FISHERIES & ESTUARINE SESSION

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Large Volume Stackable Fish Traps for Offshore Fishing

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INTRODUCTION

Fish traps account for a very significant proportion of the catch from coralline tropical seas, where the presence of coral reefs precludes or severely restricts the use of trawls or other nets. In the coralline portion of the Western Atlantic Ocean and of the Caribbean Sea, only a very small proportion of the area of shallow water is trawlable, and the greatest proportion of fishing effort is devoted to fishing by means of traps, hook-and-line and spears.

Antillean fish traps have previously been described and illustrated by Munro, Reeson and Gaut (1971). The commonest type of trap is in the form of a double chevron or Z, with two down-curved "horse-neck" entrance funnels, and measures 183-229 cm (72-90 in) long, 122 cm (48 in) wide and 61 cm (24 in) deep, with an overall volume of 1.4-1.7 m^3 (48-60 cubic ft). The framework is normally constructed of mangrove or other sticks and is covered by wire mesh having a maximum aperture of 4.13 cm (1-5/8 in). There is some regional variation in design, size and method of construction according to local tradition or preferences.

The use of traps is advantageous in that traps require little maintenance and can easily be repaired if superficially damaged. A substantial proportion of the catch is normally represented by reef fishes such as Scaridae (parrot fish), Acanthuridae (surgeon fish), Palinuridae (spiny lobsters), Mullidae (goat fish) and Chaetodontidae (angel fish), which cannot easily be caught by other means, and other groups such as Balistidae (trigger fish) which are not readily taken on hook and line.

Low density fish stocks can be economically exploited by means of traps where other methods are uneconomical or have become uneconomical through overfishing.

The disadvantages of the traps presently in use in the Caribbean region relate to the fact that they have evolved for use from small open boats or canoes operating near shore under circumstances where several traps will be carried to sea on a small boat and set in a suitable location. Such traps are then hauled and reset at will and are not normally returned to shore except for purposes of repair. As such, a fisherman operating a fleet of approximately 20 traps has to make up to 10 trips to the fishing grounds in order to set his entire fleet; his mobility is therefore severely limited and he cannot easily move to new fishing areas. Similarly, in the event of storms or hurricanes he is totally unable to withdraw his fishing gear.

As a result of the low mobility of the fishermen and the continuous operation of the traps, most nearshore shelf areas in the Antilles are probably severely over-exploited and yield less than the potential maximum sustainable yield. The over-exploitation of nearshore stocks by means of traps leads to hook-and-line fishing becoming increasingly uneconomical causing even more fishermen to adopt the use of traps. However, such over-exploitation is confined to areas within the normal operating range of small outboard-powered craft, and the fish stocks of substantial areas of coralline shelf or oceanic banks lying beyond the operating range of small craft are very lightly exploited or completely unexploited. These areas include most of the extensive Nicaragua-Honduras shelf (about 20,000 sq miles), the large oceanic banks such as Pedro Bank (2,344 sq miles) and Rosalind Bank (1,441 sq miles), many small oceanic banks in the western Caribbean, the Saba, Barbuda and Anguilla Banks of the eastern Caribbean, various banks lying to the north of Hispaniola and the extensive shallow areas of the Bahamas.

In Jamaica, over the past few years, several 10-20 m (33-65 ft) vessels have been introduced and exploit the Pedro Bank by means of traps. The mobility of the vessels is highly restricted. The carrying capacity is around 20 traps, but upwards of 100 traps can be hauled and reset in a day. To set a fleet of 200 traps the vessels must make around 10 trips from the home port, and in order to move the fleet of traps to a new fishing area, a similar number of trips must be made. In the case of the above-mentioned vessels, the areas in which they operate lie no more than 60-100 miles from the home port and, despite their restricted mobility, they would appear to be operating on an economical basis.

Other vessels have attempted to extend operations to the more productive Rosalind Bank, 200 miles from Jamaica (Kawaguchi, 1971), or to parts of the Honduras shelf, up to 300 miles from Jamaica. These efforts have not had significant success. The trap-carrying capacity of such vessels is insufficient, and all of the traps can be hauled and reset within a few hours. The remainder of the day is then spent line fishing, which, although promising in some areas, yields very variable results (Kawaguchi, 1971).

Wolf and Chislett (1971) showed that trap fishing in the Caribbean gave consistently good results in many areas. However, it may be deduced from their results that the trap-carrying capacity of the fishing vessel poses a major obstacle to economic success, or that the profitability of the operation could be increased several times by carrying more traps. For example the *Alycon* and *Calamar*, twin

25-m (81-ft) exploratory fishing vessels of the UNDP/FAO Caribbean Fisheries Development Project, carried a maximum of only 24 Z traps. In contrast their hauling capacity when operating traps in deep water (110-146 m; 60-80 fm) amounted to 30-40 traps per 8- to 10-hour day. Wolf and Chislett (1971) therefore suggested that such vessels should haul each trap twice daily in order to maximize their catch. However, their results show that the greatest catch per trap is obtained when baited traps are soaked for 2 to 3 days, a fact confirmed by recent tests conducted on Pedro Bank (Munro, in press). In order to maximize the daily catch, the *Alycon* and *Calamar* would therefore have had to carry 60-120 traps, depending upon whether 2-day or 3-day soaks yielded the greater margin of profit.

Previous investigations (Munro *et al*, 1971; Munro, in press) have shown that the magnitudes of trap catches relative to any particular soak are determined by relative rates of ingress and escapement of fishes, and that these rates are influenced by factors such as conspecific attraction, moon phase or the corresponding tides, composition of the fish community, configuration, size and structure of traps and presence or absence of bait.

It has been shown that escapement rates from Antillean traps amount to about 12% per day, and that catches stabilize when the number of fishes entering the trap is balanced by the number escaping. Also, escapement via the inlet funnels is proportional to the area or volume within which fishes are contained, or inversely proportional to the number of entrance funnels and the size of the inlet apertures. Escapement is probably a result of random movements within the traps, particularly at night. Therefore, catches are proportional to the size of traps when the number and size of entrance funnels remains constant. The size of entrance funnel inlets should be restricted to the greatest extent practicable. Non-return devices to prevent escapement have been tested, but all reduce the rate of entry into the traps and thus reduce catch rates to below that obtained without such devices.

The circumstances outlined above led to the conclusion that stackable traps were required if trap fishing was to prove economically profitable in the Caribbean area and, in so far as possible, such traps should incorporate desirable characteristics of traditional Antillean traps: large size and twin, down-curved, "horse-neck" funnels, plus inexpensive construction and high durability.

STACKABLE TRAPS

CONSTRUCTION

The basic solution to the problem of developing stackable Antillean traps has been derived from the fact that the traditional S-trap can be split through the vertical-longitudinal axis into identical halves. If the outer dimensions of one-half a trap are reduced to smaller than the inner face of a vertical-longitudinal split through the trap, then one half can be rotated through 180° and stacked inside or on top of the other half.

Two designs have been developed and tested: the stackable "Dollar"- or split-S-trap, derived from the Cuban S-trap (Buesa Mas, 1962), and a stackable

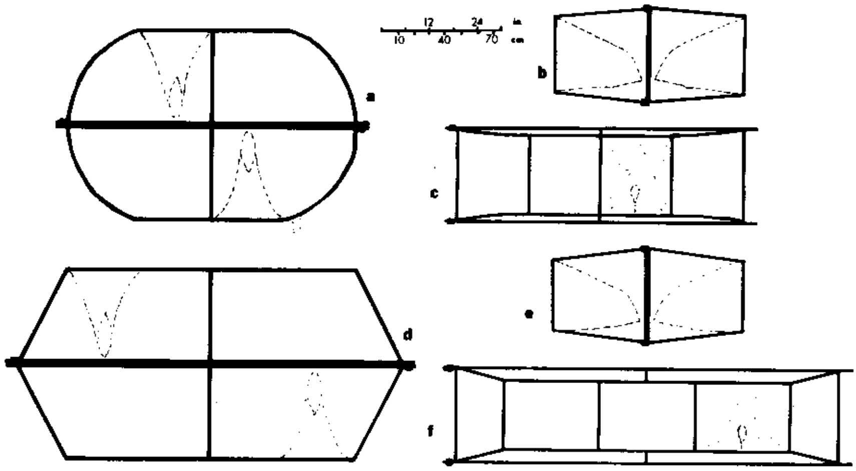

Fig. 1. Configuration of stackable traps. Plan (a), end (b) and lateral (c) views of split-S or Dollar-trap. Plan (d), end (e) and lateral (f) views of Hexagonal-trap.

Hexagonal trap based in turn on our experience with the Dollar-trap. Both designs are shown in Figure 1. To date, the frames of the stackable traps have been constructed of 1.27 cm (1/2 in) box-section steel. The frames are welded throughout and all ends are sealed. The box-section steel possesses very high structural rigidity.

The assembled Dollar-trap is 183 cm (6 ft) in length, 122 cm (4 ft) in overall width and 61 cm (2 ft) deep at the center. The sides taper to 51 cm (20 in) high, giving a 5 cm (2 in) taper on each side. The corners of the trap are gently curved to maintain the sigmoid shape of the Cuban S-trap.

The Hexagonal trap differs from the Dollar-trap in length and taper. The trap is 244 cm (96 in) in overall length and at the sides tapers to 46 cm (18 in) in height. The curved corners of the Dollar-trap have been replaced by a 117° angle.

Figure 2 illustrates how the traps can be split and the halves stacked. Each half has an asymmetrical horse-neck funnel constructed as shown in Figure 3, and therefore has a fixed upper and lower surface and similarly a fixed right or left side. In our traps the half sections have been joined by fitting the central rectangular frame of each half with two projections at the right hand side (when viewed laterally) and two small pieces of 1 in box-section steel on the left hand side of the frame. Each spike has a small hole drilled vertically about 1-1/4 inches out from the outer margins of the central rectangular frame. When two trap halves are paired the spikes pass through the piece of 1-inch box-section at each corner, thus lending support at all corners of the central rectangular frame. The two halves are then locked in position at any corner by means of a locking pin. The locking pin is merely a 7.6 cm (3 in) galvanized nail with about 15 cm (6 in) of galvanized wire attached below the head of the nail.

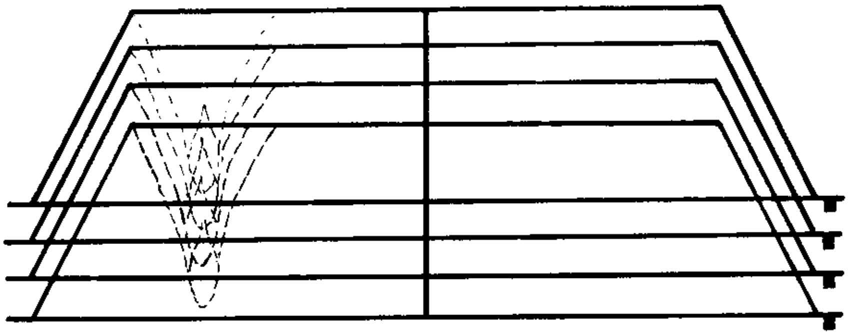

Fig. 2. Stacked Hexagonal-trap frames. Twenty-one frames can be stacked in the space normally occupied by two traditional Antillean traps.

The completed Dollar-trap weighs 20.9 kg (46 lb); the Hexagonal trap 24.5 kg (54 lb). The half sections weigh only 10.5 and 12.3 kg (23 and 27 lb), respectively, and can easily be handled by one man even under severe weather conditions. The weight of the Dollar-trap is approximately equal to that of the wood and wire Antillean Z-trap (44 lb), but the weight in water is greater because of the absence of a buoyant frame work. As a result, the stackable traps rest more firmly on the bottom and are less readily displaced by waves and currents.

The stackable traps have to date been covered with 3.18 cm (1.25 in) galvanized chicken-wire mesh, which is the traditional material for Antillean fish traps. However, the use of other materials is possible, particularly PVC coated wire and rectangular welded wire mesh.

COMPARATIVE PERFORMANCE

The performance of Dollar-traps and Hexagonal traps was compared at a series of 31 stations on Pedro Bank and on the South Jamaica Shelf between February and October 1972. The mean catch per Hexagonal trap was 2.41 kg

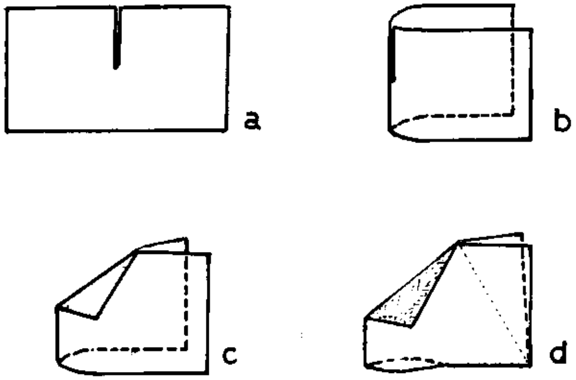

Fig. 3. Details of construction of a horse-neck funnel; the rectangle of wire (a) measures 109 x 61 cm (43 in x 24 in) and is cut and folded as illustrated (b-d).

compared with 2.00 kg/trap for Dollar-traps. A one-tailed "t" test of the departure of the catch rates of Hexagonal traps from the mean catch rates of Dollar- and Hexagonal traps combined, showed Hexagonal traps to be significantly better than the Dollar-traps ("t" = 1.697, P + 0.05), and the best estimate of the difference is + 20.5%.

Munro (in press) has shown that catch rates in Antillean traps are proportional to the area covered by the traps, and that the relative efficiency of Dollar-traps per unit area was about 21% less than that of Antillean traps. The catch rates in Hexagonal traps suggest that this proportionality has been maintained and that the catching power of the stackable traps is about 25% less than that of wooden-framed traps of equivalent size. There is no satisfactory explanation for this difference at the present time.

HANDLING TIME

The time required for preparing, baiting and shooting an Antillean or a stackable trap does not differ substantially but the physical effort required is less in the case of the stackable traps. The time required to haul traps to the surface is proportional to the depth at which they are set and also does not differ. However, emptying and stowing a stackable trap requires only 30 seconds; the trap is placed on its side, one-half removed and stacked and the other half upended and emptied into a fish box, rotated in the process and similarly stacked. In contrast, Antillean traps require up to 3-1/2 minutes to empty and stow depending upon the size of the catch. This results in the ship having to wait until the crew is ready to retrieve the next trap, in contrast to the stackable traps where the limiting factor is the speed with which the vessel can approach successive trap buoys. Consequently, stackable traps require fewer crew to handle the operation and the crew actually has time to rest or organize affairs on deck between successive traps.

Our results suggest that a professional crew could easily haul and reset 120 traps in a 10-hour working day, and any remaining time could be devoted to line-fishing on an opportunistic basis.

COSTS

The cost of the completed prototypes has been about J $20.00 (US $24.00) for the Dollar-trap and J $17.50 (US $21.00) for the Hexagonal trap. The cost of materials for the Hexagonal traps is greater than for the smaller Dollar-traps, but the labor costs for Dollar-traps are greater. Large scale production techniques would reduce labor costs to some extent. Materials and costs are given in Table 1.

The life of a trap in continuous operation with no protection against rust is conservatively estimated at 12-18 months. Plastic or other coatings on the wire and frame would undoubtedly reduce rusting and greatly extend the life of the trap.

CARRYING CAPACITY AND OPTIMUM SOAK

Catch per trap is related to the soak and, in the case of baited traps, reaches a maximum shortly before the bait in the trap is exhausted (Munro, in press).

Table 1. Materials and costs for construction of prototype stackable Dollar– and Hexagonal traps (Jamaican Dollars = 1.2 U.S. Dollars)

Item	0.5 in box section steel		1.25 in 18G wiremesh		Labor and Supervision		
Cost per unit ($J)	0.07/foot		0.023 sq ft		2.10/hour		
	ft	$	sq ft	$	hr	$	Total costs
Dollar trap	81.3	5.69	86	1.96	6	12.31	$19.96
Hexagonal trap	102.0	6.58	110	2.50	4	8.42	$17.50

When the bait is exhausted, the catch declines and stabilizes when escapement equals ingress. The optimum soak is therefore a variable that depends upon the rate at which the bait is consumed, the numbers of fishes which enter the trap and the amount of bait provided. On Pedro Bank the maximum is reached in 2 or 3 days.

In order that a vessel be fully occupied, the carrying capacity should be the product of the optimum soak and the daily hauling capacity. For example, if the hauling capacity is 120 traps per day and the optimum soak is 2 days, then 240 traps should be carried. Carrying more than 240 traps will result, in this case, in the mean soak exceeding the optimum and will result in a lower catch per trap and a lower daily catch.

ECONOMICS OF OPERATION

The economics of operating such traps is dependent, as with other gear, on the construction and maintenance cost, useable life, average catch per trap, price of fish and cost of vessel operations; all of which are highly variable from place to place. However, it is sufficient to point out that vessels using Antillean traps are operating on an economical basis at the present time. If stackable traps are used on a commercial scale, the greater carrying capacity and mobility, the higher durability of the traps and the lower operating costs for vessels would appear to ensure their profitability.

The catch rates obtained on the deeper parts (>15 m) of the southern portion of Pedro Bank indicate that a mean catch rate of about 8.2 kg (18 lb) per trap can be expected when using Hexagonal traps soaked for 2 days. At current average fish prices of J $0.48/kg (J $0.22/lb), the cost of a Hexagonal trap would be paid off in 4-5 hauls or in 8-10 days of operations.

SUMMARY AND CONCLUSIONS

(1) Traps are used for fish capture in most coralline tropical seas. They offer many advantages but are bulky and the mobility of fishermen is very

restricted. Fishing vessels cannot carry sufficient traps to sustain a commercial operation in distant waters.

(2) Stackable traps, based on one of the traditional Antillean designs, have been developed and tested. Hexagonal traps yielded catches about 20.5% greater than obtained in stackable S-traps (Dollar-traps), but the stackable traps were about 25% less efficient than traditional traps of equivalent size.

(3) The trap-carrying capacity of a vessel is increased six to seven times and the handling time and physical labor is substantially reduced.

(4) Over 120 traps can be hauled and reset in a day in depths of 20-50 m (10-25 fm), and a 2-day soak would appear to be optimal on Pedro Bank. The total number of traps carried should be the product of the optimum soak in days and the daily hauling capacity.

(5) The cost of a Hexagonal trap operated on the southern portion of the Pedro Bank is likely to be paid off in four to five hauls or 8-10 days of fishing.

ACKNOWLEDGEMENTS

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