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BETWEEN FISHERIES AND BIRD CONSERVATION: THE CORMORANT CONFLICT

NOTE

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POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES

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NOTE

This document was requested by the European Parliament's Committee on Fisheries.

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Abstract

Across Europe, there have been large increases in the numbers of Great Cormorants that have brought the protected birds into conflict with man through impact on inland fisheries and aquaculture. This note provides an overview of the conflict, an assessment of the effectiveness of the measures adopted to address the conflicts, including a pan European management plan, and recommendations for a management strategy to reduce the damages caused by cormorants to fisheries and aquaculture.

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CONTENTS

LIST OF ABBREVIATIONS

CORMAN	EU Project: Sustainable Management of Cormorant Populations
EAA	European Anglers Alliance
EIFAAC	European Inland Fisheries and Aquaculture Advisory Commission
FACE	Federation of Associations for Hunting and Conservation of the European Union
FAO	Food and Agriculture Organization of the United Nations
FRAP	Development of a procedural framework for action plans to reconcile the conflict between large vertebrate conservation and the use of biological resources: fisheries and fish-eating vertebrates as a model case
INTERCAFE	EU COST Action Project:Interdisciplinary Initiative to Reduce pan-European Cormorant-Fisheries Conflicts
IUCN	International Union for Nature Conservation
NACEE	Network of Aquaculture Centres in Central-Eastern Europe
PCB	Polychlorinated biphenyl
REDCAFE	EU FP5 Concerted Action Project: Reducing the conflict between cormorants and fisheries on a pan-European scale
RSPB	Royal Society for Protection of Birds
WI-CRG	Wetlands International Cormorant Research Group

LIST OF TABLES

LIST OF FIGURES

LIST OF BOXES

EXECUTIVE SUMMARY

Background

Across Europe, there have been large increases in the numbers of Great Cormorants over the past decades. Cormorants are now thought to be more frequent and widespread in Europe than at any time in the last 150 years at least. Populations have returned to some areas after a long absence and have also moved into other previously unoccupied areas. The current population trend in Europe is considered as increasing, as well as most national trends of breeding numbers.

The Great Cormorant is protected under Directive 79/409/EEC (the Birds Directive). Its deliberate capture and killing, disturbance, destruction of its nests or taking of its eggs can only be allowed by Member States if this is done in accordance with the derogation system set out in Article 9 of the Directive. The *sinensis* subspecies was previously listed in Annex I of the Birds Directive (species for which specific conservation measures were required), but as a consequence of the rapid population growth it was removed from Annex I in 1997.

This increase in numbers and distribution has brought the protected birds into conflict with man. In many European regions, great cormorant populations, in particular of the continental subspecies *sinensis*, can have potentially serious economic implications by damaging fish stocks and by reducing catches, putting pressure on fishing and aquaculture activities and thus creating various types of socioeconomic conflicts.

On 4 December 2008, echoing concerns from the various sectors affected, the European Parliament adopted a Resolution (P6_TA(2008)0583) towards a European Cormorant Management Plan to minimise the increasing impact of cormorants on fish stocks, fisheries and aquaculture. The Parliament called on the Commission to consider all the legal means at its disposal to reduce the negative effects of the cormorant population on fishing and aquaculture, and to submit a management plan coordinated at European level. However, the European Commission has not considered that an EU-wide management plan would be an appropriate measure to address this issue, arguing that the cormorant problem is of regional scale.

Aim

The aim of this note is:

- to present examples of the cormorant conflict from different EU countries/regions, the ways they have been addressed, and the effectiveness of the adopted measures;
- outline the main economic effects of the conflict, and attempt to define the major problems which prevent solving it;
- describe similar conflicts occurring, and the management measures applied;
- discuss the Commission's response to the 2008 Resolution of the EP - to what extent the measures proposed by the Commission support the development of a long-term solution to the cormorant-fisheries conflict?
- recommend a management strategy to reduce the damages caused by cormorants to fisheries and aquaculture.

The note makes use of recent information from publications, academic studies, research projects, websites and databases, European Institutions, authorities of the Members States, and any other relevant sources to review the impact of cormorants on inland fisheries and aquaculture, measure to ameliorate the problems and their efficacy and recommendations for management of the fisheries cormorant conflict in Europe.

Key findings

Two pan European censuses conducted by Wetlands International in 2003 (wintering) and 2006 (breeding) estimated a minimum of 372,00 breeding pairs for the whole of the Western Palearctic Region and the presence of at least 520,000 *P. c. sinensis* and *P. c. carbo* overwintering in Europe. Whilst an overall increase in breeding pairs was evident across Europe, different scenarios were found in different regions and countries, such that population numbers are rapidly expanding in some countries, stabilised in other and contracting in a few.

To understand any potential impact requires an understanding of both the overwintering and breeding distributions, and the recognition that cormorants have a highly active dispersal behaviour. Thus when attempting to manage the expansion of cormorant population across Europe, consideration must be given to the dispersal mechanisms of the various populations and particularly the role of juveniles to buffer mortality in existing and new colonies.

The upsurge of fish eating birds, especially cormorants, in inland waters in Europe since the late 1980s has created considerable conflict between conservationists and fisheries managers and practitioners. Damage at fisheries is rarely measured in economic terms rather as potential loss of fish stock based on consumption estimates of known numbers of birds with losses up to 80 kg/ha/yr, decline in catch per unit effort of the fishery, and wounding damage and scarring on individual fish.

Depredation at fish farms can be high and result of aquaculture units becoming economically unviable.

One aspect that is often overlooked is the indirect damage of large numbers of cormorants on ecosystem dynamics. Damage includes destruction of forestry around breeding and overwintering sites, water quality deterioration and significant influx of energy and matter from water to terrestrial ecosystems.

The main measures to control cormorant depredation or reduce numbers are: lethal measures; reducing reproductive success through egg destruction; scaring cormorants; exclusion techniques; habitat modification techniques; and fish stock management techniques. Each measure has restrictions on use and limitations on success. The main conclusion is that no one single management intervention is effective at mitigating the problems created by cormorants.

The feasibility of implementing a wide scale management plan is demonstrated through a example from Lake Huron in North America, but it is questionable whether this strategy is viable in the European scenario because of variation in management emphasis between national jurisdictions.

Several knowledge gaps were identified:

- There is a paucity of studies at different fishery types to help define impact, and there are no precise guidelines or criteria available to assess the scale of alleged damage to fish stocks and fisheries.
- Detailed research into the effectiveness of various measures to reduce the impact of cormorant depredation is needed.
- Few studies have quantified the movements, mortality/survival, immigration and emigration of birds or investigated density-dependent population regulation and carrying-capacity or cormorant populations in different systems.
- There is a need to understand the human dimensions of the conflict, and improve knowledge about how stakeholders respond to various interventions as well as defining collaborative approaches to managing the problems.

Given the complexity of the issues that must be captured if a management plan is to be successful, a multifaceted approach is required that integrates the ecological-social-economic dimensions and addresses the limitations of the current knowledge base.

To resolve the problems generated by cormorants moving inland, there is a need to examine the reasons for the colonisation and increased abundance of inland waters. **It is recommended that research efforts focus on understanding the reasons for the range expansion of cormorants across Europe and determining the ecological relationships between cormorant abundance and food resources.**

In order to formulate viable management options and resolve outstanding issues over causality in the cormorant fish conflict, there is an urgent need to assess and quantify the ecological, economic and social damages both at the European level but also damages in the different member states. **It is recommended that a study is carried out as a matter of urgency to quantify the impact of cormorants on inland waters.**

It must be recognised that fisheries and conservation management is today more a multidimensional approach that has to balance human requirements against protection of the environment and biodiversity. Consequently**, strategies to resolve the conflicts between conservation and fisheries protagonists must apply the stakeholder approach to decision-making**. The key to success involves building up relationships and sharing in the decision-making process based on sound science or factual evidence.

The main challenge is linking local, regional, national and European policy processes together in an appropriate coordinated manner. There is a need for a central coordinating unit because of the varying competencies of national and regional management bodies and inconsistencies of management approaches between Member States.

1. BACKGROUND

KEY FINDINGS

- In the past 30 years the number of breeding and overwintering great cormorants has increased dramatically across Europe creating conflict between bird conservation and fisheries and aquaculture.
- The European Parliament adopted a Resolution (P6_TA(2008)0583) towards a European Cormorant Management Plan to minimise the increasing impact of cormorants on fish stocks, fisheries and aquaculture but require objective and updated information that would be widely accepted by all stakeholders to resolve the conflicts.

1.1. Nature of the conflict

Interactions between birds and fish and fisheries have long been recognised, especially as functional units within both marine and freshwater ecosystems. In recent years, however, there has been increasing awareness of the effect of fisheries activities, mainly exploitation, on bird populations (Tasker *et al.* 2000) and vice versa, i.e. the impact of expanding populations of fish-eating birds on fish stocks (Cowx 2003a). Both interactions have led to growing concerns about, on the one hand conservation of birds, and on the other sustainability of the fisheries resources for both commercial and recreational exploitation and aquaculture development.

One of the more prominent conflicts is that between the cormorant (*Phalacrocorax* species) and inland fisheries and aquaculture. In the past 30 years the number of breeding and overwintering great cormorants has increased dramatically across Europe. Cormorants are now thought to be more frequent and widespread in Europe than at any time in the last 150 years. Populations have returned to some areas after a long absence and have also moved into previously unoccupied areas. This increase is based on the geographical distribution of two sub-species: the great cormorant (*Phalacrocorax carbo*) that lives on the Atlantic coast (the "Atlantic race"), and the subspecies *Phalacrocorax carbo sinensis* (the "continental race"), which lives on the continent from Western Europe across the whole of the Asian Continent to China and India. Similar large increases in the number of cormorants have also been experienced in North America with the double breasted cormorant (*Phalacrocorax auritus*).

The great cormorant is protected under Directive 79/409/EEC (Birds Directive[1]). Its deliberate capture and killing, disturbance, destruction of its nests or taking of its eggs can only be allowed by Member States if done in accordance with the derogation system set out in Article 9 of the Directive. The *P. c. sinensis* subspecies was originally listed in Annex I of the Birds Directive (species for which specific conservation measures were required), but as a consequence of rapid population growth it was removed from Annex I in 1997[2].

This increase in numbers and distribution has brought the protected birds into conflict with man. In many European regions, great cormorant populations, in particular of the continental subspecies *P. c. sinensis*, can have potentially serious economic implications by

[1] OJ L 20, 26.1.2010, p.7 (codified version replacing Directive 79/409/EEC).
[2] Commission Directive 97/49/EC, OJ L 223, 13.8.1997, p.9.

damaging fish stocks and reducing catches, putting pressure on fisheries and aquaculture activities and thus creating socioeconomic conflicts.

On 4 December 2008, echoing concerns from the various sectors affected (Kindermann 2008), the European Parliament adopted a Resolution (P6_TA(2008)0583) towards a European Cormorant Management Plan to minimise the increasing impact of cormorants on fish stocks, fisheries and aquaculture. The Parliament called on the Commission to consider all the legal means at its disposal to reduce the negative effects of the cormorant population on fishing and aquaculture, and to submit a management plan coordinated at European level. However, the European Commission considered that an EU-wide management plan would not be an appropriate measure to address this issue, arguing that the cormorant problem is of regional scale. This arises, partly because there is no consensus between Member States on the type of action to take, or on the need and value of managing cormorant populations at a pan-European scale. The Commission is, however, in favour of ensuring better scientific data, and making available objective and updated information that would be widely accepted by all stakeholders regarding the populations and the biology of the cormorants across the EU, and their impact on fisheries.

The following activities are currently being undertaken by the Commission:

- Elaboration of a guidance document on Article 9 of the Birds Directive in relation to cormorants, addressing issues such as "serious damage" as well as indicating what actions would be acceptable and compatible with the Directive (draft, submitted to public discussion in September 2011);
- A technical internet platform (the EU Cormorant Platform[3]), through which information of relevance for Member States and other users is made available; the Platform will be further developed during 2012 and 2013;
- "Best Practice" solutions to reduce the impact of cormorants on fisheries to be disseminated through the EU internet Cormorant Platform;
- Collaboration with the IUCN/Wetlands International Cormorant Research Group [WI-CRG] to organize pan European counts of breeding colonies (in 2012) and of night roost used in winter (January 2013).

1.2. Aim of the document

The aim of this note is:

- to present examples of the cormorant conflict from different EU countries/regions, the ways they have been addressed, and the effectiveness of the adopted measures;
- outline the main economic effects of the conflict, and attempt to define the major problems which prevent solving it;
- describe similar conflicts occurring, and the management measures applied;
- discuss the Commission's response to the 2008 Resolution of the EP - to what extent the measures proposed by the Commission support the development of a long-term solution to the cormorant-fisheries conflict?
- recommend a management strategy to reduce the damages caused by cormorants to fisheries and aquaculture.

[3] The EU Cormorant Platform - http://ec.europa.eu/environment/nature/cormorants/home_en.htm.

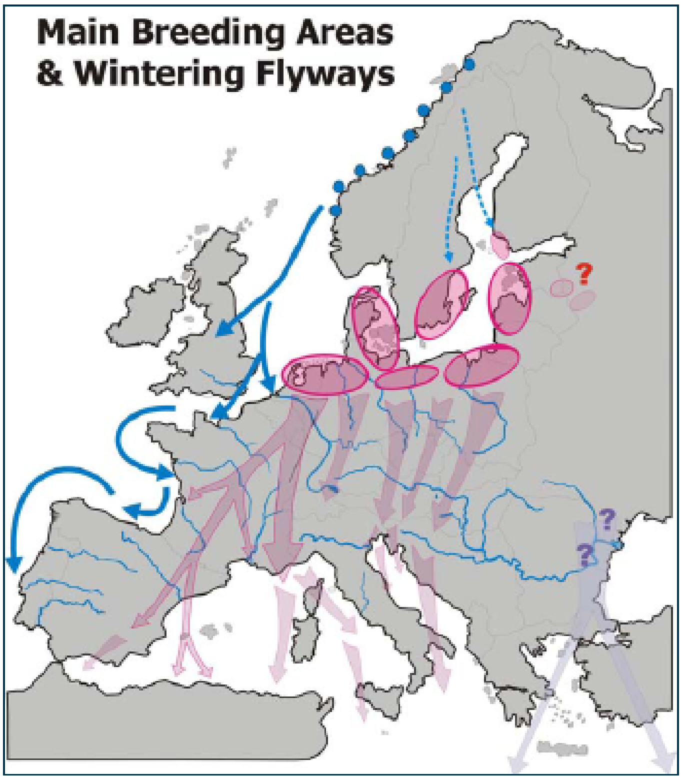
2. DISTRIBUTION AND ABUNDANCE OF BIRDS

KEY FINDINGS

- Two pan European censuses conducted by Wetlands International in 2003 (wintering) and 2006 (breeding) estimated a minimum of 372,000 breeding pairs for the whole of the Western Palearctic Region and the presence of at least 520,000 *P. c. sinensis* and *P. c. carbo* overwintering in Europe.
- Whilst an overall increase in breeding pairs was evident across Europe, different scenarios were found in different regions and countries, such that population numbers are rapidly expanding in some countries, stabilised in other and contracting in a few.
- To understand any potential impact requires an understanding of both the overwintering and breeding distributions, and the recognition that cormorants have a highly active dispersal behaviour.
- When attempting to manage the expansion of cormorant population across Europe, consideration must be given to the dispersal mechanisms of the various populations and particularly the role of juveniles to buffer mortality in existing and new colonies, and the likely implications of climate change on range expansion.

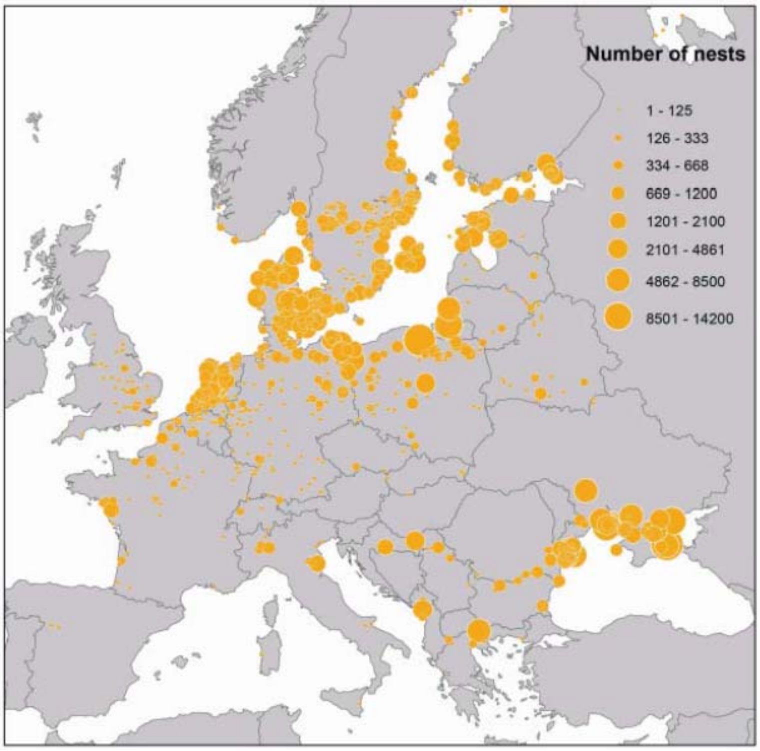
The great cormorant is a highly mobile species that can move several hundred kilometres between breeding colonies in the north towards the south in autumn, returning again in spring (Figure 1). In addition, the species exhibits an active dispersal behaviour on a broad spatial scale, often across several countries. Ringing studies showed that birds breeding in one European country usually spend the winter in others, often to the south, moving across the continent in a partial migration after breeding. For example, Danish-born cormorants

Figure 1: Main breeding areas and winter flyways for great cormorant in Europe



Source: Kohl (2004).

Figure 2: Distribution and relative size of great cormorant colonies in the Western Palearctic around 2006. The map only denotes the location of colonies where the subspecies *sinensis* was breeding. No geo-reference data were available for *sinensis* colonies in Hungary, Bosnia-Herzegovina, Albania, Macedonia, Moldova, Turkey and information was missing for some colonies or areas in: Latvia, France, Spain, Greece, Romania, Ukraine and Russia. The two subspecies *carbo* and *sinensis* breed in mixed colonies in inland colonies in England and in coastal and inland colonies in France and most of these colonies are included on the map.



Source: Bregnballe *et al.* (2011a) http://ec.europa.eu/environment/nature/cormorants/breeding-distribution-2006.htm

have been recorded in over 26 European and African countries (Bregnballe *et al.* 1997), and cormorants wintering in Switzerland come from the entire European breeding range (Reymond and Zuchuat 1995). This has important implications when discussing an international management plan for the European cormorant populations.

The number of cormorants in Europe declined to a very low level in the first half of the 20th Century, mainly as a result of persecution, leading the near extirpation of the sub species *Phalacrocorax carbo sinensis* in several countries. Following the species being afforded legal protection, numbers increased throughout the 1980s, and apparently stabilising in the 1990s in some countries (e.g. Denmark, The Netherlands) under natural (non-human) influences (Bregnballe *et al.* 2011a), but populations of both subspecies are still increasing elsewhere (Carss 2003; Carss and Marzano 2003). This appears to be colonisation of suitable habitat not yet occupied by young birds. [Note: movement between colonies by established breeders is relatively uncommon, and mainly occurs in response to human disturbance.]

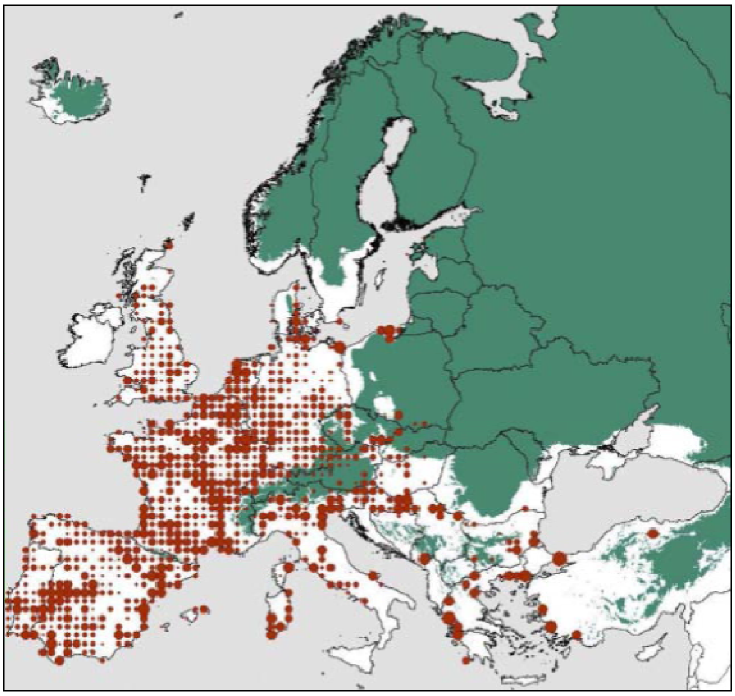
The first pan-European census of cormorants in 1992, estimated some 105,000 breeding pairs of *P. c. sinensis* and 45,000 pairs of *P. c. carbo*. In Central Europe, the number of breeding pairs of *P. c. sinensis* rose from 40,000 to 77,000 pairs between 1988 and 1992, a

93% increase. Data for *P. c. carbo* from the same period are less complete, but the population increased by less than 20% during this time.

The most recent coordinated count of breeding colonies of cormorants in Europe in 2006 (Figure 2; Bregnballe *et al.* 2011a) suggested the presence of about 52,000 pairs of the subspecies *P. c. carbo* (Greenland not included). Norway had the largest breeding population of 30,000 pairs. Fewer were breeding in the United Kingdom (8,500 pairs), Ireland (4,500 pairs), Iceland (4,100 pairs) and probably fewer than 3,000 in France. The vast majority of the subspecies *P. c. sinensis* were breeding around the Baltic Sea, with 165,650 breeding pairs associated with 517 breeding colonies. The most important breeding areas for *P. c. sinensis* in western and central Europe were The Netherlands (23,500 nests), France (≈6,000 nests) and Hungary (3,200 nests). The largest breeding numbers close to the Mediterranean Sea were in Montenegro (2,000 nests) and Greece (>4,600 nests). The size of the breeding population in the Danube Delta and the northern coastal areas of the Black Sea (Ukraine) could not be precisely estimated due to incomplete coverage, but a total of 120,750 nests were observed.

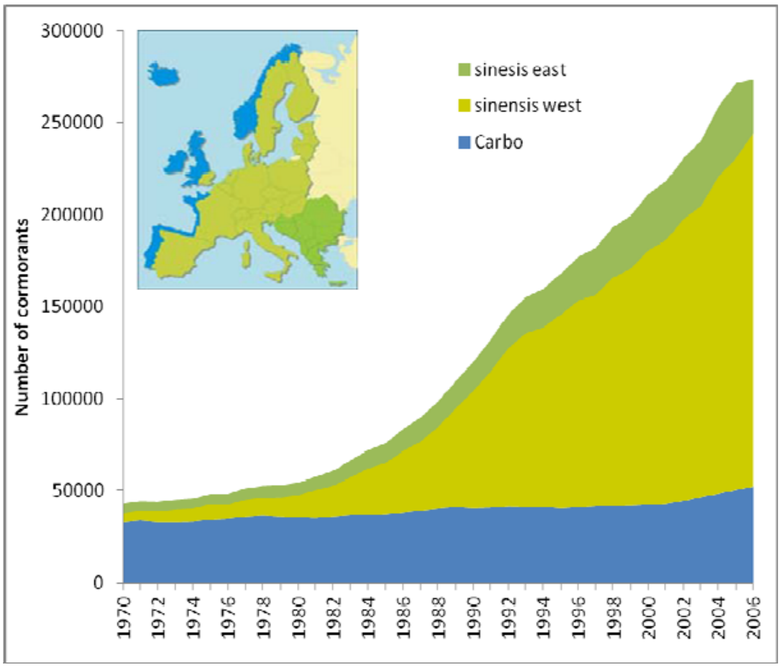
Winter numbers have increased in accordance with increases in the breeding populations, and 2003 estimates for the winter period indicated the presence of at least 150 000 *P. c. sinensis* and 120 000 *P. c. carbo* in Europe (Figure 3). However, these data are known to be incomplete and thus provide minimum estimates. The most important wintering areas for *P. c. carbo* are Norway, France and Great Britain, whilst France, Italy and Spain, collectively supporting more than 50% of the population, are the primary wintering areas in western Europe for *P. c. sinensis*.

Figure 3: Distribution of cormorants in Europe in January 2003. Only geo-referenced data are shown, thus excluding most *carbo* birds in Norway, Iceland and Ireland, as well as birds in Ukraine, Russia and parts of Turkey. Green area depicts the average long-term winter temperature of -5.5°C that largely coincides with areas not used by wintering cormorants.



Source: Van Eerden *et al.* (2011b)

Figure 4: Trends in number of breeding *P. c. carbo* and *P. c. sinensis* (West and East in Europe between 1970 and 2006. Data exclude Belarus, Ukraine, Russia and Moldova.



Source: Kohl (2006) reviewed and updated

Despite the pan-European coordinated counts, there remains a lack of consensus between stakeholder groups about the data and any trends arising. It arises because of an apparent lack of consistent census methods between countries, to which geographical region or year the counts relate, and the frequency of counting. Consequently, a pan-European census of breeding is being coordinated by WI-CRG[4] under the CORMAN project in the 2012 breeding season and in the winter of 2012/13 to clarify the current status. Nevertheless, exploration of the literature coupled with initial findings of more recent censuses of breeding pairs (Kohl 2006 reviewed and updated) gives insights into trends in breeding numbers (Figure 4). In essence, the number of *P.c. carbo* in western Europe is increasing only marginally, whilst huge expansion in both the range and abundance of *P.c. sinensis* is apparent in west, central and northern Europe, but less so in the south and eastern Balkan states.

Whilst an overall increase in breeding pairs was evident across Europe, different scenarios were found in different regions and countries highlighting several issues about counts (Figure 5 and Annex 1):

- Breeding numbers in Finland were rapidly expanding[5], stabilising in Germany and declining in Denmark (Bregnballe *et al.* 2011b);[6]
- The breeding population in Denmark has gradually become more and more dispersed over the last 30 years with cormorant breeding now far more evenly distributed over the country.
- The number of breeding pairs in Denmark has declined some 35% from a relative stable population size of 36,500 to 42,500 nests between 1993 and 2006 to 25,189 nests in 2011.

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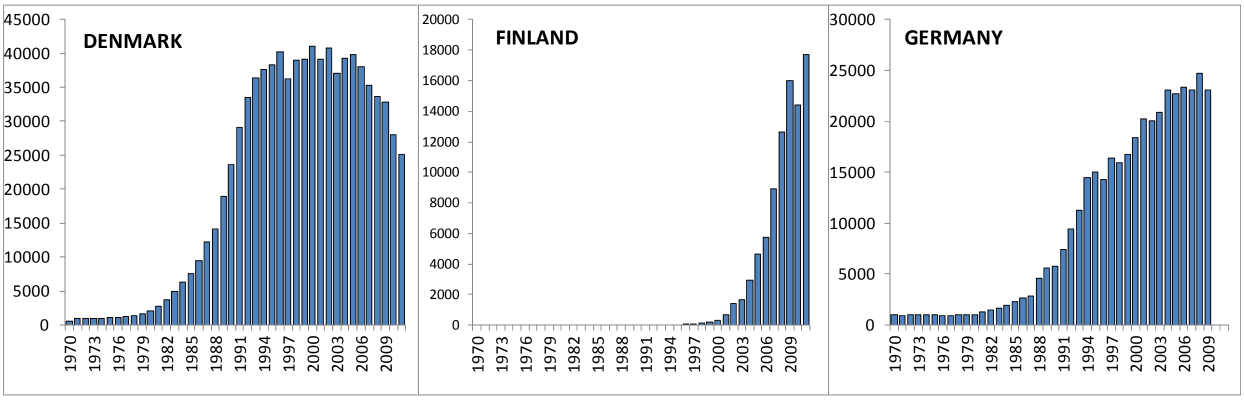
[4] http://www.cormocount.eu/
[5] http://www.ymparisto.fi/default.asp?contentid=390720&lan=en
[6] http://www.cormocount.eu/results/denmark.aspx

Figure 5: Trends in number of breeding *P. c. sinensis* in Demark, Finland and Germany between 1970 and 2011.



Source: Bregnballe *et al.* 2011a; http://www.dmu.dk/dyrplanter/dyr/skarv_-_udvikling_i_bestande/; http://www.ymparisto.fi/default.asp?contentid=390720&lan=en; http://www.cormocount.eu/results/denmark.aspx; http://www.environment.fi/

A number of factors have been suggested to explain the various trends observed (Frederiksen and Bregnballe, 2000).

- The high population growth rate sustained by European *P. c. sinensis* in the 1970s and 1980s can partly be accounted for by unusually high survival of immature and adult birds, probably caused by absence of hunting, low population density and high food availability.
- Colony fidelity declined after 1990 from nearly 1 to approximate to 0.90, implying 10% permanent emigration per year. This change coincided with a decline in food availability.
- Survival is heavily influenced by winter severity, especially when population size was high. This could be caused by saturation of high-quality wintering habitat, forcing some birds to winter in less good habitat where they would be more vulnerable to cold winters. There is thus evidence for density dependence in adult survival, at least in cold winters.

The latter is particularly pertinent because the reduction is numbers in Denmark is thought to be the outcome of the particularly harsh winter of 2010. This highlights the potential implications of climate change on distribution and survival of great cormorant, which may contribute to the range expansion.

Whilst these trends are indicative of breeding population change, it should be recognised that estimates of the total cormorant population sizes should account for both breeding and non-breeding birds. The counts of breeding populations are based on nest counts and do not account for juvenile birds in the first two years of life prior to them reaching breeding age. Under these circumstances, the estimated numbers of birds will typically depend on how the respective models incorporate estimates of reproductive output, as well as annual mortality, for different age birds. Accounting for juvenile birds is essential because these are likely an important component of the range expansion and act as the buffer for maintaining established populations should they suffer high levels of mortality through, for example, shooting or harsh overwinter conditions.

3. IMPACT OF CORMORANTS ON INLAND FISHERIES RESOURCES

KEY FINDINGS

- The upsurge of fish eating birds, especially cormorants, in inland waters in Europe since the late 1980s has created considerable conflict between conservationists and fisheries managers and practitioners.
- Damage at fisheries is rarely measured in economic terms rather as potential loss of fish stock based on consumption estimates of known numbers of birds with losses up to 80 kg/ha/yr, decline in catch per unit effort of the fishery, and wounding damage and scarring on individual fish.
- Depredation at fish farms can be high and result of aquaculture units becoming economically unviable.
- One aspect that is often overlooked is the indirect damage of large numbers of cormorants on ecosystem dynamics. Damage includes destruction of forestry around breeding and overwintering sites, water quality deterioration and significant influx of energy and matter from water to terrestrial ecosystems.

3.1. Background

The upsurge of fish eating birds, especially cormorants, in inland waters in Europe (Carss 2003; Carss and Marzano 2003; Bregnballe *et al.* 2011b; van Eerden *et al.* 2011a) and elsewhere in the world (see for example Burnett *et al.* 2002; Johnson *et al.* 2002; U.S. Department of Interior Fish and Wildlife Service 2003; Hebert and Morrison 2003; Rudstam *et al.* 2004; Fielder 2008) since the late 1980s has created considerable conflict between conservationists and fisheries managers and practitioners. Whether this is a new phenomenon is debateable because cormorants existed around inland waters in the past (see Wright, 2003), but their numbers were reduced by shooting or other control measures, and/or bird population breeding success was adversely affected by chemical pollutants, especially PCBs. In Western Europe there is also debate as to whether the influx of cormorants is of the European inland species *P. c. sinensis* or the endemic *P.c. carbo* species. Notwithstanding these arguments, the increased presence of cormorants is perceived as detrimental for a number of reasons (Carss 2003; Carss and Marzano 2003). Both fish farmers and commercial fishermen argue they have resulted in reduced catches, whilst the most important issue for both recreational anglers and nature conservationists is reduced fish stocks through lowered production and loss of biodiversity. Recreational fisheries stakeholders frequently report conflicts over reduced catches and effects on fish population dynamics and community structure, an issue that is also important to nature conservationists. Fish farmers and commercial fishermen are concerned over loss of earnings from the fishery, the former stakeholders cite conflicts over loss of stocked fish and the latter conflicts over reduced stock through lowered production. Finally, nature conservationists also frequently express concerns over loss of juvenile fish and lowered recruitment, scaring/shooting disturbance, and damage to vegetation and the landscape, especially forestry.

Despite the apparent conflict, there appears to be a paucity of definitive information at the fish population level to provide useful quantitative measures of impacts or direct economic loss to fisheries. Instead the information is determined through modelling or associated change in performance of fishery and aquaculture enterprises. The aim of this section is to review available information on fish population levels, the dietary habits of feeding birds, and robust calculations of fish consumption to provide a basis for assessment of impact. It should be noted that similar protection and resultant conflicts over fish-eating birds have been enacted in other parts of the world, especially North America and Japan, leading to similar scenarios (U.S. Department of Interior Fish and Wildlife Service 2003; Kameda *et al.* 2003).

3.2. Cormorant depredation on open water fisheries

Global conflict between cormorants (*Phalacrocorax* spp.) and fish harvesters is one of the most widespread wildlife management issues in history. The impact of bird depredation on fisheries is varied and open to debate, both in real and perceived terms (Cowx 2003b). Numerous studies have been carried out on the food intake and diets of cormorants in many water body types (e.g. see Carss 2003; Carss and Marzano 2003 and edited volumes by Cowx 2003a; Keller *et al.* 2003; Bregnballe *et al.* 2011a). The main conclusions are that they consume shoaling species such as roach, perch, ruffe as well as carps in still waters, and mid-water species such as trout, grayling, chub and dace in rivers. In North America, alewife, yellow perch and walleye and channel catfish are common species consumed by cormorants. Salmon smolts are also heavily predated upon as they emigrate through estuaries (Koed *et al.* 2006; Harris *et al.* 2008).

There is considerable evidence that these birds can, in some situations, remove large numbers of fish from stocked and natural fisheries, but there is a lack of information at the fish population level, integrating robust calculations of fish consumption by feeding birds with fish stock dynamics to provide useful quantitative measures of impact (see Annex 2). As a consequence, few studies have demonstrated significant reductions in numbers of breeding fish or fish productivity due to predation by piscivorous birds, or direct economic loss to fisheries (Harris *et al.* 2008). There is also considerable debate over the apportioning impact of cormorants to declines in fish stocks, fisheries and angling (see Russell *et al.* [1996] for review and Suter [1995, 1998] v Staub *et al.* [1998] for an example of the conflicting debate). Much of the problem in assessing the impact of cormorants on fisheries arises because the spatial distribution, abundance, size distribution, recruitment and growth of fish populations/communities are regulated/controlled by many biotic and abiotic factors, of which bird predation is but one. There is, therefore, no single factor that is directly responsible for constraining the development of fish populations, rather there are complex interactions between many factors. In addition, one must consider the effects that human activities have had on the freshwater environment and how these might influence fish populations/communities (see Welcomme *et al.* 2010 for overview).

Notwithstanding the conflicts between parties and complexity of providing empirical evidence of impact of fish-eating birds on fish stocks, some indicators of potential impact are available.

- Cormorants consume 672 g/day (predicted maximum range 441-1095 g/day) per individual bird (Carss *et al.* 1997, Gremillet *et al.* 2003)
- The length of fish consumed ranged from 40-335 mm, with 47% of the fish belonging to the length category 100-149 mm. Predation on this size range is critical because cormorants are feeding on fish that are beyond the size range where compensatory density-dependent mechanisms are important.
- Loss or considerable reduction of stock - usually on fish farms and intensively stocked fisheries, e.g. cormorants took 21% of the total annual fish production in Bavarian lakes (Keller 1995) and 8.2% of vendance (about 4 t/yr) in Polish lakes

(Wziaqtek *et al.* 2007). Predation can equal or exceed that of fisheries on the same water body (e.g. Fielder 2008; Zydelis and Kontautas 2008). Huge biomasses of fish can be removed annually from heavily depredated fisheries, e.g. 14,000 t/yr in Lake Ontario (Johnson *et al.* 2002) and 18,776 t/yr in Lake Erie (Hebert and Morrison 2003).

- Predation on part of the stock - usually natural fisheries (see Russell *et al*. 1996 for examples). Predation rates as high as 80 kg/ha per year (Evrard *et al.* 2005) (but more typically in the range <15 kg/ha, e.g. Dirksen *et al.* 1995; Engstrom 2001), which can be considerable when related to typical stock abundance in temperate rivers and lakes of 50-150 kg/ha (Welcomme *et al.* 2010).
- Decline in catch per unit effort of both commercial and recreational fisheries, as much as a 100-fold decline reported (Vetemaa *et al.* 2010).
- Wounding/damage to fish - mainly where the stock comprises large individuals and often fish that are the target of valuable recreational fisheries such as big carp (Russell *et al*. 1996).
- Scaring of fish, especially on natural water bodies (Russell *et al*. 1996).

These impacts can all lead to direct economic loss to the fishery. The net loss of fish through increased depredation, and wounding and scaring of fish, all potentially reduce the fishery performance and this has economic implications for the fishery owners. Where the loss is realised in a decline in the catch, the usual response is to replace the fish through stocking, which has financial implications. In addition, reduced fishery performance tends to discourage anglers and this leads to a reduction in economic rent/income. Occasionally, however, depredation can result in a positive outcome realised through accelerated growth rates and improved quality of fish for capture (Britton *et al.* 2002, 2003). Basically, the reduced stock density creates great scope for growth, and fish pass the critical stage of intense predation pressure (100-140 mm in length) quicker, thus making more, larger fish available to recreational fishing. This latter aspect serves to illustrate the problems with assessing impact in real terms. These problems led Feltham *et al*. (1999) to conclude that assessing the "impact by fish-eating birds is a problem for specific fisheries rather than a general one". It appears that at some sites depredation levels may be high enough to cause a decline in the fishery and at others they may not. There is no single level of depredation in terms of, for example, the proportion of standing crop removed by birds, and no single estimate of impact (e.g. percentage annual decline in catches) that can be taken as the threshold above which loss is considered detrimental. Each fishery appears to have its own threshold set by the complex interaction between bird depredation and fish population dynamics, and between consumption and production.

3.3. Depredation at aquaculture facilities

Despite the considerable concern expressed about the impact of depredation and wounding at aquaculture facilities, little quantitative evidence exists about the scale of the problem, especially in Europe. Perhaps the most definitive assessment is that of Glahn and Brugger (1995) and Glahn *et al.* (2002), who used the energetic requirements of double-crested cormorant, *Phalacrocorax auritus*, their relative abundance and the state of the southeastern USA channel catfish, *Ictalurus punctatus*, aquaculture industry to predict the economic impact of cormorants. They estimated the cost of replacing the 18-20 million catfish fingerlings consumed by cormorants to be in the region of US$7 million annually, and the actual economic loss of overall production to the catfish farmers in southeast USA may approach US$25 million (Glahn and Dorr 2002), although Dorr *et al.* (2012) suggested that these economic losses are highly variable because of volatility in production costs and sale prices.

Within Europe, Lekuona (2002) found depredation by cormorant and grey heron at a fish farm in Arcachon Bay (southwest France) (estimated at 53.0% and 10.8% respectively of the annual yield of the fish farm) imposed a significant economic loss because of reduced productivity of the farm, and Opacak *et al.* (2004) found cormorants consumed 47% of fish in the 100-149 mm length class in fish ponds at Donji Miholjac in eastern Croatia, thus causing damage to the viability of the farm.

3.4. Wounding and scaring

Whilst depredation remains the overriding impact of cormorants on fish populations, there are also concerns raised about the effects of wounding and scaring on fish stocks. Gremillet *et al.* (2003, 2006) found that, despite cormorants being regarded as highly efficient predators, they aborted about half of their pursuits because fish escaped from the cormorant's grasp and/or could not be swallowed due to their size. Some of these fish suffer from various injuries, resulting in infections and subsequent increased mortality (Adamek *et al.* 2007). Although the proportion of injured fish is generally low in natural fisheries (<5%), up to 18% of fish have been found injured by cormorant attacks in farm ponds (Kortan and Adamek 2011). Kortan *et al.* (2008) also found that up to 47% of two-year-old mirror carp, *Cyprinus carpio,* (TL 200-300 mm, W 200-300 g) showed these injuries, which can cover up to 10% of the total body surface but with damaged epithelium (scars) in up to 35% of the body surface and deeper sub-dermal wounds caused by the beak tip pervading into muscle tissue covering an area of 1-2% of the total body surface. This scarring can lead to significant economic losses in both stillwater (Callaghan *et al.* 1998) and commercial fisheries, such that fish are undesirable for capture or cannot be sold (Engstrom 1998).

In the same context, cormorants are known to scare fish into refuge habitat. This is into small streams or under overhanging structures of complex habitat, which means the fish are no available to the fishery (Feltham *et al.* 1999). In some cases, the densities of fish in these refuge habitats can be so high that they are vulnerable to oxygen depletion and ultimately mortality.

3.5. Ecosystem dynamics

The numerous studies on the diets of cormorants suggest that cormorants forage on a diverse array of fish species. Nevertheless, Doucette *et al.* (2011) argued that cormorants may have specific and uniform dietary niche requirements, which could have adverse effects on food webs. For example, cormorants should have little economic impact where food webs are diverse with abundant prey species. Alternately, food webs with less diversity of prey species may be more affected by cormorant predation. Consequently there is a need to avoid assuming that cormorants will have negative impacts on fisheries and instead consider the structure of the food web as well as the niches occupied by cormorants and fish species of economic interest.

In this context, the expansion of cormorant numbers, and specifically the large aggregations of birds into nesting and overwintering colonies, has also brought about several other ecosystem effects. Specifically cormorants affect forest ecosystems (Goc *et al.* 2005). They damage pine trees by picking their twigs as nest material. A huge amount of bird droppings is harmful to trees and plants growing below the canopy, and large areas of forest associated with big colonies can be killed, e.g. in Poland where damage to trees in the Kąty Rybackie colony (covering some 100 ha of pine forest) has caused a conflict between cormorants and foresters. Eggshells and contents of cormorant pellets neutralise soil acids. The faecal material also fertilises the soil resulting in increased loadings of nitrogen, saturation of total phosphorus and reduction in phosphate adsorption capacity (Breuning-Madsen *et al.* 2008), ultimately potentially leading to leaching into nearby water courses resulting in nutrient enrichment, and possibly inducing eutrophication, which may have implications for Water Framework Directive designation in relation to water quality. Carcasses of adults and chicks also attract predators and scavengers. In general, the presence of a colony changes many of the habitat parameters and initiates a chain of succession stages. Cormorants shorten the food chains and as a result accelerate the turnover rate in the biogeochemical cycle. Cormorants can thus be responsible for a significant influx of energy and matter from water to terrestrial ecosystems.

4. CURRENT ACTIONS TO RESOLVE THE IMPACT OF PISCIVOROUS BIRDS ON FISH STOCKS

KEY FINDINGS

- The main measures to control cormorant depredation or reduce numbers are: lethal measures; reducing reproductive success through egg destruction; scaring cormorants; exclusion techniques; habitat modification techniques; and fish stock management techniques.
- Each measure has restrictions on use and limitations on success. The main conclusion is that no one single management intervention is effective at mitigating the problems created by cormorants.
- The feasibility of implementing a wide scale management plan is demonstrated through an example from Lake Huron in North America, but it is questionable whether this strategy is viable in the European scenario because of variation in management emphasis between national jurisdictions.

4.1. Management measures

Several reviews of various management measures to control damage by fish-eating birds to inland fisheries have been carried out regarding the effectiveness of cormorant control measures (Kirby *et al.* 1996; McKay *et al.* 1999), including syntheses under the REDCAFE and INTERCAFE projects. The main measures can be broken down as follows:

- Lethal measures to reduce cormorant number directly;
- Reducing reproductive success through egg destruction;
- Scaring cormorants away from fishery or aquaculture unit;
- Exclusion techniques;
- Habitat modification techniques to reduce availability of fish to cormorants.
- Fish stock management techniques to reduce availability of fish to cormorants;

It is not the intention to discuss individual measures as the INTERCAFE project will provide this through the TOOLBOX, and the document will be available through the EU Cormorant Platform. Instead the objective and efficacy of each measure is summarised in Table 1 and insights to the outcomes of applying the main measures are presented through case studies (Boxes 1-5).

The various measures are deployed in different European countries to different extents, and with varying degrees of success. The choice of measures depends on the scale of the fisheries cormorant conflict, the type of water body or fishery operation impacted and the potential economic losses incurred. For example, large scale shooting takes place in France (Box 1), Norway, Sweden, Denmark and parts of Germany (Table 2), although the effectiveness of these measures is questionable (see section 4.5). Similarly, oiling and egg pricking (Box 2) is used in several countries with limited effect on controlling cormorant numbers.

Table 1: Overview of measures to reduce impact of cormorants on fisheries and aquaculture.

MEASURE AND OBJECTIVE	EFFICACY AND ACCEPTABILITY
Lethal measures to reduce cormorant numbers directly (Case study 1)	
• Active removal of adult breeding birds or overwintering birds from the population. • Shooting at a site-specific or local level. • Coordinated culling for population control.	• Effect short-lived and bird numbers recover to pre-treatment levels over a period of a few weeks. • To be effective in the longer term, shooting needs to be repeated at frequent intervals. • Killing birds at roosts near aquaculture ponds or on the ponds is likely to create only short-term respite and may also push birds into other areas where they might become a problem. • Localized culling around fish aquaculture and hatchery sites could become large population sinks, where culled birds are replaced by others seeking a rich food source. • Local reductions on the non-breeding grounds would have a trivial impact on a continental scale, and thus the same problem will recur in the next season when new wintering birds appear. • Shooting adults also helps reduce cormorant predation pressure through harassment of the remaining birds. • Lethal means of regulating cormorant numbers have not yet met with success (Belant *et al.* 2000, Glahn *et al.* 2000). • Raises ethical, moral and legal questions. • Dispute over whether Article 9 derogation is valid for non hunting birds.
Reducing reproductive success (Case study 2)	
• Egg destruction, for example, by oiling [*spraying eggs with inert mineral or vegetable oil*] and egg pricking.	• Benefit of egg oiling over destroying eggs is that cormorants will continue to incubate the eggs and are less likely to attempt to re-nest. • Reduces the number of hatchlings. • Takes about two years before there is a noticeable change in number. • Raises ethical, moral and legal questions.
• Destruction of nests and breeding habitat.	• Nests or nesting trees can be removed or physically broken up with the hope that adult birds will either leave the area, or fail to rebuild and re-nest successfully that season. • Nest destruction is relatively labour intensive, although can be practical on smaller colony sites. • Requires more than one visit per colony as birds are known to re-nest and lay additional eggs if nests and eggs are destroyed (time consuming). • Constrained by factors such as adverse environmental or amenity impact and influenced by the availability of alternative roosting sites. • Raises ethical, moral and legal questions.
Scaring cormorants away from fishery or aquaculture unit (Case study 3)	
• Auditory deterrents: automatic exploders, pop-up scarecrows with exploders, pyrotechnics,	• Can discourage cormorants from using specific sites. • Roost dispersal may move depredating birds from the area but pass on the problem. • Measures are only thought to have an effective range up to

alarm or distress calls. • Visual deterrents: laser guns, reflecting tapes, eyespot balloons, scarecrows, lights, water spray devices. • Aerial harassment with ultralight aircraft, radio-controlled model airplanes; ground harassment with vehicle patrols. • Chemical [conditioned taste aversion] deterrents.	200 m so of little use on river systems or larger sites. • Cormorants learn quickly and these methods often do not deter the birds for long. • For harassment to be effective, a variety of techniques should be used in combination, and the location and combination of devices should be changed frequently for best results. • Cormorants only move to another site so will only work if there are alternative feeding areas nearby. • Use of such devices may be constrained where there are risks of disturbing other wildlife or human habituation.
Exclusion techniques (Case study 4)	
• Netting enclosures using nets, wires, floating plastic balls. • Facility design and construction.	• Nets provide a physical barrier and are effective as long as the edges of the nets extend to the ground surrounding the pond. • Cost may be prohibitive for large ponds. • Overhead wire systems work by making it difficult for cormorants to land on, and take off from, ponds. Although these systems are effective at preventing large flocks from landing, individual birds often learn to fly between the lines, or land on levies and walk into the pond despite the wires • Success of both wire systems and floating ropes depends on the availability of alternative foraging areas nearby. • Construction of pond margins and bottom profile, location of fingerling ponds, and feeding techniques may lessen damage.
Habitat modification techniques to reduce availability of fish to cormorants (Case study 5)	
• Elimination of resting or roosting places. • Elimination of nests. • Improving habitat quality for fish. • Construction of artificial fish refuges.	• Fish refuges can reduce fish losses, the foraging efficiency of cormorants and the incidence of damage to fish. • Practical constraints regarding the use of refuge structures in rivers and larger still-waters (especially those that are also used for water-sports). • Causes obstructions and snagging to anglers but also increases flooding risk in large rivers.
Fish stock management techniques to reduce availability of fish to cormorants	
• Increase the size of individuals stocked, regulation of stocking density. • Alter stocking strategy [timing of stocking, frequency and location of stocking]. • Use of buffer species to divert cormorants from predating on valuable species.	• Reduces depredation on small sized individuals, but can increase scarring on larger individuals. • Not always feasible because of availability of stock. • Increases cost of stocking.
No control	
• Allows for a natural balance in species interrelationships to become established.	• Outcry from stakeholders affected by cormorant depredation. • May not be acceptable where the survival of an endangered species is at risk.

Scaring is a well established method that is applied across Europe with varying degrees of success. Scaring devices cover a range of visual and auditory tools from shooting, through gas cannons, fireworks, reflectors, bells and the presence of people during daylight hours. The method is considered locally effective but requires considerable coordinated effort to be regionally effective (see Hula Valley case study: Box 3).

Scaring methods can, and often are, coupled with other exclusion (Box 4) and habitat modification (Box 5) methods that control access of cormorants to the fish and fisheries. These include wires and netting that prevent cormorants from landing on the water and foraging or habitat modification and complexity that act as refugia for fish from cormorants. Whilst these are effective at the local level in small scale water bodies or small fish farm ponds, they are largely impractical for large water bodies, especially where they are utilized for angling, navigation or other conservation species, including birds. These exclusion actions can be supported by modification to the fish stocking protocols, such that larger fish, outside the normally foraging size of cormorants (i.e. >180 mm long) are stocked and at times when cormorant numbers are lowest.

4.2. Lethal actions against cormorants in Europe

As with all wild bird species naturally occurring in the European territory of the Member States, the great cormorant *Phalacrocorax carbo* is covered by the general protection scheme under Directive 2009/147/EC on the conservation of wild birds (the Birds Directive)[7]. Its deliberate capture and killing, disturbance, destruction of its nest or taking of its eggs can only be allowed by Member States in accordance with the derogation system of the Directive (Article 9). Most EU countries permit lethal control, mostly shooting, under the Article 9 derogation (Table 2). However, other countries, such as the Netherlands, do not apply the derogation. This has implications if a pan-European cull is to be considered.

According to reports submitted to the European Commission under the Article 9 derogation system, 235,000 cormorants have been killed in the EU between 2001 and 2006 to prevent serious damage or to protect flora and fauna, of which 56% were killed in France (**Error! Reference source not found.**). This equates to approximately 40,000 birds per year and represents about 3% of the total annual overwintering bird population. This figure is in agreement with the 55,000 birds killed, which was derived under the EU REDCAFE project for 25 countries, including Norway, where some 10,000 are killed annually. In Norway, cormorants are hunted legally for food under an open season, but afforded protection at other times.

More recent estimates of the number of birds killed outside the breeding season derived under the EU INTERCAFE project indicated that some 87-90,000 were killed over the winter of 2006-2007. This again includes some non EU countries.

[7] OJ L 20, 26.1.2010, p.7 (codified version replacing Directive 79/409/EEC).

Table 2: Variation in use of lethal control measures, compensation and adoption of management plans between European countries.

Country	Bird numbers (breeding pairs)	Shooting allowed	Number shot annually	Is there a management plan in place	Compensation
Austria	230[3]	No		Yes	
Belaurus	1500[3]				
Belgium	2000[3]	No		No	Yes[1]
Bulgaria	2800[3]			No	
Croatia		Yes[1]			Yes[1]
Czech Republic	300	Yes	Between 2000 and 3800 annually between 2000 and 2009	No	
Denmark	33,500 in 2008	Yes	4000 to 5000[2]	Yes	
Estonia	13,569 in 2009[3]	Yes[1]	500-1000[3]	No	No[1]
Finland	12626 in 2009[3]	Yes[1]	annual max. of 53[1]	No	Yes[1]
France	4000 sinesis[3]; 2000 carbo[3]; 99,110 individuals overwintering in 2007[1]	Yes	40,000 but realistically about 33,000.	Yes	
Germany	25000 [3]	Unclear[1]	200 annually in Saxony and between 2500 and 8700 annually in Bavaria since 1995	Yes	Yes[1]
Greece	5500[3]			No	
Hungary	3500; 26000 overwintering[1]	Yes[1]		No	Yes[1]
Iceland	4500 nests in 2007[3] 3210 in 2008[3]				
Ireland	5500 in 2006[3]	Yes	150[1]	Yes	No[1]
Israel		Yes[1]		Yes	
Italy	1500[3]			Yes	
Latvia	1000 in 2008[3]	Yes[1]		No	No[1]
Lithuania	4100 in 2009[3]		500-2500[3]	No	Yes
Moldova	400[3]				
Netherlands	23,139 in 2006[3]	No[1]		No	No[1]
Norway	30,000 nests in 2006[3]	Yes[1]		Yes	No[1]
Poland	25,830 in 2006[3]			No	
Romania	25,000[3]	Yes[1]		No	Yes[1]
Russia	48,000[4]				

Country	Bird numbers (breeding pairs)	Shooting allowed	Number shot annually	Is there a management plan in place	Compensation
Slovakia	300[3]	Yes[1]		Yes	Yes[1]
Spain	75,000 overwintering birds	Yes	850 annually	No	No
Sweden	45,000 distributed at around 200 colonies (2006)[1]; 42,000 in 2009[3]	Yes[1]	7000 birds annually and egg pricking more than 10,000 eggs[1]	Yes	
Switzerland	5000–6000 birds[1]; 500 [3]	Yes[1]	1000 annually	Yes	No[1]
Ukraine	70,000[4]				
United Kingdom	Breeding = 9018; overwintering = 35000; UK *sinesis* 2000[3]; UK *carbo* 7000[4]	Yes[1]	1458 in 2008	No	No[1]

Sources: [1] EIFAC Workshop on a European Cormorant Management Plan; [2]http://ec.europa.eu/environment/nature/cormorants/numbers-and-distribution.htm; [3] CormPopulation Europe Final_issue01_per 2010 04 27.pdf.

It should be recognised that culling cormorants under Article 9 is not endorsed by all management organizations and stakeholders. BirdLife International and FACE have submitted a joint statement on the derogation under Article 9 opposing any proposal of listing the cormorant as huntable species in Annex II of the Birds Directive.[8] They argue that there is no legal possibility under the Birds Directive for a binding EU wide framework obliging Member States to reduce cormorant populations. Instead they stress that it is the right of each EU Member State to decide on the application of derogations of Article 9, and suggest management should focus efforts on the follow-up and promotion of the work undertaken by the REDCAFE and INTERCAFE projects.

Table 3: Number of cormorants (and percentages of the total in each category) killed using derogations between 2001 and 2006.

Reasons	Cormorants killed in EU (% total)	Cormorants killed in France (% EU)
Prevent serious damage	167,773 (71.4%)	76,503 (45.6 %)
Protection of flora and fauna	62,664 (26.7 %)	55,885 (89.2 %)
Unknown reasons	4500 (1.9%)	0
Total	234,937	132,388 (56.4%)

Source: http://www.google.co.uk/search?q=GREAT+CORMORANT%3ADerogations+under+the+article+9+of+the+Birds+Directive&sourceid=ie7&rls=com.microsoft:en-gb:IE-SearchBox&ie=&oe=&redir_esc=&ei=KpGpUJqOMaej4gTHlYHoCQ

8 Joint Statement of BirdLife International and FACE on Cormorants *June 2008:* http://www.eaa-europe.org/fileadmin/templates/uploads/Cormorants/Joint_Statement_Cormorant_BirdLife_FACE_26_June_2008.pdf

4.3. Compensation

Many national authorities take the view that the cost of managing cormorant conflicts should be borne by the stakeholder. Nevertheless, some countries or regions apply compensation schemes to offset the consequences of cormorant predation for certain stakeholders (Box 6). These include Czech Republic, Finland, Lithuania, Romania, Saxony (Germany), Slovakia, and Wallonia (Belgium) (Table 2). Such measures are largely, but not exclusively, restricted to fish farms and hatcheries, with losses of fish consumed covered (though not always fully) by compensatory payments. The calculation of compensation payments is seldom rigorous and often simply an approximation related to the farm system and visualization of cormorant presence. In some countries it is also possible to apply for financial aid for the construction of netting enclosures or scaring programmes. It should also be recognised that compensation payments are not necessarily related to financial losses but more to encourage fish farmers to maintain the heritage value of cultural landscape (Box 6).

4.4. Management plans

National management plans to address the cormorant fisheries conflict exist in several European countries (Table 2), but these are neither comprehensive nor integrated between countries. The plans are generally related to control of bird depredation on open water bodies, and in Switzerland and Austria, target control of birds exploiting river fisheries. This lack of integrated planning coupled with inconsistency over culling populations between countries has considerable implications for establishing a pan-European approach to managing the cormorant fisheries conflict. Although transnational management plans are generally lacking in Europe, the feasibility of such an approach to address the conflict is possible, as can be seen from implementation of such an approach in North America on lakes Huron and Ontario (Box 7; U.S. Fish and Wildlife Service 2003; Fielder 2008, 2010). Here multi-faceted large scale plans have proven successful to reduce the depredation pressure from cormorants. The plans are structured with alternatives, which are introduced progressively and only implemented if the previous stage remained unsuccessful: 1. no intervention, 2. scaring birds (without shooting), 3. limiting local damage at commercial fish ponds, 4. strictly monitored reduction of resources, 5. reduction of regional populations, and 6. opening up national hunting as a last alternative.

4.5. Conclusions

The main conclusions are that no one single management intervention is effective at mitigating the problems created by cormorants. Shooting (on a large scale) does not appear to be a viable option unless the numbers are reduced to the levels of the past. Continuous dispersal and turnover of birds appears to result in a more or less stable population size at particularly fisheries. Furthermore, legislation and public reaction would prevent such a large scale action, and derogation under Article 9 is likely problematic as there remain difficulties in proving cormorants do 'serious' damage beyond a local scale. Controlling of the bird population density by destroying nesting areas, oiling eggs etc. is again only likely to have a localised effect and be short term. Similarly, scaring methods (human disturbance, laser guns and taste aversion) do not appear to be effective because they must be carried out on a continuous basis, birds become accustomed to the methods employed and the problem is probably dissipated to other fisheries. Large scale exclusion devices are only viable on aquaculture facilities, and are not feasible in open fisheries because they restrict or prohibit fishing activities. Some success has been achieved with fish refuge devices (McKay *et al.*, 1999; Russell *et al.* 2003, 2008; Orpwood *et al.* 2010), but again only at a localised scale. These features included artificial reefs or underwater fenced off zones that do not allow access to fish-eating birds. The problem is the refuge structures often interfere with angling either by concentrating fish, thus making them more easily caught, or by snagging gears.

The solution to the problem of bird depredation is thus complex and multi-facetted. It is unlikely legislation to protect birds will be relaxed in the future and scientific evidence/advice seems unable to provide any easy solutions. Furthermore, irrespective of the physical measures necessary to reduce the problems, the conflicts that now exist are deep-rooted, societal issues and will not be resolved unless all stakeholders are involved in the debate. Part of this latter problem arises because the fisheries and bird antagonists have in the past often operated in isolation, and thus the prospects for resolving the issues are compromised. Behrens *et al*. (2008), Rauschmayer *et al.* (2008) and Marzano *et al*. (in press) came to a similar conclusion and advocate more local actions and working with the various stakeholder groups affected to resolve the problems faced.

Box 1: LARGE SCALE SHOOTING OF OVERWINTERING CORMORANTS

CASE STUDY 1: LARGE SCALE SHOOTING OF OVERWINTERING CORMORANTS

France

France now has the largest overwintering population of cormorants in Europe, many using inland waters, creating conflict with fish farmers and anglers, the latter especially on rivers. Shooting started in 1992 during the overwintering period, initially at a few sites. Levels of shooting have increased since that time and it is the main measure used to control cormorants in France, with 41,800 birds permitted to be shot in 2009-10, although only approximately 33,000 were actually shot. This represents 40% of the overwintering population.

Despite continuous large scale shooting since 1992 there appears to have been no obvious effect on the number of cormorants overwintering in France, although stakeholders are reluctant to relinquish the option. A favoured solution appears to be implementation of a pan-European scheme that would limit the cormorant breeding population in Northern European countries.

Bavaria, Germany

Cormorant culling in Bavaria (mostly during the winter migration: August – March) began in 1995 and developed subsequently through various State regulations and legislation from the Bavarian State Government. Although 2,547 – 6,258 cormorants have been shot each winter - sometimes in greater numbers than the average number counted during regular surveys – the number of birds wintering in Bavaria has remained remarkably stable. Moreover, since shooting began, the number of night roosts in Bavaria has increased. It was concluded that uncoordinated shooting of cormorants over seven winters had not reduced the overall, nor the local, numbers of birds wintering throughout Bavaria. Thus, there must be a high turnover of migratory birds through Bavaria, even in midwinter. As cormorant numbers had not been reduced, there was no reason to believe that there had been a reduction in the amount of fish consumed by them. However, the number of cormorant night roosts in Bavaria increased during the years of shooting, suggesting that birds may now be more evenly distributed in the region than before.

Source: http://www.intercafeproject.net/workshops_reports/documents/Israel_Meeting_Summary.pdf

Box 2: REDUCING REPRODUCTIVE SUCCESS

CASE STUDY 2: REDUCING REPRODUCTIVE SUCCESS

Little Galloo Island, Lake Ontario

For almost two decades Little Galloo Island (LGI) has supported the largest colony of double-crested cormorants (*Phalacrocorax auritus*) in the eastern basin of Lake Ontario. Cormorant nest counts on the island since the early 1990s have averaged 4,495 per year, reaching a high of 8,400 in 1996. Johnson *et al.* (2011) estimated that cormorants from LGI alone have consumed 444 million fish since 1992. The proliferation of cormorants in the eastern basin of Lake Ontario coincided with declines in two important recreational fish species, smallmouth bass and yellow perch.

Strategy

All accessible double-crested cormorant nests on Little Galloo Island were treated with pure food grade vegetable oil during the incubation in each year since 1999. The oiling process was conducted four times at 2 week intervals, ensuring each nest would be treated at least twice during the incubation period. Oil was applied from a backpack sprayer unit in sufficient volume to cover the exposed surface of each egg (approximately 6 ml/egg).

Outcome

Since the egg oiling program was initiated in 1999 the number of cormorant nests at LGI has decreased from 5,681 (1999) to 2,730 (2006). The cormorant reproductive suppression program on LGI has cumulatively reduced fish consumption by chicks at the colony by 50.8 million fish since it was initiated in 1999. Included in this estimate are approximately 8.7 million yellow perch and 2.3 million smallmouth bass that were not consumed by cormorants. These two species are especially important since declines in their abundance in the eastern basin of Lake Ontario have been associated with cormorant population increases.

Source: Johnson *et al.* (2011)

Box 3: LARGE SCALE SCARING

CASE STUDY 3: ON SCARING

Hula Valley, Israel

The Hula Valley lies within the northern part of the Syrian-African Rift and is a major centre for aquaculture in Israel. Aquaculture production systems include conventional earthen ponds, dual purpose reservoirs used for both irrigation and fish culture, reservoir dependent systems that re-circulate water from reservoirs to hard-bottomed intensive ponds and closed water systems. Great cormorants have established an increasing number of roosting sites at flying distances from fish farms and Lake Kinneret, and pygmy cormorants have established new breeding sites in several areas. About 9,000 cormorants winter in the Hula Valley and the birds cause major conflicts at fishponds. Hundreds of cormorants were shot every winter through the 1990s but the problem remained at the same level; shooting was costly and ineffective, and polluted the environment (bird carcasses and lead shot). The direct fish losses from cormorants were huge, including a 50% decline in fish catches from Lake Kinneret, despite restrictions on fishing effort in the lake.

Strategy

Biologists, fish farmers and NGOs developed a co-operative management scheme for the Hula Valley. On arrival, cormorants are scared from fishponds in a co-ordinated manner using laser guns and fireworks, particularly those ponds holding preferred prey [*Tilapia* spp]. Cormorant numbers declined very quickly at fishponds and the programme was effective throughout the winter. As a result of this large-scale, co-ordinated disturbance (with minimum killing), cormorants are now feeding at the less sensitive Lake Kinneret on the commercially unimportant Kinneret bleak (*Acanthobrama terraesanctae*), a fish species removed by fishermen in an attempt to increase water quality (transparency) in the lake.

Outcome

As this control programme has developed, operating costs (e.g. staff time, ammunition), numbers of dead cormorants, and estimated fish losses all declined. The key reasons for the success of the Hula Valley scheme has been the availability of alternative foraging sites for cormorants [Lake Kinneret], good organizational logistics among interest/expert groups, and availability of manpower and resources to coordinate the scaring in a timely manner. There was also a wealth of knowledge on cormorant ecology and fish stock dynamics to underpin the policy formulation. It is also suggested that deterring the great cormorants from feeding on the fish ponds to feed at Lake Kinneret may have indirectly improved water quality of Israel's main water source.

An underlying problem is returning numbers of cormorants following relaxation of the coordinated scaring. It is essential the effort is maintained otherwise cormorant numbers will explode again.

Source: http://www.intercafeproject.net/workshops_reports/documents/Israel_Meeting_Summary.pdf

Box 4: EXCLUSION

CASE STUDY 4: EXCLUSION

Fish farms in Saxony Germany

Strategy
Following increasing depredation at carp farms in Germany, wires were deployed in a regular grid pattern on a series of eight ponds. The action reduced over-winter fish losses from 88% (in the winter before protection) to about 10% in the following year. During the trial, 113 cormorants were recorded over a period of 27 days at the farm, but none were observed to land on the ponds once wires were in place.

Outcome
Netting and grid wires can prevent or deter cormorants from preying on fish in hatchery or aquaculture ponds. Nets provide a physical barrier and are effective as long as the edges of the nets extend to the ground surrounding the pond. If nets do not extend to the ground, cormorants may learn to walk into the water and around the netting. Although netting can be effective, the cost may be prohibitive for large ponds. In some instances, the levies between ponds are too narrow to hold net support structures, and netting may interfere with machinery needed for daily operations. Overhead wire systems work by making it difficult for cormorants to land on, and take off from, ponds. Although these systems are effective at preventing large flocks from landing, individual birds often learn to fly between the lines, or land on levies and walk into the pond despite the wires. Floating ropes, sometimes called bird balls, are a less expensive and less labour-intensive alternative to wire systems.

Source: http://www.intercafeproject.net/project_info/documents/REDCAFE_FINAL_REPORT.pdf

Box 5: HABITAT MODIFICATION

CASE STUDY 5: HABITAT MOFIFICATION

Provision of refuge habitat in UK

The rise in cormorant numbers in England and Wales over the last 25 years and the greater use of inland feeding sites has increasingly brought these birds into conflict with freshwater fisheries. One technique that is considered to have some potential in recreational coarse fisheries is the use of artificial refuges. The habitat of roach and perch was investigated in a small stillwater fishery in eastern England based on the movements of a small number of acoustically tagged fish and an acoustic positioning system. The main aims were to determine the extent to which the fish utilised natural and artificial refuges, and to assess whether cormorant foraging behaviour was influenced by the presence of artificial refuges.

The results indicated that the tagged roach and perch both exhibited diurnal patterns of habitat use, utilising open water more by night. Roach tended to refuge in the marginal vegetation during the day and made no use of the artificial refuges. However, in the absence of cormorants the roach spent significantly more time in open water. The perch, in contrast, spent significantly less time in the marginal vegetation and more in one of the artificial refuges over the duration of the study; there was no significant increase in the use of open water. There was no evidence that cormorant foraging behaviour was influenced by deployment of the artificial fish refuges.

Source: Russell *et al.* (2003, 2008)

Box 6: FINANCIAL COMPENSATION

CASE STUDY 6: ON FINANCIAL COMPENSATION

Carp ponds in Saxony

There is a long tradition of carp faming in large open pond systems in Saxony. Carp are farmed in a three-year cycle, the production of one- and two-year old fish being most important. Fish ponds areas in Saxony are amongst the most valuable cultural landscapes and their value is closely connected with the maintenance of carp production. The increasing numbers of cormorants are considered an economic problem for the inland fishery in Saxony. Between May and November up to 3000 cormorants roost close to fishponds and feed on the carp produced in the ponds.

Strategy

The interactions between cormorants and fish appear to be complex and, as a result, are not fully understood. Nevertheless, there is considered enough information available upon which to base a financial compensation scheme. Consequently, since 1996, fish farmers have been paid compensation for fish looses to cormorants if this is seen as threatening to their livelihood. Up to 80% of the estimated damage is compensated on condition that reliable evidence of heavy cormorant damage is available and that losses amount to at least 1,000 Euro per year. Cormorant damage at carp ponds is assessed from (a) numbers of cormorants visiting ponds daily, (b) an estimated daily food intake of 500 g per bird, and (c) estimates of 'normal' stock losses in ponds (i.e. excluding cormorant predation). In addition to fish consumed, an additional, arbitrary, 10% is added to account for 'stressed and injured' fish. Financial help is also available to those farmers who farm their fish in an environmentally friendly way (e.g. according to nature protection regulations, low stocking levels, no supplementary feeding, and long-term rotation of ponds).

Outcomes

Although the compensation scheme is acknowledged to be subjective, all feel that it is based on current best estimates of the situation – and it has gone some way to mitigate local concerns about fish losses to cormorants. However, there is debate about whether the compensation scheme is realistically targeting damage caused by cormorants or is a mechanism to maintain the cultural landscape. This is particularly true given the low profitability of carp farming in the region. There is thus a need to mix compensation payments with more localised control and mitigation measures if the overall conflict is to be managed.

Source: http://www.intercafeproject.net/project_info/documents/REDCAFE_FINAL_REPORT.pdf

Box 7: LARGE SCALE MANAGEMENT PLAN

CASE STUDY 7: LARGE SCALE MANAGEMENT PLAN

Lake Huron

Since the 1970s, populations of the double-crested cormorants of North America (*Phalacrocorax auritus*) have been increasing. Breeding and wintering areas are distributed over the entire continent and therefore over different Federal States.

Strategy

After an intensive consultation process, a management plan with over 200 pages was compiled in 2003, which is now being applied religiously. This plan is structured with alternatives, which are introduced progressively and only implemented if the previous stage remained unsuccessful:

1. no intervention,
2. scaring birds (without shooting),
3. limiting local damage at commercial fish ponds,
4. strictly monitored reduction of resources,
5. reduction of regional populations, and
6. opening up national hunting as a last alternative.

In this way the cormorant population in North America is to be reduced by approximately 160,000 birds, which according to estimations from the U.S. Fish and Wildlife Service will not lead to any apparent negative consequences for the population.

Outcome

The cormorant population around Lake Huron was reduced by 15% the first year and by more in subsequent years. Today, there are around 500 nests in the area, down from a peak of 5,500, showing that it was possible to reduce the cormorant population. This was accompanied by recovery of the walleye population at Brevort Lake, and positive effects on other inland lakes. Anglers indicated the fisheries on Big Manistique Lake have recovered.

Source: http://www.michigan.gov/dnr/0,1607,7-153-10366_46403_46404-215325--,00.html

5. RECOMMENDATIONS FOR A MANAGEMENT STRATEGY

KEY FINDINGS

- There is a paucity of studies at different fishery types to help define impact, and there are no precise guidelines or criteria available to assess the scale of alleged damage to fish stocks and fisheries.
- Detailed research into the effectiveness of various measures to reduce the impact of cormorant depredation is needed.
- Few studies have quantified the movements, mortality/survival, immigration and emigration of birds or investigated density-dependent population regulation and carrying-capacity or cormorant populations in different systems.
- There is a need to understand the human dimensions of the conflict, and improve knowledge about how stakeholders respond to various interventions as well as defining collaborative approaches to managing the problems.
- Given the complexity of the issues that must be captured if a management plan is to be successful, a multifaceted approach is required that integrates the ecological-social-economic dimensions and addresses the limitations of the current knowledge base.

5.1. Current position

The evidence reviewed in the previous sections suggests considerable interaction between cormorants and fisheries. Piscivorous birds, especially cormorants, can potentially have considerable impact on fisheries, although the extent depends upon locality and intrinsic predation pressure by the resident cormorant populations. The common strategies to ameliorate the problems caused by fish-eating birds, e.g. scaring, shooting, seem to be largely ineffective except in specific well coordinated situations (e.g. Hula Valley Israel, Box 3), thus alternative approaches need to be developed. Furthermore it is believed that many of these interventions simply transfer the problem to other locations and do not address the underlying reasons for the increasing numbers of cormorants and expansion in their range. Unfortunately, a comprehensive population model, incorporating 'bottlenecks' and mechanisms for population expansion, is currently not available for the cormorant. Thus, management actions are based largely on local knowledge, and consequently the outcome of such measures is uncertain, especially in a European-wide context.

Many of the problems that exist with respect to the conflicts between fisheries and birds arise because the social and economic importance of inland fisheries is not well defined and the intrinsic value of these fisheries is largely underestimated (Beard *et al.* 2011). Further, there is little robust information on the scale of damage to these fisheries and the stocks, especially in financial and economic terms, against which to manage impact. Nevertheless, it should be recognised that inland fisheries throughout Europe are not typically heavily exploited for commercial purposes, management is orientated towards recreation and conservation and the economic importance of recreational fisheries is huge (Arlinghaus *et al*. 2002; Cowx *et al.* 2010). Arlinghaus and Cooke (2009) estimated 9.8% of the European population (49 million people) participate in angling, spending 73.5 billion Euro annually. This would be equivalent of an estimated 730 000 jobs (see Arlinghaus, 2004). For comparison, in the USA, 33.1 million anglers spent US$41.8 billion in 2011 (USFWS, 2012), and in Canada, 3.3 million anglers spent 43 million days spending $CDN 5.5 billion in 2010 (Department of Fisheries and Oceans, 2010).

As a consequence of their importance, any problems that affect the recreational resources are deemed unacceptable by the recreational angling sector, and become the subject of intense discussion and demands for control. The cormorant debate is one such interaction. Fisheries owners and managers consider the presence of cormorants has a direct impact on their stocks and livelihoods. Such arguments are the source of the recurrent pressure on the European Commission to resolve the conflict, and are backed up by NGOs such as the European Angling Alliance [EAA], and supported by advisory bodies such as EIFAAC and NACEE. Unfortunately the arguments remain subject to debate despite documented 'impacts' of cormorant presence and depredation on fisheries and aquaculture (Section 3 and Annex 2), but it appears the problems are, in part, site specific and not necessarily always detrimental (Britton *et al.* 2003). Part of the problem arises because of lack of awareness by all stakeholders. Fisheries managers and owners perceive the removal of fish by birds as detrimental to the stocks and are not always conversant with the positive aspects that natural mortality/predation can have on regulating the dynamics of fish populations (Britton *et al.* 2003). Managers and owners are concerned mainly with providing a quality fishing experience and thus removal of fish is seen as reducing this prospect. This is not to say that in certain fisheries bird predation does not reduce stocks, because evidence exists to show birds can reduce stocks dramatically to very low levels (Annex 2; Winfield *et al.* 2007; Cech and Vejrik (2011).

Conversely, the bird conservation lobbies are often negligent of the resource depletion and economic impact that birds can have on inland fisheries. They often consider that birds are a component of the ecosystem and that they have an equal right to exploit the resources. One of the fundamental causes of this conflict is that many inland waters are intensively stocked, at great expense, to ensure good angling performance, thus cormorant depredation is directly impinging on this objective (Cowx *et al.* 2010).

Further problems exist with the current legislation governing fish eating birds. Many species are protected under national and EU (Birds Directive) legislation. This prevents large scale culling of the birds to benefit fisheries. If legislation is amended to allow selective hunting for cormorants or facilitated through Article 9 derogation, this is likely to have little effect in controlling bird numbers because of the need for large scale culling over a wide area. This would also be socially unacceptable and contrary to wider conservation and biodiversity initiatives.

The interaction between birds and fisheries also has serious conservation issues. Many fisheries managers and practitioners are polarised in their views about the impact of piscivorous birds on fish stocks because of problems perceived with cormorants. However, there are many other piscivorous birds that are reliant on fish stocks in inland waters for their continued survival. Perhaps the most notable in Europe is the bittern, *Botaurus stellaris* L. (Noble *et al.* 2004), which is critically endangered and the subject of large-scale conservation initiatives (Newbery *et al.* 1997; José 2000; Brown *et al.* 2012). Care must be taken to ensure actions to mitigate problems caused by cormorants do not compromise initiatives to conserve and enhance endangered piscivorous bird populations. In this respect, breeding and feeding areas of endangered birds, such as the bittern, tend to be in Special Areas of Conservation or nature reserves so the birds and their food resources are afforded some protection against indiscriminate actions against birds.

5.2. Gaps in knowledge

In an effort to mitigate the cormorant-fish conflict, the European Commission has commissioned a number of actions, not least the REDCAFE and INTERCAFE projects, but also activities to elaborate guidance documentation on Article 9 of the Birds Directive, launch the EU Cormorant Platform, facilitation of "Best Practice" solutions to reduce the impact of cormorants on fisheries and support to update pan-European counts of breeding and overwintering birds (see Section 1.1). These actions will provide valuable inputs to improve the knowledge base and dissemination to stakeholders, but there remain a number of gaps in information to support management of the conflict.

Despite the considerable research undertaken and collaborative projects such as REDCAFE and INTERCAFE, gaps in knowledge to underpin management frameworks remain. This partly arises because the research concentrates on understanding the foraging behaviour of cormorants and less attention is paid to quantifying the impact of the depredation of fish stock dynamics and the economic impacts thereof. Unfortunately, assessing the status of fish stocks in large rivers and still waters is generally problematic, thus compounding this problem. Nonetheless, **there is a paucity of detailed studies at different fishery types and in a range of situations to help define impact, and there are no precise guidelines or criteria available to assess the scale of alleged damage to fish stocks and fisheries.**

Although there are a number of reviews and the forthcoming INTERCAFE TOOLBOX that will provide descriptions of measures, there are few studies that assess in quantitative terms the efficacy of the various measures employed to minimise impacts on fish stocks and fisheries. In particular there is little documentation on the success of shooting and other scaring techniques, interventions that are already employed in many countries. **There is a fundamental requirement for more detailed research into the effectiveness of various measures to reduce the impact of cormorant depredation on fish and fisheries in a range or water body types. In addition, there is a need for research into how cormorant populations respond to regulation attempts, and the consequences of such actions with respect to numbers and distribution.**

Considerable effort has focussed on counting and elucidating trends in abundance of cormorants across Europe, together with understanding their spatial distribution. However, **few studies have quantified the movements, mortality/survival, immigration and emigration of birds or investigated density-dependent population regulation and carrying-capacity of cormorant populations in different systems**. Further, few studies have focussed on the key factors influencing the selection of breeding, roosting and feeding sites. This is key information as it could help frame interventions to address any impact of cormorants on fisheries and aquaculture facilities.

Most studies on the cormorant fish conflict have focussed on the direct interactions between birds and fisheries and aquaculture production. Whilst these are important for underpinning the management decisions, the complexities of the interactions are such that they are unlikely to be resolved through direct interventions and **require greater understanding of the human dimensions of the conflict, and improve knowledge about how stakeholders respond to various interventions as well as defining collaborative approaches to managing the problems.**

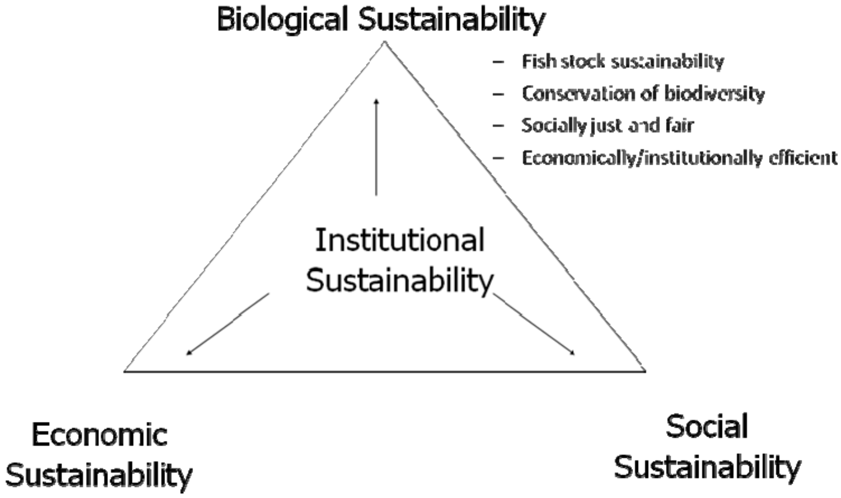
5.3. Recommendations

The well documented expansion of the cormorant populations across Europe in the past 30 years has resulted in considerable conflict with the fisheries and aquaculture sectors and there is a clear need for a management strategy to reduce the damages caused by cormorants to fisheries and aquaculture units. Following considerable pressure and lobbying from fisheries stakeholder (Kindermann 2008), the European Parliament adopted a Resolution (doc ref. SP(2009)401) on the adoption of a European Cormorant Management Plan to minimise the increasing impact of the birds on fish stocks, fishing and aquaculture. However the European Commission has responded by saying that it did not consider that an EU-wide management plan would be an appropriate measure to address this problem under present circumstances[9]. The review of information provided in this note supports this argument, highlighting the conflicts are complex, dynamic, and played out within diverse ecological, social, cultural and economic contexts at multiple geographic scales making such a strategy inappropriate. Whilst it is acknowledged that the highly migratory nature of the cormorant populations and their capacity to buffer against measures to control population size indicates that a pan-European approach is required, this is considered impractical for several reasons.

- There are now in excess of 500,000 cormorants across Europe, thus tens of thousands of cormorants would have to be killed annually to begin to reduce the population (van Dam and Asbirk 1997). Such large scale culls will probably not be socially acceptable or economically viable. It is likely the animal rights and bird conservation lobbies will oppose such intervention and the mobility of birds means that intensive management would undoubtedly be expensive, time-consuming and may not be possible in practice because cormorants are attracted to the most optimal food sources and shot birds are often quickly replaced by others (Wright 2003).
- There is disagreement about the evidence base and overall impacts of cormorants on the fisheries, largely arising from weaknesses in assessment studies.
- Different stakeholders and European States have different views on species protection and conservation management. For example, The Netherlands strictly protects conservation species whilst France, Sweden, Denmark and certain landers in Germany allow extensive culling (Box 1).
- Similarly some stakeholders are calling for large-scale culling and an overall reduction of the population, whilst others argue that the population should self regulate through access to food supply - the concept of carrying capacity, and that there is no reason for human intervention.
- There has been a recent shift in human – nature interactions and strengthening of the concept of conservation ethics, with, for example, animal rights activists now influencing hunting legislation and practice (see Arlinghaus *et al.* 2009 and Cowx *et al.* 2010 for debates on this issue).
- There is a shift in natural resource management that recognises not only the biological dimensions of natural resource management but the social and economic dimensions, which has resulted in a shift to inclusive arrangements for decision support systems (see Figure 6; Charles 1994; Costanza and Patten 1995; Arlinghaus *et al.* 2002).

[9] http://ec.europa.eu/environment/nature/cormorants/Background-and-Activities.htm

Figure 6: Sustainability as a process



Sources: Charles (1994); Costanza and Patten (1995); Arlinghaus *et al.* (2002)

Given the complexity of the issues that must be captured if a management plan is to be successful, **a multifaceted approach is required that integrates the ecological-social-economic dimensions and addresses the limitations of the current knowledge base.**

In the first instance, lessons can be learnt from the strategy adopted in North America. The United States adopted a federal management plan on the double crested cormorant in 2003 (Box 7; US Fish and Wildlife Service 2003). The relevant authorities' define six management alternatives with increasing levels of intervention, but also incorporate a stakeholder-participation, decision-making approach. This differs from European efforts because the agencies dealing with this problem in each of the Federal States can take up the viewpoints of different stakeholders, employ professionals, and therefore increase the chance of implementing the action plan. They also have more flexibility to cull cormorants if deemed necessary. **It is recommended each Member State organises their national responses to cormorant management around the six alternatives adopted by the US Fish and Wildlife Service (see Box 7).** In this context the Member States should build on the experiences of projects like REDCAFE and INTERCAFE and give clear guidance on ways to address the cormorant issue, including how Article 9§1 of the Birds Directive can be applied by Member States.

To resolve the problems generated by cormorants moving inland, there is a need to examine the reasons for the colonisation and increased abundance of inland waters. As indicated, protection of the birds under the EU Birds Directive is almost certainly a prime driver. They have benefited from the reduced persecution and adopted a strategy to exploit available food resources, both inland and presumably in coastal waters. The question that must be asked, however, is why the prevalence of cormorants around inland waters has increased so dramatically since the mid to late 1990s. The reasons possibly lie in the interactions between fisheries and birds such that bird numbers and distribution are very much dictated by availability of food resources. The over-harvesting of fish resources around the coastal waters of Europe potentially mean that there are few resources for cormorants in these waters and they have moved inland for more lucrative feeding opportunities. However, the greatest expansion in numbers and range appear to be of the *P. c. sinensis* sub-species. This could be linked to climate change whereby the reduction in severity of harsh winters has allowed the *sinensis* stain to survive in a wider range of habitats. Further, the recent practices to intensively stocked fisheries, especially in still waters, for the benefit of anglers, and the increased prevalence of fish farms, have offered an ideal opportunity for cormorants. This scenario is, in part, supported by anecdotal information that suggests it is the more intensively stocked waters that are subjected to greatest predation pressure (Feltham *et al*. 1999). **It is recommended that research efforts focus on understanding the reasons for the range expansion of cormorants across Europe and determining the ecological relationships between cormorant abundance of food resources,** i.e. the carrying capacity of different systems.

In order to formulate viable management options and resolve outstanding issues over causality in the cormorant fish conflict, there is an urgent need to assess and quantify the ecological, economic and social damages both at the European level but also damages in the different member states. This requires both direct assessment but also a fundamental review of existing evidence using, for example, a literature-based decision making tool like Eco Evidence[10]. The Eco Evidence method and software facilitate applying causal criteria to environmental questions and facilitates translation into defensible management actions (Norris *et al.* 2012). **It is recommended that an exercise using this approach is carried out as a matter of urgency to quantify the impact of cormorants on inland waters.**

The question still remains as how to minimise potential conflicts between fisheries and bird conservation. The solution probably lies in the optimisation of resource allocation of the fish stocks to satisfy both groups (Paterson 2006; Justus *et al.* 2009), coupled with stakeholder engagement in the decision-making processes. This requires understanding the socio-economic and human dimensions of the fish-cormorant conflict. Essentially, sufficient fish must be available to satisfy the demands of the anglers/fishermen in terms of catching success whilst allowing the birds to co-exist. The principal mechanism adopted by fisheries managers to enhance fish stocks is stocking. Whilst stocking has potentially benefits it is not an overarching mechanism to achieve optimal resource allocation because stocked fish tend to be naïve and prone to predation, although tactics can be employed to minimise depredation by birds on stocked fish. **A better strategy is to improve the status of the stocks by addressing the bottlenecks in natural recruitment and enhancing the prospects of survival to an exploitable size, including accounting for depredation by cormorants.** Several tactics can be employed to achieve these objectives.

- Rehabilitation or habitat improvement to reinstate spawning and nursery areas, and provide optimal conditions for growth and survival. The mechanisms by which this is carried out are varied and should target the bottlenecks to recruitment and enhance survival within the specific waters (Cowx and Welcomme 1998). To ensure the expected outcome of the rehabilitation exercise requires careful assessment and planning, but will have the dual benefit of supporting ecological status under the Water Framework Directive.
- Reduce foraging opportunities for the birds. This can be achieved in several ways. Some success has already been achieved with refuges that allow access to fish but exclude cormorants (Russell *et al.*, 2003, 2008; McKay *et al.* 1999). However, these will only function on a small scale and have the disadvantage of interfering with angling practices, e.g. snagging hooks. A better strategy might be to examine why cormorants do not forage on all available waters. It may be that there are habitat features that make certain sites unattractive to cormorants (possibly because of water depth, poor access, poor loafing sites or similar), and if these could be recreated in other waters the problems may be reduced by habitat means.

[10] http://www.toolkit.net.au/Tools/Eco-Evidence

Consideration should also be given to the stocking strategies adopted to enhance the fish populations. The latter includes stocking with larger individual fish that are greater than the preferred size range foraged on by birds, and stocking at times when predation pressure is at its lowest, i.e. in the summer when birds are feeding elsewhere. Although this may impose additional costs they should be offset by improved survival of stocked fish.

Finally, and perhaps most importantly, it must be recognised that fisheries and conservation management is today more a multidimensional approach that has to balance human requirements against protection of the environment and biodiversity (Cowx and Portocarrero 2011). Modern conservation challenges for fisheries management encompass all aquatic resources within the whole ecosystem, but also the fishery *per se*. One of the major challenges is to make sound management decisions to ensure viable commercial and recreational fisheries are compatible with aesthetic and nature conservation values in the 21st Century (Arlinghaus *et al.* 2002). However, this requires harmonisation of philosophical views of rather biocentric (e.g. environmentalists) and anthropocentric (e.g. inland fishermen) oriented stakeholders, which resembles a socio-cultural and political conflicting issue. Behrens *et al*. (2008), Rauschmayer *et al.* (2008) and Marzano *et al*. (in press) came to a similar conclusion and advocate improved integration of different stakeholder needs and aspirations in resolving the cormorant fish conflict. Consequently, **strategies to resolve the conflicts between conservation and fisheries protagonists must apply the stakeholder approach to decision-making.** The key to success involves building up relationships and sharing in the decision-making process based on sound science or factual evidence (Rauschmayer and Behrens 2006; Behrens *et al*. 2008). It should also include: (1) expanding the manager's view of who is substantially affected by fish and wildlife management (stakeholder); (2) identifying and understanding stakeholder views; (3) seeking compromise between competing and conflicting demands when appropriate; and (4) improving communication between stakeholders. Ultimately, due to the expanded notion of values such as responsibility (for the fisheries resources), fairness, justice, and long-term concern for the sustainability of resources, the stakeholder approach forces fisheries managers and conservationists to consider ethical questions in decision making, which can only be to the benefit of all parties concerned (Decker and Enck 1996, Justus *et al.* 2009).

The main challenge is linking local, regional, national and European policy processes together in an appropriate coordinated manner. Evidence suggests that measures taken in one country may influence the population in other countries and therefore the uncoordinated handling of conflicts via culling is hampered by failure to address issues at a wider regional scale. For that reason, the concerned countries should reconsider the establishment of an international co-operation (Rauschmayer and Behrens 2006). There is, however, the need for a central coordinating unit because of the varying competencies of national and regional management bodies and inconsistencies of management approaches between Member States. EIFAAC, which has consistently advocated a pan-European Management Plan is unlikely to be appropriate as it is a regional fisheries body of the FAO and is only an advisory commission with no permanent staff. It could be argued that funding for management could be from the European Fisheries Fund, given the potential impact of cormorants on fisheries and aquaculture production from inland waters.

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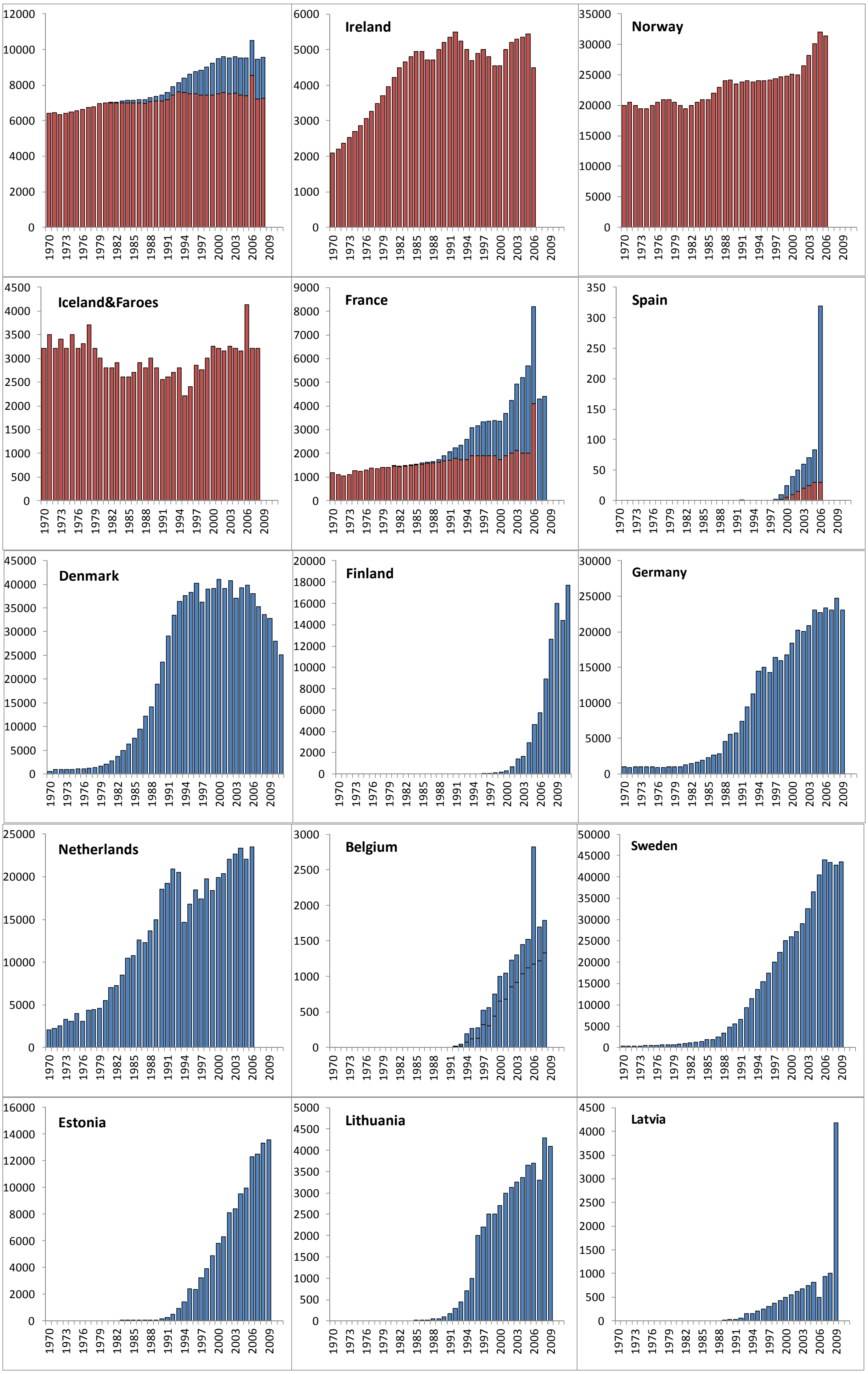
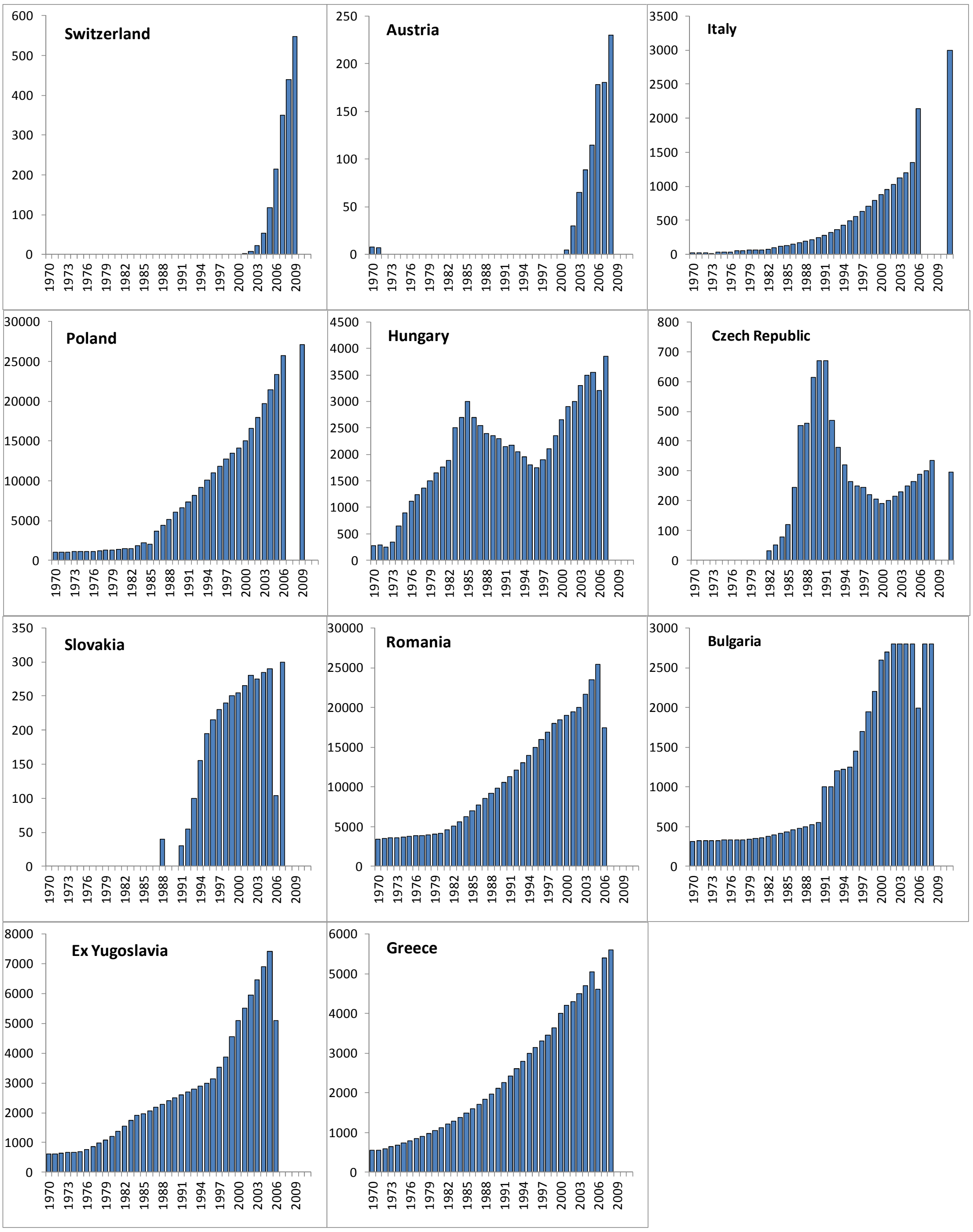
ANNEX 1:

Trends in number of breeding *P. c. carbo* (red) and *P. c. sinensis* (blue) in European countries.





Sources: Bregnballe *et al.* (2011a);
http://www.ymparisto.fi/default.asp?contentid=390720&lan=en;
http://www.cormocount.eu/results/denmark.aspx

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ANNEX 2:

Review of impact of cormorants on freshwater fisheries.

Water body	Effect of cormorant depredation on fisheries	Implications for fishery performance	Source
River Vltava at Vyssi Brod and in Prague, Czech Republic	Loss of fish due to overwintering great cormorants estimated to be 22 kg/ha, but as high as 79 kg/ha. During 6540 bird days on targeted fisheries total fish removal comprised 37 638 fish (3924 kg), mainly roach (1608 kg), chub (971 kg) and perch (1028 kg).	Great cormorants and anglers responsible for the decrease in catches of brown trout (*Salmo trutta*) and grayling (*Thymallus thymallus*)	Cech and Vejrik (2011)
Kaina Bay in Vainameri, Estonia	Catch per unit effort declined more than 100-fold after arrival of cormorants.	Analysis of food of cormorants indicates the decline in fish abundance might be related to the increased numbers of cormorants	Vetemaa *et al.* (2010)
France	Mortality of eels *Anguilla anguilla* in a large shallow lake in France due to predation by *P. carbo* moderate compared to fishery catches over 9-year period.	*P. carbo* predation not major contributor to *A. anguilla* mortality, even in the presence of large colonies	Carpentier *et al.* (2009)
Bride Lake, south-central Connecticut, USA	Decline of anadromous alewife (*Alosa pseudoharengus*) threatening important recreational and commercial fishery	Cormorants important predators for anadromous alewives, but do not pose an immediate threat to the recovery of regional alewife stocks.	Dalton *et al.* (2009)
Lithuanian section of the Curonian Lagoon, Lithuania	Four piscivorous bird species consumed nearly 700 t of fish during the breeding season of 2001 and winter 2001/2002, corresponding to 9% of the total fish resources in study area. Bird consumption equalled two-thirds of fish landed by commercial fishermen.	Results do not support the common public perception that cormorant predation greatly exceeds that of other piscivorous birds, and is detrimental to commercial fisheries.	Zydelis and Kontautas (2008)
Les Cheneaux Islands, Lake Huron, Canada	Double-crested cormorants increased exponentially in the Les Cheneaux Islands area during the 1980s and 1990s. The yellow perch fishery and population declined by the late 1990s and finally collapsed in 2000. Total annual mortality rates high as 85% during much of this time and increased over the time series.	Double-crested cormorant predation chief among the forces shaping local yellow perch population and contributing to the collapse of the fishery.	Fielder (2008) Fielder (2010)

Water body	Effect of cormorant depredation on fisheries	Implications for fishery performance	Source
Haweswater, UK	Whitefish (*Coregonus lavaretus*) declined in the 1990s.	Predicted that without management this source of mortality will drive the whitefish population to extinction in the near future	Winfield *et al.* (2007);
Wigierski National Park, Poland	Vendace constituted 8.2% of the total mass of consumed fish, representing on average 4.0 t/y.	Great Cormorant does not currently pose a significant threat to the whitefish stock in Poland, but suggest diet should be monitored regularly to detect any changes of coregonids share.	Wziaqtek *et al.* (2007)
River Skjern, Denmark	Estuarine mortality mainly caused by cormorants (*Phalacrocorax carbo sinensis*) differed significantly between species, but was high for both Atlantic salmon (39%) and brown trout (12%).		Koed *et al.* (2006)
Loch Leven, Scotland, UK	Over a 7-month period cormorants consumed 80,803 kg (41,617-128,248) brown and 5213 kg (830-12,454) rainbow trout, compared to average annual fishery catches of 5828 kg brown and 12,815 kg rainbow trout (1996-2000).	High potential for competition between the birds and the fisheries for available fish.	Stewart *et al.* (2005)
River Meuse, Belgium	Relative predation exerted by cormorants evaluated for this part of the Meuse river at 77.0 kg/ha/year (2001-2002) and 84.3 kg/ha/year (2002-2003).		Evrard *et al.* (2005)
Oneida Lake, New York, USA	Mean mortality rates of adult percids attributed to cormorant predation were 1.1% per year for walleye and 7.7% per year for yellow perch.	Predation by cormorants on subadult percids major factor contributing to decline in both walleye and yellow perch populations. The likely impact of bird predation on percid populations occurs because cormorants feed on larger fish that are beyond the size range where compensatory mechanisms are important.	Rudstam *et al.* (2004)
Lake Erie, Canada	The total quantity of fishes consumed annually by resident and migrating birds on Lake Erie was 18,776 t.		Hebert and Morrison (2003)

Water body	Effect of cormorant depredation on fisheries	Implications for fishery performance	Source
Little Galloo Island, Lake Ontario, Canada	Cormorants consumed about 32.8 million fish annually, weighing about 14,000 t.	Cormorants consumed more biomass of smallmouth bass and yellow perch annually, than is taken by sport (bass and bellow perch) and commercial (perch) fishermen.	Johnson *et al.* (2002)
Eastern basin of Lake Ontario, Canada	Loss of fish due to overwintering great cormorants estimated to be 65 kg/ha.	Cormorant predation had the potential to play an important role in regulating perch population levels in the eastern basin during the 1990s.	Burnett *et al.* (2002)
Lake Ymsen, south-central Sweden	Estimated fish outtake by the cormorants 12.8 kg/ha/yr compared to 8.6 kg/ha/yr for the fishery.	Despite considerable fish withdrawal by the cormorants, fish populations did not seem to change in numbers or biomass.	Engstrom (2001)
Stillwater game fisheries in England and Wales, UK	Cormorants are widely perceived by fishery managers to be responsible for significant economic losses through consumption and/or injury of stock fish.	While this may be justified locally no overall relationship between cormorant density and anglers' catches of rainbow trout, the principal stock fish.	Callaghan *et al.* (1998)
UK		No study in Britain (or Ireland) has accurately quantified cormorant losses to fisheries, and the significance of depredation by them therefore remains unclear.	Kirby *et al.* (1996)
Rivers in north-eastern Switzerland		No evidence to support predictions of a negative effect on fish population dynamics by cormorants. Predation intensity on grayling was positively correlated with yield in the largest grayling population of Switzerland.	Suter (1995)
Lakes Veluwemeer and Woldenwijd, The Netherlands	Total consumption up to 12.5 kg/ha		Dirksen *et al.* (1995)

Water body	Effect of cormorant depredation on fisheries	Implications for fishery performance	Source
Lakes and rivers in Bavaria, southern Germany	Main prey species consumed were cyprinids (rudd, roach, chub and bream), and whitefish in lake Chiemsee. Cormorants took 21% of the total annual fish production	In view of species composition in the cormorants' diet and of the consumption estimates, considered unlikely that cormorants impose a serious threat to commercial fisheries, but may inter with recreational angling (e.g. for grayling).	Keller (1995)
Dalãlven River, Sweden	Predatory impact on salmon was low, as no tags were recovered. Impact on trout was estimated 1.9%.		Bostrom *et al.* (2009)
Horsens Fjord, Denmark	Direct observation revealed cormorants emptied pound net in about 30 min, consuming 110 fish weighing a total of approximately 50 kg		Dieperink (1995)
Sportfishing waters in southwestern Utah, USA	Estimated annual consumption of fish by cormorants ranged from 0 to 15.8 kg/ha.		Ottenbacher *et al.* (1994)

ANNEX 3:

Shooting of cormorants in Denmark, Sweden, the Baltic Federal States of Germany, Estonia and Lithuania.

Year	Denmark	Sweden	Mecklenburg -Western Pomerania	Schleswig - Holstein	Estonia	Lithuania	Finland	Total
1993	1600		232	225	0			
1994	2400		191	245	0			
1995	3000		321	136	0			
1996	3700		675	117	0			
1997	4300		748	110	4			
1998	3600		1142	626	0			
1999	3700		363	677	41			
2000	2400		603	681	42			
2001	3700		829	610	102			
2002	3400		1011	699	83			
2003	3800	9028	1555	777	158			15318
2004	4900	5702	586	896	127			12211
2005	3700	3729	881	684	101	2596		11691
2006	4400	2157	688	1076	290	1782		10393
2007	5100	3504	1245	929	345	761		11884
2008	3900		1385	1244	407	484	96	
2009	4300		1660	820	707		568	

Source: http://www.helcom.fi/BSAP_assessment/ifs/ifs2011/en_GB/Cormorant/?u4.highlight=cormorant

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