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Catches of lost fish traps (ghost fishing) from fishing grounds near Muscat, Sultanate of Oman

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Abstract

A field study was undertaken to quantify the catch rate of simulated lost fish traps at five traditional fishing grounds near Muscat and Mutrah, Sultanate of Oman. Twenty-five traps were set at depths between 16 and 36 m during the period late November 2000 to mid-July 2001. Ghost fishing mortality was estimated at 1.34 kg/trap per day, decreasing over time. An exponential model, to estimate trap ghost fishing mortality, predicted a mortality rate of 67.27 and 78.36 kg/trap during 3 and 6 months respectively, with trapped fish having a value of 55.565 RO/trap (∼US$145) and 64.725 RO/trap (∼US$168) respectively.[1] To reduce the negative impacts of ghost trap fishing here and elsewhere, it is recommended that future traps be better marked, equipped with timed-release or degradable sections or panels, and that openings be included in the traps to release undersized animals.

Keywords: Ghost fishing; Basket traps; Lost traps; Oman

1. Introduction

Ghost fishing is defined as the ability of fishing gear to continue fishing after all control of that gear is lost by fishermen (Smolowitz, 1978a). The rate at which fish perish to lost gears—the ghost fishing mortality rate—is currently an intangible and remains of significant concern to both fishers and fisheries managers (Jennings and Kaiser, 1998). Gears may be lost for a variety of reasons including, but not limited by: inclement weather (e.g., storms, ice chaffing of ropes), bottom snags, navigational collisions (e.g. with surface vessels and wrecks and entanglement with other gears), faulty fishing methods, abandonment, human error, vandalism, and gear failure (Laist, 1995). Irrespective of the fact that fishers are aware of the preceding risk factors, sustained losses due to ghost fishing continue to occur (Carr and Harris, 1994). Lost or abandoned gears have the potential to fish for prolonged periods (Erzini et al.,

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[1] 1 Rial Omani (RO) equals 2.604 US$.

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1997; Huse et al., 2003) and ghost fishing accounts for between 5–30% of annual landings on some commercial grounds (Laist, 1995). In the trap fishery of Kuwait financial losses due to "ghosting" may reach 3–13.5% of total catch value (Mathews et al., 1987).

The period during which ghost gears continue to fish varies with gear type and construction (i.e., natural versus artificial twines), fishing area, depth, current, and species (Carr and Cooper, 1987; Symes, 1998). Pots, traps and gillnets clearly have the greatest potential for ghost fishing for extended durations, while long lines, trawls, jigging systems and wires may entangle individual animals but generally have lesser impact (Carr and Harris, 1994). Lost gillnets and traps can remain intact and still catch marine life for many years (Laist, 1995; Bullimore et al., 2001) including target, non-target and even endangered/protected species such as marine turtles and sea birds (Dayton et al., 1995). Lost fishing gear and gear scraps have been categorized as one of the most hazardous types of marine pollution (Laist, 1995). Fishing gear used in the Sultanate of Oman consists of trawls, bottom set and drift gillnets, traps (wire mesh and plastic types), barrier traps, hand lines, and bare hands and knives (to dislodge abalone) (Siddeek et al., 1999). Al-Masroori (2002) described two methods used by the local trap fishers to mark traps; either by marking each trap with a buoy, which however, increases the risk of theft and vandalism or by connecting a group of traps by rope. The length of rope between two traps is approximately 1.5 times the depth. Some fishers mark the gear position by separate buoys, which are unconnected to the trap(s). Others rely on their experience and a landmark to identify trap positions. Traps are retrieved using a drag anchor to pick up the rope connecting the traps.

Dependent upon fishing locality and season, trap fishing in Oman may represent up to 19% of all gears employed by the artisanal fishery (Al-Oufi et al., 2000). Traps are constructed of wood, wire mesh, plastic coated steel mesh or netting, using designs developed to suit local conditions. Generally, Omani fishers employ wire basket traps, that are semi-circular in cross-section. These are also used in other Gulf States and Iran. Preliminary studies have shown that approximately 20% of these traps are lost each year (Al-Masroori, 2002), but no studies have examined the potential negative impact of trap losses on the fishery. Accordingly, the objectives of the present study were: to quantify catch rate of lost traps and thereby estimate ghost fishing mortality and to describe such changes in catch rates over time.

2. Materials and methods

2.1. Gear deployment and data collection

The study sites were located near the capital city, Muscat and the town of Mutrah, at five traditional fishing grounds known to suffer trap losses; A'Sifah, Yeti, Bander Jissah, Al-Bustan and Fahal Island (Fig. 1). Twenty-five traps of medium size were deployed at depths ranging between 17 and 35 m on each of these fishing grounds (A'Sifah = 12; Yeti = 5; Bander Jissah = 2; Al-Bustan = 3; Fahal Island = 3) during late November 2000 to mid-July 2001 (Table 1). These traps were constructed by interweaving three sets of parallel steel wires, since this is the type most commonly deployed here (Fig. 2). They were baited with bread placed in plastic bags, to simulate the local fishing techniques as closely as possible. To deploy the traps, a long-line method was used, three traps being joined together in a gang. Trap positions were recorded using GPS and were marked using white buoys. Warning notices were issued and also attached to the buoys at each site.

Some workers have suggested quantifying ghost fishing is best achieved from underwater observations of simulated lost traps (Breen, 1990). However, in this study depth prohibited the use of SCUBA such that mortality could only be assessed by lifting the traps. During each visit, traps were hauled to the surface whereby individual fish were identified and their length and weights recorded. The traps were then reset and returned to the same position. All traps were hauled on the same day, every 3 days for the first 2 weeks, then weekly thereafter (see Smolowitz, 1978b) for a period of 21 weeks. Estimates of length and weight for individual species from previous observations were employed as a means of differentiating new from old catch. Due to inclement weather there were some days when traps could not be checked. Hence, trap working days were assessed as a week from any checkup date (i.e. any missed week/s were then subtracted from the working days when calculating trap ghost fishing catch per day). Finally, the catch per day was calcu-

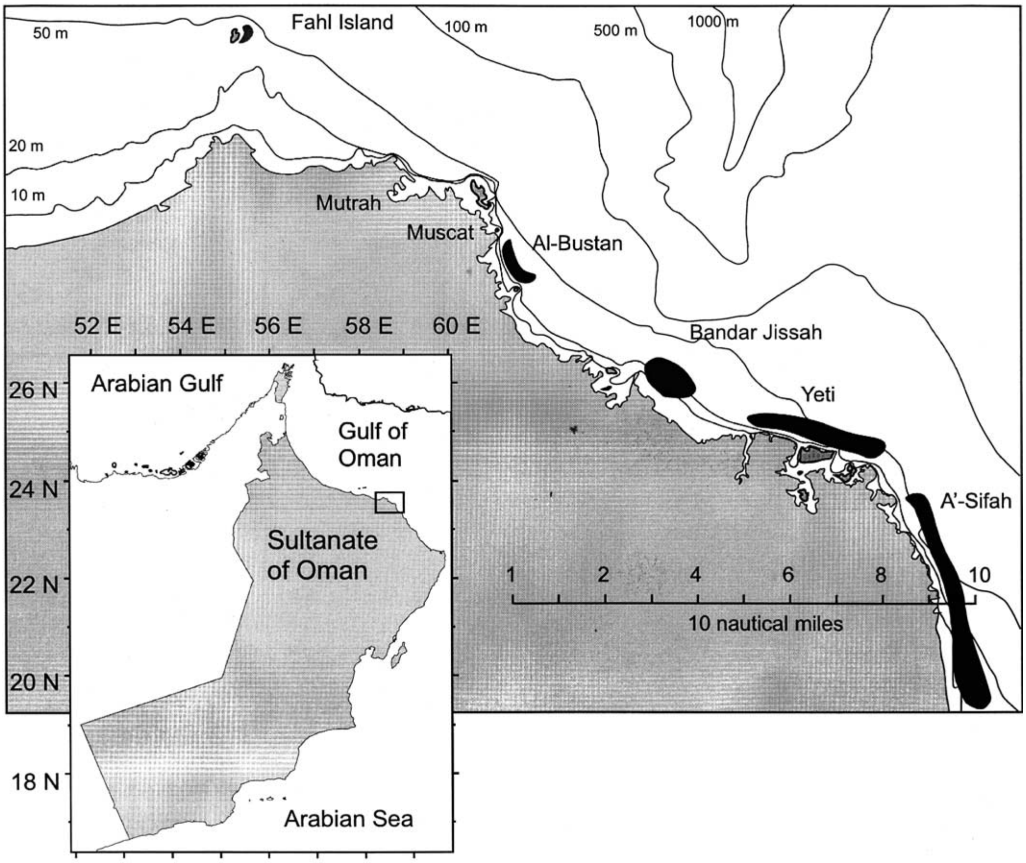

Fig. 1. A map of Muscat depicting the location of the main study sites where the traps were deployed.

lated for each trap to provide average catch/trap or CPUE/day.

2.2. Data analysis

The fish were identified following Randall (1995) and frequencies of commercial and non-commercial fish catch (by-catch) were categorized so that the mean catch and ghost fishing catch rates could be calculated. A single factor analysis of variance (ANOVA) was used to test for differences between the five fishing grounds. The value of commercial fish at the time was obtained from Ministry of Agriculture and Fisheries (MAF) and Ministry of National Economy (MNE) records. These values were used to calculate potential economic loss to the fishers and to gain an indication of their significance to the national fishery sector.

3. Results

3.1. Catch frequency

During a period of 21 weeks, the 25 simulated lost traps caught 426 fish and 60 cuttlefish, weighing a total of 434.3 kg. Of these, 404 (83%) animals were classified as commercial catch, with the remainder (82 animals or 17% of the total) being considered as by-catch, or of no commercial value. On a weight basis, 94% of animals caught in the traps were commercially valuable. Of these the ephippids, cuttlefish (mostly *Sepia pharaonis*) and sparids dominated both the total number (42%) and weight (61%) of the catch (Fig. 3). Of the non-commercial catch species, the tetraodontids comprised 44% of the total number and 38% of the total weight.

Table 1
The fishing grounds, working days, total catch and catch rate of 15 of the 25 traps deployed

Trap number	Fishing ground	Average depth (±1.6 m)	Working days	Total catch (kg)	Catch (kg/trap per day)
1	A'Sifah	22.5	7	5.3	0.76
2	A'Sifah	22.5	7	1.9	0.27
3	A'Sifah	31	27	14.3	0.53
4	A'Sifah	31	26	16.1	0.62
5	A'Sifah	31	26	27.5	1.06
6	Al-Bustan	35	82	26.5	0.32
7	Al-Bustan	35	82	18.5	0.23
8	Al-Bustan	35	82	74.8	0.91
9	Bander Jissah	24.5	37	43.4	1.17
10	Bander Jissah	24.5	37	26.0	0.70
11	Yeti	17	7	53.1	7.59
12	Yeti	17	7	7.3	1.04
13	Yeti	17	7	29.6	4.23
14	Yeti	20	53	61.2	1.15
15	Yeti	20	53	28.8	0.54
Total				434.3	21.13
Average catch (kg/trap (CPUE) per day)					1.41
Ghost fishing mortality (kg/trap per day)[a]					1.34

[a] 10% escapement rate was assumed, of which 50% were assumed to survive.

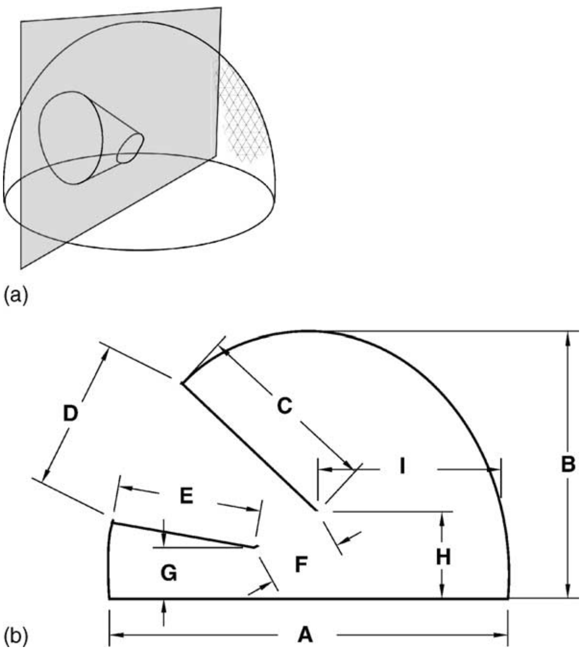

Fig. 2. The (a) design and (b) dimensions of a typical trap used by traditional fishermen in Oman. This study utilised traps of a medium size. Dimensions (in cm) of the trap are: *A* = 210.9; *B* = 134.5; *C* = 95.8; *D* = 103.4; *E* = 68.5; *F* = 53.3; *G* = 18.8; *H* = 44.4; *I* = 94.8.

3.2. Catch rate

During the present trials, the entire catch of each trap was recorded and the new catch separated from the old, then combined to determine total catch. Of the 25 traps set only 15 provided catch data of any magnitude (Table 1).

The escape rate of cuttlefish was considered to be low as there was often cuttlebones found in the bottom of the traps. Sparidae and Ephippidae (*Platax orbicularis*) remained alive in the traps for periods of up to 37 days. Monacanthidae, Tetraodontidae and Carangidae (*Gnathanodon speciosus*) survived for periods up to 35, 32 and 26 days respectively. Dead fish, their skin and skeletal remains, indicative of some mortality, were observed in all traps. It is to be expected that degraded flesh, fish bones and remains of smaller animals would have passed through the trap's mesh between samplings and hence are unaccounted for. In total, these observations suggest that escapement from traps was probably minimal. However, to allow for unaccountable escapement it was assumed that an escapement rate of 10% occurred and of this 10%, only 50% of the animals survived. Accordingly, a ghost fishing mortality of 95% was assumed for the

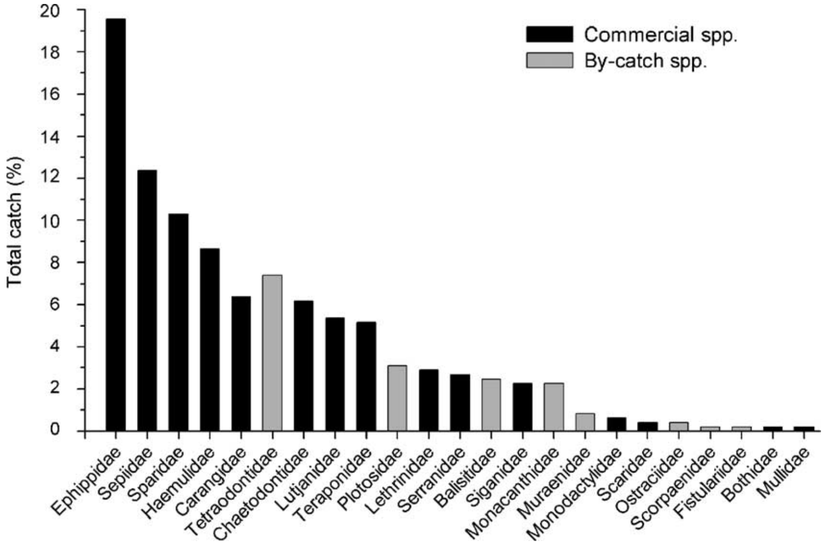

Fig. 3. The total catch (%) of fish and invertebrates (mostly cuttlefish) caught during the study period, separated into families and commercial and by-catch categories.

present study, accounting for 1.34 kg of trap ghost fishing mortality per trap per day (Table 1).

The average catch per week per trap for all traps was calculated and the set-over day or catch per unit of effort (CPUE) was then developed (Fig. 4). As traps were hauled and checked at weekly intervals, CPUE was calculated to take account of weekly catch rather than a daily one. Catch fluctuations observed during the present trial may be related to the availability of animals in the fishery and the amount of bait (dead animals) inside each trap (Fig. 4). Analysis of variance (ANOVA) demonstrated no significant difference (P = 0.146, d.f. = 107.3) in catches between the five fishing grounds. As with the studies of Parrish and Kazama

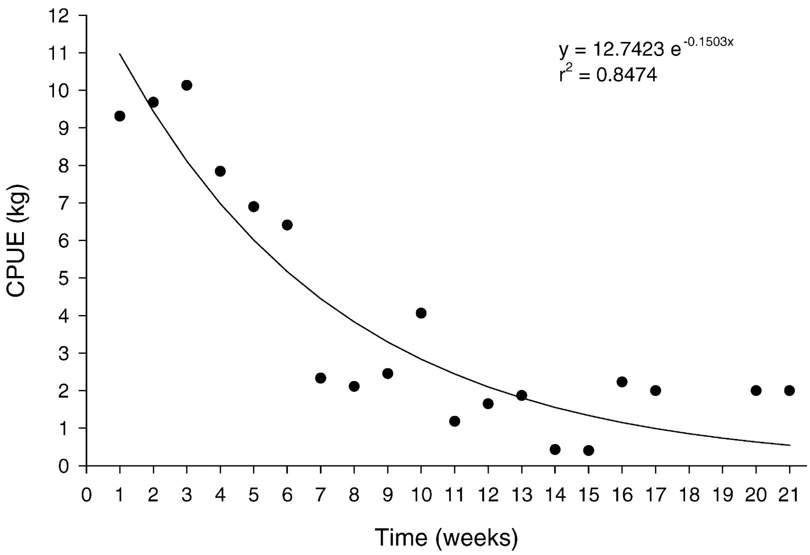

Fig. 4. Set-over day or CPUE for a single fish trap deployed for the duration of the study.

(1992) and Bullimore et al. (2001), the line of best fit for the catch curve (Fig. 4) was an exponential (r^2= 0.847). A logarithmic curve was not seen as appropriate since it would have yielded a CPUE curve below zero. Integration of the exponential curve (Eq. (1)) over the same period of time to indicate cumulative catch, enables prediction of CPUE at any time (t_n) after which time a trap was lost (t_0).

For this purpose, the exponential formula was integrated as follows:

$$Y = 12.7423(\exp(-0.1503X)) \quad (1)$$

where Y is the catch (kg) and X or (t) is time in weeks from the time at which the trap was lost to any time (t_n) was integrated, giving the following equation:

$$\text{Cumulative total catch (kg)} = 84.779(1 - \exp(-0.1503(t_n))) \quad (2)$$

Eq. (2) was used to calculate the cumulative catch of a lost trap at any point in time (t_n), where the unit of time was 1 week. Then, 5% as a rate of escape was subtracted in order to calculate the amount of trap ghost fishing mortality.

3.3. Ghost fishing mortality and economic losses

Using Eq. (2), the total trap ghost fishing mortality was estimated for different weeks. Table 2 summarizes the level of ghost fishing rate on a weekly basis. Each trap produced catches of 67.27 and 78.36 kg 3 and 6 months post-loss, respectively. The average price of commercial fish caught by the traps per day was 0.826 RO/kg (∼US$2). Therefore, the average equivalent annual tangible economic loss produced by trap ghost fishing to the study area was estimated as 55.565 RO/trap (∼US$145) and 64.725 RO/trap (∼US$168) for 3 and 6 months respectively (Table 2).

Table 2
Cumulative trap ghost fishing mortality (kg) and economic loss for 15 of the 25 traps deployed

Week	Mortality (kg)	RO	Value US$
1	11.24	9.284	24.18
2	20.91	17.272	44.98
3	29.23	24.144	62.87
4	36.39	30.058	78.27
5	42.55	35.146	91.52
6	47.85	39.524	102.92
7	52.42	43.299	112.75
8	56.34	46.537	121.18
9	59.72	49.329	128.45
10	62.62	51.724	134.69
11	65.12	53.789	140.07
12	67.27	55.565	144.69
13	69.13	57.101	148.69
14	70.72	58.415	152.11
15	72.09	59.546	155.06
16	73.27	60.521	157.60
17	74.28	61.355	159.77
18	75.16	62.082	161.66
19	75.91	62.702	163.28
20	76.55	63.230	164.65
21	77.11	63.693	165.86
22	77.59	64.089	166.89
23	78.00	64.428	167.77
24	78.36	64.725	168.55
25	78.66	64.973	169.19
26	78.92	65.188	169.75
27	79.15	65.378	170.24
28	79.34	65.535	170.65
29	79.51	65.675	171.02
30	79.65	65.791	171.32

4. Discussion

In another trap study conducted in Oman, ephippids, cuttlefish and sparids contributed only 2% to the total catch (El-Etreby et al., 2001). The latter authors identified Lethrinidae (26%), Haemulidae (21%) and Balistidae (13%) as being the most dominant families in the Raysout trap fishery, Dhofar, approximately 900 km to the south (Fig. 1). In contrast, these three families contributed only 25% to the total catch in this study. This marked difference however, probably reflects differences in the oceanographic conditions of the two regions (Dhofar and Muscat), which may affect the catch composition at different times of the year. An alternative explanation might be that the observed differences in catch occurred because of differences in bait type, fishing depth and habitat between regions.

In a similar study that considered parlour pots, Bullimore et al. (2001) observed that once captured, certain species appeared to remain resident in the traps, being recorded on subsequent sampling dates. They suggest that as the captured animals die or escape, they are replaced by conspecifics. However, this was not observed in this study as traps were occupied by different species at different sampling times. This distinction between the two studies may have occurred due to the type of pots employed (parlour versus wire baskets), their size, and/or nature of the fisheries examined (crustacean versus a teleost/cephalopod fishery).

Bullimore et al. (2001) found that corpses of thornback rays (*Raja clavata*), used as bait, remained in lobster pots for up to 27 days. The bait within the trial traps used in this study however, was consumed within an average of 3 days. The relatively short half-life of the bait was likely due to its nature (bread placed in a plastic bag) and the effect of warm seawater temperatures experienced year round at Muscat (average 24 °C, M.C. Claereboudt, pers. comm.), which would act to break down the bread quickly. It should be emphasized however, that dead animals (fish and cephalopods) within the trap could also provide a readily available source of food and act as bait for fish and cuttlefish. Indeed, in the current study, cuttlebones and fish remains were a common feature of trap contents. The possibility of self-sustaining baiting by traps has also been considered by other workers (see Kaiser et al., 1996; Bullimore et al., 2001).

Our observations indicate that baited traps in Oman fished at an average rate of 1.41 kg per day. In the Kuwait trap fishery, estimates based upon a variety of assumptions, showed that the volume of fish killed in non-recovered traps was between 140 and 510 tons/year (Mathews et al., 1987). Catch rate alone, or ghost catch rate, likely over-estimates the magnitude of the total mortality associated with ghost fishing because some escapement undoubtedly takes place. Therefore, an estimation of escapement rate is necessary to obtain the true level of trap ghost fishing mortality. Even with such data however, the possibility that escaped fish could perish from secondary (stress-related) infections due to abrasions and other injuries exists. During the course of this study several individual *Platax orbicularis* (Ephippidae) were observed with skin wounds. These abrasions probably resulted from their attempts to pass through the trap's mesh. Similar findings were reported by Bullimore et al. (2001) for wrasse caught in parlour pots.

Although some information is available on the escape rate of crustaceans from traps, there are few studies in which the escape rate of finfish from traps has been estimated. Due to differences in trap design and species involved, direct comparison of results is difficult. Perhaps the most relevant data for fish escapement is provided by the study of Scarsbrook and MacFarlane (1988), in which different experimental escape mechanisms were examined. These trials indicated an escape rate of 0% from traps used for sablefish (*Anoplopoma fimbria*). Various observations made during the present study suggest that the escapement rate observed in Oman was comparable to that reported by Scarsbrook and MacFarlane (1988).

The average trap catch increased sharply from 0 at setting day to 10.13 kg by the third week (Fig. 4). Thereafter, CPUE declined at a varying rate. This observation supports the theoretical model presented in Munro (1974), which suggests that the number of fish escaping unbaited traps per day may be a fixed fraction of the current trap occupancy. He also suggests that catch eventually reaches an asymptote when trap entrances are balanced by exits. From the catch curve calculated for this study (Fig. 4), the total occupancy of traps declined weekly until a low and varying level was achieved. These findings support those presented by Parrish and Kazama (1992), who reported that the departure rate of lobsters from traps was roughly matched by their rate of entrance.

This study suggests that the current problem of trap ghost fishing at the fishing grounds near Muscat could be severe. As emphasized by Bullimore et al. (2001) such losses are undesirable from both an economic and conservation viewpoint. In Oman, trap ghost fishing could be prevented or reduced by introducing timed-release panels or degradable sections that open to release the catch after a period of time. Use of materials that dissolve in seawater after a few days represents an ideal technique as does natural fiber twine used to make timed-release panels or to sew a timed-release panel shut (Breen, 1990). Such a mechanism could be easily adapted in the Oman trap fishery simply by substituting the synthetic rope (polypropylene) with other natural fibers such as Manila, cotton or sisal or fibers from palm or coconut trees. These materials could be introduced at minimal cost to the fishermen. An alternative approach, described by Blott (1978) involves the use of a timed-release panel held shut with a degradable metal ring. An additional method that could be adopted is a trap designed in Kuwait by Mathews et al. (1987) in which the trap door consists of an artificial anode that dissolves in 2–3 weeks through the process of electrolysis. The presence of the sacrificial anode door also protects the metal trap and extends its service life.

If these methods are investigated and applied it will not only reduce ghost fishing significantly, but will reduce the cost to the fishers and the effects that lost traps have on Oman's environment. The incorporation of sub-legal gaps into the construction of traps could also prevent retention of under-sized finfish or shellfish. Regardless of the phase of fishing, the use of such vents is undoubtedly a conservation practice that must be encouraged in all trap fisheries (Smolowitz, 1978b). Future studies should be carried out to further investigate the problems of ghost fishing in Oman and to test different solutions previously discussed aimed at either reducing trap loss or trap ghost fishing. Specifically, investigations that determine the level of trap escapement and to test different marking and release mechanisms are required.

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