Scarus iserti* | 0.66 | 3 | 0.14 | 1 | 0 | 0 | 0.53 | 2 | 0 | 0 | 0 | 0 | **1.32** | **6** |
| | *Sparisoma viride* | 0 | 0 | 0.61 | 4 | 0.36 | 2 | 1.56 | 9 | 3.98 | 12 | 0.40 | 2 | **6.90** | **29** |
| Sciaenidae | *Equetis punctatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.36 | 1 | 0 | 0 | **0.36** | **1** |
| Serranidae | *Cephalopholis fulvus* | 3.66 | 14 | 1.12 | 5 | 1.31 | 5 | 0.78 | 2 | 10.77 | 35 | 9.12 | 24 | **26.76** | **85** |
| | *Paranthias furcifer* | 0 | 0 | 0.31 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.31** | **4** |
| | *Cephalopholis cruentata* | 3.07 | 16 | 5.38 | 3 | 8.97 | 39 | 4.20 | 21 | 0 | 0 | 0.49 | 2 | **22.10** | **81** |
| | *Epinephelus guttatus* | 0 | 0 | 0.76 | 3 | 0 | 0 | 0 | 0 | 1.25 | 1 | 3.53 | 4 | **5.54** | **8** |
| | *Epinephelus adscensionis* | 2.27 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 12.37 | 13 | 3.21 | 3 | **17.84** | **17** |
| | *Mycteroperca sp.* | 0.19 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.19** | **1** |
| Sparidae | *Calamus bajonado* | 0.09 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.47 | 1 | **0.56** | **2** |
| | *Calamus calamus* | 0 | 0 | 0.25 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.25** | **1** |
| Sphyraenidae | *Sphyraena barracuda* | 0 | 0 | 1.36 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1.36** | **1** |
| INVERTEBRATES | | | | | | | | | | | | | | | |
| Crustacea | *Carpilius corallinus* | - | 2 | - | 1 | - | 2 | 0 | 0 | - | 1 | - | 2 | **-** | **8** |
| | *Panulirus argus* | - | 10 | - | 4 | - | 4 | - | 3 | - | 2 | - | 1 | **-** | **24** |
| | conch | 0 | 0 | 0 | 0 | 0 | 0 | - | 1 | 0 | 0 | 0 | 0 | **-** | **1** |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | 1 | 0 | 0 | **-** | **1** |

**Table 2.** Finfish catch composition of regulation and conventional traps at three sites in Barbados between January and May 1999, shown by total weight (kg) and number of fish, summarised by family.

| | SIX MEN'S | | | | WESTON | | | | OISTINS | | | | ALL SITES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reg. traps | | Con. traps | | Reg. traps | | Con. traps | | Reg. traps | | Con. traps | | All traps | |
| FAMILY | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish | Wt (kg) | # Fish |
| Scaridae | 28.82 | 197 | 45.08 | 300 | 2.54 | 18 | 3.65 | 25 | 39.34 | 213 | 40.46 | 229 | 159.89 | 982 |
| Monacanthidae | 10.57 | 22 | 10.88 | 25 | 4.66 | 7 | 6.53 | 15 | 29.70 | 80 | 17.98 | 41 | 69.12 | 190 |
| Acanthuridae | 2.68 | 35 | 2.01 | 25 | 3.65 | 35 | 2.51 | 28 | 22.2 | 214 | 44.19 | 343 | 77.22 | 680 |
| Serranidae | 9.19 | 32 | 7.57 | 15 | 10.28 | 44 | 4.98 | 23 | 24.39 | 49 | 16.34 | 33 | 72.74 | 196 |
| Holocentridae | 11.75 | 116 | 19.30 | 143 | 5.73 | 56 | 3.93 | 41 | 16.59 | 127 | 10.60 | 79 | 67.89 | 562 |
| Haemulidae | 5.08 | 33 | 3.07 | 27 | 3.69 | 41 | 6.06 | 66 | 12.86 | 119 | 9.29 | 76 | 40.04 | 362 |
| Balistidae | 15.36 | 106 | 18.31 | 102 | 0 | 0 | 0.73 | 1 | 2.41 | 3 | 3.04 | 4 | 39.85 | 216 |
| Mullidae | 3.56 | 23 | 2.28 | 17 | 0.88 | 5 | 0.11 | 1 | 12.52 | 75 | 14.07 | 86 | 33.41 | 207 |
| Lutjanidae | 2.68 | 11 | 9.91 | 21 | 1.14 | 4 | 0 | 0 | 1.58 | 11 | 2.83 | 8 | 18.14 | 55 |
| Pomacanthidae | 0.44 | 2 | 0.54 | 4 | 0 | 0 | 0 | 0 | 4.06 | 15 | 12.58 | 12 | 17.62 | 33 |
| Ostraciidae | 3.97 | 12 | 5.28 | 19 | 0 | 0 | 0 | 0 | 3.01 | 14 | 5.28 | 21 | 17.53 | 66 |
| Carangidae | 0.6 | 5 | 1.03 | 9 | 0 | 0 | 0 | 0 | 0.23 | 3 | 8.22 | 28 | 10.07 | 45 |
| Labridae | 0 | 0 | 0 | 0 | 0.28 | 1 | 0 | 0 | 3.64 | 9 | 1.28 | 5 | 5.20 | 15 |
| Diodontidae | 1.13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2.32 | 3 | 0.87 | 4 | 4.32 | 8 |
| Chaetodontidae | 0.55 | 11 | 0.66 | 15 | 0 | 0 | 0 | 0 | 1.11 | 23 | 1.43 | 29 | 3.75 | 78 |
| Bothidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.41 | 1 | 3.07 | 2 | 3.48 | 3 |
| Grammistidae | 0.69 | 5 | 0.74 | 4 | 0 | 0 | 0 | 0 | 0.64 | 3 | 0.50 | 3 | 2.57 | 15 |
| Priacanthidae | 0.45 | 5 | 0.15 | 2 | 0 | 0 | 0 | 0 | 1.05 | 2 | 0.48 | 1 | 2.14 | 10 |
| Malacanthidae | 0.62 | 2 | 1.09 | 4 | 0 | 0 | 0. | 0 | 0 | 0 | 0 | 0 | 12.90 | 6 |
| Sphyraenidae | 0 | 0 | 1.36 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.36 | 1 |
| Kyphosidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.68 | 2 | 0.55 | 1 | 1.24 | 3 |
| Sparidae | 0.09 | 1 | 0.25 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.47 | 1 | 0.82 | 3 |
| Pomacentridae | 0 | 0 | 0.12 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.46 | 6 | 0.58 | 7 |
| Aulostomidae | 0.48 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.48 | 2 |
| Echeneididae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.41 | 1 | 0 | 0 | 0.41 | 1 |
| Sciaenidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.36 | 1 | 0 | 0 | 0.36 | 1 |
| ALL FINFISH | 98.70 | 621 | 129.81 | 735 | 32.82 | 211 | 28.51 | 200 | 179.50 | 968 | 193.98 | 1012 | 663.13 | 3747 |

**Table 3.** A summary of the key characteristics and finfish catch performance of regulation and conventional traps at three sites in Barbados between January and May 1999.

| CHARACTERISTIC | SIX MEN'S | | WESTON | | OISTINS | | ALL SITES | |
|---|---|---|---|---|---|---|---|---|
| | Regulation traps | Conventional traps | Regulation traps | Conventional traps | Regulation traps | Conventional traps | Regulation traps | Conventional traps |
| N (no. hauls examined) | 33 | 27 | 30 | 30 | 31 | 31 | 94 | 88 |
| Mean weight/trap/haul (kg) | 3.01 | 4.82 | 1.08 | 1.05 | 5.75 | 5.82 | 3.31 | 4 |
| Mean number/trap/haul | 20 | 28 | 7 | 7 | 31 | 33 | 19 | 22 |
| Mean size of fish (g) | 159 | 176 | 156 | 143 | 184 | 192 | 173 | 181 |
| Dominant family by weight | Scaridae | Scaridae | Serranidae | Haemulidae | Scaridae | Acanthuridae | Scaridae | Scaridae |
| Weight as % of total catch | 23.6 | 29.2 | 31.3 | 21.3 | 21.9 | 22.8 | 22.7 | 28.7 |
| Dominant family by number | Scaridae | Scaridae | Holocentridae | Haemulidae | Scaridae | Acanthuridae | Scaridae | Scaridae |
| Number as % of total catch | 24.8 | 40.8 | 26.5 | 33 | 22 | 33.9 | 23.8 | 28.4 |
| Dominant species by weight | princess parrotfish | princess parrotfish | graysby | scrawled filefish | whitespotted filefish | redband parrotfish | redband parrotfish | princess parrotfish |
| Weight as % of total catch | 29.2 | 28.2 | 27.3 | 19.6 | 15.1 | 14.2 | 10.1 | 13.4 |
| Dominant species by number | princess parrotfish | princess parrotfish | graysby | french grunt | redband parrotfish | ocean surgeon | redband parrotfish | princess parrotfish |
| Number as % of total catch | 31.7 | 31.6 | 18.5 | 30.5 | 17.5 | 19.5 | 11.8 | 14.5 |
| Normal soak time (days) | 3-4 | 3-4 | 7 | 7 | 3-4 | 3-4 | 3-7 | 3-7 |
| Trap size ($m^3$) | 1.81 | 1.81 | 1.13 | 1.13 | 2.83 | 2.83 | 1.31-2.83 | 1.31-2.83 |
| Depth range (m) | 25, 40-50 | 25, 40-50 | 6-8 | 6-8 | 19-20, 26 | 19-20, 26 | 6-50 | 6-50 |

The Six Men's fisher did not always follow instructions to fish regulation and conventional traps side-by-side in pairs. Therefore two analyses were conducted, the first examined all traps regardless of whether or not they were strictly paired, and the second used only strict pairs. The mean weight of fish per trap haul differed significantly between regulation traps (3.01 kg/ trap haul) and conventional traps (4.82 kg/trap haul) when all traps were considered (Mann-Whitney test: U = 2.474, n = 33+27, P = 0.013), with slightly higher catches for conventional traps. However, the mean number of fish per trap haul (20 for regulation traps; 28 for conventional) was not significantly different between the two trap types (Mann-Whitney test: U = 1.502, n = 33+27, P = 0.133). Interestingly, when only strict pairs of traps were used, both weight and number of fish per trap haul varied significantly between traps (Wilcoxon paired-sample test; for weight: T = 2.676, n = 21, P = 0.0077; for numbers: T = 2.572, n = 21, P = 0.010) with both weight and number per trap haul being greater for conventional traps.

*Weston* — At the Weston site, the mean weight of fish per trap haul was not significantly different between regulation traps (1.08 kg/trap haul) and conventional traps (1.05 kg/trap haul) (Wilcoxon paired-sample test: T = 0.165, n = 30, P = 0.869). The mean number of fish per trap haul (7 for regulation traps; 7 for conventional traps) was also not significantly different between the two trap types (Wilcoxon paired-sample test: T = 0.114, n = 30, P = 0.909).

*Oistins* — At the Oistins site, the mean weight of fish per trap haul was also not significantly different between regulation traps (5.75 kg/trap haul) and conventional traps (5.82 kg/ trap haul) (Wilcoxon paired-sample test: T = 0.088, n = 31, P = 0.930). The mean number of fish per trap haul (31 for regulation traps; 33 for conventional) was also not significantly different between the two trap types (Wilcoxon paired-sample test: T = 0.108, n = 31, P = 0.914).

*Overall sites* — When the data from all the three sites (Six Men's, Weston, and Oistins) were pooled the mean weight of fish per trap haul was not significantly different between regulation traps (3.30 kg/ trap haul) and conventional traps (3.88 kg/trap haul) (Wilcoxon paired-sample test: T = 1.012, n = 82, P = 0.311). The mean number of fish per trap haul (20 for regulation traps; 22 for conventional) was also not significantly different between the two trap types (Wilcoxon paired-sample test: T = 1.379, n = 82, P = 0.168).

### Comparison of Catch Composition between Regulation and Conventional Traps

Again as a result of differences in gear and habitat among sites, initial analyses were site specific.

*Six Men's* — A total of 1,356 finfish belonging to 56 species from 21 families were recorded at the Six Men's site (Table 1). Not surprisingly, the most abundant species in the catches of regulation traps was the princess parrotfish which represented 24 % of total weight and 25 % of total number (Table 1). The most abundant family was Scaridae which represented 29 % of total weight and 32 % of total number (Table 2). In conventional traps, the most abundant species was also princess parrotfish which represented 28% of total weight and 32% of total number, and the most abundant family was also Scaridae which represented 29 % of total weight and 41% of total number (Tables 1,2).

A statistical comparison of the catch composition using the top ten families (by weight) showed no significant difference between regulation and conventional traps (2 x 10 Chi-squared contingency test: $X^2 = 7.014$, $P = 0.636$).

*Weston* — A total of 411 finfish belonging to 21 species from 12 families were recorded at the Weston site (Table 1). The most abundant species (by weight) in the catches of regulation traps was the graysby (*Cephalopholis cruentata)* which accounted for 27% of the total catch weight. Three species (graysby; french grunt, *Haemulon flavolineatum;* and longspine squirrelfish, *Holocentrus rufus*) were the most abundant by number, accounting for 18%, 18% and 17 % of total numbers respectively (Table 1). The most abundant families in regulation traps were Serranidae (which accounted for 31% of total weight) and Holocentridae (which accounted for 27% of the total number). In conventional traps, the most abundant species by weight were scrawled filefish (*Aluterus scriptus*) and french grunt which represented 20% and 19% of total weight respectively (Table 1). French grunt was the most abundant species by number, accounting for 31% of the total catch of conventional traps. The most abundant family was Haemulidae which represented 21% of total weight and 33% of total number taken by conventional traps (Table 2).

Again the top ten families were used to compare the catch composition (by weight) of regulation and conventional traps. No significant difference was found between them (2 x 10 Chi-squared contingency test: $X^2 = 5.933$, $P = 0.747$).

Oistins — A total of 1,980 finfish belonging to 54 species from 24 families were recorded at the Oistins site. The most abundant species (by weight) in the catches of regulation traps were whitespotted filefish (*Cantherhines macroceros*) and redband parrotfish, each representing 15% of total weight (Table 1). Redband parrotfish was the most abundant species by number, accounting for 17% of the total catch. The most abundant family in regulation traps were Scaridae which represented 2 % of total weight, and Acanthuridae and Scaridae which each accounted for 22% of total number taken. In conventional traps, the most abundant species (by weight) was redband parrotfish which represented 14% of total weight, while ocean surgeon was the most abundant by number, accounting for 19% of the total. The most abundant family in conventional traps was Acanthuridae which represented 23% of total weight and 34% of total number.

Again the top ten families (excluding Carangidae (bar jacks) on the basis that they are essentially mobile pelagic species) were used to compare the catch composition (by weight) of regulation and conventional traps. As with Six Men's and Weston, there was no significant difference found between them (2 x 10 Chi-squared contingency test: $X^2 = 14.470$, $P = 0.107$).

*Overall sites* — Although there were no differences in the taxonomic composition of catches between regulation and conventional traps, there was an interesting and significant difference in the catch composition among sites (using pooled data from both trap types; 3 x 10 Chi-squared contingency test: $X^2 = 139.289$, $P < 0.001$) and between all pairs of sites ($P < 0.001$ in all cases) (Table 4).

## DISCUSSION

Acceptance of fishery regulations by fishers (which is essential for effective enforcement) is much more likely if they are conceptually simple, and are proven to be effective in achieving the stated fishery management objective without causing unnecessary hardship to fishers (e.g. Adams 1996).

In this case, the primary objective of the new fish trap regulations (which require a minimum mesh size of 3.18 cm, an escape panel and an identification marker) is to reduce fishing mortality in the trap fishery by minimising the level of ghost fishing. Since the regulated minimum mesh size corresponds to the size currently used by the vast majority of trap fishers in Barbados (Selliah, in press) this specification is clearly not intended to have any impact on current levels of fishing mortality or current catch rates. It should however, sensitise fishers to the need for control on mesh size (and thereby prepare them for possible increases in minimum mesh size in the future). It should also prevent fishers from moving to smaller mesh sizes in the future if further decreases in reef fish abundance occur. This may be particularly important given the very recent large-scale reef fish kills affecting Barbados (Fisheries Division 1999).

The identification marker is also not intended to have any impact on fishing mortality or catch rates within the trap fishery.

**Table 4.** Comparison of finfish catch composition by weight (using pooled data from regulation and conventional traps) among the three sites in Barbados between January and May 1999, shown by the top 10 families at each site.

| | SIX MEN'S | | WESTON | | OISTINS | |
|---|---|---|---|---|---|---|
| FAMILY | Wt (kg) | Rank | Wt (kg) | Rank | Wt (kg) | Rank |
| Scaridae | 73.90 | 1 | 6.19 | 5 | 79.80 | 1 |
| Balistidae | 33.68 | 2 | 0.73 | 9 | 5.45 | 10 |
| Holocentridae | 31.04 | 3 | 9.66 | 4 | 27.18 | 5 |
| Monacanthidae | 21.45 | 4 | 11.19 | 2 | 47.67 | 3 |
| Serranidae | 16.76 | 5 | 15.25 | 1 | 40.73 | 4 |
| Lutjanidae | 12.59 | 6 | 1.14 | 7 | 4.42 | - |
| Ostraciidae | 9.25 | 7 | 0 | - | 8.42 | 8 |
| Haemulidae | 8.14 | 8 | 9.75 | 3 | 22.14 | 7 |
| Mullidae | 5.84 | 9 | 0.99 | 8 | 26.59 | 6 |
| Acanthuridae | 4.69 | 10 | 6.16 | 6 | 66.38 | 2 |
| Pomacanthidae | 1.65 | - | 0 | - | 7.64 | 9 |
| Labridae | 0 | - | 0.28 | 10 | 4.92 | - |

Ghost fishing is recognised by trap fishers and managers alike to be a significant problem in the trap fishery, with the rate of trap loss estimated to be as high as 25 % of all traps per year (Wilson 1983). The use of an escape panel in each trap to minimise ghost fishing by lost traps is a conceptually simple and "common sense" measure. However, it is important that the escape panel functions effectively (i.e. that it becomes operational shortly after the trap is lost, but not during the normal coarse of fishing), so that ghost fishing is significantly reduced. It is also important that no unintentional hardships are incurred by fishers through loss of catches resulting from early opening of escape doors. Furthermore, it is important that the visual impact of the escape panel and identification marker does not cause unintended reduction in ingress rates and therefore result in reduced catch rates. Visual image effects on ingress rates and thus catch rates have been reported by several authors (e.g. Luckhurst and Ward 1987, Bohnsack et al. 1989).

In this study, we have tested a number of biodegradable materials for suitability as escape panel fasteners, and investigated the effects of the presence of the required escape panel and identification marker on the catch rates of trap fishers.

Hemp twine was found to be a very effective fastener for the Modified Dowridge Design escape panel, and functioned equally well with or without the tyre inner tube spring.

Catch rates (by number of fish per trap haul) were not affected by the regulation specifications for traps at any of the sites (except at Six Men's when only strictly paired traps were analysed). There was also no difference in the catch rates (by weight of fish per trap haul) between regulation and conventional traps at Weston and at Oistins. However, there was a difference detected at Six Men's with regulation traps catching less on average than conventional traps. The lower catch rate at this site could not be attributed to early opening of the escape panel doors, which suggests that it could have been caused by lower ingress rates for regulation traps. This may be so, but we feel that it is more likely a reflection of the more casual attitude of the Six Men's fisher to hauling his traps. Unlike the other fishers, the Six Men's fisher would frequently abandon a fishing trip before all traps (especially conventional traps) had been hauled. This meant that even within strictly paired traps (regulation and conventional traps fished side-by-side) soak times varied, usually with greater soak times for the conventional traps. This could account for the larger catches (see Munro et al. 1971, Luckhurst and Ward 1987). Interestingly when paired data from all three sites were pooled there was no significant difference in the weight of fish per trap haul, and there was no difference in the size (weight) of individual fish taken by the two trap types.

The taxonomic composition of catches was also unaffected by the regulation specifications. Despite large between-site differences in the species of fish caught (which most likely reflects the different habitats being fished), there were no within-site differences in the species taken by regulation and conventional traps.

In conclusion, the newly regulated trap specifications do not appear to have unintentional negative impacts on the fishing power of the trap, and are therefore likely to be well accepted by trap fishers. This should assist in achieving the management objective of reducing ghost fishing in the trap fishery.

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