

Introduction

The recent rise in cormorant numbers in England and Wales has increasingly brought them into conflict with freshwater fisheries. This has highlighted the need for effective management measures to reduce the level of cormorant impact on fish stocks. One technique that is showing potential is the deployment of artificial fish refuges in recreational coarse fisheries. The installation of refuge structures aims to provide secure 'holding areas' for fish to reduce the level of interaction between cormorants and their prey. Understanding how fish respond to, and use, such structures is a key requirement in assessing refuge designs and evaluating their potential.

System requirements

In order to investigate the behaviour of fish in and around artificial fish refuges, and to evaluate the efficacy of different refuge designs, we needed a system that:

- was portable,
- was suitable for use with small fish (<10cm),
- was suitable for detecting large numbers of individuals,
- had high temporal and spatial resolution,
- could target specific locations within the refuges,
- allowed continuous remote monitoring.

Methodology

Passive integrated transponder (PIT) tagging technology is now widely used in the study of fish behaviour.

Tags – PIT tags provide unique codes, are simple to apply and are suitable for use with small fish – tags measuring 12 mm long by 2.1 mm diameter were successfully used in this investigation to tag fish as small as 5 cm in length.



Fish detection – Custom-made, fish detection antenna arrays were developed for this study based on the multi-point decoder (MPD) system described by Riley *et al* (2003). A PIT detection system of four free-standing antenna arrays (Figure 1) was positioned in open water or inside fish refuges as appropriate (Figure 2 a & b). Each stand was designed to provide coverage throughout the water column at the chosen trial site (old water treatment lagoons).

Each array consisted of eight individual PIT antennae, made of high impact PVC box section and were waterproof (IP68) and fitted with 10m cables. Each antenna was linked to a multi-point PIT decoder (MPD) unit (two were used in these trials), consisting of a 24 V DC integrated MPD/antenna multiplexer (16 channel), powered by two 12 V (120/140 Ah) lead-acid batteries. Each MPD unit was capable of sequentially interrogating up to 16 individual PIT detector antennae every 3.2s and thus supported two arrays. This, in effect, provided continuous remote monitoring of tagged individuals in the immediate vicinity of the detector arrays.



Cormorants loafing at an inland fishery

Experimental Trials

The MPD and detector arrays have been used to provide rapid feedback on issues relating to refuge design and refuge use by fish. For example:

1. Optimising refuge design

Single detector arrays were deployed within four different refuge designs:

- a) a simple frame covered with protective mesh,
- b) as (a) but incorporating internal 'structure' (old Christmas trees),
- c) as (a) but incorporating overhead shading,
- d) as (a) but incorporating both internal 'structure' and overhead shading.



Figure 1: A free-standing detector array comprising eight individual PIT detector antennae; stands were constructed to allow full coverage of the water column within the trial lagoon.



Figure 2: Detector array positioned in a) open water and b) inside a fish refuge within the trial lagoon (note - lagoon only part full and refuge construction finalised after positioning of detector array).

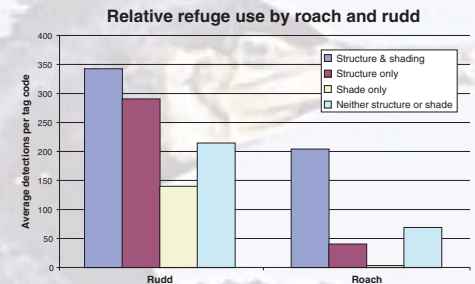
PIT tagged roach (*Rutilus rutilus*) (n = 100, mean length 13.3 cm) and rudd (*Scardinius erythrophthalmus*) (n = 100, mean length 12.0 cm) were introduced and detections recorded over a period of 7 days, with refuges being moved every 24 h to allow for possible pond effects or effects due to proximity of adjacent refuges.



Roach (*Rutilus rutilus*)

Results

- Both species showed a clear preference for the refuge containing both internal 'structure' and overhead shading.



2. Assessing refuge use

Two PIT detector arrays were deployed within a fish refuge and two others in open water (Figure 2). The refuge incorporated overhead cover and internal 'structure', measured 2m x 2m x 1.55m and comprised 0.4% of the total water volume. PIT tagged roach (n = 73, mean length 14.0 cm) and rudd (n = 131, mean length 12.6 cm) were then introduced to the pond. After a 48 h recovery and acclimatisation period, fish detections at the various arrays were recorded for 24 h (Phase 1), after which the refuge and non-refuge positions were switched and detections recorded for a further 24 h (Phase 2).

Results

- Both species displayed a strong preference for the refuges, with over 100 times more detections in refuges (Table 1) than open water.
- Refuges were located rapidly by both species.
- There was greater use of refuges by day.

Table 1: Percentage of tagged fish recorded by the refuge and open water detectors in each 24 h period

	Refuge		Open water	
	Roach	Rudd	Roach	Rudd
Phase 1	99%	96%	3%	37%
Phase 2	100%	97%	16%	48%

Future work

The antenna array system will be used in further trials of fish refuges to assess factors such as:

- refuge carrying capacity and effective range,
- species-specific refuge designs,
- refuge use by fish in the presence and absence of cormorants.

Conclusions

- The antenna arrays and MPD system have provided a powerful tool for evaluating fish behaviour in relation to fish refuges and in refining refuge design.

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Reference

Riley, W.D., Eagle, M.O., Ives, M.J., Rycroft, P. & Wilkinson, A. (2003). A portable passive integrated transponder multi-point decoder system for monitoring habitat use and behaviour of freshwater fish in small streams. *Fisheries Management and Ecology* 10: 265-268.