American Fisheries Society Symposium 75:189–200, 2011

Great Cormorant *Phalacrocorax carbo* Is Threatening Fish Populations and Sustainable Fishing in Europe

Werner Steffens*
German Anglers Association
Weißenseer Weg 110, D-10369 Berlin, Germany

Abstract.—Based on the EU Council Directive 79/409/EEC on the Conservation of Wild Birds (1979), the number of great cormorants *Phalacrocorax carbo* has increased enormously in many European countries and the distribution of the species has extended considerably. In the middle of the last century, breeding sites were mainly limited to coastal areas; however, today, colonies have become numerous on inland waters. In Germany, for example, breeding pairs expanded from 794 in 1980 to about 23,000 in 2005, and the growth of the population still continues. In the whole of Europe today, there are more than 350,000 breeding pairs constituting more than 2 million cormorants. The increasing expansion of cormorants in Europe causes ecological damage to fish populations and economic and sociocultural damage to fishing. An estimate of the daily food intake of cormorants in Europe is about 1,000 metric tons. Special concern exists for endangered fish species such as grayling *Thymallus thymallus*, brown trout *Salmo trutta*, and European eel *Anguilla anguilla*. Rearing of fish in farms and stocking of juveniles in natural waters are often unsuccessful because of cormorant predation.

Introduction

The great cormorant *Phalacrocorax carbo*, belonging to the order Pelecaniformes and the family Phalacrocoracidae, is distributed in temperate regions of all continents except South America. In general, six or seven subspecies have been identified worldwide. In Europe, two subspecies are found: *P. c. carbo* and *P. c. sinensis*.

Phalacrocorax carbo carbo is distributed in the Atlantic coastal areas of Greenland, Iceland, Great Britain, Ireland, Norway, and France. *Phalacrocorax carbo sinensis* is the prevailing continental subspecies and is now widespread in nearly all European countries (Rutschke 1998).

Both cormorant subspecies have a similar morphology, are hard to distinguish, and are able to interbreed in overlapping territories. While the coastal subspecies, *P. c. carbo*, is more stationary, the continental form, *P. c. sinensis*, migrates and can cover great distances (Rutschke 1998; Piwernetz 2008). Thus, Scandinavian cormorants migrate southward and are wintering in central or southern Europe (Müller-Braun 2006).

In this review, the development of the population of the great cormorant in Europe is described and the impact of the great cormorant on fish populations and fishing, with special respect to central Europe, Germany, and Austria, is demonstrated.

Development of the Population of Great Cormorant in Europe

In the middle of the last century, the species was scarce in most European countries. The birds mainly lived near the coast or estuaries and rarely in the vicinity of inland waters (Peterson et al. 1965).

The Atlantic subspecies, *P. c. carbo*, has not appreciably change its population size in the past 30 years (Table 1). During the last three decades, the number of breeding birds of this subspecies in Europe only increased from about 60,000 to about 80,000 (Kohl 2008; Piwernetz 2008).

Conversely, the continental subspecies, *P. C. sinensis*, has seen the number of breed-

* Corresponding author: steffens@anglerverband.com

Table 1.—Number of breeding *Phalacrocorax carbo carbo* in Europe (Kohl 2008; Piwernetz 2008).

	1980	1995	2001–2002
Norway	ca. 42,000	48,000	50,000
United Kingdom	ca. 12,000	16,000	18,200
Ireland	ca. 6,000	9,400	9,100
France	ca. 3,000	3,300	3,500
Spain			100
Russia		300	1,000
Total	ca. 63,000	77,000	81,900

ing birds change from about 12,000 in 1970 to 300,000 breeding birds in 1995 (Table 2). From 1995 to 2000, the breeding population increased from 300,000 to more than 600,000 (Kohl 2008).

This population expansion continues today in most European countries. The birds also now colonize more inland areas near rivers and lakes where they were not formerly found (Figure 1).

In Germany, for example, breeding was restricted to the northern part of the country until about 1980. Today, there are numerous colonies in the south as well, and their numbers have increased rapidly (Table 3).

Figure 2 illustrates the dramatic growth of the cormorant population in several European countries, which is believed to be representative of cormorant expansion as a whole across Europe.

In summarizing the figures for the two subspecies of great cormorant in Europe (Tables 1 and 2), it can be estimated that today, the number of breeding birds of the great cormorant in Europe is at least 700,000 (Steffens 2007a, 2007c).

This is in accordance with the estimates of Wetlands International (2008). Based on breeding counts in summer 2006, the total number of nests in the western Palearctic (including North Africa and the Middle East) was 372,336, which equates to 744,672 breeding birds.

Based on Suter (1995) and Kohl (2006–2007), the total number of birds corresponds to the number of breeding birds multiplied by a factor of 2.8. Therefore, the total estimated number of great cormorants in Europe is about 2 million birds.

The main reason for this growth of the cormorant population in Europe is the issuance of the European Union's Council Directive on the Conservation of Wild Birds (79/409/EEC) in 1979 and the measures based on it for protection of the breeding sites. Originally, the subspecies *P. c. sinensis* was listed in Annex I of this directive as a bird species to which special conservation measures applied. But in 1997, it was deleted from this list because the state of the population had ceased to be unfavorable since 1995.

Member states have the possibility to deviate from the strict conservation measures of the

Table 2.—Number of breeding *Phalacrocorax carbo sinensis* in some European countries and in the whole of Europe (Kohl 2008).

	1970	1980	1995	2000
Denmark	1,800	4,080	72,600	80,000
Sweden	300	1,540	30,800	52,000
Romania		8,300	30,000	40,000
Netherlands	4,100	9,000	32,000	39,000
Germany	1,700	1,760	34,400	33,600
Poland	1,900	2,780	22,000	25,000
Estland			4,760	20,000
Europe total	11,560	31,380	302,100	617,370

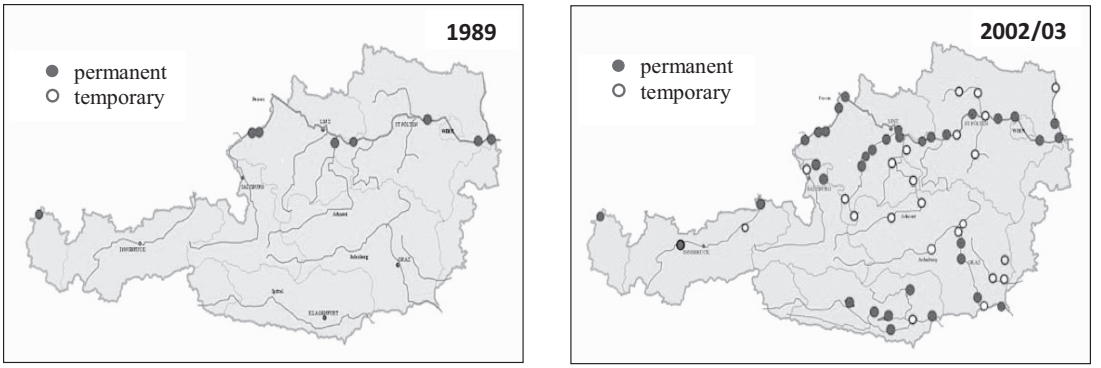

Figure 1.—Wintering roosts of cormorants in Austria in 1989 and 2002–2003 (Kohl 2008).

directive "to prevent serious damage to crops, livestock, forests, fisheries and water" or "for protection of flora and fauna," provided that there is no other satisfactory solution.

On the strength of this derogation, in some member states, scaring is allowed in order to reduce or prevent serious damage by the birds. Permissions to limit cormorant damage are restricted in space or time and differ from country to country. In limited instances, lethal means (shooting) are possible. In Germany, every federal state has specific regulations. In Denmark, it is possible to interrupt the embryonic development of the eggs by oiling them in some ground-nesting colonies. In France, there are fixed quotas for shooting. However, in the Netherlands, on the other hand, no measures of any kind are permitted against cormorants.

In general, scaring of birds, if successful, only has a consequence of them hunting and feeding in neighboring waters. And even a reduction of a local population by shooting is not necessarily a solution; the birds killed are often replaced by cormorants from other areas. In spite of large-scale shooting of several thousands of wintering cormorants in Bavaria, the population remained stable (Keller and Lanz 2003).

Impact of the Great Cormorant on Fish Populations and Fishing in Europe

The great cormorant is an exclusive fish eater; other food organisms are insignificant. In Czech investigations, thousands of fish were detected in the diet of cormorants, but only in one case was a frog and, in another case a crayfish, found (Cech 2007).

Meanwhile, it is generally accepted that the daily feed intake of the great cormorant is 400–600 g (Guthörl 2006; Knösche 2008). This corresponds to about 18% of the weight of the bird. Referring to the base metabolic rate, the weight of prey fish required by individual birds per day was inferred to be 524 g (Sato et al. 1988).

A variety of fish species- and size-classes are taken by cormorants; therefore, these birds can be considered generalists and opportunists. The prey species mainly depend on the compo-

Table 3.—Number of breeding pairs and breeding colonies of great cormorant in Germany, 1980 to 2005 (Kieckbusch and Knief 2007).

Year	Breeding pairs	Breeding colonies
1980	794	
1990	5,700	22
1995	15,000	64
2000	18,000	91
2005	23,000	118

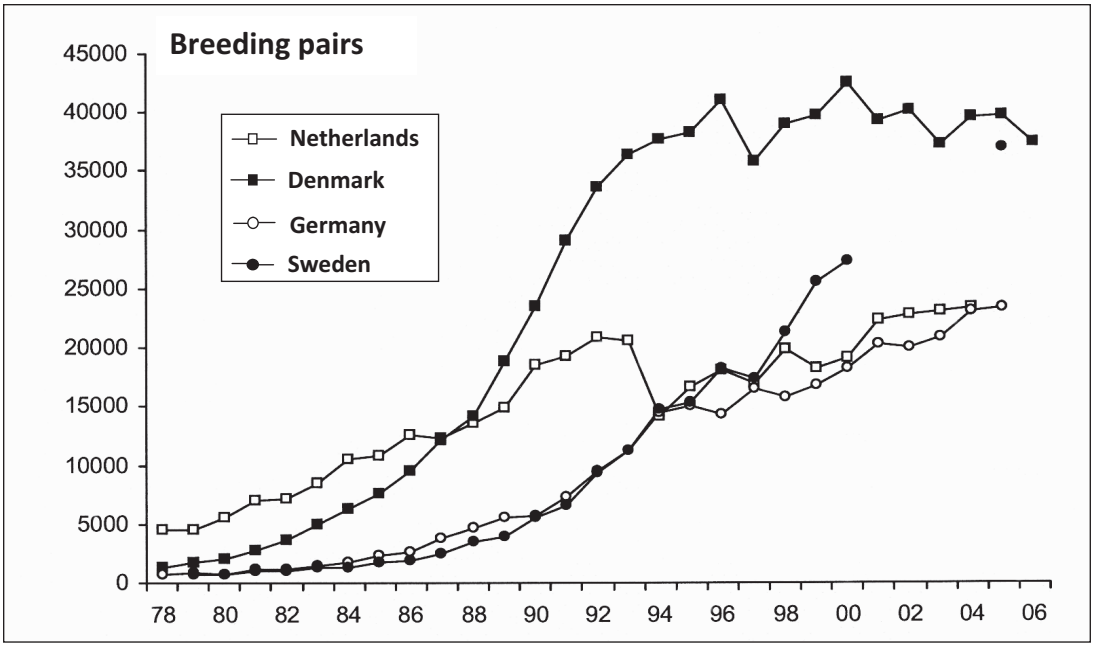

Figure 2.—Development of the breeding populations of great cormorants in the Netherlands, Denmark, Germany, and Sweden, 1978 to 2006 (Kieckbusch and Knief 2007).

sition and availability of the fish communities (Suter 1997). Prey size can be up to 800 or 900 g (Suter 1997; Schröder et al. 2007; Schwarten 2009); however, in most cases, individual fish size is less than 500 g. According to Rutschke (1998), the individual weight of fish consumed is between 50 and 200 g.

With the understanding that there are approximately 2 million cormorants in Europe, the estimated amount of fish eaten by the birds is 1,000 metric tons (mt) per day. In Germany, for example, the loss of 23,000 mt of fish per year due to the feeding of the great cormorant exceeds the catches of professional and sport fisheries in natural inland waters, which averaged 20,000 mt in the years from 2000 to 2005 (Steffens 2007a).

Of course, the influence of the cormorant in different waters is variable. Damage to a fish population in small brooks or rivers generally is greater than in large lakes. Remarkable losses often occur in aquaculture ponds (Stiehler 2007).

Today, many results of scientific investigations concerning the damage of cormorants on fish populations and fishery are known. Following, some examples for different waters in central Europe are presented.

Impact on Fish Fauna and Fishing in Rivers

River Mur.—River Mur is an alpine river in Austria. Investigations on the influence of cormorants were made downstream of a power station where the width of the river was between 10 and 40 m, the depth less than 1 m, and water volume averaged 3 m^3/s. Biomass of the fish fauna was determined before (October 1995) and after (March 1996) the incidence of cormorants during the winter (Woschitz and Parthl 1997; Kohl 2005).

The fish population was reduced after only one winter appearance of the birds (Figure 3). Fish biomass decreased to 36% of the initial value. Especially high losses (81%) were observed in the grayling *Thymallus thymallus* population, but there was also a substantial decrease in small fish species, for example gudgeon *Gobio gobio* and spine loach *Cobitis taenia*.

River Enns.—River Enns is a large alpine river in the centre of Austria with excellent conditions for graylings. Two different regions of the river were examined; the upper section was canalized with rock on the bank, and the

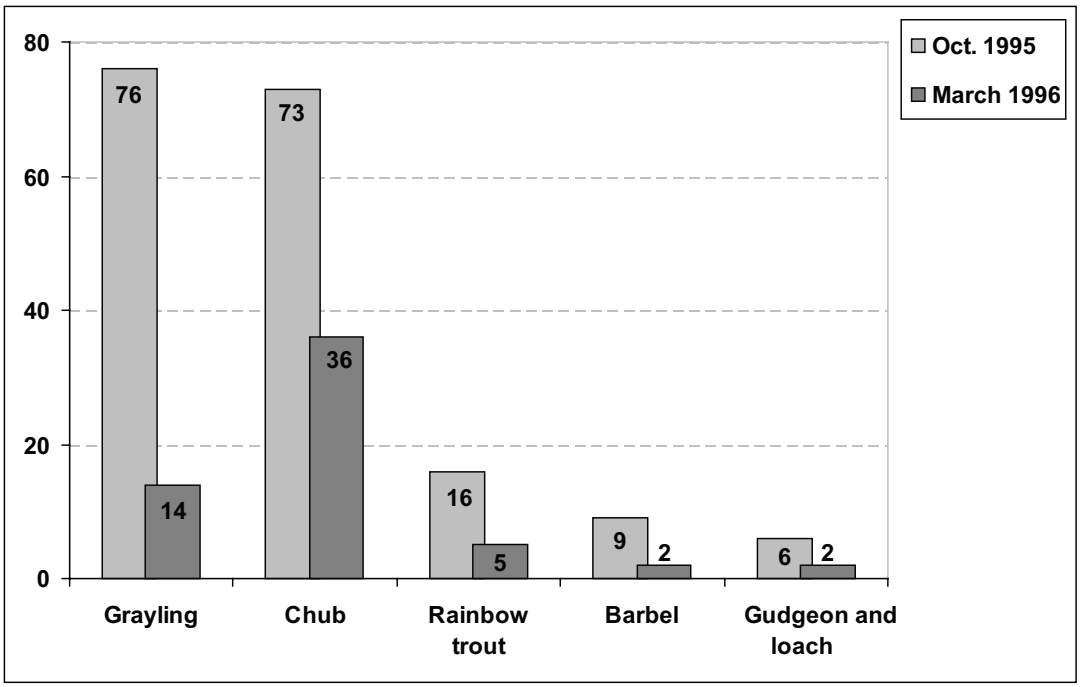

Figure 3.—Fish biomass (kg/ha) in the River Mur before and after the invasion of cormorants (Woschitz and Parthl 1997).

lower one was a natural section. Biomass and composition of the fish fauna before the appearance of cormorants in autumn 1994 was compared with the situation in 1998 after the incidence of the birds in every winter since 1995 (Zauner 1999; Kohl 2005; Schröder et al. 2007).

Biomass of the total fish population was reduced to 6% by cormorant predation. Especially high losses were observed in the grayling and brown trout *Salmo trutta* populations (Figure 4). Impact of the cormorant predation was nearly the same in both the canalized and the natural section of the river.

River Ilm.—The River Ilm located in the hills of Thuringia (Germany) has brown trout, grayling, and barbel *Barbus barbus* sections. The river has a length of about 130 km and is very important for sport fishing in this region.

Careful investigations in the whole river revealed a dramatic reduction of the fish fauna as a result of increasing numbers of cormorants in winter (Görlach and Wagner 2008). During past years, often more than 1,000 birds were observed in Thuringia during winter, with a maximum number of 1,700. Thus, particularly in the grayling and barbel section of the river, only remnants of the former (or expected) fish population were found (Table 4).

In a small section of the river near the city of Stadtilm, anglers caught 90–200 graylings in the years between 1999 and 2002 (Görlach and Müller 2005). After intensive predation of cormorants in winter 2002–2003, only two fish were caught by sport fishers in the 2003 season (Figure 5).

Similar results are known from many other brooks and rivers in Europe (Görner 2006, 2007; Guthörl 2006; Füllner and George 2007; Wagner et al. 2008). The main problem is that the birds are now present and fishing during autumn and winter in small streams in the mountains where they never before occurred. Cormorant predation in fall and winter can result in a serious reduction of a fish population and in the loss of genetic diversity (Steffens 2007b). Exceptionally endangered are graylings and brown trout, but even bottom-dwelling fish, such as sculpins *Cottus gobio*,

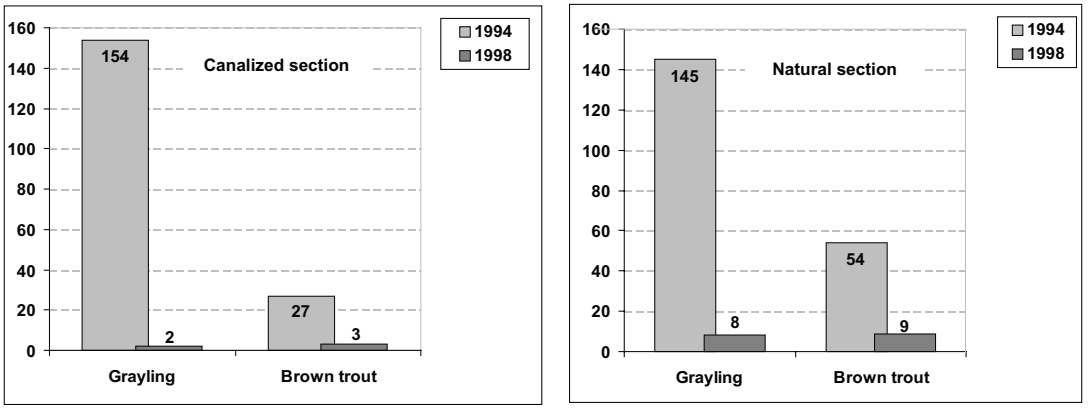

Figure 4.—Fish biomass (kg/ha) of grayling and brown trout in the River Enns before and after the invasion of cormorants (Zauner 1999).

hidden between stones are captured by the birds (Görner 2008).

Cormorants were observed fishing in small and shallow rivers with relatively dense tree embankment, within and outside of urban areas and also under ice layers. In natural river regions, the losses caused by cormorants in some cases were higher than in canalized ones (Schwevers and Adam 1998).

Most of the European rivers are used and managed by anglers. In general, anglers catch only the increment of the fish stock, which is about 15–25% per year (Kohl 2006–2007). The development of the fish fauna is supported by harvest regulations such as closed seasons or, if necessary, by stocking. The very predation of 10–20% of the fish population by cormorants can cause considerable damage to the fish stock; however, cormorant predation often exceeds 50% (Kainz 1994, 1995; Görlach and Müller 2005; Kohl 2005; Görner 2006; Guthörl 2006; Görlach and Wagner 2008). Given the high level of consumption by cormorants, both ecological and socioeconomic losses are inevitable.

Impact on Fish Fauna and Fishing in Lakes

Lake Chiemsee.—Lake Chiemsee in Bavaria is a large German lake and covers 80 km^2. Mean depth is 24.5 m. Cormorants have been breeding there since 1994 (Klein 2000, 2005).

Even in this large lake, the increasing cormorant predation results in problems for fishermen. While the catch of the commercial fishery during the past years amounts to 9–11 kg/ha, the estimated cormorant predation was to 4–4.6 kg/ha (Figure 6). In addition to the fish losses, the nets of the fishermen are destroyed by the birds.

Lake Dümmer.—Lake Dümmer in the north of Germany (Lower Saxony) is a shallow lake with a maximum depth of 3.4 m and an area of 12 km^2.

Although there is no breeding colony of cormorants at this lake, higher numbers of birds have been observed throughout the year since about 1995. This resulted in a decrease of the fish yield (Kämmereit at al. 2005). Today, fish consumption of the cormorants is considerably

Table 4.—Comparison of the expected fish density to the average fish density 2006 after occurrence of great cormorant in the River Ilm (Görlach and Wagner 2008).

	Expected fish density kg/ha	Fish density 2006 kg/ha
Trout section	100–200	107
Grayling section	100–200	19
Barbel section	200	9

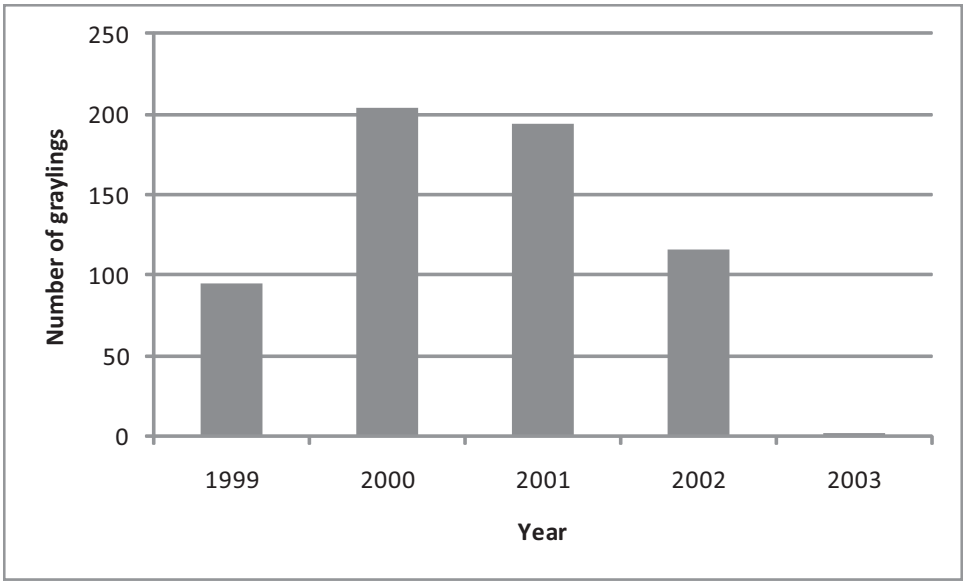

Figure 5.—Decrease of the number of graylings in the River Ilm near Stadtilm after invasion of cormorants in winter 2002–2003 (Görlach and Müller 2005).

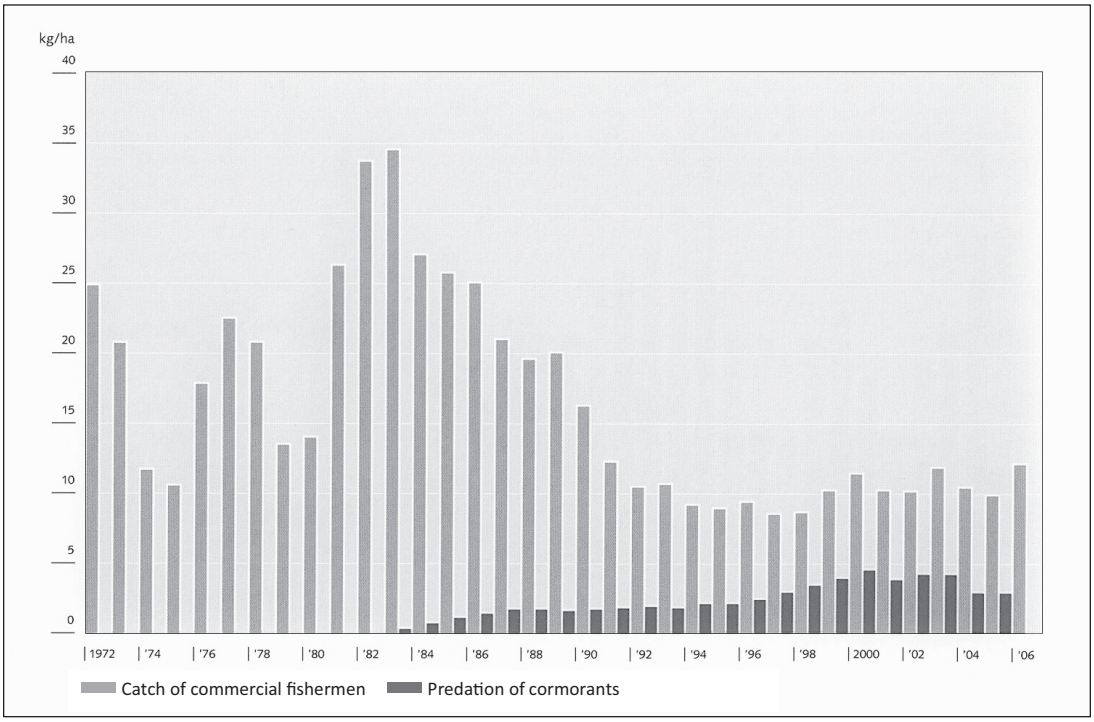

Figure 6.—Catch of commercial fishermen and predation of cormorants in Lake Chiemsee (Klein 2005; Schröder et al. 2007).

higher than the catch of the commercial fishery (Kämmereit et al. 2005).

Inland waters in Brandenburg.—The state of Brandenburg in central Germany is rich in lakes. Total water surface is about 77,000 ha. From an economic point of view, the European eel *Anguilla anguilla* is the most important fish species for commercial fisheries using fishing nets (e.g., fish traps and seines).

The cormorant population increased from 70 breeding pairs (two colonies) in 1990 to more than 2,500 breeding pairs (12 colonies) in 2004. The total number of birds is more than 11,000 (Brämick and Fladung 2005). In a comprehensive investigation, it was determined that the birds counted in Brandenburg consume about 1 kg/ha of eel. Compared to this value, the eel catch of commercial fishermen in Brandenburg is about 2.4 kg/ha. Thus, fishermen lose 77 mt of the potential catch per year, and the predation of cormorants is responsible for the reduction of contribution margin 1 by 40% (Brämick and Fladung 2005; Brämick 2007). This cannot be compensated by catch of other fish species in the commercial fishery and reduces the possibilities of recreational eel angling too. Further, European eel is considered an endangered species and the European Union has started strong protection measures for the conservation of this fish species.

Impact on Fish Farms

In most European countries, fish culture is based on farming of rainbow trout *Oncorhynchus mykiss* and common carp *Cyprinus carpio*. Trout farms generally comprise only a small area of ponds or raceways and are often encased with nets or a similar covering. However, carp farms in many cases can be larger than 100 surface hectares and are, therefore, considerably vulnerable to cormorant predation because the birds can find high concentrations of appropriate-sized fish in the ponds.

For the carp farms in Saxony (8,382 ha), a yearly loss of about 250 mt of stocking material of juvenile carp by cormorant predation is reported (Stiehler 2007). These losses correspond to an economic loss of 750,000 to 1 million euros per year.

In the Netherlands, the fish farm Lelystad (220 ha) was closed due to cormorant damage (Kohl 2008). A fast-growing colony was situated at a distance of only 10 km and the cormorants caused high fish losses in the farm.

In European carp farms, juveniles of other fish species are also reared for stocking natural waters for angling. Thus, threatening of pond culture by the predation of cormorants damages the recreational fisheries, too.

Impact on Fish Fauna and Fishing in Coastal Waters

Even in coastal waters, large numbers of cormorants can affect fish fauna and fisheries and thus can cause dramatic problems.

In Denmark, the cormorant population has grown by a factor of ten in 20 years. Special investigations were carried out in Ringkøbing Fjord, which is a large (300 km^2) and shallow brackish estuary of the River Skjern (Jepsen and Olesen 2006). Since 1992, cormorants have established colonies, amounting today to about 4,000–7,000 cormorants, feeding in the fjord during May to September. Through micro-tagging of fish and examining regurgitated pellets of the birds, it was shown that the cormorants consume a significant part of the recruitment of different important fish species. Losses amounted to 50% of tagged eel in 1 year and 25–40% of tagged Atlantic salmon *Salmo salar* smolts during migration in spring. Nearly all tagged juvenile European flounder *Platichthys flesus* was eaten by the cormorants soon after stocking. Yield of fishermen decreased considerably in this region because of the reduction of fish stocks due to cormorant predation (Jepsen and Olesen 2006).

In Germany, the state of Mecklenburg-Vorpommern (Baltic coast) has the highest density of breeding cormorants. Here, 53.5 breeding pairs/100 km^2 were counted, compared to the 3.3 breeding pairs/km^2, on average, of all other German states. In a coastal area of about 100 km length, about 60,000 cormorants are estimated (Schlieker 2007). Within a period of 6 months (April to September), these birds consume 30 mt of fish per day and 5,400 mt/year. High losses by the birds are caused in the population of Atlantic cod *Gadus morhua* in this region. The predation on juvenile cod by cormorants results in catch losses of the commercial fishermen and anglers of at least 3,750 mt (Schlieker 2005, 2007). Cormorant predation has a serious

impact on the coastal fish fauna and fishery in the Baltic.

Fish Lesions due to Cormorants

Besides the direct losses by predation of fish, cormorants cause additional damage and indirect losses. These are related to damaging the trees and other vegetation where the birds are nesting or roosting and destroying fish nets (Wissmath et al. 2000; Wissmath 2009).

Remarkable indirect losses occur as a result of lesions (wounds) in fish that could not be swallowed by the birds. Escaped fish often exhibit considerable injuries of skin and muscle. These lesions can weaken the fish and reduce feed intake and growth. Secondary bacterial or fungous infections frequently lead to increased mortality (Guthörl 2006). Moreover, damaged fish cannot be sold by fishermen. Detailed descriptions of fish wounding by cormorants were given by Adámek et al. (2007). The average Fulton´s coefficient of condition was 1.48 in healthy 2-year-old carp and 1.33 in wounded fish.

Moerbeck et al. (1987) observed that in carp ponds in the Netherlands, fish up to 550 g were eaten by cormorants, and larger fish up to 700 g had severe injuries. In Hungarian carp ponds, up to 0.3–0.4 kg of fish per cormorant per day were wounded (Poór 2005). After an invasion of cormorants in a region of the River Rhine, 46.5% of the fish that survived the attacks were injured (Kramer 2007).

Discussion and Outlook

Data from Europe have shown that the cormorant population has increased dramatically during the past two to three decades, and the increase in cormorant populations has resulted in a decline of fish stocks in different waters and in a reduction of the catch of commercial and recreational fishermen. In other words, the positive development of a bird species has caused unintended and unanticipated ecological damage to the fish fauna and socioeconomic losses to fishery.

Similar development of cormorant populations was observed in other parts of the world, for example in Japan for the subspecies P. c. hanedae (Ishida et al. 2000; Kameda et al. 2003) or in North America for the double-crested cormorant *P. auritus* (Wires at al. 2001; U.S. Fish and Wildlife Service 2003). Obviously, there is not only an increase of the number of cormorants globally, but also a subsequent range expansion of the birds.

In Japan and North America, the increased populations of cormorants have resulted in declines of fish stocks and socioeconomic losses to commercial and recreational fishery. Moreover, other damage occurs, such as destruction of vegetation and adverse effects on other bird species.

Contrary to some nature conservationists and ornithologists, fishery authorities and fishing associations in Europe are convinced that only a remarkable decrease of the cormorant population in the whole of Europe can reduce or solve the conflict. For that, a management plan at the European level is necessary (Hilge 2007; Steffens 2007a, 2007b, 2007c; Behrens et al. 2008; FAO 2008). Treating the problem at a local, regional, or national level can only mitigate the situation. Including great cormorant in Annex II of the Council Directive 79/409/EEC (chasable birds) seems helpful and desirable (Müller 2007; FAO 2008).

At present, members of the European Parliament are engaged in this problem and in finding a solution that enables the protection of the fish fauna and the prevention of socioeconomic damage to fishery in Europe.

References

Adámek, Z., J. Kortan, and M. Flajšhans. 2007. Computer-assisted image analysis in the evaluation of fish wounding by cormorant [*Phalacrocorax carbo sinensis* (L.)] attacks. Aquaculture International 15:211–216.

Behrens, V., F. Rauschmayer, and H. Wittmer. 2008. Managing international ´problem´species: why pan-European cormorant management is so difficult. Environmental Conservation 35:55–63.

Brämick, U. 2007. Schäden durch Kormorane an Fischbeständen und Fischerei in Seen. [Damages by cormorants to fish populations and fisheries in lakes.] Arbeiten des Deutschen Fischerei-Verbandes 84:67–86.

Brämick, U., and E. Fladung. 2005. Quantifizierung der Auswirkungen des Kormorans auf die Seen- und Flussfischerrei Brandenburgs am Beispiel des Aals. [Determination of the influences of

the cormorant on fish yield in lakes and rivers.] Arbeiten des Deutschen Fischerei-Verbandes 82:82–98.

Cech, M. 2007. Die Kormoransituation in Tschechien. [The cormorant situation in the Czech Republic.] Arbeiten des Deutschen Fischerei-Verbandes 84:161–173.

FAO (Food and Agriculture Organization of the United Nations). 2008. Report of the EIFAC Workshop on a European Cormorant Management Plan. Bonn, Germany, 20–21 November 2007. FAO, European Inland Fisheries Advisory Commission, EIFAC Occasional Paper 41, Rome.

Füllner, G., and V. George. 2007. Zum Einfluss des Kormorans (*Phalacrocorax carbo sinensis*) auf den Fischbestand der Mulde. [To the influence of the cormorant (*Phalacrocorax carbo sinensis*) on the fish population of the River Mulde.]Fischer und Teichwirt 58:290–294.

Görlach, J., and R. Müller. 2005. Die Bestandssituation der Äsche (*Thymallus thymallus*) in Thüringen. [The situation of the grayling population (*Thymallus thymallus*) in Thuringia. Arbeiten des Deutschen Fischerei-Verbandes 82:59–81.

Görlach, J., and F. Wagner. 2008. Überprüfung des winterlichen Kormoraneinflusses auf die Fischbestandssituation der Ilm/Thüringen. [Checking the influence of cormorants during winter time on fish populations in the River Ilm/Thuringia.] Artenschutzreport 22:30–45.

Görner, M. 2006. Der Einfluss des Kormorans (*Phalacrocorax carbo*) und weiterer piscivorer Vögel auf die Fischfauna von Fließgewässern in Mitteleuropa. [The influence of cormorants (*Phalacrocorax carbo*) and other predatory birds on the fish fauna of running waters in central Europe.] Artenschutzreport 19:72–88.

Görner, M. 2007. Schäden durch Kormorane an Fischbeständen in Fließgewässern. [Damages by cormorants to fish populations in running waters.] Arbeiten des Deutschen Fischerei-Verbandes 84:115–135.

Görner, M. 2008. Zum Verhalten des Kormorans (*Phalacrocorax carbo*) an und in Fließgewässern des Binnenlandes. [The behavior of the cormorant (*Phalacrocorax carbo*) at and in running inland waters.] Acta ornithoecologica 6:131–142.

Guthörl, V. 2006. Zum Einfluss des Kormorans (*Phalacrocorax carbo*) auf Fischbestände und aquatische Ökosysteme: Fakten, Konflikte und Perspektiven für kulturlandschaftsgerechte Wildhaltung. [A study of the interrelationship of the great cormorant (*Phalacrocorax carbo*) and fish populations and aquatic ecosystems: facts, conflicts and perspectives for the keeping of wildlife in cultivated landscapes.] Wildlife Weltweit, Rolbing, France.

Hilge, V. 2007. Europäisches Kormoran-Management aus Sicht der EIFAC. [European cormorant management from the point of view of EIFAC.] Arbeiten des Deutschen Fischerei-Verbandes 84:255–262.

Ishida, A., T. Matsuzawa, K. Kameda, and M. Narusue. 2000. The population increase of the great cormorant *Phalacrocorax carbo* and its damaging effect on fisheries and trees in Japan: the present situation, the problems in each area and future measures. Journal of Field Ornithology 18:1–28.

Jepsen, N. and T. Olesen. 2006. Cormorants in Denmark: re-enforced management and scientific evidence. Framework for Biodiversity Reconciliation Action Plans, FRAP Project EU, WP11-D21, Leipzig, Germany.

Kainz, E. 1994. Auswirkungen von Kormoranen auf die Fischbestände von zwei oberösterreichischen Fließgewässern. [Influences of cormorants on the fish populations in two running waters of upper Austria.] Österreichs Fischerei 47:238–250.

Kainz, E. 1995. Zu den Auswirkungen des Kormorans auf die Fischbestände in der Steyr. [The influence of the cormorant on fish populations of the River Steyr.] Fischer und Teichwirt 46:74–81.

Kämmereit, M., U. Matthes, R. Werner, and H. Belting. 2005. Zur Entwicklung der Fischbestände im Dümmer. [The development of the fish populations in Lake Dümmer.] Arbeiten des Deutschen Fischerei-Verbandes 82:7–39.

Kameda K, A. Ishida, and M. Narusue. 2003. Population increase of the great cormorant *Phalacrocorax carbo hanedae* in Japan: conflicts with fisheries and trees and future perspectives. Vogelwelt 124(Supplement):27–33.

Keller T. M., and U. Lanz. 2003. Great cormorant *Phalacrocorax carbo sinensis* management in Bavaria, southern Germany: what can we learn from seven winter with intensive shooting? Vogelwelt 124(Supplement):339–348.

Kieckbusch, J. J., and W. Knief. 2007. Bestandsentwicklung des Kormorans (*Phalacrocorax carbo sinensis*) in Deutschland und Europa. [Develop-

ment of the cormorant population (*Phalacrocorax carbo sinensis*) in Germany and Europe.] Fachtagung Kormorane, 26–27 September 2006. BfN-Skripten 204:28–47.

Klein, M. 2000. Neubewertung des Einflusses von Kormoranen auf Fischbestände in großen Voralpenseen. [Novel assessment of the influence of cormorants on fish populations in large pre-Alpine lakes.] Fischer und Teichwirt 51:211–216.

Klein, M. 2005. Die Kormoransituation in Bayern unter besonderer Berücksichtigung der Verhältnisse am Chiemsee. [The cormorant situation in Bavaria with special respect to the circumstances in Lake Chiemsee.] Arbeiten des Deutschen Fischerei-Verbandes 82:40–58.

Knösche, R. 2008. Der Kormoran: ein gesundes Regulativ oder eine Gefahr für die Süßwasserfischbestände? [The cormorant: a sound regulation or a danger for the opulations of freshwater fish?] Seminar Kormoran und Fischartenschutz. Schriftenreihe Landesfischereiverband Baden-Württemberg, Stuttgart 3:11–26.

Kohl, F. 2005. Kormoranschäden an Forellen- und Äschengewässer: Beispiele aus Österreich. [Damages by cormorants to trout and grayling waters: examples from Austria.] Arbeiten des Deutschen Fischerei-Verbandes 82:99–130.

Kohl, F. 2006–2007. Zur Kormorandiskussion in Europa. [The cormorant discussion in Europe.] Fischwaid 2006(5):14–17; (6):18–21; 2007(1):10–13.

Kohl F. 2008. Cormorants and protection of fish stocks: a pan-European problem. Paper presented to the Committee on Fisheries, EU Parliament, Brussels, Belgium.

Kramer, I. 2007. Fischschäden durch Kormorane. [Damages by cormorants to fish.] Fischer und Teichwirt 58:204–205.

Moerbeck, D. J., W. H. van Dobben, E. R. Osieck, G. C. Boere, and C. M. Bungenberg de Jong. 1987. Cormorant damage prevention at a fish farm in the Netherlands. Biological Conservation 39:23–38.

Müller, P. 2007. Jagdliche Aspekte des Kormoran-Managements. [Hunting aspects of cormorant management.] Arbeiten des Deutschen Fischerei-Verbandes 84:199–253.

Müller-Braun, T. 2006. Der lange Weg des finnischen Kormorans. [The long way of the Finnish cormorant.] Fischer und Teichwirt 57:95.

Peterson R., G. Mountford, and P. A. D. Hollom. 1965. Die Vögel Europas. [The birds of Europe.] 7th edition. Paul Parey, Hamburg, Berlin.

Piwernetz, D. 2008. "Der Kormoran" und sein Einfluss auf Ökosysteme in Gewässern. ["The cormorant" and its influence on aquatic ecosystems.] Fischer und Teichwirt 59:83–90.

Poór, C. 2005. The influence of cormorant (*Phalacrocorax carbo* Linné, 1758) on fish population in open waters in Hungary. Page 6 *in* Topical problems in water ecosystems protection. Research Institute for Soil and Water Conservation, Průhonice, Czech Republic.

Rutschke E. 1998. Der Kormoran: Biologie, Ökologie, Schadabwehr. [The cormorant: biology, ecology, damage protection.] Parey Buchverlag, Berlin.

Sato, K., J. Hwang-Bo, and J. Okumura. 1988. Food consumption and basal metabolic rate in common cormorants (*Phalacrocorax carbo*). Bulletin of Applied Ornithology 8:58–62.

Schlieker, E. 2005. Wachsende Probleme mit der Bestandsentwicklung des Kormorans in der Küstenregion des Landes Mecklenburg-Vorpommern und erkennbare Möglichkeiten zur Entspannung der Situation. [Growing problems with the development of the cormorant population in the coastal areas of Mecklenburg-Western Pomerania and the recognizable possibilities for decrease in tension.] Arbeiten des Deutschen Fischerei-Verbandes 82:131–146.

Schlieker, E. 2007. Schäden durch Kormorane an Fischbeständen und Fischerei in Küstengewässern. [Damages by cormorants to fish populations and fisheries in coastal waters.] Arbeiten des Deutschen Fischerei-Verbandes 84:87–102.

Schröder, W., F. Kohl, and S. Hanfland. 2007. Kormoran und Fischbestand. [Cormorant and fish populations.] Kritische Analyse und Forderungen des Landesfischereiverbandes Bayern e.V. Landesfischereiverband Bayern, München, Germany.

Schwarten, S. 2009. Fischfraß durch Kormorane. [Fish predation by cormorants.] Fischer und Teichwirt 60:207.

Schwevers, U., and B. Adam. 1998. Zum Einfluß des Kormorans (*Phalacrocorax carbo sinensis*) auf die Fischbestände der Ahr (Rheinland-Pfalz). [The influence of the cormorant (*Phalacrocorax carbo sinensis*) on the fish populations of the River Ahr (Rheinland-Pfalz).] Österreichs Fischerei 51:198–210.

Steffens, W. 2007a. Auswirkungen der Kormoranpopulation auf Fischbestände und Fischerei.

[Influences of the cormorant population on fish populations and fisheries.] Fischer und Teichwirt 58:249–253.

Steffens, W. 2007b. Kormorane als Gefährdungsfaktor aquatischer genetischer Ressourcen. [Cormorants endanger aquatic genetic resources.] Fischer und Teichwirt 58:409–410.

Steffens, W. 2007c. Europäisches Kormoran-Management aus der Sicht des Deutschen Fischerei-Verbandes. [European cormorant management from the point of view of the German Fisheries Association.] Arbeiten des Deutschen Fischerei-Verbandes 84:277–293.

Stiehler, W. 2007. Schäden durch Kormorane an Fischbeständen und Fischerei in der Teichwirtschaft. [Damages by cormorants to fish populations and fisheries in pond culture.] Arbeiten des Deutschen Fischerei-Verbandes 84:103–113.

Suter, W. 1995. Are cormorants *Phalacrocorax carbo* wintering in Switzerland approaching carrying capacity? An analysis of increase patterns and habitat choice. Ardea 83:255–266.

Suter, W. 1997. Roach rules: shoaling fish are a constant factor in the diet of cormorants *Phalacrocorax carbo* in Switzerland. Ardea 85:9–27.

U.S. Fish and Wildlife Service. 2003. Final environmental impact statement. Double-crested cormorant management in the United States. U.S. Fish and Wildlife Service, Washington, D.C.

Wagner, F., W. Schmalz, and M. Görner. 2008. Zum Einfluss des Kormorans (*Phalacrocorax carbo*) auf den Fischbestand der Ulster (Thüringen). [The influence of the cormorant (*Phalacrocorax carbo*) on the fish population of the River Ulster (Thuringia).] Artenschutzreport 22:1–10.

Wetlands International. 2008. Cormorants in the western Palearctic. Distribution and numbers on a wider European scale. Wetlands International, Ede, Netherlands.

Wires, L. R., F. J. Cuthbert, D. R. Trexel, and A. R. Joshi. 2001. Status of the double-crested cormorant (*Phalacrocorax auratus*): eastern and central America. U.S. Fish and Wildlife Service Report, Washington, D.C.

Wissmath, P. 2009. Neues zur Kormoranplage am Ammersee. [News concerning the cormorant plague at Lake Ammersee.] Fischer und Teichwirt 60:323.

Wissmath, P., M. Reschenauer, and U. Limburg. 2000. Kormoranschäden in der Netzfischerei am Ammersee im Dezember 1999. [Cormorant damages to fishing nets at Lake Ammersee in December 1999]. Fischer und Teichwirt 51:82–84.

Woschitz, G., and G. Parthl. 1997. Die Auswirkungen des erstmaligen Kormoraneinflugs im Winter 1995/96 auf die Fischfauna der Mur im Bereich der Entnahmestrecke KW Laufnitzdorf, Stm. [Influences of the first cormorant invasion during winter 1995/96 on the fish fauna of the River Mur in the region of the intake of water power plant Laufnitzdorf, Stm.] Landesregierung Umweltanwalt.

Zauner G. 1999. Einfluss des Kormorans auf die fischökologischen Verhältnisse der steirischen Enns zwischen Liezen und Johnsbach. [The influence of the cormorant on the fish-ecology situation in the Styrian River Enns between Liezen and Johnsbach.] Publikationsreihe Universität für Bodenkunde Wien, im Auftrag der stmk. Landesregierung, Germany.