Cyfoeth Naturiol Cymru
Natural Resources Wales

Appraisal of the effectiveness of non-lethal and lethal control of fish-eating birds in preventing serious damage to natural and stocked fisheries

Report No: 594

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Author, date

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Crynodeb Gweithredol

Mae poblogaethau o adar pysgysol penodol, fel y fulfran (*Phalacrocorax carbo)* (“mulfran”), a'r hwyaden ddanheddog (*Mergus merganser*), wedi cynyddu yn y DU dros y degawdau diwethaf, ac mae'r adar hyn bellach wedi'u dosbarthu'n eang ledled Cymru. Dros gyfnodau tebyg o amser, gwelwyd gostyngiadau amlwg yn statws stociau o bysgod dŵr croyw penodol yng Nghymru, yn enwedig eog yr Iwerydd (*Salmo salar*) a brithyll y môr (*Salmo trutta*). Mae dosbarthiad ‘mewn perygl’ neu ‘yn debygol o fod mewn perygl’ o fethu â chyflawni terfynau cadwraeth bellach wedi’i bennu i’r mwyafrif o stociau o’r fath yng Nghymru. Mewn ymateb i'r dirywiadau hyn, gyda chefnogaeth cais Gweinidogol, cyhoeddodd Cyfoeth Naturiol Cymru y Cynllun Gweithredu ar gyfer Eogiaid a Brithyllod y Môr ym mis Ebrill 2020. Mae'r cynllun hwn yn cydnabod bod ystod eang o bwysau yn effeithio ar y stociau hyn ac yn nodi'r camau gweithredu parhaus a newydd i fynd i'r afael â hwy. Wrth geisio cael dealltwriaeth well o’r graddau y gall gwahanol faterion fod yn effeithio ar stociau o bysgod, nododd y cynllun yr angen i gynnal adolygiad o ysglyfaethu gan adar pysgysol.

Cymeradwyodd Bwrdd CNC sefydlu Grŵp Cynghori Cymru ar Adar sy’n Bwyta Pysgod (y "Grŵp Cynghori") o dan arweiniad, er mwyn asesu'r sefyllfa yng Nghymru a chynghori ar y camau gweithredu posibl y mae angen eu cymryd. Wedi hyn, gwnaeth y Grŵp Cynghori nodi wyth maes tystiolaeth allweddol lle roedd angen gwybodaeth i lywio'r adolygiad. Mae'r adroddiad hwn yn mynd i'r afael â Thema 1 yr adolygiad -“arfarnu effeithiolrwydd, lle y bo'n rhesymol bosibl, rheolaeth anfarwol a marwol adar pysgysol o ran atal difrod difrifol i bysgodfeydd naturiol a physgodfeydd sydd wedi'u stocio.”

Mae'r adroddiad yn disgrifio’r amrywiaeth eang o dechnegau rheoli sydd ar gael i helpu buddiannau pysgodfeydd wrth gyfyngu ar lefel y rhyngweithio rhwng mulfrain, hwyaid danheddog a physgod ar draws sbectrwm eang o gynefinoedd dyfrol a mathau o bysgodfeydd. Yn fras, mae'r technegau hyn yn perthyn i un o bedwar categori eang, fel a ganlyn:

- **Dychryn adar i ffwrdd o bysgodfa**, e.e. drwy ddefnyddio ataliadau clywedol neu weledol anfarwol gwahanol.

- **Diogelu'r pysgod**, e.e. drwy ddefnyddio technegau i gadw adar allan megis rhwydi a weiars.

- **Lleihau argaeledd pysgod i adar**, e.e. drwy ddefnyddio technegau rheoli stociau pysgod neu sicrhau bod pysgodfa'n llai deniadol fel safle fforio am fwyd, neu ddiwygio safleoedd pysgod eraill sy’n llai sensitif er mwyn iddynt weithredu fel safleoedd eraill ar gyfer fforio am fwyd.

- **Lleihau niferoedd yr adar** - drwy ddulliau rheoli marwol.

Mae'r adroddiad hwn yn trafod rhinweddau a chyfyngiadau cymharol y dulliau gwahanol hyn. Prin yw’r technegau (e.e. gosod rhwydi dros amgaeadau) sy'n cynnig datrysiadau untro posibl i wrthdaro a all fod yn effeithiol dros yr hirdymor, ac mae'n anochel bod y technegau hyn wedi’u cyfyngu i safleoedd llai o faint. Er y ceir amrywiaeth o dechnegau cyfreithiol eraill a all fod yn effeithiol wrth rwystro adar, mae eu heffaith yn debygol o leihau gydag amser oherwydd bod elfen o gynefino yn dueddol o ddigwydd gydag unrhyw dechneg dychryn nad yw'n cael ei hatgyfnerthu gyda pherygl gwirioneddol.

Er mwyn bod yn effeithiol dros gyfnodau hwy, mae'n debygol y bydd mesurau i gyfyngu ar nifer yr adar ar safle yn gofyn am gyfuniadau o dechnegau rhwystro a newidiadau rheolaidd fel rhan o strategaeth reoli drylwyr, integredig. Yn gyffredinol, ystyrir mai technegau lle mae angen presenoldeb dynol yw'r rhwystrau mwyaf effeithiol, ac mae'r rheiny sydd ag elfen fiolegol amlwg ac sy'n dynwared bygythiadau i adar yn dueddol o fod yn fwy effeithiol a hirhoedlog na dyfeisiau eraill.

Bydd materion allweddol i'w hystyried wrth ddyfeisio rhaglen liniaru briodol yn cynnwys y canlynol:

- **Maint y safle/pysgodfa** i'w ddiogelu ac a ddylai camau gweithredu fod yn lleol ac yn benodol i'r safle neu fod wedi'u cydlynu dros ardal ehangach (e.e. is-afon neu ddalgylch afon);

- **Ymwybyddiaeth a glynu wrth ofynion deddfwriaethol**. Er enghraifft, mae pob aderyn wedi'i ddiogelu o dan Ddeddf Bywyd Gwyllt a Chefn Gwlad 1981 a'r angen i weithredu'n ofalus;

- **Amseru'r broblem** yr ymdrinnir â hi, ac **ymddygiad a nifer** yr adar (e.e. bridio, clwydo, byw, ymfudo) ac argaeledd safleoedd eraill ar gyfer fforio am fwyd;

- Yr **amser a'r costau cysylltiedig** y gellir eu neilltuo i fynd i'r afael â phroblem yn erbyn y colledion disgwyliedig o bysgod a'r amserlen y gallai fod angen cymhwyso mesurau rheoli drosti (h.y. dadansoddiad cost a budd syml ond realistig);

- **Cyfyngiadau** posibl ar ddefnyddio technegau gwahanol megis agosrwydd fannau byw pobl, safleoedd sensitif, neu'r effaith bosibl ar fywyd gwyllt arall.

O ran rheoli gwrthdaro posibl mewn dalgylchoedd afonydd, sy'n ystyriaeth allweddol yng nghyd-destun yr adolygiad hwn, mae'r adroddiad yn cydnabod y bydd camau gweithredu cydlynol ar draws ardal ehangach yn debygol o fod yn hanfodol er mwyn mynd i'r afael â'r pryder mai efallai ond pellter bach i fyny neu i lawr yr afon y bydd adar a symudir oddi wrth ran benodol o afon yn mynd, gan ddwyn buddion prin i stociau o bysgod, yn gyffredinol, os o gwbl. Bydd angen parhau i fod yn wyliadwrus er mwyn sicrhau nad yw hyn yn digwydd ac er mwyn deall yn well sut mae adar yn ymateb i gamau rheoli, yn nhermau'r pellteroedd a symudir ac am ba hyd y mae safleoedd yn parhau i fod yn anneniadol. Mae'r achos dros drwyddedau ardal neu drwyddedau dalgylch yn cael ei adolygu mewn adroddiad tystiolaeth ar wahân i'r adolygiad (Russell *et al*., 2022).

Mae'r adroddiad hwn yn darparu trosolwg cryno o ddulliau a ddefnyddir i reoli rhyngweithiadau rhwng adar pysgysol a physgodfeydd mewn rhannau eraill o'r DU ac amryw o wledydd eraill yn Ewrop. Mae hefyd yn cynnwys gwybodaeth am rinweddau cymharol technegau sydd wedi cael eu defnyddio'n yn Lloegr yn ddiweddar, lle mae dulliau ar draws ardal/dalgylch o reoli gwrthdaro wedi cael eu cyflwyno dros y blynyddoedd diwethaf yn dilyn adolygiad polisi yn 2013. Mae'r adborth hwn yn seiliedig ar brofiadau ymarferol Ymgynghorwyr Rheoli Pysgodfeydd a gyflogir gan yr Ymddiriedolaeth Genweirio.

Daw'r adroddiad i ben gyda chrynodeb o negeseuon allweddol a chan dynnu sylw at nifer o fylchau mewn tystiolaeth. Mae'r negeseuon allweddol yn cynnwys y canlynol:

- ystyriaethau cyffredinol ynghylch natur y gwrthdaro rhwng adar pysgysol a physgodfeydd;
- y defnydd o fesurau anfarwol;
- y defnydd o saethu er mwyn dychryn a saethu er mwyn lladd;

- argymhellion ar yr arferion gorau.

Mae'r adroddiad yn cydnabod y disgwylir i'r dewis o fesurau rheoli a ddefnyddir yn amrywio rhwng safleoedd dŵr llonydd a safleoedd afonol. Bydd modd cymhwyso amrywiaeth ehangach o dechnegau anfarwol yn y cyntaf, a bydd llawer o dechnegau o'r fath yn anymarferol ar raddfa dalgylch afon. Ar hyd afonydd, mae ymdrechion rheoli yn debygol o fod o'r budd mwyaf pan fônt wedi'u targedu at fannau ysglyfaethu problemus megis yn ystod y rhedfa leisiaid neu o amgylch rhwystrau i fudo pysgod, ac yn enwedig yn ystod cyfnodau o lif isel.

Nod y negeseuon allweddol hyn yw helpu Cyfoeth Naturiol Cymru i fodloni ei gyfrifoldebau statudol o ran diogelu statws dynodedig rhywogaethau pysgod, ac o ran sicrhau bod unrhyw gamau gweithredu a gymerir yn erbyn adar pysgysol, fel yr awdurdod trwyddedu cymwys, yn cyd-fynd â rhanddirymiadau caniataol a'r gyfraith. Amcan yr adroddiad yw helpu Cyfoeth Naturiol Cymru i ddiogelu adar a physgod a gweithio tuag at adfer a diogelu bioamrywiaeth iach a chytbwys yn ecosystemau dyfrol Cymru.

Executive summary

Populations of certain fish-eating birds, notably the cormorant (*Phalacrocorax carbo)* and goosander (*Mergus merganser*), have increased in the UK in recent decades, and these birds are now widely distributed across Wales. Over similar timescales marked reductions have been observed in the status of certain freshwater fish stocks in Wales, particularly Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*). The majority of such stocks in Wales are now classified as being 'at risk' or 'probably at risk' of failing to achieve their conservation limits. In response to these declines, supported by a Ministerial request, Natural Resources Wales published a Plan of Action for Salmon and Sea Trout in April 2020. This Plan recognises that there are a wide range of pressures affecting these stocks and sets out the ongoing and new actions to address these. In seeking to better understand the extent to which different issues might be impacting on fish stocks, the Plan identified the need to undertake a review of predation by fish-eating birds.

NRW's Board endorsed the establishment of an NRW-led fish-eating birds Advisory Group (the "Advisory Group") to assess the position in Wales and advise on potential actions required. The Advisory Group subsequently identified eight key evidence areas where information was required to inform the review. This report addresses Theme 1 of the review – "appraise the effectiveness, where practically possible, of non-lethal and lethal control of fish-eating birds in preventing serious damage to natural and stocked fisheries."

The report describes the wide range of management techniques that are available to aid fishery interests in limiting the level of interaction between cormorants, goosanders and fish across a broad spectrum of aquatic habitats and fishery types. In brief, these techniques fall into one of four broad categories:

- **Scaring birds away from a fishery**, e.g. through the use of different non-lethal audible or visual deterrents.
- **Protecting the fish**, e.g. through the use of exclusion techniques such as nets and wires.
- **Reducing fish availability to birds**, e.g. by using fish stock management techniques or making a fishery less attractive as a foraging site or modifying other less sensitive fish sites to act as alternative forage sites.
- **Reducing bird numbers** - through lethal control.

This report discusses the relative merits and limitations of these different approaches. Few techniques (e.g. netting enclosures) offer potential one-off solutions to conflicts that might be effective in the long-term, and these are inevitably restricted to smaller sites. While there are a range of lawful alternative techniques that can be effective at deterring birds, their impact is likely to diminish with time as habituation tends to occur with any scaring technique that is not reinforced by a demonstration of actual danger.

To be effective over longer periods, measures to limit bird numbers at a site are likely to require combinations of deterrent techniques and regular changes as part of a rigorously applied, integrated control strategy. Techniques that require human presence are commonly regarded as the most effective deterrents, and those that carry biological significance and

mimic threats known to birds tend to prove more effective and longer-lived than other devices.

Key issues to consider in devising an appropriate mitigation programme will include:

- The **size of the site/fishery** to be protected and whether actions are to be local and site-specific or co-ordinated over a wider area (e.g., tributary or river catchment);

- **Awareness and adherence to legislative requirements**, for example, all birds are protected under the Wildlife and Countryside Act (1981), and the need to operate safely;

- The **timing of the problem** being addressed, and **numbers and behaviour** of the birds (e.g., breeding, roosting, resident, migrating) and the availability of alternative foraging sites;

- The **time and associated costs** that can be devoted to addressing a problem viewed against expected fish losses and the timescale over which management measures might need to be applied (i.e., a simple but realistic cost-benefit analysis);

- Possible **constraints** on the use of different techniques such as the proximity of human habitation, sensitive sites or the potential impact upon other wildlife.

In managing potential conflicts on river catchments, a key consideration in the context of this review, the report recognises that co-ordinated actions across a wider area will probably be essential to address the concern that birds moved from a particular stretch of river may simply relocate a short distance up- or downstream with little, if any, overall benefit for fish stocks. Ongoing vigilance will be required to ensure that this does not occur and to better understand how birds react to management actions, in terms of distances moved and how long sites remain unattractive. The case for area- or catchment-based licences is reviewed in a separate evidence report to the review (Russell *et al*., 2022).

The report provides a brief overview of approaches used to manage interactions between fish-eating birds and fisheries in other parts of the UK and various other European countries. It also includes information on the relative merits of techniques that have recently been applied in England, where area/catchment-wide approaches to managing conflicts have been introduced in recent years following a policy review in 2013. This feedback is based on the practical experiences of the Fishery Management Advisors employed by the Angling Trust.

The report concludes with a summary of key messages and highlights a number of evidence gaps. The key messages include:

- general considerations regarding the nature of conflicts between fish-eating birds and fisheries;
- the use of non-lethal measures;
- the use of shooting to scare and shooting to kill; and,
- recommendations on best practice.

The report recognises that the choice of management measures used will be expected to differ between stillwater and riverine sites. A wider range of non-lethal techniques will be

applicable at the former, and many such techniques will be impractical at the river catchment scale. On rivers, management efforts are likely to be most beneficial when they are targeted at identified predation ‘hot spots’ such as during the smolt run or around barriers to fish migration, and particularly during periods of low flows.

These key messages aim to help Natural Resources Wales in meeting their statutory responsibilities for protecting the designated status of fish species and in ensuring that any actions taken against fish-eating birds, as the competent licensing authority, are compatible with the permissible derogations and the law. The objective of the report is to assist Natural Resources Wales in protecting both birds and fish and in working towards the restoration and protection of a healthy and balanced biodiversity in Welsh aquatic ecosystems.

1. Introduction

There have been large increases in populations of great cormorant (*Phalacrocorax carbo*) across Europe over the past 40–50 years (van Eerden *et al*., 2012; Bregnballe *et al*., 2014). This increase has been mirrored in the UK (Chamberlain *et al*., 2013a), with birds also making increased use of inland fishery sites at which to feed and breed (Newson *et al*., 2013). Goosanders (*Mergus merganser*) have also increased in numbers across the UK in recent decades and spread to many parts of the country (Musgrove *et al*. 2013). The UK Breeding Bird Survey (Harris *et al*., 2020) suggests a gradual long-term (23 year) decline (-25%) in goosander breeding numbers, but with a 12% increase in the short-term trend (10 years). In Wales, the Wetland Bird Survey (WeBS) index for wintering goosander shows an increase of 184% over the long-term (25 years) and a 44% increase over the short-term (10 years) (Frost *et al*., 2021). For cormorants, the UK Breeding Bird Survey (Harris *et al*., 2020) suggests a gradual long-term (23 year) increase (24%) in breeding numbers, but with a 3% decrease in the short-term trend (10 years). In Wales, the WeBS index for wintering cormorants shows an increase of 62% over the long-term (25 years) and a 22% increase over the short-term (10 years) (Frost *et al*., 2021).

Both bird species are widely distributed in Wales and, as elsewhere in the UK, this has resulted in widespread conflicts with fishery interests. Principal concerns in Wales have centred on the potential impact of these fish-eating birds on river catchments supporting populations of salmonid species, mainly Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*). However, concerns have also been raised about the potential impact of the birds on other riverine fish stocks and on stillwater fisheries, both stocked and ‘natural’, that all support important fisheries.

Atlantic salmon and many sea trout populations in Wales have been in decline for many years and the majority of stocks are currently classified as either ‘at risk’ or ‘probably at risk’ (Cefas, Environment Agency and Natural Resources Wales, 2020; Natural Resources Wales, 2019). In light of these declines, and in response to a Ministerial request, Natural Resources Wales (NRW) published a Plan of Action (“Plan”) for Salmon and Sea Trout in Wales in April 2020. The overall objective for migratory salmon and sea trout stocks in Wales is: “*To protect, through the application of best-practice science and management, the sustainability of our natural resource of wild salmon and sea trout stocks in Wales.”* The Plan details ongoing and new actions to address the many pressures affecting salmon and sea trout stocks in Wales, including catch control regulations, river habitat restoration and a renewed focus on water quality management. In seeking to better understand the extent to which issues might be impacting on stocks, and to better support delivery of their statutory responsibilities, the Plan also identified the need to undertake a review of the impacts of predation by fish-eating birds on fisheries in Wales.

In delivering Plan objectives, NRW have highlighted their statutory responsibilities to conserve salmon populations which are designated as features of Special Areas of Conservation (SACs) under the Habitats Regulations (Council Directive 92/43/EEC) (the “Habitats Directive”) and also to ensure that any actions taken against fish-eating birds are compatible with the derogations permissible under Council Directive 2009/147/EC on the conservation of wild birds (the “Birds Directive”).

All species of wild bird are protected in law. It is an offence to intentionally kill or capture a wild bird or to take, damage or destroy their eggs or nests. Under section 16 of the Wildlife and Countryside Act 1981, as amended ("the Act"), NRW may grant licences authorising otherwise unlawful killing or taking of wild birds, eggs or nests. NRW may only grant a licence where - among other considerations - both of the following statutory tests are satisfied:

(i) The action authorised is necessary for one or more of the purposes set out in section 16 of the Act, which include:

- to conserve other wildlife (including other species of birds and fish);
- to protect public health or safety;
- to prevent serious damage to crops, livestock, livestock foodstuffs, timber, fisheries or inland waters.

(ii) NRW is satisfied that there are no other satisfactory solutions in relation to that purpose. In other words, to be satisfied that granting a licence authorising lethal control is the only satisfactory way of achieving the purpose

NRW are the competent licensing authority in Wales. In balancing these responsibilities, NRW seeks to work towards the restoration and protection of a healthy and balanced biodiversity in Welsh aquatic ecosystems, extending to populations of both fish and birds. NRW has also recognised the need to protect birds and populations of fish species other than migratory salmonids, including non-migratory brown trout in rivers and lakes, and other fish species in stillwaters.

To deliver the review of predation, NRW's Board endorsed the establishment of an NRW-led fish-eating birds Advisory Group to assess the position in Wales and advise on potential actions required. In January 2020, the NRW Board also asked for a wider review of NRWs approach to to the permissions it gives for the shooting and trapping of wild birds in Wales. The policy development to address the impacts of predation by fish-eating birds on Welsh fisheries now falls within this wider review.

This report seeks to address Theme 1 of the Fish-eating Birds Advisory Group Delivery Plan – "appraise the effectiveness, where practically possible, of non-lethal and lethal control of fish-eating birds[1] in preventing serious damage to natural and stocked fisheries." In doing this, the report summarises the main techniques available for managing interactions between fish-eating birds and fish stocks, discusses the relative merits and limitations of different approaches and provides a brief overview of approaches used to manage fish-eating birds in other parts of the UK and a number of other European countries. The report also includes information on the relative merits of techniques that have recently been applied in England, where catchment-wide approaches to managing conflicts have been introduced in recent years. The report concludes with a summary of key messages aimed at informing the NRW review.

[1] In the context of this report, fish-eating birds relate specifically to cormorants and goosanders, as these are the only species relevant to the NRW review. It might be noted, however, that many of the techniques described would be pertinent for use with other species of fish-eating birds.

2. Tools for managing conflicts between fish-eating birds and fisheries

The interaction between fish-eating birds and fish can be managed in a number of ways, each falling into one of four broad categories of action:

- **Scaring birds** away from a fishery;
- **Protecting the fish** — use of exclusion techniques;
- **Reducing fish availability to birds** - fish stock management techniques / making a fishery less attractive as a foraging site;
- **Reducing bird numbers** — lethal control.

Each of these categories includes a number of different potential techniques and these are summarised briefly in the following sections, along with key messages. The wide range of measures used in managing cormorant / fishery conflicts were subject to detailed review as part of an earlier EU-funded project – INTERCAFE (Conserving biodiversity – interdisciplinary initiative to reduce pan-European cormorant fishery conflicts) and this provides a much more detailed appraisal of the various different techniques (Russell *et al*., 2013). This review summarised information on each category of action with regard to the methods available, their efficacy, practicality, acceptability and relative cost. The aim was to provide a useable guide on the many management techniques available to aid fishery interests across a broad spectrum of aquatic habitats and functions (e.g. commercial and recreational fisheries, and aquaculture facilities). The guide was not intended as a list of solutions that, if followed, would solve the issue of predation by fish-eating birds on fish populations. Instead, it was produced to demonstrate that some deterrent methods could be useful, in some places, at sometimes. It also acknowledged that solving problems was seldom simple and often required considerable time, effort, and cost. Users were encouraged to experiment with techniques – or combinations of them – and to experiment with new ones, to address their specific needs. While the review was aimed specifically at cormorant / fishery conflicts, the majority of techniques are expected to be equally applicable for use against other fish-eating birds, including goosanders. However, there is relatively little information available in the scientific literature pertaining to measures applied specifically against goosanders.

In respect of the first three categories listed above, the underlying assumption is that the methods applied will make a particular site less attractive to foraging birds, such that they move to other sites at which to feed. As such, there will be no overall reduction in the biomass of fish consumed. Indeed, the quantity of fish consumed may increase due to birds having heightened energy requirements as a consequence of being disturbed or having to move over longer distances to find food. The application of such measures simply aims to reduce losses of particular fish species at particular sites due, for example, to concerns about economic losses for a fishery and/or potential impacts on fish species of conservation concern. It is typically assumed that birds will be displaced to other water bodies / fishery sites where there is less concern about possible impacts on the fish stocks. It might be noted, however, that the movement patterns of birds following displacement remains an important evidence gap.

2.1 Scaring birds away from a fishery (deterrents)

The basic philosophy behind techniques to scare birds away from a fishery is that birds are startled sufficiently to move to another foraging site by means of auditory, visual or even chemical deterrents. The effectiveness of these techniques relies on the deterrents being sufficiently frightening to birds to make them move elsewhere, and there being a suitable alternative site to which they can move.

i) Auditory deterrents

Auditory deterrent techniques range in complexity (and cost) from simple tools to relatively sophisticated, automatic devices. Options include:

- Gas cannons;
- Pyrotechnics;
- Shooting to scare;
- Bio-acoustics, acoustics, ultrasonics and high intensity sound;
- Other simple sound-producing techniques – e.g. windmills and humming tapes.

Auditory deterrents have been shown to be effective against a range of fish-eating birds. However, the effectiveness varies with the device chosen, the method of use, the size of the site on which they are being deployed and the availability of alternative foraging sites to which the birds can relocate. Such devices have a limited range, and are thus most effective at smaller sites, or at particular locations at larger sites (e.g. known predation 'hot spots') to address specific, local problems. All audible deterrent techniques are subject to habituation (birds learn that they pose no danger and ignore them), and hence they are more likely to be of short-term benefit. However, efficacy can be extended considerably by moving devices regularly, reinforcement through human presence, and by employing them as part of an integrated control strategy alongside other measures.

ii) Visual deterrents

There is a wide range of visual deterrents, which can potentially be used to deter fish-eating birds. These also range from relatively simple and inexpensive tools to more costly and labour-intensive methods. Options include:

- Human disturbance / dogs;
- Scarecrows (both static and automated/inflatable options);
- Predator models;
- Balloons and kites;
- Radio-controlled model aircraft;
- Mirrors / reflectors / reflective tape;

- Lights;
- Flags, rags and streamers;
- Lasers;
- High-pressure water jets, which might also pose a physical deterrent;
- Dyes, colourants and turbidity.

As with auditory deterrents, the effectiveness of visual deterrents varies with the device chosen, the method and timing of use, the size of the site and the availability of alternative foraging sites for the birds.

Typically, fixed visual deterrents are only thought to have an effective range of up to about 200m. As such, these techniques will be of limited, if any, use on river systems or larger stillwater sites, with the possible exception of localised predation 'hot spots'. Visual deterrents, particularly static ones, are subject to habituation by birds, and hence are typically only of short-term benefit. They are considered most effective if they are life-like, move and possess biological significance, or if they are associated directly with a real threat. For example, scarecrows have been noted to have greater impact if they are dressed in the same high-visibility colours as humans carrying out other deterrent activities, such as shooting to scare. Disturbance by humans is generally regarded as the most effective visual deterrent. In addition, although relatively costly and subject to regulatory controls, the use of laser light has been shown to be effective in relocating cormorant night roosts. This technique is subject to further discussion in the later section reporting on recent experiences in England in managing fish-eating birds at the catchment scale.

iii) Chemical deterrents

Chemical taste repellents are quite widely used for reducing the impact of 'pest' birds in agriculture and forestry, as well as a means of deterring birds from perching on buildings. Trials have demonstrated that cormorants can be conditioned to avoid certain fish prey species through a process of condition taste aversion (McKay *et al*., 1998). However, it is difficult to see how such an approach might be applied in the wild, and other possible approaches, such as using chemical deterrents at fisheries, have not been widely tested against fish-eating birds.

Overview of deterrent techniques

The main drawback of the various deterrent techniques is that birds eventually (often quite quickly) realise that they offer no real threat and become habituated to the noises, sights or smells/tastes, ignoring them thereafter. Thus, the key to the successful use of deterrents seems to be to make them as unpredictable as possible by changing their location and frequency of use, and by using a number of techniques in combination. There is also good evidence that birds are scared consistently by human presence if they perceive that humans are associated with danger. Thus, using deterrents in conjunction with highly-visible human presence will increase their overall efficacy, but most likely increase their cost through the need for additional staff time.

The costs and practicality of deploying different deterrents vary widely. Simple static visual deterrents or humming tapes can be readily deployed at most sites, although will be impractical at the scale of river catchments. More sophisticated techniques require greater outlay and likely require suitable site security to avoid the risk of theft, damage and potential risk to the public. Noise and visual amenity considerations also come into play in some locations. The potential use of laser devices as a deterrent is subject to various constraints and training requirements, and the use of these devices is discussed in more detail later in the report.

As with many other management methods, scaring techniques seem to work best where these are used as soon as birds arrive at a site – thus preventing them from getting used to the area as a foraging site in the first place. Once birds have learned that a site is good for foraging or breeding, it will probably be much harder to deter them from arriving at a site and utilising its resources.

2.2 Protecting fish using exclusion techniques

These tools involve excluding the birds from accessing fish. Not surprisingly, the techniques work best when fish are concentrated in relatively small areas. Thus, they are ideal for smaller ponds or fish farms where netting enclosures can be fixed permanently. In larger water bodies, complete exclusion is much more difficult and may well be impractical.

i) Netting enclosures

Complete enclosure of a site with netting is undoubtedly the most effective option for preventing predation by fish-eating birds. Lightweight netting enclosures have been used to protect water bodies extending to several hectares as well as long lengths of linear waterways (extending to several km) at some fish farm sites on the continent. Properly designed, such netting enclosures can provide easy human access to enclosed waters, allowing fishery management or aquaculture tasks to be performed unimpeded. Such enclosures are widely used to protect fish farm sites in many countries, although initial installation costs can be substantial. Submerged netting enclosures are also widely used in aquaculture to protect fish held in floating fish cages from diving predators, including fish-eating birds.

Partial enclosures or only overhead netting can also be used to protect part of a larger water body. Such an approach has been applied on some extensive fish farm sites in Germany, for example, with the netted area operating as a refuge in the location where the fish aggregate to feed and could be vulnerable to predators (reported in Russell *et al*., 2013). Similarly, wires have been used on upland tributaries in Austria to protect salmonid species (reported in Russell *et al*., 2013) and have also been deployed on various fisheries in England (see further details below). Secured on poles well above the water surface means that waters protected in this way can still be accessed for angling purposes. In Denmark, trials are currently being undertaken to explore the efficacy of installing netting covers to reduce losses of juvenile salmonids to cormorants along short sections of river (Niels Jepsen, *pers comm*).

ii) Ropes and wires

Fish-eating birds searching for feeding opportunities can be deterred at waters that are protected by wires because these affect the birds' ability to land, feed and take off, for example, cormorants require 8–12m of open water to take-off. There are various ways in which wires can be deployed in order to deter foraging fish-eating birds from a site. Commonly, wires are held taut above the water surface fixed securely to posts set into the banks, but ropes can also be floated on the water surface, and a wide range of spacing and deployment patterns can be used to facilitate other uses of the water bodies.

Wires and ropes provide a cheaper alternative to full enclosures and have been deployed with some success on larger stillwaters and even river tributaries to deter cormorants (reported in Russell *et al*., 2013).

iii) Facility design and construction

When establishing new aquaculture facilities or stock ponds, careful design of a site can facilitate incorporation of measures to reduce the risk of predation. Thus, for example, locating ponds adjacent to buildings or other areas of increased human activity may aid the deterrence of predators.

Overview of exclusion techniques

Nets and wires, if properly installed and maintained, can provide reliable, long-term, cost-effective options for removing or reducing the risk of predation at a site. Indeed, netting enclosures that completely enclose a site provide the only reliable means of excluding all birds (and other predators) from a site. In contrast, 'wires' typically deter birds from using sites, but are unlikely to exclude them altogether, and efficacy may decrease over time as birds learn to avoid them.

In practice, netting exclusion structures are likely to be restricted to protecting small areas of water and particularly valuable fish stocks, such as those found at fish farm sites. Permanent wiring systems are probably more widely applicable than netting and can be used for protecting larger fish farms and stock ponds but will probably also be more cost-effective at relatively small sites. Both nets and wires will be inappropriate at most fishery sites where the size of the water bodies will be a major constraint and their presence will probably represent an impediment to angling. With the possible exception of using nets or wires on smaller tributaries, such techniques will not be appropriate for use on river systems.

2.3 Reducing fish availability to birds

The idea behind this group of tools relies on the assumption that fish-eating birds need to make a number of choices when selecting where to forage in order to meet their daily food requirements. A number of issues affect these food requirements, such as environmental conditions (more food/energy is required during colder/wetter weather), periods of migration or dispersal, whether birds are rearing young and the distances between roosts or colonies and feeding sites. Foraging site choice is also dependent on the availability of suitable places

to feed and both their number and quality. In simple terms, high-quality foraging sites will be those that offer risk-free, undisturbed access and feeding, and plentiful supplies of relatively easy-to-catch fish.

Managing the fish stock itself can therefore be used in some instances to reduce potential conflicts. This technique attempts to alter the 'quality' of the foraging opportunities available to birds by making fish less easy for them to catch. The underlying principle being that if fish are difficult to catch, which requires additional energy expenditure, then the birds may choose to feed on other waters where the fishing is easier. Such techniques fall into two broad categories: those that involve direct management of fish stocks, and those concerned with modification of the habitat, both above and below the water.

i) Fish stock management techniques

Where fishery managers have control over fish stocking regimes, there are several options that can be used to reduce fish losses and make sites less attractive to foraging birds. These include:

- Timing of stocking – timing the introduction of fish so as to minimise the likelihood of encounters between birds and fish. For example, delaying stocking can be appropriate for put-and-take trout fisheries, particularly where these mainly operate from spring through to autumn and where the risk of predation may be highest in winter, as commonly the case with cormorants in the UK.

- Frequency and location of stocking – regulating stocking practices can also be managed to reduce the chance of large aggregations of recently released fish attracting predators. Newly-stocked fish can be at a significant predation disadvantage, as there is evidence that anti-predator behaviours are learned during a fish's lifetime as well as through instinct.

- Regulating fish density - this simple approach may provide an effective short-term measure at aquaculture sites where there may be opportunities for regulating fish densities during periods of potential elevated predation threat. However, stock density manipulation is unlikely to be feasible at most recreational fishery sites and is clearly not an option for rivers.

- Size of fish at stocking - in some situations, the ability to stock with larger fish (or different, larger fish species) has been successful in reducing losses to predators. This is because above a certain size, fish become less vulnerable to capture and, ultimately, too large to be swallowed by fish-eating birds. The potential for stocking larger fish will typically apply only to fisheries that are dependent on regular introductions of fish, such as put-and-take trout fisheries. Such an approach has been adopted quite widely at such fisheries in the UK. However, the measure is not suitable for 'natural' fisheries, and particularly those on rivers.

- Buffer species - the idea of managing fish stocks to enhance or introduce alternative, less valuable prey species, either in the 'target' fishery or in nearby bodies of water, has been proposed as a way of reducing cormorant impact on more valuable species. It is unclear whether or not higher overall fish densities, due to stocking buffer prey alongside favoured 'target' species, may serve as an increased attraction to

predators. Nonetheless, the natural availability of different fish species in a fishery may also provide a buffering effect: if a proportion of the birds' diet comprises fish species of little recreational or economic value, this will reduce the impacts on more desirable or valuable species.

- Provision of alternative foraging sites – another possible option to alleviate predation on particular fish stocks or fisheries (albeit one apparently not yet used or tested at European or UK fisheries) could be the establishment of alternative sites where birds could be allowed to forage undisturbed. Thus, for example, it may be possible to establish or utilise small ponds as alternative favoured foraging sites through locating these in the vicinity of fisheries where efforts were deemed necessary to deter predators. In practice, there is no guarantee that 'displaced' birds would use the alternative site, or to the degree necessary to effectively deter them from the locations of concern. Even if birds did use alternative sites, this is likely to be a relatively costly approach, at least if it is necessary to maintain such sites as favoured feeding areas through the regular stocking of fish. There is also a risk that such 'free' foraging locations would merely attract more birds to feed at them as optimal sites and that those birds unable to feed here would be forced to use sub-optimal sites, including those fisheries that alternative sites were supposed to protect.

- Location of fish holding facilities – locating the most susceptible species or size classes of fish close to centres of human activity or near buildings is a simple option for reducing predator impact at fish farm sites.

ii) Habitat Modification Techniques

The philosophy of making fish less easy to catch and sites less attractive for roosting, nesting or feeding fish-eating birds also lies behind the use of habitat modification techniques. Such tools will never stop birds from roosting, breeding or feeding altogether. However, at a site-specific level they can reduce or eliminate their presence in an area, prevent birds colonising, or may help to make foraging sites less attractive to birds thus encouraging them to move elsewhere. As with most, if not all, of the potential management techniques, their use will be most effective if applied with a good knowledge of the region and the behaviour, movements and daily foraging patterns of birds in the area. There are a number of options for modifying the habitat to reduce the impact of predators, and these can be both above and below the water.

iii) Elimination of resting or roosting places

Removing roosting sites is a technique that could be applied to address conflicts between fish-eating birds and fisheries; it is likely to be particularly applicable for cormorants, given their common use of specific trees as favoured roosts. If there are no other safe roosting sites for some distance, cutting down (or otherwise modifying – e.g. with wires or netting) a few trees on the banks of a pond may be enough to make a site unattractive for birds. There are, however, clear disadvantages to such an approach from an environmental perspective and removing roosts will generally not be appropriate for rivers or larger sites where there are likely to be numerous alternative roost sites available for the birds. However, there may still be potential benefits from taking action at roost sites. Preventing the establishment of a roost site may stop cormorants being attracted to an area by the presence of other birds or may prevent subsequent attempts at breeding, since roosts are often the precursors of

colonies. Various deterrent techniques such as pyrotechnics and laser light can be used, either on their own or in conjunction with physical methods, to make roosts unattractive and encourage birds to relocate. Recent experiences in England in using lasers against night roosts are discussed further later in the report.

iv) Improving habitat quality for fish

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 by fish predators. Research has shown that the survival of some prey species can increase, and the growth rate of predators decrease, as submerged vegetation density becomes greater. The extent to which similar factors might regulate interactions between fish-eating birds and fish is less well established, but there is every reason to believe that they will apply to all fish-eating predators be they fish or birds. Indeed, prey accessibility as well as prey density has been shown to influence the foraging success of fish-eating birds and, consequently, the selection or abandonment of specific feeding sites. Thus, habitat features are expected to play a major role in the anti-predator behaviour of many freshwater fish species and in determining their vulnerability to predators.

Good habitat is vital for successful, all-round fisheries management and for healthy, sustainable fish stocks 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 making sure that the environment provides fish with the best opportunities to use their natural defence instincts, as well as meeting feeding and spawning requirements. In seeking to provide adequate cover for fish in fisheries, there may be potential for enhancing natural habitat features through, for example, the creation of marginal reed fringes, permanent overhead and in-stream cover (e.g. additional boulder cover for juvenile salmon and trout) and off-channel areas (e.g., shallow pools, backwaters and ditches).

v) Artificial Fish Refuges

In the UK, conflicts between cormorants and stillwater and riverine fisheries tend to be greatest in the winter months when cormorant numbers, particularly at inland sites, tend to be highest. This coincides with the period when natural cover available to fish is at its lowest because aquatic weed has died-back. Fish swimming speeds, which are governed in part by water temperature, are also at their slowest during this period, and cormorants can typically swim faster than most of their prey species at this time of year. Providing artificial refuges for fish can therefore be used to provide additional cover and reduce their vulnerability to cormorants at a time of the year when they might otherwise be particularly at risk from predation (Russell *et al*., 2008).

To be effective, artificial refuges need to both attract fish and provide them with protection from predators. The key design features to help ensure fish use artificial refuges and confer some benefits are:

- **Structure** — many species of fish are attracted to natural habitat features, such as weed beds and underwater tree roots. The inclusion of some form of structure (e.g., brushwood bundles) within a refuge is thus seen as an essential requirement to help attract and hold fish.

- **Overhead cover** — it is also well known that shading/overhead cover attracts fish. Additionally, shading also provides fish with an enhanced ability to detect oncoming predators. For example, a shaded observer can see a sunlit target at more than 2.5 times the distance that a sunlit observer can see a shaded target.

- **Predator exclusion** — refuges need to be surrounded with a protective mesh to make them cormorant-proof. Research has indicated that use of a mesh of about 10 cm spacing (e.g. typical stock fencing) will effectively exclude cormorants, while optimising access for fish.

Trials using simple cage refuges have provided clear evidence that refuges can protect fish and reduce the foraging efficiency of cormorants (Russell *et al*., 2008; Russell *et al*., in press). The applicability of using refuges will vary with the fish species present and from site to site. The approach is considered to be most suitable for smaller coarse fish species such as roach (*Rutilus rutilus*), perch (*Perca fluviatilis*), rudd (*Scardinius erythrophthalmus*), small bream (*Abramis brama*) and carp (*Cyprinus carpio*). They are also likely to be most effective in smaller stillwater fisheries, particularly where there is an absence of available natural cover for fish. Costs and practicalities will likely preclude the use of refuges in larger stillwaters. Their use also needs to take account of the needs of recreational fishermen and any other water users and ensure that they do not represent a hazard to other wildlife. Such structures are unlikely to be suitable for deployment in rivers, so are not expected to be applicable for protecting migratory salmonids (although see habitat quality above).

Overview of techniques aimed at reducing fish availability

Modifying the habitat, both above and below the water, may provide options for reducing impacts of fish-eating birds for more extended periods than other possible management options. However, much will depend on the characteristics of a site, particularly its size, and the number and proximity of alternative foraging sites to which birds can move. The management of water bodies to optimise environmental conditions for fish will clearly also be critical to ensuring that fish populations are maintained at healthy and sustainable levels. Targeted management of the natural environment, or the use of natural or artificial structures, can thus also be used to provide additional cover for fish and reduce predator impact.

The ability to apply habitat modification techniques will be constrained by practical considerations and potential costs. Thus, for example, removing or modifying roost sites will probably only be practical at smaller sites where other roosting sites are limited. Similarly, modifying underwater habitat features will also likely be constrained by the size of a particular site. However, for all habitat management techniques, the cost-effectiveness should take into account the potential durability and longer-term efficacy of the measures, as well as the scale of potential losses to predators. These should therefore be viewed against the potential recurrent costs of using alternative deterrent measures.

2.4 Reducing bird numbers — lethal control

Legal framework

Under the Wildlife and Countryside Act, 1981 all wild birds in Wales have legal protection. Cormorants and goosanders, like most wild birds, are subject to legal protection, throughout much of their European range, under the Birds Directive. Although the UK is no longer an EU member state subject to the Birds Directive, the terms of the Birds Directive are still relevant under Regulation 9(1) of Conservation of Habitats and Species Regulations 2017 (as amended), here NRW:

"…must exercise [its] functions which are relevant to nature conservation….so as to secure compliance with the requirements of the Directives."

Article 1 of the Directive provides that all birds naturally occurring in the wild and their habitat should be protected; this extends to their eggs and nests as well as all stages of their life cycle. Article 5 of the Directive requires Member States to prohibit the deliberate killing of all naturally occurring wild birds, unless this is carried out under the provisions of Articles 7 or 9. Article 7 allows the hunting of certain listed species but does not apply to cormorant and goosander. However, Article 9 provides that Member States may derogate from the protection of the Directive for a number of purposes, including preventing serious damage to crops, livestock, forests, fisheries and water, or the protection of flora and fauna, provided that there is no other satisfactory solution. Such derogations are used widely across Europe.

Article 2 and Article 13 of the Birds Directive imply, but do not explicitly state, that Member States take measures to achieve and maintain favourable conservation status of birds. Interpretation of Articles 2 and 13 by NRW will influence the way in which derogations to control wild birds in Wales are assessed to meet the legal provision that there is no deterioration in the conservation status of those wild birds subjected to derogated licensed control from the provisions of Articles 5 and 8 of the Birds Directive.

Implementation of lethal control

To many fishery stakeholders, the notion of killing fish-eating birds is very attractive since one dead bird represents one less bird to eat fish. It can also be seen as providing the satisfaction of an 'instant solution'. Equally, the notion of killing these birds, simply because of their propensity to eat fish, is as unattractive to many wildlife conservationists as it may be attractive to fishery stakeholders.

Even when used, there can be problems with killing birds in practice because dead birds can be quickly replaced by others. This is particularly true for sites on bird migration routes and where birds are frequently moving between different locations. Further, sites offering favourable foraging conditions – e.g. minimal disturbance, high densities of fish, or seasonal aggregations of fish during migration or spawning – may be predictable and are always likely to remain attractive to opportunistic predators. Nonetheless, lethal control can be used to reduce the impacts of predators and, alongside non-lethal measures, is widely used for helping to manage conflicts between fisheries and fish-eating birds. As with non-lethal measures, available evidence relating to lethal control of goosanders is scarce.

In Wales, shooting fish-eating birds, under licence, is usually done for one of two reasons:

1. As an aid to scaring, in order to reinforce the impact of other deterrents (e.g. auditory or visual ones).

2. To (temporarily) reduce the number of individual birds feeding at a particular site, or in a particular area (e.g. river catchment).

NRW have stipulated in the Terms of Reference and Delivery Plan of the Fish-eating Birds Advisory Group that matters related to a possible national cull of cormorant or goosander are out of scope. NRW would not licence any activity which, in its opinion, would adversely affect the conservation status of any avian species.

It might be noted that while there have been a number of efforts to initiate a pan-European programme to regulate cormorant numbers across the continent over recent decades (cormorants have long been regarded as the principal predation concern for fisheries), no such plan has materialised. Indeed, the policies related to the control of fish-eating birds are a matter of national competence and different Member States have adopted quite widely differing strategies. Some have explored more intensive levels of control using techniques such as nest destruction, egg oiling or shooting to reduce bird numbers in particular areas to safeguard important fisheries. However, other countries have opted for more local, and less intensive, management options, or do not allow lethal control at all. A brief review of the current policies related to the management of cormorant/fishery conflicts in some European countries is provided in a later section of this report.

Further information on the issues surrounding longer-term, internationally co-ordinated cormorant control at the pan-European level is available in the INTERCAFE 'Toolbox' (Russell *et al*., 2013). The possibility of control at this level, with the aim of reducing the overall population size of cormorants across Europe, has been the subject of previous investigation using population models, with efforts to determine the levels of control necessary to reduce the overall population size and to predict the ultimate size and distribution of the population. However, the widespread nature of cormorant breeding populations, with birds mixing and dispersing across Europe in winter, makes this a particularly challenging task (Frederiksen *et al*. 2018).

Shooting can be deployed as an avian deterrent using two different approaches: shooting to kill and shooting to scare. Shooting at a site-specific or local level is one of the most commonly used techniques for reducing numbers of fish-eating birds. However, investigations at sites where licensed control was applied in England, suggested that cormorant removal at a local scale had no effect on longer term (year to year) population size at a site level (Chamberlain *et al*., 2013b).

Case study: When used in combination - does shooting to kill enhance shooting to scare?

It has generally been accepted as a principle that shooting to scare should be applied in combination with shooting to kill (Civil Aviation Authority, 2017). However, prior to a review of alternative lawful methods (Parrott *et al*., 2003), there are not thought to have been any detailed field studies experimentally testing this. The following provides a synopsis of the main outcomes of Parrott *et al*. (2003):

- A large-scale field experiment was established to investigate the effectiveness of shooting as a method for reducing cormorant numbers at inland fisheries. Two questions were considered:

(i) were cormorant numbers significantly reduced at fisheries where shooting (lethal or non-lethal) was undertaken compared to those at which no shooting occurred?

(ii) was lethal shooting more effective in reducing cormorant numbers than non-lethal shooting, i.e., did killing a small number of birds enhance the scaring effect of shooting?

- Thirteen six-week field trials were undertaken over two winters at a range of fishery sites, including river and stillwater fisheries. The experimental design involved three treatments: control (no shooting), lethal (shooting up to 20 birds over two weeks) and non-lethal (shooting at the same intensity using blanks). Each six-week trial was divided into three two-week phases: pre-treatment, treatment, and post-treatment.

  At the four sites with lethal shooting, the number of cormorants killed ranged from 6 to 18 birds per site, representing 12% to 43% of the mean number of cormorants present before shooting.

- The results indicated a significant difference, between control and shooting sites, in changes in the number of cormorants. At control sites (no shooting) cormorant numbers increased, on average, by 25% and 40% during treatment and post-treatment phases respectively, whilst at lethal and non-lethal shooting sites (combined), there was a mean reduction in numbers of cormorants of 45% and 41% respectively. However, assuming numbers of cormorants at shooting sites would have increased if shooting had not occurred in the same way as they did at control sites, then the reduction in cormorants would have been over 50%.

- The results did not provide evidence of a significant difference between the effects of lethal and non-lethal shooting. It was, therefore, not possible to prove or disprove the hypothesis that killing enhances the scaring effect of shooting. It was noted that this does not mean that killing *does not* enhance scaring, only that the case is unproved. A significant difference may not have been detected because (a) one does not exist, or (b) killing does indeed enhance scaring, but it was not possible to detect the effect using the particular experimental design and methodology.

- Only the short-term effectiveness of shooting as a management technique was investigated in the study and was likely not representative of real strategies employed by fishery managers. It was therefore unclear whether habituation to shooting over the longer-term (leading to a decrease in effectiveness) would differ between lethal and non-lethal operations.

- At shooting sites (lethal and non-lethal sites pooled) there was a significant negative correlation between the proportional reduction in numbers of cormorants and site size. That is, shooting was more effective at smaller sites.

- The duration of the deterrent effect of shooting was limited. Numbers of cormorants at two sites recovered to pre-shooting levels within two weeks of the end of shooting. At four other sites recovery was noted within six weeks (at the remaining two sites there appeared to be no difference between numbers before and after shooting). This

highlighted the need for repetition of shooting to reinforce and maintain the reduced numbers.

Effectiveness of lethal control

The effectiveness of shooting depends on a number of factors: the target species, the site characteristics and the shooting regime. Individual birds of the same species may also respond differently. For cormorants, shooting is more effective at smaller sites than at large ones (Parrott *et al*., 2003). The frequency of shooting and the number of consecutive days over which shooting occurs have also been shown to affect the magnitude of reduction in bird numbers (reported in Russell *et al*., 2013). It is also generally accepted that shooting is best used in conjunction with, and to reinforce, other non-lethal deterrent measures (reported in Russell *et al*., 2013).

Typically, shooting is applied at a relatively local, site-specific level, the aim being to reduce the numbers of birds visiting specific sites or areas, often over the short term. However, in order to be effective over a wider area (e.g., river catchment, network of particular habitat types, or to deter birds from using areas containing valuable, extensive aquaculture facilities), shooting, and the use of any other associated deterrents, also needs to be coordinated effectively. The success of such coordinated activities has previously been reported in Israel (Carss and Marzano, 2005), where birds were displaced to alternative foraging sites through collective early efforts to prevent birds from foraging at intensive aquaculture facilities. A three-year study on two large fjords in Denmark (Bregnballe *et al*., 2015) also provided evidence that coordinated shooting could be used as a tool to make cormorants depart from larger water bodies earlier in the autumn. It was, however, noted that success may require coordinated shooting near day and night roosts. These authors also concluded that large efforts can be invested in shooting to scare and kill cormorants without reaching any desired reduction in numbers, in particular when the shooting is not coordinated in time and space and not undertaken at key roosting sites. Further evidence on the efficacy of coordinated approaches is provided in the later section reporting on the recent use of catchment-based licences in England.

Overview of lethal measures

Shooting birds to reinforce other, non-lethal deterrent techniques is widely used under licence. For cormorants, its effectiveness is generally reported to be short-term, ranging from days at larger sites to weeks or months at smaller fishery sites. Shooting is thought to be most effective where it is used in combination with other deterrent measures. The duration of any effect is influenced by the level of bird ‘turnover’ at a site, but also factors such as the physical characteristics of a site, the shooting strategy and the availability of alternative sites to which the birds can move. At particularly attractive feeding sites, birds removed by shooting may rapidly be replaced by other birds from elsewhere. Shooting may thus largely just move birds to alternative feeding sites in a locality and alter their distribution, rather than reduce their overall numbers in an area.

Various factors can affect the practicality of shooting, such as: the size of the water body to be protected, staff resources/availability, the nature of the local population (e.g. relatively sedentary or highly mobile) and the proximity of alternative feeding sites. Shooting may also be constrained in some areas due to the proximity of human habitation, designated nature conservation sites or in areas of public access due to safety concerns. Where lethal measures are to be employed on a larger scale — for example, to protect particular areas

— an additional significant practical consideration will be the need to coordinate actions effectively. This may require the establishment of collaborative stakeholder groups and effective, real-time communication networks to ensure that efforts are targeted to best effect at appropriate times and places. Thus, knowledge of the local behaviour, movements, and favoured locations (for foraging, roosting, loafing and feeding) of birds is likely to important to the effectiveness of any widespread shooting actions.

3. Summary of management measures

Conflicts between fish-eating birds and fisheries are complex, challenging and emotive - they are seen in different ways by different stakeholders, and they affect a range of fishery sectors across a variety of aquatic habitats. Moreover, conflicts are also subject to change because of the population dynamics of both birds and fishes; seasonal and annual variations in external factors (notably, weather conditions); alterations to the perception of the nature and severity of the conflicts; and the efficacy of management measures. Managing such conflicts is also complex and influenced by wide-ranging factors, making it impossible to provide specific recommendations for different sectors or habitats, or to recommend a list of actions that could instantly solve any particular problem. It should also be recognised that potential management tools will not always work to the satisfaction of any or all of those involved in a conflict. That said, there are numerous tools available and ample evidence that these can prove effective in some places at sometimes. Identifying the most appropriate deterrents or other mitigation techniques requires careful consideration by individual stakeholders, as will the decision on whether or not efforts may need to be coordinated over a wider area. In any event, those faced with addressing conflicts are strongly encouraged to experiment with different techniques and to be creative in devising mitigation programmes to best suit their individual needs.

Many of the available techniques work by making birds leave a particular feeding site and move elsewhere. The ease at which the birds can be made to move from a site will depend on both the severity of the ‘persuasion’ to leave but also, and perhaps most importantly, on the relative attractiveness of alternative feeding sites in the area. Thus, the effective deployment of mitigation techniques at a specific location may depend on a good knowledge of a wider area. Understanding the nature and extent of the problem being addressed will therefore be helpful in devising an appropriate mitigation programme.

Key issues to be considered will include:

- The size of the site to be protected and whether actions are to be local and site-specific or coordinated over a wider area.

- The nature and size of the problem being addressed (including the type of fishery, time of year, number of birds / fishes involved, trends in bird / fish numbers, etc.).

- The behaviour of the birds (e.g. breeding, roosting, resident, migrating) and the availability of alternative foraging sites.

- The time that can be devoted to addressing the problem (deploying deterrents, coordinating actions, etc).

- The associated costs (personnel and equipment) that can be devoted to addressing the problem viewed against expected fish losses (i.e. some sort of simple but realistic cost-benefit analysis).

- Awareness and adherence to local, national and international legislation on the use (or otherwise) of particular techniques, and the need to operate safely.

- Possible constraints on deterrent use such as: the proximity of human habitation and sensitive sites (e.g. airfields); the availability of electrical power; the security of unattended devices against possible theft and vandalism; accessibility to the land or water areas where deterrents could be deployed; and wider conservation concerns (e.g. any designated nature conservation status of a site and the potential impact upon other wildlife).

- Individual managers will probably also need to consider the timescale over which management measures might need to be applied.

Relatively few techniques (e.g. netting enclosures) offer potential one-off solutions to conflicts that might be effective in the long-term (years) and these are typically restricted to smaller sites. While there are a number of techniques that can be effective at deterring birds in the short term, these will typically require regular repetition, reinforcement and alteration to remain so in the longer term. With many deterrents, their impact is likely to diminish with time as habituation tends to occur with any scaring technique that is not reinforced by a demonstration of actual danger. Thus, to be effective over longer periods, it is advisable to constantly change the appearance and location of devices, and to use combinations of harassment techniques in a rigorously applied, integrated control strategy. Managing conflicts is also likely to require striking an appropriate balance between the use of non-lethal deterrents and, where they are justifiable and approved, lethal measures. Shooting, too, is thought to be most effective where it is used in combination with other deterrent measures. Techniques that require human presence are commonly regarded as the most effective deterrents, and those that carry biological significance and mimic threats known to birds tend to prove more effective and longer-lived than other devices.

For potential conflicts on river catchments (a key focus of the NRW review) it will be particularly important to take account of bird movements following management actions. There will likely be minimal, if any, benefit for fish stocks if birds are simply moved a few hundred metres up or downstream. As such, coordinated actions across a wider area are likely to be required, recognising that many of the available techniques described above will be impractical at the catchment scale. (N.B. The potential application of area- or catchment-based licences to facilitate such coordination is discussed in a separate evidence report submitted to this review - Russell *et al*., 2022).

The frequency with which deterrents might need to be applied will also depend on the local situation. Particular focus may be required at certain stages of a fish's life cycle, for example during the smolt run in spring, or at specific predation 'hot spots' such as potential barriers to fish migration, particularly during periods of low flows. Further, more frequent use of measures will be required where there is a high degree of turnover of birds, to reinforce the

scaring effect on birds newly arrived at the site, and where there are fewer alternative feeding sites available for the birds. As a general guide, it is likely that a management programme will need to be applied consistently and intensively to be successful. Appropriate management measures should start as soon as birds first arrive, before they are able to establish feeding habits at the water bodies to be protected. Thus, for example, on waters that typically experience cormorant depredation in winter, a scaring programme should start in the autumn when the first birds arrive. Evidence suggests that cormorants stop visiting some water bodies for a month or more after initial intense scaring efforts and, since birds arriving later in the season often follow birds that are already present to feeding areas, conditioning the early birds to avoid certain waters should help to reduce damage by later arrivals. However, control measures may have to be applied consistently throughout the season at water bodies located on major daily flight paths, migration routes or near large roosting areas.

The application of management measures should also be timed to coincide as far as possible with the daily patterns of bird behaviour at a site. Typically, cormorants feed at first light and this is likely to be the key period for applying deterrents, so that birds can be scared away from a site before they start to feed and begin to establish habitual feeding patterns. However, birds can feed at other times of day and may use a site for other purposes such as roosting or loafing. Similarly, an understanding of the times when goosanders commonly feed would help with planning possible management actions. Regular patrols to monitor a site are therefore vital for targeting measures most effectively. When the potential for bird predation is at its highest, measures may need to be reinforced at regular intervals throughout the day from first light to dusk to be most effective. When birds only visit water bodies for certain periods of the day, such as morning and evening, employing scaring efforts only during those periods may be sufficient.

4. Recent practical experiences of management actions in England

Feedback from the Angling Trust Fishery Management Advisors

Background

One of the main recommendations arising from the most recent review of policy relating to fish-eating birds in England, was the appointment of Regional Fishery Management Advisors (FMAs) (Defra, 2013 a & b). It was envisaged that the FMAs (Jake Davoile and Richard Bamforth *pers comm*.) would provide a knowledgeable face-to-face source of advice for inland fishery managers and guidance on a range of relevant issues, including:

- offering advice on best practice for non-lethal measures to mitigate problems with fish-eating birds;
- assisting fishery managers in drawing up bespoke management plans;
- offering guidance and support on preventing serious damage to fisheries and support in submitting licence applications, where required;
- providing signposting to other sources of information;
- advising fishery managers on how to design fisheries that incorporate the best mitigation measures for addressing the impact of fish-eating birds;
- offering advice on wider issues relating to fisheries management, ecology, and the impact and management options relating to other predators such as otters.

A further key role required of the FMAs was facilitating another of the review's key recommendations - the establishment of catchment-wide approaches to the management of fish-eating birds through a system of area-based licences. These licences were intended to give fisheries the opportunity to operate together under an umbrella licence and co-ordinate their actions to reduce predation by piscivorous birds.

A further recommendation was that the FMAs should be employees of the Angling Trust funded by government. This was to ensure that these staff were viewed as the 'angler's friend' and thus be more acceptable and effective in delivery as opposed to being staff employed by the regulator. The selection procedure and interview process were conducted by staff from the Angling Trust, Natural England and the Environment Agency. In addition, upon appointment, the successful candidates underwent a detailed two-week induction period conducted by representatives from these three organisations, Cefas and an independent fisheries consultant.

Area-based licences (ABLs)

Following on from the Defra 2013 review a three-year trial, supported by the FMAs and overseen by a project group, was conducted to evaluate the efficacy of ABLs at three

different sites. The trial was deemed successful and, subsequent to this, the numbers of such licences have increased steadily; there are now around 20 ABLs operating in England. Many of these have been set up to coordinate management activities on a particular river catchment, or part of it. Others cover both river sections and adjacent stillwater sites, and some cover aggregations of stillwaters. The licences are issued by Natural England, typically cover the period from September 1st – April 15th. Licences are managed by a 'primary contact' and authorise the shooting of a certain number of birds. However, fisheries have flexibility to move the allocation between the various individual fisheries covered by the licence to target areas of highest predation or most vulnerable fish populations.

In establishing and implementing the various ABLs, FMAs have worked with fisheries to collate knowledge on the resident populations of fish-eating birds (primarily cormorants) to get a better understanding of the feeding patterns of the birds and to help develop bespoke strategies to deal with predation. Information collected has included the number and location of roosts and breeding colonies, patterns of movement (directions / times), favoured feeding locations and variations in bird numbers. This shared knowledge on bird movements and behaviour has been used to inform licensing decisions by Natural England and to facilitate management activities to combat predation and protect fish stocks, for example by enabling actions to be targeted flexibly and where the need is perceived to be greatest. Such activities have typically included:

- A co-ordinated plan for lethal control to enhance scaring – e.g. weekly shoots.
- Improvement in non-lethal techniques to complement lethal control, including habitat improvements to provide better cover for fish.
- Establishing a reporting procedure for efficient monitoring – individual fisheries are strongly encouraged to maintain logbooks of bird numbers, etc.
- Developing effective communication links between fisheries (e.g. mobile telecommunications / group email).

In general, ABLs are considered to have worked reasonably well, particularly where the primary contact is proactive and effective co-ordination between fisheries has been maintained over time. Successes in removing night roosts have been noted on a number of catchments through the use of deterrents, such as lasers, over a number of successive days. In addition, adjacent fishery beats have been shown to work collaboratively to reinforce scaring programmes and avoid the danger of birds simply relocating a short distance up- or downstream. Co-ordination between fisheries has also been demonstrated in mobilising teams to deter birds during critical periods, such as during the smolt run, or at known 'pinch points', such as weirs. Good communication between individual fisheries is seen as being key to the effective application of ABLs. However, it has also been noted that focus on the co-ordination of activities can wane over time and loss of interest in maintaining deterrent actions can see bird numbers recovering quickly.

Recent Fishery Management Advisor experiences with management measures

While recognising the wide range of techniques that fisheries can use to scare off fish-eating birds, the FMAs have noted that many deterrents can be ineffective, largely as a result of

rapid habituation to their presence. It is reported to be rare to find a fishery that has reduced levels of predation to an acceptable level without the need for some level of licensed shooting to enhance the use of scaring technqiues. That said, various techniques have been found to offer some level of benefit:

- Human presence is seen as one the most efficient methods for deterring birds, although is recognised as being very labour intensive**.**

- Mannequins have proved effective in deterring cormorants from landing at fishery sites where this is reinforced by targeted shooting to scare. The mannequins need to be located in clear view (they have also been seen to work well set up in a boat), look as life-like as possible and carry a mock-up gun (Figure 1). To fool a cormorant, it is suggested that mannequins should also fool a human.

Figure 1. Life-like mannequin deployed at fishery site.

Figure 2. Parallel wires deployed at a stillwater fishery.

- At smaller sites, the use of wires, nets and ropes have demonstrated benefits. Wires set high above the water surface (Figure 2) can still allow for access to a site for fishing.

- Shooting to scare has been seen to have positive results in reducing visits by cormorants but works best if adopted on a regular basis and targeted at times when birds arrive to feed. At some fisheries covered by area-based licences, bailiffs (who may not have a shotgun certificate) carry starting pistols allowing rapid and effective opportunistic action to deter birds.

- The FMAs have noted that cormorants will frequently affect fish behaviour and have been seen to ‘drive’ fish into the margins and corners of stillwaters. In response to this, they have encouraged fisheries to create refuge areas in these locations and have witnessed various good examples of work to enhance habitat for fish. These measures have included: reed beds, sanctuary areas that are left to grow over, lily beds, marginal planting of alder and willow, and management of submerged weed growth. However, since birds are still able to hunt and forage in these areas of enhanced natural cover for fish, further exclusion materials are advised. For example, either stock netting or chestnut paling (Figure 3) can be installed to allow safe passage for fish into these sanctuary areas whilst excluding cormorants. Artificial refuges can also provide protection for fish, although it has been noted that these may deteriorate over time and need to be maintained in order to remain effective.

Figure 3. A simple chestnut paling fence that could be deployed to protect fish habitat in the margins.

- Lasers have been observed to have marked success both in breaking up the establishment of cormorant night roosts and in deterring birds in flight (Figure 4). Lasers have now been used at a number of sites to relocate night roosts on river catchments. Commonly available laser pointers emit light at a range of different wavelengths (e.g., red, blue and green), but those which emit green light (with a wavelength of 532 nm) are considered the most efficient for scaring cormorants. Lasers have proven to be most effective when used at dusk on overnight roosting birds but can also work well on fisheries in low light conditions. Lower light conditions are required as the laser is more visible to both the user and the intended target. Typically, a laser is directed at a bird's body and the light beam flicked across its wings, breast, and abdomen, although the beam can also be flicked across multiple birds in a roost. A safe backdrop should be ensured to prevent laser light travelling beyond the intended target. A key advantage of this technique is that it is target selective, as the operator can scare off cormorants without affecting other, non-target, species. A bird's normal response will be to leave for a short period, before returning to the site, so repeat scaring will likely be required over a number of consecutive days to have a lasting effect on roosting behaviour.

Figure 4. Illustration of laser light being deployed at dusk.

- The FMAs also advise that deterrent measures have also been successfully coordinated along a catchment (using mobile phones) to ensure birds don't just move a short distance. In such instances, deterrents (e.g. shooting to scare) are used on the last of the birds moving over an adjacent stretch of river to avoid the risk of targeting the 'lead' birds and simply turning a flock around.

5. Arrangements for managing fish-eating birds in other parts of the UK

England

As with other parts of the UK, derogations to permit the lethal shooting of fish-eating birds in England are subject to a licensing system. Licences are issued by Natural England and applicants need to demonstrate that their fisheries are at risk of suffering serious damage and that lawful non-lethal measures have been used and proved ineffective or impractical at the site.

Licensing decisions for cormorants are informed each year by a modelling process which uses annual winter counts of the birds (WeBS counts) and details of the numbers of birds shot under licence to assess the potential impact of further licensed control on the English cormorant population. This adaptive management approach is aimed at ensuring that licensing decisions do not jeopardise the conservation status of the birds.

The most recent review of policy related to fish-eating birds in England (Defra 2013 a & b) made a number of recommendations for delivering improvements to the way that fisheries and fish-eating birds are managed to minimise the risk of serious damage. One of the key recommendations of this review was the establishment of area-based licences with the aim of better coordinating management actions against fish-eating birds at appropriate scale, commonly a river catchment. Further details on the establishment of area-based licences are provided in the previous section of this report.

Scotland

Licences in Scotland are issued by NatureScot (formerly Scottish Natural Heritage) and are granted in order to permit the killing or taking of wild birds to prevent serious damage to fisheries. These licences are issued on the basis of shooting as an aid to scaring. Applicants for licences are required to complete an application form each year detailing the problems experienced, details of non-lethal scaring activities undertaken (methods used and duration) and supported by current bird count data.

In deciding on whether to issue licences, NatureScot consult with Science and Advice for Scottish Agriculture (SASA), a Division of the Agriculture and Rural Delivery Directorate, and Marine Scotland Science (if the fishery is stocked). Licences are granted only in instances where evidence of serious damage can be provided and when non-lethal methods of control have proven to be unsuccessful or are impractical. Guidelines have been developed setting out criteria against which 'serious damage' is assessed; these include the damage or risk to fish stocks and numbers of birds recorded at the time of year that conflicts occur. Licences stipulate the number of birds that can be shot (understood to be around 15% of the estimated bird count available); the numbers actually killed are monitored through licence returns.

A number of reviews have been undertaken to assess the impact of piscivorous birds on salmonid populations and game fisheries in Scotland (Marquiss *et al*., 1998; Harris *et al.,* 2008; Humphreys *et al.,* 2016).

Northern Ireland

A licensing system operates in Northern Ireland enabling angling clubs or other fishery interests to apply for a licence to shoot cormorants (https://www.daera-ni.gov.uk/publications/licence-shoot-cormorants). Applications need to be supported by some proof of a predation 'problem'. Licences are typically only for a relatively small number of birds (often <10) and mandate the use of shotguns - the emphasis is on scaring rather than killing.

Investigations in the 1980s indicated high losses of salmon smolts to predating cormorants on the River Bush (Kennedy & Greer, 1988), although a subsequent study indicated that losses of salmon could be influenced by the relative abundance of other prey species (Warke & Day, 1995). Cormorant predation is considered to be an ongoing issue on the River Bush (Richard Kennedy & Dennis Ensing, *pers comm*.), particularly of salmon smolts in the lower river, and investigations to better understand the potential impact are ongoing.

6. Strategies for managing fish-eating birds (mainly cormorants) in various other European countries

Background

Widely differing strategies are employed across Europe to address conflicts between fish-eating birds, largely cormorants, and fisheries. In part, these differences reflect the numbers, distribution and movement patterns of the birds, but also the nature of the fisheries affected. Numbers of cormorants in Europe as a whole far exceed those in the UK, and populations are subject to extensive seasonal migrations between breeding and wintering areas. Goosanders are far less numerous in Europe and do not attract anything like the same level of concern with regard to fishery conflicts as cormorants. This is reflected in the relative paucity of information on management measures specifically targeting this species.

Numbers of wintering cormorants in the western Palearctic (an approximation for European populations), were tentatively estimated at 1.2 million in 2007[2]. There have been further population increases since this time, particularly in the Baltic areas and around the Black Sea. However, breeding numbers have been fairly stable or even declining in many of the original core breeding areas in northern and western Europe. These declines may be partly explained by extra-cold winters adversely affecting survival and individual body condition prior to breeding, but colonies in some of these areas may also be at or around carrying capacity.

Cormorants in Europe also undergo wholesale migrations from predominantly northern breeding areas to southern wintering areas. A map showing the main breeding distribution of cormorants (*sinensis* sub-species only) in Europe is available at:

[2] Cormorants in the western Palearctic – leaflet prepared by the IUCN/Wetlands International Cormorant Research Group. Available at: http://ec.europa.eu/environment/nature/cormorants/breeding-distribution-2006.htm

http://ec.europa.eu/environment/nature/cormorants/breeding-distribution-2006.htm. In large part, the southerly migrations are driven by the cold winters in more northern and central parts of Europe and the freezing over of many water bodies. As a result, many countries experience large, seasonal migrations of birds on top of any resident populations. Some cormorants from continental Europe also migrate to the UK over the winter period, with the number of birds believed to be linked to the severity of the winter conditions in mainland Europe.

Similar overwintering movements are also thought to occur for goosanders, as described by Hearn (2015). WeBS count data show that the trend in UK goosander numbers has declined since the mid-1990s, in line with trends elsewhere in western Europe and a shift towards the north and east, where there have been large increases (Lehikoinen *et al*., 2013). Furthermore, UK goosander numbers increase rapidly in winters with significantly colder than average weather. Available data thus suggest that migratory goosanders continue to winter in the UK, even if this has probably become less regular. Hearn (2015) also reports that new national trends in goosander counts are in line with our understanding that the increasing British-breeding population is largely sedentary and that significant numbers of migratory goosander do not winter in Scotland and Wales. Thus British-breeding goosanders, found predominantly in Scotland and Wales, disperse locally during the non-breeding season (with some moving to England) and migratory goosander from continental Europe are found predominantly in England during winter (Little & Marchant, 2002). Further, it is this English-wintering migratory component of the UK winter population that is driving the overall UK trend (a decline of 31% during 1998/99 – 2008/09; Eaton *et al*., 2012).

The fisheries affected by cormorants also vary widely across Europe. While the main focus of cormorant/fishery conflicts in the UK centres around recreational fisheries in rivers and often relatively small, widely distributed stillwater bodies, conflicts in other countries affect various other fishery sectors. Thus, for example, large extensive fish farms for carp and other freshwater species are prominent conflicts in large parts of central Europe, while commercial coastal fisheries are often affected in Baltic states, and recreational fisheries on alpine rivers (grayling and trout) are a major concern in countries such as Austria, Switzerland and Slovenia. Cormorant management strategies in different countries have thus typically been set up to address the different conflict issues that pertain in these countries. These vary widely in terms of their timing (wintering birds, breeding birds, migrating birds, or some combination of these), the numbers of birds involved, and the nature and extent of the 'fishery' interests affected.

For countries within the EU, actions taken against fish-eating birds need to be compatible with the derogations permissible under the Birds Directive (Council Directive 2009/147/EC) on the conservation of wild birds. The European Union has produced a guidance document relating to the application of derogations under Article 9 of the Birds Directive in respect of the Great Cormorant (European Union, 2013)[3].

The following provides summary details of current cormorant strategies in a few, selected European countries. It is intended for illustrative purposes only, to provide an indication of the differing approaches used, and it is not exhaustive.

[3] https://ec.europa.eu/environment/nature/pdf/guidance_cormorants.pdf

France

France is the largest cormorant wintering area in Europe, with most of these birds using inland waters. In addition to resident birds, many other cormorants migrate into France and also through France to wintering areas further south. In the most recent survey for 2017/18 (Marion, 2018), the estimated mean number of cormorants in the country over the winter was 103,484 with an estimated peak in December of 172,602 birds.

The distribution of the cormorant wintering population in France has significantly changed over the last three decades (Marion & Bergerot, 2018) with a rapid increase in the 1980s and 1990s followed by levelling-off of the national population. Initially, birds tended to occupy areas deemed optimal (i.e. those with the most surface water such as lakes and rivers over 50 m wide), with subsequent progressive spread to areas considered less optimal (i.e. low surface water areas and colder regions in northern parts of the country). The authors concluded that competition between birds for optimal foraging areas was the dominant factor in this process, with temperature playing only a relatively minor role. This suggestion implies that intraspecific competition may trigger movement of cormorants to new areas where numbers are relatively low.

The presence of large numbers of wintering birds has generated strong conflicts with fishery interests in France, primarily involving fish farmers (a number of areas support extensive fish-pond aquaculture interests) and recreational fishers. Authorised shooting started in France in 1992 during the over-wintering season (October-March), with annual quotas set for particular administrative areas (départements). Shooting was initially restricted to fish pond areas and only in some départements, but was later extended to other open water bodies and rivers, and then progressively to the whole country. Initially (mid 1990s), quotas represented about 6% of the wintering cormorants in mid-January but have increased substantially since then (e.g. 43.5% in 2013) (Marion & Bergerot, 2018). In the most recent year, a quota of 46,000 birds was allocated (Loic Marion, *pers comm*) representing almost half of the wintering population. In reality however, not all the 'allocated' birds are killed.

In spite of this large-scale shooting, no correlation has been demonstrated between shooting intensity and trends in wintering populations from winter to winter at a département scale (Marion, 2012; Marion and Bergerot, 2018). Similar patterns have been reported for Bavaria (Keller & Lanz, 2003) and Denmark (Bregnballe *et al*., 2014), with authors suggesting that shot cormorants are rapidly replaced by new 'recruits' after the next breeding season. Investigations in England have also provided no evidence that cormorant removal at local scales is having an effect on longer term (i.e. year-to-year) population size at a site level (Chamberlain *et al*., 2013b).

Denmark

Denmark is part of the core area for cormorant breeding in Europe. Since 2014, the population has been relatively stable at between 30,500 and 33,200 breeding pairs, with annual fluctuations below 5% (Sterup & Bregnballe, 2020). The current population size is around 20% lower than during 1996-2005, when the population peaked at around 40,000 pairs. A total of 90 breeding colonies was reported in Denmark in 2020, 15 more than in 2019 and the largest number ever recorded. The large increase in colonies may reflect management measures, predation/disturbance by white-tailed eagles (*Haliaeetus albicilla*),

or other natural causes. The growing population of white-tailed eagles in Denmark is reported to be having an increasing impact on cormorant colonies resulting in a decline in breeding success and a delay in the timing of onset of breeding (Sterup & Bregnballe, 2020).

Increases in cormorant numbers in Denmark, as in other countries, led to growing conflicts with fishery interests. Initially, many of these conflicts related to commercial fisheries operating in fjords and coastal areas, but there have been growing concerns about the impact of predation on riverine fish species and migratory salmonids in particular.

The Danish Ministry of the Environment first established a cormorant management plan in 1992 in response to the marked increase in the breeding population of cormorants in the country and there have been a number of iterations since. Existing management strategies in Denmark are currently under evaluation.

Under existing management measures, lethal actions against cormorants can be approved at fishery sites and measures can also be targeted at breeding colonies (Thomas Bregnballe, *pers comm*). A web-based platform has recently been introduced to enable angling interests, fishermen and landowners to seek permission to scare cormorants at fishery sites, including the shooting of some individuals. This relatively simple process has resulted in a marked increase in the numbers of applications in recent years as well as in the numbers of cormorants permitted to be shot; licensees are requested to report on subsequent actions. Permission can also be obtained to scare cormorants away from night roosts (in inland areas), including the shooting of some individuals, although relatively few such permissions are sought.

Under the current management plan, approval has also been granted for larger-scale shooting of birds by hunters throughout the hunting season in the extensive Ringkøbing Fjord area. Previous results from such shooting in this fjord suggested that it may be possible to use shooting as a tool to 'force' cormorants to advance their departure from certain large water bodies in the autumn (Bregnballe *et al*., 2014). However, it was concluded that success may require co-ordinated shooting near day and night roosts.

Some control measures are also allowed at cormorant breeding sites, many of which are ground-nesting colonies. The main aim is to try to avoid the successful establishment of new colonies. This strategy has, in part, been based on the hypothesis that confining birds to particular areas will aid control of overall numbers through competition for resources – i.e., allowing density-dependent processes to work in your favour. Such measures have typically been concentrated on sites in or close to important areas for fish or fisheries. In 2020, actions were applied at 20 colonies (Sterup & Bregnballe, 2020), here 3,695 nests were exposed to management, mainly by spraying eggs with vegetable oil to prevent them from hatching, or by nest removal. In addition, 291 cormorants were shot in the vicinity of five colonies.

There is no limit on the overall numbers of birds permitted to be shot under the various management initiatives. Since 2017, around 6,000 birds are reported to have been killed each year in Denmark. Previous Danish management plans have included a requirement for the continued monitoring of the cormorant population with a view to ensuring that the conservation status of the species remains satisfactory.

There have been growing concerns about the impact of cormorants on salmonid stocks in Denmark in recent years (e.g. Jepsen *et al*., 2019). In response, there has been increased focus on actions to deter cormorants from rivers and estuaries, particularly during the period

of the smolt run. It has been further suggested (Thomas Bregnballe, *pers comm*) that the management plan currently under development may include provisions for angling clubs (and others) to get assistance from the regional authorities to help ensure that efforts to reduce numbers of cormorants on rivers and river mouths are conducted in an organised and effective way.

Sweden

There has been a marked increase in the numbers of cormorants in Sweden in recent decades, particularly in the numbers of breeding birds. Similar increases have also been noted in other Nordic countries. Winter conditions generally have a large impact on the numbers of birds remaining in the country, and most cormorants typically leave in the autumn. However, there has been a tendency for more birds to overwinter in recent decades, possibly due to improved winter conditions (less ice cover and perhaps more food availability). There are currently estimated to be about 40,000 breeding pairs, with around 14,000 individual birds over-wintering. This increase in bird numbers has resulted in growing numbers of conflicts with a range of fishery interests in freshwater and coastal areas.

A cormorant management plan was introduced in Sweden in 2014 and is due to be updated in the near future (Ebba Henning Planck, *pers comm*.). Derogations allowing the use of lethal measures against cormorants are widely used to protect fisheries and fish stocks. In 2018/19 approval was given to shoot up to 12,000 birds across Sweden (2,857 were reported to have actually been killed). In 2019/20, the numbers permitted to be shot increased to 25,368 (9,762 were reported to have actually been killed). Management of colonies (egg pricking and oiling) has also been practiced in some areas with the aim of reducing the overall reproductive output and decreasing the pressure on fish populations and fisheries.

Norway

Norway supports populations of both the Atlantic (*P.c. carbo*) and Continental (*P.c. sinensis*) races of cormorant. Norway has a long tradition of hunting cormorants (and shags) where the hunting season on the coast extending from 1 October to 31 November, with a longer hunting season (10 August to 23 December) applying on inland waters (Oddgeir Andersen, *pers comm*.). Both races of cormorant are treated as the same species (great cormorant) under the Norwegian national hunting regulations, although, in practice, it is mainly only *P.c. sinensis* that occurs on freshwater systems. The ability to hunt cormorants on inland waters was extended to cover additional Norwegian counties under the latest hunting regulations (2017-2022). Under these regulations, a new measure was also introduced for hunting on the coast, this restricted shooting to birds with a white chest (juveniles). There are no bag limits on the numbers of birds that can be shot in either coastal or inland areas.

Netherlands

The situation with respect to active management of cormorants in the Netherlands has not changed for many years – no derogations for lethal control measures to control new colonies or to limit the numbers or breeding success in existing colonies are allowed.

On a country-wide scale the breeding population of cormorants in the Netherlands in summer is reported to be stable (Mennobart van Eerden, *pers comm*.). However, very large

declines have been observed in some of the largest individual colonies, for example, the colony on the Ijsselmeer was below 4,000 breeding pairs in 2020 compared with over 16,000 breeding pairs in the early 1990s. Further, white-tailed eagles have now occupied what once was the biggest colony in Europe, Oostvaardersplassen, where breeding has now almost completely ceased. Other colonies (ground nesting) have been disturbed by foxes (*Vulpes vulpes*), pine martens (*Martes martes*) and other natural predators. Currently, therefore, breeding colonies are mainly smaller, more numerous and more scattered through the country. These changes have occurred without any human intervention. Changes have also occurred in the wintering populations, with more cormorants present in the Ijsselmeer area than previously due to the immigration of birds from the Baltic region.

There is much focus in the Netherlands on improving aquatic habitat connectivity and diversity for the benefit of fish stocks. Measures include trials with dead wood structures underwater, promoting growth of aquatic vegetation, making shallower habitat and nature islands, increasing natural shore length and more natural water table management. Changes in fish stock composition have also been noted as a consequence of efforts to reduce eutrophication and improve water quality, with potential consequences for cormorants.

Austria

A particular concern in Austria, in common with a number of other countries with similar 'alpine' rivers, has been the impact of cormorants on locally endangered salmonid populations (including grayling), key target species for recreational anglers. Peak cormorant numbers occur in winter as birds migrate south. Wintering numbers in Austria as a whole are reported to be relatively constant year on year with only moderate fluctuations (Rosemarie Parz-Gollner, *pers comm*.).

There are no common rules covering the use of derogations to Article 9 of the Birds Directive in Austria, since legislation relating to hunting, fishing and nature conservation is the responsibility of each of the nine Austrian provinces. In general, all provinces prohibit shooting on, or within a certain distance of, roost sites, on larger stillwaters (lakes) and larger rivers, and along watercourses which are located in bird sanctuaries including Natura 2000 sites or National Parks. Where shooting is allowed, this typically occurs during the winter months (e.g. 1 September to 31 March), but some local variations apply. However, there are differing strategies in different provinces, for example:

- In one province, no limit is applied to the numbers of cormorants that can be killed. However, shooting is limited to specific waterbodies or stretches of river. The objective here is to focus activities on smaller tributaries to protect trout and grayling, but to leave bigger lowland river systems free from shooting so that they can serve as 'refuge' areas for cormorants dispersed from elsewhere.

- In another province, permitted levels of cormorant occupancy are advised (e.g. 5 birds for a given section of river) and it is then permissible to shoot any birds in excess of this number. The aim is to enable fishery interests to respond to the sudden arrival of large flocks of birds. No quota limit applies.

- In a further province, the number of birds permitted to be killed depends on the overall wintering numbers. In this case, if the sum of the birds counted at the end of a month

on all known roosts exceeds a certain level (e.g. 800 birds in the whole province) people are allowed to shoot 10% (or more) of the wintering population. Shooting is then permitted within a certain distance from and along all waterbodies in the whole province (bird sanctuaries excluded).

- Elsewhere, the birds permitted to be killed are defined and allocated to particular districts (smaller spatial units), and fishery interests are required to apply for approval to shoot based on declared fish losses.

- In one province, a recent time-limited trial has been initiated to allow a limited number of cormorants to be shot per month including in some existing Natura 2000 bird sanctuaries. One of the objectives here has been to examine the potential benefits of enlarging the areas covered by management actions to better protect salmonid stocks.

Concerns are also commonly expressed in Austria about the impact of otters and goosanders on fish stocks. Limited shooting of goosanders is permitted under derogations, but these are considered more sensitive and are of limited extent.

Ireland

There is not thought to be any specific policy or approach to dealing with cormorant/fishery conflicts in Ireland (Michael Millane, *pers comm*.). Any derogation to shoot cormorants would require a licence from the National Parks and Wildlife Service, but few, if any, such licences are thought to have been issued in recent years.

A preliminary study of cormorant predation on four rivers in Ireland (Tierney *et al*., 2011) concluded that the birds did not selectively targeted the smolt run and that the impact of cormorant predation on local salmonid populations was limited. However, there are reported to be growing concerns among fishing interests about the impact that cormorants may be having on salmon stocks, in particular through their predation on smolts.

Poland

A cormorant population management strategy has been in place in Poland since 2011. Under this strategy, it is not permissible to disturb or kill birds during the breeding season or on roosts, but birds can be scared from fishponds during migration and wintering periods (gas cannons are commonly used) and lethal measures were also permissible on fish ponds (without approval) between 2004 and 2016. Authorisation is now required to use lethal measures against cormorants on all waters and approval is also required for non-lethal measures to disturb birds on rivers and lakes. Such authorisations only apply during the migration and wintering periods.

In 2015 and 2016 permission was granted for the killing of 9,184 and 8,700 cormorants. However, the numbers actually reported to have been shot were 1,510 and 1,844, respectively (Robert Gwiazda, *pers comm*.).

Italy

A range of conflict issues between cormorants and fishery interests are reported in Italy and are widespread across the country. These occur in coastal wetlands and lagoons where

both extensive fish-farming and fisheries operate but affect recreational fisheries also. A particular concern among anglers is predation of marbled trout (*Salmo marmoratus*) and grayling (*Thymallus thymallus*) in alpine / sub-alpine rivers, where cormorant numbers are reported to be increasing.

There is no national management plan for cormorants in Italy, and conflicts are managed at a regional level or locally to cover a specific wetland area. Management actions follow the derogation requirements under Article 9 of the Birds Directive – when damage is first expected non-lethal measures are applied initially, typically using well known measures such as audible and visual deterrents. If these prove insufficient, as is commonly the case, approval can then be sought for other non-lethal measures (disturbance, etc.) and lethal shooting. The licensing authority provides technical advice (e.g. techniques to be used, best times to take action) and allocates a quota of birds permitted to be killed. In some cases, applicants request additional quota if problems persist.

The numbers of birds allowed to be killed are low relative to overall wintering numbers and are not considered to be having any effect on the conservation status of the birds at either the local or national scale (Stefano Volponi, *pers comm.*).

7. Summary of key points pertinent to the NRW review

General considerations

- Conflicts between fish-eating birds and fisheries are complex – they occur in a range of fishery sectors across a broad spectrum of natural and man-made aquatic habitats.

- Managing such conflicts is also complex and influenced by wide-ranging factors. Conflicts can be dynamic and are subject to change through factors such as: the population dynamics, relative abundance and spatial distribution of birds and fishes; variations in external factors, particularly weather conditions, stakeholder perceptions and fisheries' economics.

- Numerous evidence gaps remain in our understanding of the interaction between fish-eating birds and fisheries and the efficacy of different management approaches. This is particularly apparent for goosanders for which the available evidence is very limited.

Use of non-lethal measures

- Prior to issuing a licence permitting the killing or taking of wild birds, NRW must be satisfied there are no other satisfactory solutions as regards the purpose of that killing or taking. Before authorising the use of lethal methods against fish-eating birds, NRW requires evidence to demonstrate that non-lethal methods have been tried and found to be ineffective or are impractical at the site concerned.

- A large number of non-lethal management tools are available that can be used to address conflicts between fish-eating birds and fisheries. These can be effective at reducing levels of predation, at least in some places at sometimes. The measures

likely to be appropriate will vary between fisheries, and between rivers and still-waters, and there is no single solution guaranteed to be effective in every situation. Further, the efficacy of the various measures is subject to a number of constraints.

- A key factor affecting the utility of non-lethal management measures is the size of the site to be protected. Many visual and auditory deterrents are only effective over relatively short distances and will be more appropriate for use at smaller fishery sites. Thus, many potential management measures will be impractical at the scale of whole river catchments.
- A further constraint with many deterrents is that their efficacy is likely to diminish with time as birds habituate to their presence. This is considered to be most likely where such measures are not reinforced by a demonstration of real danger.
- Relatively few potential measures are likely to be effective at reducing the risk of predation over the longer term, at least without regular reinforcement. Those with the potential to provide longer term protection – e.g. netting or wire enclosures, habitat modification – are also likely to be most applicable at smaller fishery sites, usually still-waters.
- At sites where management measures are implemented, the 'willingness' of birds to move elsewhere will depend not only on how effective mitigation measures are at reducing predation, or in persuading the birds to leave, but also on the relative attractiveness of alternative feeding sites in the area.

Shooting to scare and shooting to kill

- It is generally accepted that killing enhances the scaring effect of shooting. However, it has not as yet been possible to prove or disprove this hypothesis and this remains an evidence gap.
- Studies have, however, shown that both shooting to kill and shooting to scare can be effective at reducing cormorant numbers at a site. In these trials, shooting was shown to have a larger effect at smaller sites and to need reinforcement. Bird numbers recovered after a period without the deterrent effect of shooting, and this applied to both shooting to kill and shooting to scare.
- It is also generally accepted that once lethal shooting is authorised (non-lethal methods need to have been tried first), this is best used in conjunction with, and to reinforce, other non-lethal deterrent measures.
- The duration of any effect from a shooting programme will be affected by various factors, including the attractiveness of a site to feeding birds, the size and physical characteristics of the site, the shooting strategy and the availability of alternative foraging sites to which the birds can move.
- To be effective over a wider area such as a river catchment, shooting and the use of any other associated deterrents needs to be co-ordinated effectively. The potential application of area- or catchment-based licences to facilitate such coordination is discussed in a separate evidence report submitted to this review (Russell *et al*., 2022).

Best practice

- Effective management of fish-eating birds will likely require a combination of management tools to be employed, and the most appropriate measures considered on a site-by-site basis. In short, management works best if it is adaptive and employs a variety of techniques.
- Given the likelihood of habituation to many measures, it will be advisable to regularly change the appearance and location of deterrent devices and use combinations of harassment techniques in a rigorously applied, integrated control strategy.
- Management measures should be planned to start when birds first arrive at a site, before they establish feeding habits at water bodies to be protected. Thus, for example, on waters that typically experience cormorant predation in winter, a scaring programme should aim to start in the late autumn. As birds arriving later in a season often follow birds that are already present to feeding areas, conditioning the early birds to avoid certain waters should help to reduce damage by later arrivals. For potential recurrent problems, where longer term measures such as wiring or habitat modification might be appropriate, these should be considered prior to the arrival of birds.
- Techniques that require human presence are commonly regarded as the most effective deterrents, and those that carry biological significance and mimic threats known to birds tend to prove more effective and longer-lived than other devices.
- Managing bird numbers and presence at a site is likely to require striking an appropriate balance between the use of non-lethal deterrents and, where they are justifiable and approved, lethal measures. Shooting, too, either to kill or to scare, is thought to be most effective where it is used in combination with other deterrent measures.
- The choice of management measures used will be expected to differ between stillwater and riverine sites, largely reflecting the scale of the perceived predation and the basic differences in the morphology of the two types of water body. A wider range of non-lethal techniques will be applicable at the former; indeed, many such techniques will be impractical at the river catchment scale.
- Management programmes will likely need to be applied consistently and robustly to be successful. However, the capacity and resources available to implement management actions will also be an important consideration.
- On rivers, management efforts are likely to be most beneficial when they are targeted at identified predation ‘hot spots’ such as during the smolt run or around barriers to fish migration. This will be particularly beneficial during periods of low flows.
- Recent evidence from practical trials in England suggests that lasers can be used to effectively disperse night roosts, including on river systems. Actions will likely require repetition over a number of consecutive nights, but can be targeted selectively, avoiding the disturbance of other wildlife.

- Co-ordinated management actions are to address the concern that birds moved from a particular stretch of river may simply relocate a short distance up- or downstream with little, if any, overall benefit for fish stocks. Ongoing vigilance will be required to ensure that this does not occur and to better understand how birds react to management actions, in terms of distances moved and how long sites remain unattractive.

Experiences in other European countries

- There are widely differing approaches to the management of conflicts between fish-eating birds and fisheries in different European countries. In part, this variation reflects differences in the numbers and species of birds involved, the timing of conflicts and the nature and extent of the 'fishery' interests. For example, cormorant numbers across Europe far exceed those in the UK and birds undergo wholesale migrations from northern breeding areas to southern wintering areas.
- For cormorants, guidance is available on the use of such derogations (European Union, 2013).
- In common with the situation in Wales and other parts of the UK, a number of European countries experience conflict issues between fish-eating birds and salmonid populations in rivers. Management measures to address such conflicts include targeted actions to protect migrating smolts, killing / scaring birds from upland river stretches (with the aim of relocating birds to lowland river areas), and licensed shooting of birds above prescribed density levels on stretches of river.

8. Evidence gaps / research needs

Given the complex nature of the interactions between fish-eating birds and fisheries, and views on how best to manage these, there are numerous areas where uncertainties remain and additional evidence would be welcome. There are clearly significant challenges in addressing these uncertainties, but options for further study might include:

Gaining a better understanding of bird movements following disturbance

A key gap in our current understanding of the effects of using deterrents and shooting is what happens to birds that are disturbed through management actions, and the duration of their changes in feeding behaviour and site use. This is particularly pertinent to river catchments where there are concerns that birds may simply move a short distance up- or downstream from a managed area with no resulting benefit for fish stocks. Investigations to establish how birds respond to disturbance arising from control measures would be beneficial in better understanding impacts and informing management decisions. Such work might be addressed through mark-resighting programmes (e.g. colour ringing of birds) or through the use of telemetry studies to provide the locations of birds using appropriate tags.

Proving or disproving the hypothesis that killing enhances the scaring effect of shooting

While there is general acceptance in the field of bird management that killing birds enhances the scaring effect of shooting, the scientific evidence remains equivocal. This therefore

remains an evidence gap and an area where further research would be helpful in determining management strategies. However, the practical difficulties of objectively testing this in the field should not be under-estimated.

Providing a better understanding of the relative merits of different management options

Further information is needed on the efficacy and cost-effectiveness of different management options across a range of fishery sites to give a clearer indication of the techniques / combinations of techniques that have the largest impact, both in terms of maximising the deterrent effect on birds and in optimising the benefits for fish stocks and fisheries.

Given the current paucity of information relating to the application of different management measures against goosanders, this represents a particular evidence gap. One option might be establishing a demonstration project incorporating new scientific research and practical experimentation within an adaptive management framework. A key objective of such a study would be to investigate how best to increase the scope and geographical coverage of management activities.

Developing a demonstration project for reducing predation and resolving conflict

The evidence gap here is an applied one – how best to link and integrate research, fisheries management, and policy to deliver desired outcomes. In addition to collating knowledge, there is a need to get buy-in from people on the ground, and in experimenting with things in real world situations to address the problems (and associated perceptions).

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