Natural England Technical Information Note TIN028

Reducing the impact of cormorants: the use of fish refuges

It is recognised that predation by cormorants may cause problems at individual fisheries by damaging stocks of fish and by reducing catches. While predation is just one of a wide range of factors that can affect fish populations, it can, on its own, have potentially serious economic implications for some fisheries. Under such circumstances, management action may be needed. Such action should balance the need to safeguard fish stocks and fisheries with the conservation of the birds, although striking such a balance may not always be easy. A range of potential management options exists. One particular technique, the use of fish refuges, has been the subject of Defra-funded research over recent years. The purpose of this leaflet is to advise fishery owners and managers in England about this ongoing work, and allow them to consider whether fish refuges might be an appropriate option for reducing the impact of cormorant predation.

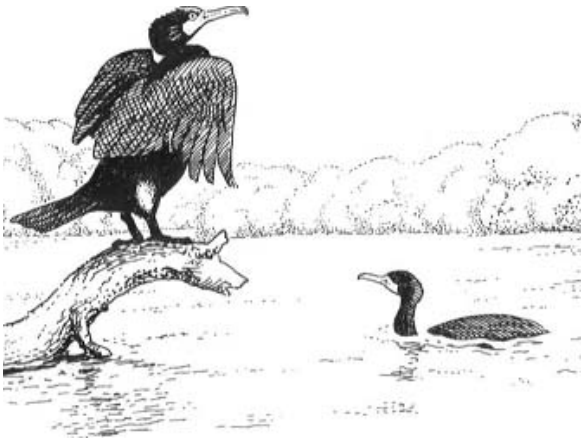
Why might you use fish refuges?

Underwater habitat plays a key part in the interaction between fish predators and their prey. Weed cover and other submerged structures are widely used by prey fish to reduce the risk of predation from pike and other predators. Research has shown that the survival of prey species increases, and the growth of predators such as pike decreases, as vegetation density becomes greater. The extent to which this might apply to cormorant/fish interactions is less well established, but there is every reason to believe that similar factors will apply.

Cormorant numbers on inland waters vary over the year as birds move between breeding and over-wintering areas, but are highest during the winter period. Unfortunately, this is when the natural cover available to fish is at its lowest level because aquatic weed dies back. In addition, fish swimming speeds are governed in part by water temperature and hence are also at their lowest level during this period. Therefore, cormorants can probably swim faster than most of their prey species at this time of year.

How might refuges work?

It is envisaged that refuges would provide fish with additional cover and reduce their accessibility to cormorants at a period of the year when they might otherwise be particularly vulnerable to predation.



Given that cormorants are able to swim faster than most small fish in winter, refuges should not be viewed as "bolt holes", but as structures that attract and "hold" fish, while providing protection from predators. If successful, refuges might be expected not only to protect fish, but also to decrease the

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Reducing the impact of cormorants: the use of fish refuges

foraging efficiency of cormorants and make sites less attractive to feeding birds to the extent that they leave and forage elsewhere.

What should refuges consist of?

It is not yet possible to suggest definitive refuge designs, which may well vary anyway according to the fish species present in a particular site and the characteristics (eg size, depth, profile) of that site. However, it is evident that there are three essential design features:

- **Structure** - anglers will be well aware that many species of fish are attracted to natural habitat features, such as weed beds, tree roots, etc. The inclusion of some form of "structure" within a refuge is thus seen as an essential requirement to help attract and hold fish. "Structure" might be provided in a number of ways, for example: brushwood bundles, branches, old Christmas trees, frayed rope to mimic artificial weed, submerged pipes, etc.
- **Overhead cover** - it is also well known that shading/overhead cover attracts fish; many anglers will have observed aggregations of fish under jetties and overhanging trees. Apart from attracting fish, shading also provides fish with an enhanced ability to detect oncoming predators.
- **Cormorant exclusion** - it is clearly necessary to exclude predators from the refuge areas if they are to be effective. Refuges therefore need to be surrounded with a protective mesh to make them "cormorant-proof". Investigations have indicated that use of a 4 inch (10 cm) mesh (eg typical stock fencing) will effectively exclude cormorants, while optimising access for fish.

Do refuges attract fish?

Experimental trials using simple cage refuges have demonstrated that fish will very rapidly locate and utilise them in the absence of other available cover, preferring these structures to open water, particularly during daylight hours. The refuges used in these trials have comprised a number of individual "cage" units, each measuring 2 m by 2 m by 1.2 m. Initially, a frame was assembled using galvanised steel tube (readily available from steel stockists) secured at the corners using proprietary fittings, and this was then covered with light-gauge stock fencing around all four sides and the top, secured with cable ties. A double layer of 85% shade netting was placed on the top to provide overhead shading, also secured with cable ties. Old Christmas trees were used inside the refuges to provide most of the internal "structure", although some additional nylon brushes were secured on the sides of the cages (Figure 1). This cage design provided a robust structure that could be re-used in a number of successive trials. The materials required for constructing each cage (~5 cubic metres in size) are estimated to have cost about £80.

Trials have confirmed that a range of coarse fish species including roach, perch, rudd, bream and carp were much more strongly attracted to cage refuges incorporating both "overhead cover" and "structure" than to bare cages or refuges incorporating only one of these features. Trials at inland fisheries have also confirmed that large numbers of fish can locate and use refuges, although observations at sites with established marginal reed beds suggest that these may have a marked effect on the extent to which fish make use of artificial fish refuges. The effectiveness of fish refuges is thus very likely to be governed by existing habitat at a site; this is discussed in greater detail overleaf.

Figure 1. Simple cage refuges used in experimental trials (photographed as the ponds were filling) showing the overhead shade netting and protective covering mesh.

Reducing the impact of cormorants: the use of fish refuges

Do refuges protect fish?

Research has provided very clear evidence that refuges can, in some cases, protect fish and reduce the foraging efficiency of cormorants. In a series of four trials conducted in 2003 and 2004, two identical adjacent ponds, one with refuges and the other without, were stocked with equal numbers of fish (roach, perch and carp), and bird numbers and behaviour were then monitored closely. After 4 to 6 weeks, the ponds were drained and the surviving fish recovered. The results were consistent in all four trials, and are summarised in the table below.

Parameter	Observed effect[1] (average of four trials)
Cormorant dive duration	Increase by 18%
Prey capture rate	Decrease by 69%
Successful foraging bouts	Decrease by 27%
No. of cormorants	Decrease by 77%
Weight of fish consumed	Decrease by 79%
Weight consumed per cormorant	Decrease by 67%

[1]Observed effect = measurement for pond with refuge relative to measurement for control pond.

Cormorant dive duration in the refuge pond increased and the foraging efficiency of the birds (prey capture rate and the proportion of successful foraging bouts) decreased significantly. In effect, the birds were working harder for fewer captured prey. As a result, birds found the refuge pond less attractive and used it less; on average, there were 77% fewer cormorant visits to the refuge pond than the control pond over the trials. The effect of these changes was to reduce the overall fish losses in the refuge pond by almost 80% and, when adjusted for numbers of bird visits to the respective ponds, this amounted to an average reduction of 67% in the weight of fish consumed per cormorant visit for birds feeding on the refuge pond. This clearly demonstrates that, under these conditions and where alternative foraging sites are available, the presence of refuges can dramatically reduce the quantity of fish eaten by cormorants at a site.

Are refuges likely to be suitable for all fisheries?

The potential benefits of using refuges are likely to vary with the fish species present and from site to site. Initial evaluation suggests that refuges might be most suitable for smaller shoaling species such as roach, perch, rudd and small bream, but a range of other freshwater species may benefit. For example, refuges have also been shown to protect small carp. However, other measures, such as stocking with larger fish, are likely to be more applicable for put-and-take trout fisheries. Refuges may not be a suitable option in fisheries where it is necessary to have large "snag-free" areas for playing larger fish, such as specialist carp fisheries.

The size of a fishery will be important in deciding whether fish refuges are likely to be a practical option. Refuges are likely to be most effective in smaller stillwater fisheries, and costs and practicalities may preclude extending the technique to large waterbodies. However, refuges have been successfully trialled by the Environment Agency on the River Lee in North London, indicating that the approach need not be confined to stillwaters. Investigations to assess the full range of sites across which refuges might usefully be deployed are continuing.

The extent of existing natural cover at a site will also need to be considered in assessing whether refuges might be beneficial. Refuges are likely to be of particular value at sites that have little or no existing cover for fish, and trials have demonstrated that fish can make extensive use of even small refuge volumes under such circumstances. However, where a site already has extensive marginal reed beds and other features that fish might preferentially use, and which might provide natural cover for fish, artificial refuges may provide little or no added value.

Reducing the impact of cormorants: the use of fish refuges

How many refuges might I need?

There is no simple answer to this question, and the numbers needed are expected to vary with the numbers and species of fish present and other site characteristics, for example, how much existing cover is present. The large benefits reported above were achieved with a refuge volume of 4% relative to the volume of the pond (no other cover was available). However, more recent trials have shown that smaller refuge volumes, down to between 0.5% and 1% of the pond volume, also have very marked positive effects. Indeed, while evidence derived from a range of trials using different sizes of refuge suggests that there is a positive relationship between refuge size and protection of fish - ie the larger the refuge size the better the protection provided - this is not a simple additive relationship. Thus the largest net benefit, in the absence of other cover, results from the provision of even a small quantity of refuge. Further, field trials at a stillwater fishery site with sparse marginal vegetation have demonstrated extensive use of a small artificial refuge, measuring just 0.02% of the pond volume, by a range of fish species. Investigations are continuing to try to establish appropriate effective refuge volumes in relation to factors such as: water size, site characteristics (eg extent of alternative cover) and fish numbers. It is hoped it will be possible to provide further guidance on this in the future.

Where are refuges best placed?

Again, there is no simple answer to this question and site-specific considerations are likely to apply. For example, refuge placement may be constrained by the needs of anglers (eg maintaining "snag-free" swims) or other water users. Refuge placement is likely to be less critical in sites that have little if any existing cover, since investigations indicate that fish will quickly find and use the new structures. In such instances, investigations have indicated that deploying refuges together in one or more bigger groups is likely to provide better protection for fish than using a large number of very small, widely dispersed refuges. However, where some existing cover is available, enhancing these natural features may be better than positioning refuges elsewhere. Thus, placing refuges adjacent to emergent vegetation may be more beneficial than providing alternative refuge areas in open water, well away from any existing cover.

As an alternative, protecting existing natural refuge areas, such as marginal emergent vegetation, by enclosing this in fenced enclosures may represent an effective refuge option. At Pound End, a mixed coarse fishery in the Norfolk Broads, a bird exclosure was constructed in the mid 1990s to protect an area of marginal vegetation (Figure 2). This was not intended as a fish refuge, but to allow better establishment of aquatic weeds by preventing damage by coots. In practice, however, monitoring of the fish populations demonstrated that the bird exclosure made an effective fish refuge. It was heavily utilised by all the resident species of fish, with significantly higher densities in the exclosure than in the Broad itself.

Investigations on where to deploy refuges to best effect, and other issues, are continuing.

Figure 2: Marginal enclosure on Pound End Broad, Norfolk

What refuge designs are in use at the moment?

Fishery managers have already installed fish refuges in a number of inland sites and a number of designs have been tried. The most widely used option to date has been that of small "reefs," constructed by joining together coils of stock fence (a detailed description of refuge construction and a case study are included in the Fisheries & Angling Conservation Trust - FACT (previously Moran Committee) booklet

Reducing the impact of cormorants: the use of fish refuges

Protecting your fishery from cormorants - see "Further information" below. The coils of wire in such designs provide both the cormorant-proofing and some "structure", although this can be further enhanced through the addition of further materials as noted above; shade netting should also be included to provide overhead cover (eg Figure 3).

Figure 3: Simple wire cage refuge.

Another popular option has been the use of floating refuges, sometimes referred to as "eco-islands" (Figure 4), since these can be planted with various emergent plants (rooted in coir matting).

Figure 4: Floating refuge (with mesh enclosure suspended underneath).

Once established, the roots from the emergent plants extend well down into the water providing cover for fish, and the vegetation also provides a habitat for other wildlife. Mesh enclosures should be suspended beneath the island to exclude cormorants and provide a secure refuge area for fish. This type of refuge has the advantages of being more "natural" and aesthetically pleasing. However, although they are available "off the shelf", they are more expensive than some other designs.

In addition to the above, fishery managers have also constructed artificial refuges from metal gabion baskets and bundles of pipes, and some have created marginal refuge areas, whereby an area is "fenced off" from the rest of the lake and in-filled with tree branches, brushwood, etc. (Figure 5).

Figure 5: Marginal refuge area created at a stillwater coarse fishery in NW England.

What about natural habitat features?

It is evident from published information and earlier investigations that habitat features play a major role in the behaviour of many freshwater fish species and in determining their vulnerability to predators. It should be recognised that good habitat is vital for successful, all-round fisheries management in both rivers and stillwaters. A successful fisheries management strategy might, therefore, be to provide sufficient cover for fish, recognising that the most cost-effective way of minimising the impact of predators on any fish population is likely to be by ensuring that the environment provides fish with the best opportunities to use their natural defence instincts. In seeking to provide adequate cover for fish in fisheries, the potential for enhancing natural habitat features should always be

considered alongside the possible use of artificial refuges.

Correctly applied, habitat enhancements can provide substantial fisheries benefits. Such works could include the creation of marginal reed fringes, permanent overhead and in-stream cover, and off-channel areas, for example shallow pools, backwaters and ditches. See 'Further information' for additional advice on this issue.

Will refuges benefit anglers?

Feedback has been actively sought from anglers at a range of sites where refuges have already been deployed, and the overwhelming response to date has been positive. While some anglers felt that it was too early to assess whether catches had improved, half of those consulted felt catches had got better and almost three quarters considered that fish stocks had benefited, with better survival, more smaller fish present and with less adverse impact on fish behaviour due to cormorant presence. Many anglers also reported that catches around fish refuges were good and that refuge structures were commonly targeted as favoured angling "marks".

Those consulted also identified a number of concerns or potential concerns. Some anglers reported loss of fishing gear on refuge structures, although it was recognised that this had, in large part, been self inflicted given that refuge structures had been actively targeted when fishing. Concerns were also expressed about the loss of available fishing area and the problems of "playing" fish, and the potential for fish to become entangled in the structures (although there was no evidence of this occurring). Further, concerns have also been expressed that the "unnatural" aggregation (and relative catchability) of fish around refuge structures might be a problem where waters are used for match fishing (fish are, ideally, required to be "equally available" to all participants during matches). It is not yet clear whether such concerns have been noted in practice, although worries that fish using fish refuges might be unavailable to anglers appear to be unfounded.

To avoid some of these problems, it is recommended that the position of any refuges is clearly marked with small floats, and that they are sited to minimise impact on angling swims. It should also be borne in mind that refuges could be used on a seasonal basis, being deployed only for the winter period, when fish are most vulnerable and there are usually many fewer anglers on the bank.

Will refuges affect other wildlife?

Based on feedback from a range of sites where refuges have been used, there have been no reports of adverse effects of fish refuges on other wildlife. Some positive effects have been reported, with floating refuges being used by waterfowl for roosting and nesting, although damage to the plant growth has been noted from such activities. Clearly, it is important that refuges are constructed carefully, using appropriate materials, to ensure that they do not pose any risk to fish or other wildlife. Feedback is continuing to be actively sought on this issue.

Summary

Investigations into the potential use of fish refuges have provided some very encouraging early results and suggest that refuges have considerable potential for safeguarding fish from cormorants and thus benefiting some fisheries. As yet, however, there are a number of questions that need to be addressed, for example, the optimum number to use at a site and how they should be placed to best effect. Investigations on these and other issues are continuing. It should also be recognised that, on their own, fish refuges will not solve 'the cormorant problem'; the technique rather provides another tool in the toolbox for managing cormorant/fishery conflicts. Fish refuges appear to be particularly suitable for smaller stillwaters dominated by smaller shoaling coarse fish species, but research is also continuing to assess how far its use might be extended to other waters. This advisory leaflet will be updated as substantive new information comes to light.

Feedback

Researchers would warmly welcome feedback from any angling clubs and fishery managers

who have practical experience or relevant comments on the design, installation and efficacy of fish refuges in fisheries. Please forward your comments to:

Address: Ian Russell, CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT.
Tel: 01502 524330;
E-mail: ian.russell@cefas.co.uk

Further information

In England, further advice on managing wildlife problems and applying for licences can be obtained by contacting Wildlife Management and Licensing at:

Natural England, Wildlife Licensing Unit, First Floor, Temple Quay House, 2 The Square, Bristol, BS1 6EB
Telephone: 0845 601 4523 (local rate)
E-mail: **wildlife@naturalengland.org.uk**

A range of leaflets on wildlife topics, including advice on managing cormorant conflicts with fisheries, is available online on the Natural England website at:
www.naturalengland.org.uk/conservation/wildlife-management-licensing/leaflets.htm

Natural England Technical Information Notes are available to download from the Natural England website: **www.naturalengland.org.uk**.

For information on other Natural England publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**

Fisheries & Angling Conservation Trust (FACT) - previously the Moran Committee
Address: c/o The Salmon & Trout Association, Fishmongers'' Hall, London EC4R 9EL
Telephone: 020 7283 5838
The FACT Joint Bird Group has published the following leaflets:

- *Protecting your fishery from cormorants*
- *Cormorants - The Facts*
- *Goosanders and Mergansers - The Facts*

These leaflets are also available from the Natural England website. The leaflet *Protecting your fishery from cormorants* includes further information on fish refuges, including case studies and details of refuge material suppliers.

Environment Agency
Further advice on fishery issues can be obtained from the Environment Agency.
HQ address: Fisheries, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD
Telephone: 08708 506 506
Web: www.environment-agency.gov.uk/

Natural England
Advice on conservation matters can be obtained from local offices of Natural England (see local telephone directory).
HQ address: Natural England, 1 East Parade, Sheffield, S1 2ET
Telephone: 0114 241 8920
Web: www.naturalengland.org.uk/

Institute of Fisheries Management
Guidance available on stillwater fishery management:
Stillwater Coarse Fisheries Code of Practice
Web: **www.ifm.org.uk/**

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