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International Council for the Exploration of the Sea

CM 1980/H:30
Pelagic Fish Committee

THE MORTALITY OF INTERNALLY TAGGED MACKEREL (*Scomber scombrus* L.)

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ABSTRACT

The mortality of internally-tagged mackerel (*Scomber scombrus* L.) was investigated in a field experiment carried out off the Cornish coast in August 1979.

Hook-and-line-caught mackerel were tagged using Norwegian type internal tags and released into a large keep net, together with a similar number of untagged (control) fish matched by eye with the tagged fish for body colour and length. Ninety-three tagged fish and 92 control fish were released into the net and final mortality rates of 22.5% and 7.6% respectively were recorded after an observation period of 15 days.

INTRODUCTION

Assessment studies of the European mackerel stocks are to some extent dependent upon data from tagging programmes which can be used to provide estimates of stock size, recruitment, mortality rates, and the mixing ratios of separate stocks in a common fishery (Anon., 1978, 1979). These estimates are all arrived at using mathematical models based upon the Petersen Index (Petersen, 1896) which relates tagging data to population size, N, using the formula:

$$\frac{N}{T} = S\frac{C}{r}$$

where T denotes the number of fish tagged, r the tag recoveries, C the catch and S the tagged fish survival rate (1- tagging mortality). Experimentally derived estimates of tagging mortality have been obtained in the past (Hamre 1970, Walsh, pers. comm.), but more recently theoretical values generated by use of VPA techniques have been used, as described by Hamre (1978). These have tended to be in the range 15 - 35%, up to 25% higher than the empirical values obtained. Such variability in theoretical estimates of tagging mortality are common and have been a major source of error in past stock assessments, often leading to an over-estimate of the stock size. As part of a wider programme associated with mackerel stock assessment, staff of the Fisheries Laboratory, Lowestoft, carried out an experiment to estimate the mortality in mackerel attributable to the tagging process.

MATERIALS AND METHODS

The work was carried out in Mevagissey Bay (50°15'N 04°47'W) Cornwall during August 1979. A site providing deep water (10 m) with weak tides, close inshore, and sheltered from all but easterly winds, was chosen as suitable for mooring a large keep net.

Local boats were used to catch the mackerel on handlines fitted with barbless, feathered hooks (Bolster, 1974), and only fish showing no external signs of damage or stress were retained. These were held in a circular deck tank, 2 m diameter 1 m deep, with a through-flow of sea water at ambient temperature, for transportation to the keep net.

The Keep net

The keep net was made of 210/18 white nylon twine with a stretched mesh size of 23 mm. Six side panels each 3 m wide x 3 m deep were cut so that the meshes hung square, with a single hexagonal panel, 3 m on each side and 6 m across the long axis, being cut for the floor. The net was suspended from six wooden spars, 75 mm x 100 mm x 3 m long, the ends of which were each reinforced with a 5 mm thick steel strap, with an eye bolt on the extreme end for attachment by a flexible coupling to the adjacent spar, and other eye bolts on the sides for the attachment of bracing stays and floats (Figure 1). Two 1075 mm x 205 mm inflated sausage floats were lashed to each spar to provide buoyancy, and each corner of the net was weighted with galvanised steel chain to help hold the side panels vertical. The total volume of the net thus formed was 70 m^3. The net assembly was moored at both ends by anchors as shown in Figure 2.

The fish

Only fish in apparently first-class external physical condition were used. These were taken from the holding tanks on board the catching boats in pairs, matched by eye for colour and size (length). One was immediately released into the net whilst the other was tagged using a Norwegian-type internal tag and modified Gundersen tagging pump (Hamre, 1970) before also being released into the net. The net was checked regularly and deaths of all fish recorded. All fish dying during the course of the experiment, and all surviving fish at the end of the period of observation (15 days), were individually inspected for external damage and the siting of the tag within the body cavity.

RESULTS

Altogether 93 tagged and 92 untagged (control) fish were released into the net and observed during the period 19 August-4 September 1979, a total of 354 hours. Table 1 gives a summary of the mortality observed; a cumulative mortality of 18.3% was recorded for the tagged fish and 4.3% for the control fish. The data were tested using a 2 x 2 contingency table which gave a chi-squared value of 9.78 (1 d.f.), indicating a statistically significant difference between the observed mortality levels of the tagged and untagged fish at the 99% level of probability.

Observations of fish condition

At liberty or when freshly caught, healthy mackerel are silver on the body and flanks, and the back is green with irregular transverse dark stripes. When mackerel were cleanly hooked in the lower lip and immediately put into the deck tank without handling, they showed little if any change in coloration, and certainly resumed normal colouring within a short time. When the fish were subjected to some form of physical stress such as handling, contact with part of the boat or even overcrowding, blue or dark-green patches were seen to develop. In some cases this patchy coloration was reversible, especially when it occurred on the back between the base of the skull and the first dorsal fin ray. As this was an unlikely area for the fish to have sustained physical damage, it was assumed to be the result of the fish recovering after physiological changes induced by the stress of its capture and confinement. Where the blue patches persisted it was thought to be due to changed interference patterns in the skin caused by the loss of scales. This was most commonly observed along the posterior flanks of the fish.

Live mackerel lose skin as a result of abrasion. In this experiment abrasion could have been caused by handling during tagging, contact with the net and in very crowded conditions, mutual abrasion between fish. As the holding density in the net was less than 3 fish per m^3, the last two causes are considered to be less likely. Whatever the cause, the more vigorous the abrasion the greater the likelihood of skin being lost. Thus, as the posterior flanks undergo the greatest movement during the lateral flexing of the body whilst swimming, it was these areas which tended to show the earliest and most extensive skin loss. This skin loss was progressive.

In extreme, if not all, cases the abrasion resulted in an immediate loss of mucus and scales from the affected areas, and after a minimum of 24 hours, but more usually 2 - 3 days, the skin began to come away. The outer layer of the epidermis first began to blister, and when these blisters burst the skin started to peel off. Immediately following skin loss the underlying muscle tissue was still covered with a silvery layer of quanine, but this was soon lost to expose the actual muscle tissue. (Lockwood *et al.*, 1977).

Where the abrasion was very slight, discoloured grey/brown patches of thickened mucus were observed over the damaged site which did not develop blisters. If these patches were lightly abraded the skin immediately came away, whereas surrounding areas of undamaged skin remained intact, even after vigorous abrasion. Because these patches were never seen in conjunction with skin blisters and were only observed on fish which had spent several days in the net, it was assumed that they formed part of the fishes' natural healing process. Such patches would not be apparent at the time of tagging.

The qualitative data on the condition of all the experimental fish are summarised in Table 2. Of the 17 tagged fish which died, in only one case was incorrect tag insertion the probable cause of death (the tag was lodged in the pyloric caecae). Two fish showed no apparent damage and the remainder (14) had suffered an extensive loss of skin, estimated as being from 10 to 60% of the total body surface area. Of the 76 tagged fish which survived the 15-day observation period, 53 showed no visible signs of damage. Of the damaged 23 fish, 4 had lost areas of skin from the flanks, 6 showed healing patches as described earlier, one had suffered a pierced mesentery (the tag being found lodged amongst the intestines) and 12 had open (but uninfected) tag wounds (but the tags of these twelve were still free in the visceral cavity).

Amongst the control group only 4 fish died; of these 3 suffered skin loss and the other was apparently undamaged. Eighty of the survivors were also undamaged; three others had lost areas of skin and 5 had healing patches.

No examples were observed where patches of lost skin appeared to be healing. If it is accepted that skin regeneration was an unlikely event in fish damaged in such a manner, then it is reasonable to assume that those surviving fish suffering from skin loss would have a negligible chance of recovery. This being the case, the number of fish dying in the experiment can be augmented by the numbers of survivors suffering from skin loss, giving totals 'dead' of 21 tagged fish (22.5%) and 7 control fish (7.6%). Thus mortality as a direct result of the insertion of the tags will not be less than 15%.

DISCUSSION

Utmost care was exercised in the selection of apparently undamaged fish for use in the experiment. They were handled as little as possible and the tagging was done under ideal conditions by a member of the laboratory staff experienced in the technique. These factors, and the relatively low number of fish used, lead to the supposition that avoidable damage to the mackerel was kept to a minimum.

Three main causes of mortality can be described from this experiment.

(1) mortality resulting from damage sustained during tag insertion;

(2) mortality caused by handling;

(3) stress mortality.

Eaton (1980) has shown that mackerel will suffer an appreciable stress induced mortality when confined in nets. This mortality will be a component of the total mortality observed in the control fish, but would have been very small at the holding density used. Most of the observed mortality was attributable to the handling of the fish. As this source of damage applies equally to both the control and the tagged fish, it is considered that the total observed mortality of 22.5% is not an unreasonable estimate of tagging mortality in this experiment. However, in a full tagging release programme where captured fish are held in nets or tanks prior to tagging at densities higher than were used in this work, it is likely that stress induced mortality would make a larger contribution to the total mortality. In addition, the scale of the operation and the often less than ideal working conditions would preclude the degree of quality control over the techniques and materials used being similar to that exercised in this investigation, and consequently the fish would suffer a greater mortality from all causes than that reported here. For these reasons, the 22.5% tagging mortality level arrived at is considered to be an absolute minimum estimate. Other recently determined empirical values for hook and line caught, internally tagged mackerel are given by M Walsh (personal communication) and Hamre (1970). These are 23% and 10% respectively. Recent estimates of tagging mortality generated by VPA techniques are in the range 15 - 37%, with a mean value nearer to 30% rather than the level of 15% used prior to 1978. (Anon., 1978, 1979).

Whilst recognising the limitations of a small-scale experiment such as this, it is clear from this and other work of a similar nature (Eaton, 1980) that mackerel is a species which is extremely susceptible to damage caused by any form of handling or stressing. Because tagging data perform such an important role in mackerel stock management strategies, it is recommended that when tagging experiments are carried out, every effort should be made to obtain a real estimate of mortality due to the tagging process and, as a simple preliminary measure to reduce the mortality of tagged fish, the use of "blue" coloured fish for tagging should be avoided if possible, as investigations have shown that such fish have high blood levels of lactate, cortisol and sodium ions (Pawson and Lockwood, 1978). Although these high levels were not statistically correlated with body colour, they are commonly observed in dead or moribund mackerel.

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Table 1 Cumulative mortality of mackerel in keep net. Nominal density in net: < 3 mackerel/m^3

Time in net (h)	Tagged		Control	
	No. alive	% dead	No. alive	% dead
0	93	0	92	0
12.0	92	1.1	92	0
15.7	92	1.1	92	0
36.5	92	1.1	92	0
61.0	91	2.2	92	0
84.5	84	9.7	92	0
108.5	79	15.1	90	2.2
131.0	79	15.1	90	2.2
138.0	76	18.3	90	2.2
156.5	76	18.3	90	2.2
162.2	76	18.3	90	2.2
180.5	76	18.3	90	2.2
184.3	76	18.3	90	2.2
186.7	76	18.3	90	2.2
204.0	76	18.3	89	3.3
251.0	76	18.3	89	3.3
256.0	76	18.3	88	4.3
277.0	76	18.3	88	4.3
282.0	76	18.3	88	4.3
306.0	76	18.3	88	4.3
325.5	76	18.3	88	4.3
348.5	76	18.3	88	4.3
354.0	76	18.3	88	4.3

Table 2 Qualitative assessment of the damage suffered by experimental fish

	No apparent damage	Skin loss	Healing patches	Internal damage	Open tag wound	Totals
Tagged fish						
Dead	2	14	0	1	–	17
Surviving	53	4	6	1	12	76
						93
Controls						
Dead	1	3	0	–	–	4
Surviving	80	3	5	–	–	88
						92

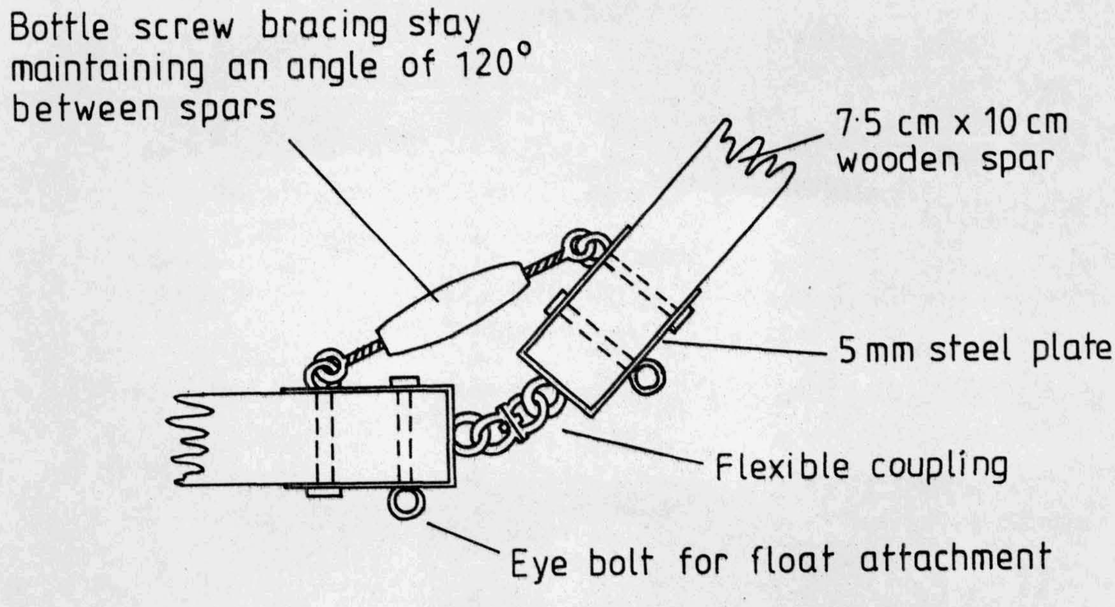

Figure 1 Linkage arrangement of the spars forming the net frame.

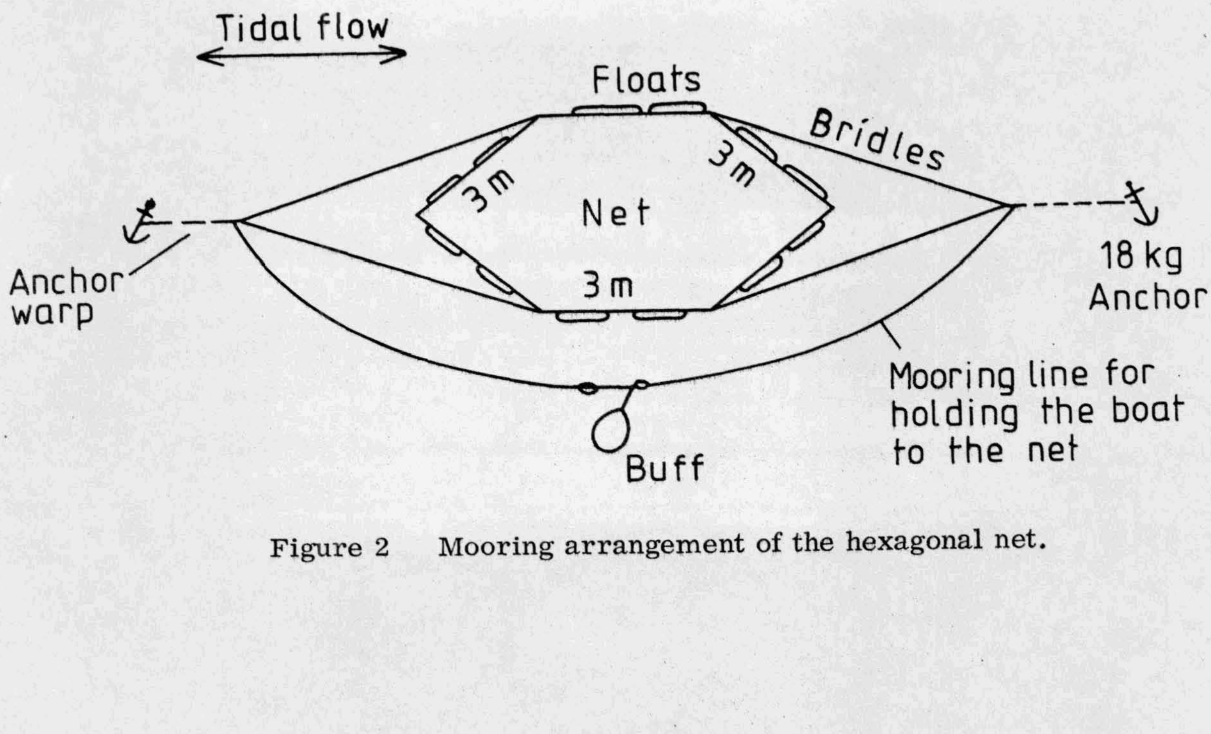

Figure 2 Mooring arrangement of the hexagonal net.