Acta zoologica cracoviensia, **47**(1-2): 17-26, Kraków, 30 June, 2004

Fish in the diet of the Cormorant and the Yellow-legged Gull breeding near fish ponds (upper Vistula river valley, southern Poland) – preliminary study

Robert GWIAZDA

Received: 16 Dec., 2003
Accepted for publication: 12 March, 2004

GWIAZDA R. 2004. Fish in the diet of the Cormorant and the Yellow-legged Gull breeding near fish ponds (upper Vistula river valley, southern Poland) – preliminary study. *Acta zoologica cracoviensia*, **47**: 17-26.

Abstract. Examination of fish in the diet of Cormorants (pursuit divers) and Yellow-legged gulls (surface plungers) in colonies in an area adjacent to fish-ponds was carried out in 2000-2003. The examined colony of Cormorants consisted of 41-45 nests and that of the Yellow-legged Gulls – 41-90 nests during the study. The diet of Yellow-legged Gulls in freshwater habitats is not well known. The prey of Cormorants consisted of only seven species of fish. Carp was the most numerous prey at 69% of consumed fish. Fourteen species of fish were recorded in the food of the Yellow-legged Gulls with the domination of carp (38%) and roach (34%). Rheophilous fish made up 5-19% of food by number. Both species caught large fish, but generally Cormorants caught on average larger fish. The same pattern was confirmed when carp was compared. The mean prey size of the Cormorants was 20.6 cm in total length (range 7-41 cm) and that of Yellow-legged Gulls 18.5 cm (range 9-47 cm). Fish are the principal food item for both Cormorants and Yellow-legged Gulls in the studied sites in southern Poland.

Key words: diet composition, feeding preferences, fish origin, fish size, *Larus cachinnans, Phalacrocorax carbo*.

R. GWIAZDA, Karol Starmach Institute of Freshwater Biology, Institute of Nature Conservation Polish Academy of Sciences, 31-120 Kraków, al. Mickiewicza 33, Poland.
E-mail: gwiazda@iop.krakow.pl

I. INTRODUCTION

The Cormorant *Phalacrocorax carbo* (LINNAEUS, 1758) and the Yellow-legged Gull *Larus cachinnans* PALLAS, 1811, are species in expansion. Numbers of Cormorants rapidly increased in the last two decades in Europe, in central Europe as well (LINDELL et al. 1995). Cormorants have begun breeding in southern Poland since 1986 (DYRCZ et al. 1991, PRZYBYSZ et al. 1988). The Yellow-legged Gull increased its range and numbers as well in the last years in central Europe (SNOW & PERRINGS 1998). This species has bred in Poland from the late 80's (BUKACIŃSKI et al. 1989, DUBOIS et al. 1990) and in southern Poland since 1999 (FABER et al. 2001). In the 80's this species was separated from the Herring Gull (GLUTZ VON BLOTZHEIM & BAUER 1982, SNOW & PERRINS 1998). Cormorants are fish-eaters and Yellow-legged Gulls or Herring Gulls *Larus argentatus* (before these species were separated) can be described as opportunistic omnivorous (CRAMP

& SIMMONS 1977, 1983, GLUTZ VON BLOTZHEIM & BAUER 1982). HILLSTRÖM et al. (1994) concluded that these Gull species foraged mostly on fish, even though other types of food were also available. HÜPPOP & HÜPPOP (1999) suggested that the inland breeding distribution of Herring Gulls is limited by the availability of fish during the breeding season rather than by the availability of human refuse or by the lack of breeding habitats. Both species can play important roles in freshwater ecosystems as top predators. The diet of Cormorants in the breeding season has been widely studied in different habitats: rivers (WOLTER & PAWLIZKI 2003), lakes (VELDKAMP 1995b, WZIĄTEK et al. 2003), ponds (MELLIN & MIROWSKA-IBRON 2002, SEICHE 2002, TROLLIET 2002) and coasts (MARTYNIAK et al. 2003, STEMPNIEWICZ et al. 2003). The diet of Yellow-legged Gulls was studied mainly in marine habitats because they breed mainly at coastal sites (GONZALES-SOLIS et al. 1997a, GONZALES-SOLIS et al. 1997b, DUHEM et al. 2003a, DUHEM et al. 2003b). The foraging techniques of these species are completely different because Cormorants are divers that search for prey in water and Gulls hunt from the air catching fish on the surface or in shallow water (CRAMP & SIMMONS 1977, 1983). They are able to forage on dead fish or steal prey caught by other species (kleptoparasitism). The Cormorant is larger and about twice as heavy as the Yellow-legged Gull. The purpose of this study was to investigate the differences in food choice of the pursuit diver (Cormorant) and surface plunger (Yellow-legged Gull) exploiting a very similar food base. Specifically:

– if prey species are the same for both birds breeding near fish ponds,

– what is the origin of prey in freshwater habitats,

– if prey size can be different for these species.

The author thanks Prof. Zygmunt BOCHEŃSKI for valuable comments improving the manuscript, Dr Antoni AMIROWICZ for helping in total fish length estimation, fish species identification and critical comments on the manuscript, Dr Jacek BETLEJA for assistance with field work and Dr Elżbieta WILK-WOŻNIAK for a map with study sites.

II. STUDY AREA AND METHODS

The investigations were carried out at two sites in southern Poland (upper Vistula River valley) (Fig. 1). The breeding colony of Cormorants was in the backwaters of the Goczałkowice reservoir (49° 51' N, 18° 52' E). This is an eutrophic reservoir with an area of c. 3000 ha and mean depth of 5.3 m. The shores are covered by a large area of submerged vegetation and wet meadows in backwaters. This reservoir is located in a large area of fish ponds at Gołysz (minimum distance c. 5 km). The fish species with the highest frequency was bream *Abramis brama* (JELONEK & AMIROWICZ 1987, STARMACH & JELONEK 2001). The Black-headed Gull *Larus ridibundus* was the dominant species in the breeding season and reached a maximum of 9000 pairs (DYRCZ et al 1991). The colony of Cormorants was located on some ash trees on two islands in the backwaters of the Goczałkowice reservoir. The number of Cormorant nests reached 41 in 2000 and 45 in 2001. The low water level at the Goczałkowice reservoir caused the Cormorants to leave the colony in 2002.

The colony of Yellow-legged Gulls was established in a gravel pit at Jankowice near Zator (50° 02' N, 19° 26' E). The area of this deep water body is c. 100 ha. The shores were not covered by macrophytes. There were some islands. Minimum distance from the nearest carp ponds in Przeręb and Spytkowice is c. 1.5 km. The breeding colony of Yellow-legged Gulls is located at a distance of less than half a kilometer from the Vistula river. Forty one pairs of the Yellow-legged Gulls in 2001 and c. ninety pairs in 2003 had bred on a small island covered by grass and partly by bushes and trees inside the colony of 1500-2000 Black-headed Gulls at Jankowice near Zator.

Food samples were collected in the colony of Cormorants on 9 June 2000 and on 6 June 2001, and in the colony of Yellow-legged Gulls on 29 April 2000, on 17 May 2000, on 16 May 2001, and in 2003 on 29 April, on 8 May and on 16 May. Twenty five pellets of Cormorants were collected for analysis. Twenty four pellets in 2003 and a total of 143 fish brought for offspring and put near nests by Yellow-legged Gulls in all studied years were examined. Fish remains (otoliths, pharyngeal

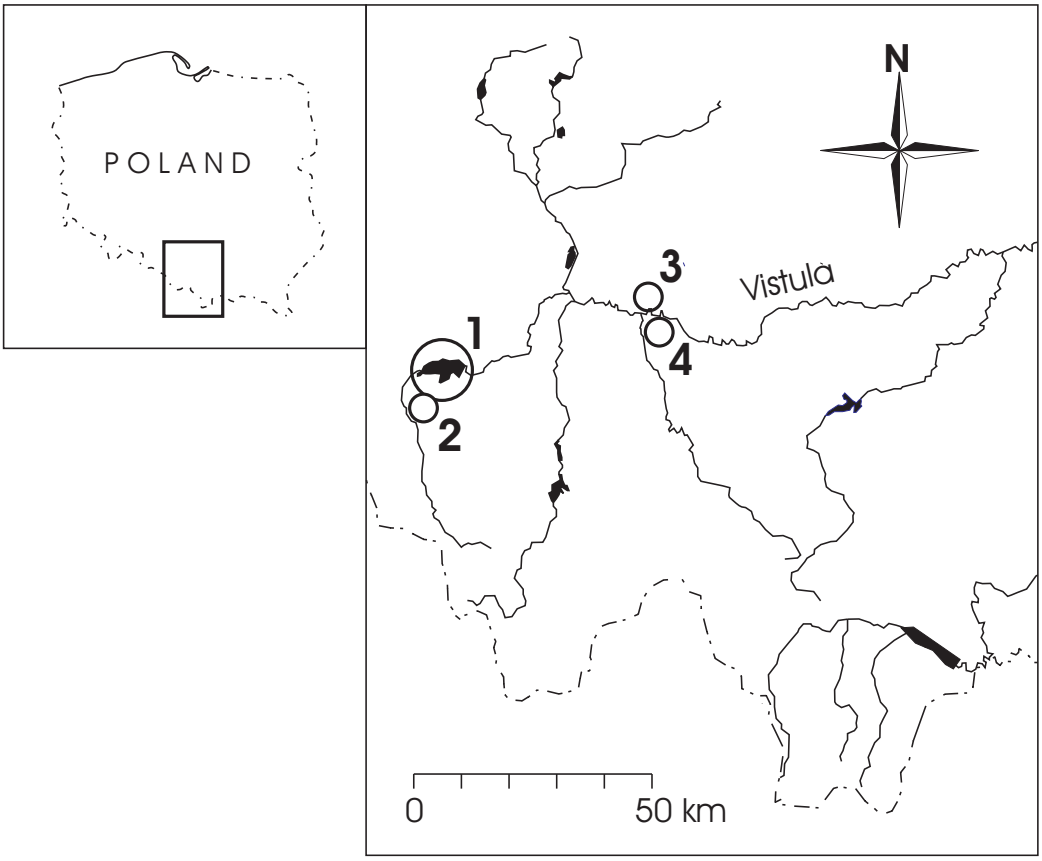

Fig. 1. Locations of study sites and nearest fish ponds in southern Poland. 1 – Goczałkowice Reservoir, 2 – Gołysz fish pond complex, 3 – Jankowice gravel-pit, 4 – Spytkowice fish pond complex.

bones and chewing pads) were identified in pellets. The number of individuals of a species in a pellet was defined as the highest total of any of the identifiable parts present, taking right and left parts separately. The length of Percidae otoliths, pharyngeal bones and chewing pads of Cyprinidae was measured and from these the total length of each fish were calculated. The recovery of otoliths of Cyprinidae fish in the pellets was very low (ZIJLSTRA & VAN EERDEN 1995, MCKAY et al. 2003)) and otoliths of most cyprinids are more or less non-specific (VELDKAMP 1995a) so they were not taken into account. The size of prey was estimated on the basis of the following regression equations:

To estimate total fish length (TL, in cm) from otolith length (OL, in mm) equations given by DIRKSEN et al. (1995) were used:

Gymnocephalus cernuus (LINNAEUS, 1758); TL=1.999xOL + 0.097

Perca fluviatilis LINNAEUS, 1758; TL=2.810xOL - 0.340

Stizostedion lucioperca (LINNAEUS, 1758); TL=4.236xOL - 3.366

To estimate fish length from pharyngeal bone length (PB, in mm) equations for body length (CL, in cm) given by HOROSZEWICZ (1960) were used. To estimate total fish length (TL, in cm) the calculated values of body length were increased by 15%.

Cyprinus carpio LINNAEUS, 1758; CL=0.92xPB – 2.93

Rutilus rutilus (LINNAEUS, 1758); CL=1.29xPB + 0.23

Abramis brama (LINNAEUS, 1758); CL=1.41xPB – 0.12

Blicca björkna (LINNAEUS, 1758); CL=1.46xPB – 0.78

Scardinius erythrophthalmus (LINNAEUS, 1758); CL=1.15xPB + 0.38

Allburnus allburnus (LINNAEUS, 1758); CL= 1.52xPB + 0.14

Carassius carassius (LINNAEUS, 1758); CL=0.9xPB – 0.38

Leuciscus cephalus (LINNAEUS, 1758); CL=1.11xPB + 0.17

Leuciscus leuciscus (LINNAEUS, 1758); CL=1.44xPB + 0.72

Chondrostoma nasus (LINNAEUS, 1758); CL=1.73xPB + 1.17

To calculate total fish length (TL, in cm) from chewing pad length (P) the regression formulae given by VELDKAMP (1995b) were used:

Rutilus rutilus (LINNAEUS, 1758); TL=20.578xP + 34.922

Abramis brama (LINNAEUS, 1758); TL=41.805xP + 7.826

For calculations of total length of *Cyprinus carpio* (TL, in cm) from chewing pads, the length of this structure (in mm) was multiplied by 3.28. Some fish remains were damaged and species identification was possible but not length estimation.

In all, 96 fish in food samples from Cormorants and 184 fish in food samples of Yellow-legged Gulls were found. The lengths of 86 fish consumed by Cormorants and 155 fish eaten by Yellow-legged Gulls were estimated.

To compare differences in fish species in diet between Cormorants and Yellow-legged Gulls, the Chi-square test was used. To compare the total length of fish in the food of the studied species, the Mann-Whitney U test was used (SOKAL & ROHLF 1987).

III. RESULTS

The pellets of Cormorants consisted of fish only, and the pellets of Yellow-legged Gulls contained fish (41 indiv.), small birds (3 indiv.), small mammals (1 indiv.) and garbage (2). The Cormorant's pellets contained from 1 to 7 fish (median=3, N=25), and the range of fish in the pellets of the Yellow-legged Gull was 1-4 (median=1, N=24). The remains of carp *Cyprinus carpio* were found in 17 of 25 pellets of Cormorants, and in 15 of 24 pellets of Yellow-legged Gulls. The prey of Cormorants in the colony at the reservoir consisted only of seven species of fish (Table I). Carp was a dominant species, representing 73% of consumed fish by number in 2000 and 65% in 2001. Rheophilous fish were not recorded at all. The remains of 14 fish species were determined in the food of Yellow-legged Gulls breeding in a gravel pit (Table II). The most numerous was carp (67% in 2000 and 57% in 2003) and roach (62% in 2001). Rheophilous fish (chub *Leuciscus cephalus*, dace *Leuciscus leuciscus,* spotted barbel *Barbus petenyi*, and nase *Chodrostoma nasus*) represented 5% in 2000, 12% in 2001 and 19% in 2003 of food by number. The fraction of carp in the diet of Cormorants in both studied years was not statistically different compared to the diet of Gulls in 2000 and 2003, and was statistically higher in 2001 ($\times^2$ =42.5, df=1, p.001; X^2=46.9, df=1, p.001, respectively). The fraction of roach in the diet of Cormorants was statistically lower in 2001 than the fraction of this species in the diet of Yellow-legged Gulls ($\times^2$ =17.2, df=1, p.001; X^2=42.8, df=1, p.001).

The total length of fish in the food of Cormorants ranged between 7 and 41 cm, and in the food of Yellow-legged Gulls: 9-47 cm. The largest Cormorant prey was pike-perch *Stizostedion lucioperca* with a total length of 40.6 cm, and the largest prey of Yellow-legged Gulls was nase with a size of 47.0 cm (l.t.).

Table I

Food contents (by number) of Cormorants breeding in the upper Vistula river valley in 2000 and 2001

Species	2000		2001		Total	
	N	%	N	%	N	%
Carp *Cyprinus carpio*	30	73.2	36	65.5	66	68.8
Grass Carp *Ctenopharyngodon idella*			4	7.3	4	4.2
Roach *Rutilus rutilus*			14	25.5	14	14.6
Bream *Abramis brama*	2	4.9			2	2.1
Ruffe *Gymnocephalus cernuus*	5	12.2			5	5.2
Perch *Perca fluviatilis*	4	9.7			4	4.2
Pike-perch *Stizostedion lucioperca*			1	1.8	1	1
Total	41		55		96	

Table II

Food contents (by number) of Yellow-legged Gulls breeding in the upper Vistula river valley in 2000, 2001 and 2003

Species	2000		2001		2003		Total	
	N	%	N	%	N	%	N	%
Carp *Cyprinus carpio*	15	68.2	10	12.0	44	55.7	69	37.5
Roach *Rutilus rutilus*	4	18.2	51	61.4	8	10.1	63	34.3
Bream *Abramis brama*	1	4.5	2	2.4	1	1.3	4	2.2
Silver Bream *Blicca björkna*					1	1.3	1	0.5
Rudd *Scardinius erythrophthalmus*			1	1.2			1	0.5
Bleak *Alburnus alburnus*			1	1.2	1	1.3	2	1.1
Crucian Carp *Carassius carassius*			2	2.4	6	7.6	8	4.3
Ruffe *Gymnocephalus cernuus*	1	4.5	3	3.6			4	2.2
Perch *Perca fluviatilis*			2	2.4	3	3.8	5	2.7
Pike *Esox lucius*			1	1.2			1	0.5
Chub *Leuciscus cephalus*			8	9.6	7	8.9	15	8.2
Dace *Leuciscus leuciscus*					1	1.3	1	0.5
Spotted Barbel *Barbus petenyi*	1	4.5	2	2.4	1	1.3	4	2.2
Nase *Chodrostoma nasus*					6	7.6	6	3.3
Total	22		83		79		184	

In general, the lengths of fish obtained from Cormorants were greater than those from Yellow-legged Gull (Z=2.395, p.02, N=241). The median length of prey taken by cormorants was 20.6 cm (Q^1=16.3, Q^3=24.6, N=86) and by Yellow-legged Gulls was 18.5 cm (Q^1=15.6, Q^3=21.5, N=155). However, this scheme is quite different when the collected records are compared in particular years. Fish represented in the food of cormorants in 2001 were statistically larger than fish caught by Yellow-legged Gulls in all studied years (Z=3,324, p.001, N=72; Z=3,376, p.001, N=125; Z=3.755, p.001, N=114 respectively) (Fig. 2). The median total length of fish caught by Cormorants in 2001 was 21.2 cm (Q^1=19.1, Q^3=25.0, N=52). The same pattern was confirmed when carp was compared. This species was also significantly larger in the food of Cormorants in 2001 than in the food of Yellow-legged Gulls in all studied years (Z=2.696, p.01, N=52; Z=2,838, p.01, N=46; Z=3.004, p.01, N=66 respectively). In 2000 such differences were not found. Differences between the length of carp and length of wild fish in the food of Cormorants in 2001 and in the food of Yellow-legged Gulls in all studied years were not found.

Most of the prey of both bird species was 14-26 cm long. About 50% of fish caught by Cormorant in 2000 and 75% in 2001 ranged 16-26 cm. Seventy to 75% of fish in the diet of the Yellow-legged Gull during the studied years were smaller in size – 14-24 cm in total length.

IV. DISCUSSION

Diet composition of Cormorants is habitat specific. Roach and perch *Perca fluviatilis* were the dominant prey of Cormorants in Switzerland (SUTER 1997a). Diet strongly dominated by roach and perch is typical for most eutrophic lakes and empounded rivers, and diet dominated by grayling *Thymallus thymallus*, trout *Salmo trutta* or riverine cyprinids is in free-running rivers (SUTER 1997a). Roach, bream and pike-perch were the most important prey species by biomass taken by breeding cormorants in NW Overijssel, The Netherlands (VELDKAMP 1995b). Roach was the dominant species (by biomass) in the diet of Cormorants from colonies in north-east Poland (MELLIN & MIROWSKA-IBRON 1997, MARTYNIAK et al. 1997). Roach was the most commonly recorded fish also (43.7% by number) in the lakes of Drawa National Park, NW Poland (WZIĄTEK et al. 2003). In this study carp and grass carp were caught from fish-ponds and other fish were probably taken from

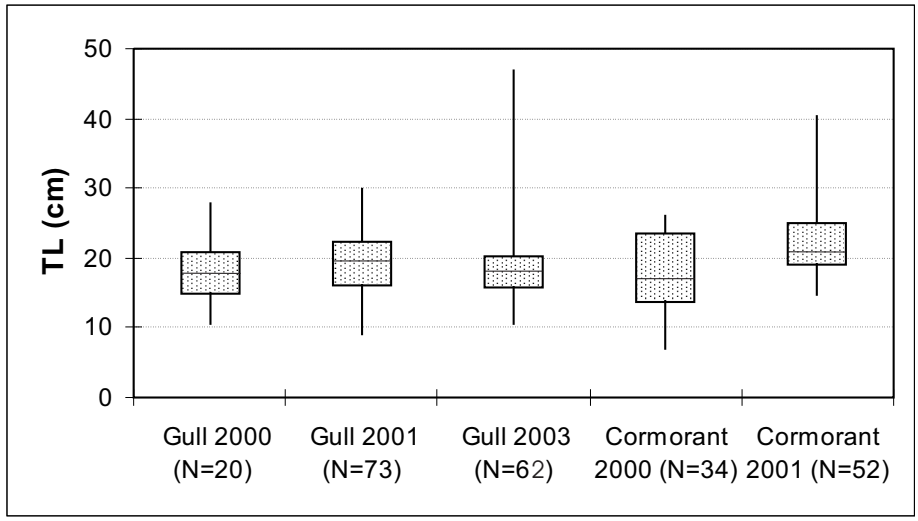

Fig. 2. Range of total fish length, median, first and third quartiles in the food of Yellow-legged Gulls and Cormorants breeding in the upper Vistula river valley during the study period.

the reservoir. Roach and other limnofilous fish were less important prey (by number) for Cormorants in Goczałkowice because carp is a more attractive prey in terms of availability. The fish are present in high densities in relatively shallow ponds. So Cormorants prefer to forage in artificial environments. The distance between the colony on the Gocza³kowice dam reservoir from the fish pond complex was small, as compared with the maximum distance of the Cormorant colony at Chausey Island in France to the foraging sites, which was 35 km (GRÉMILLET 1997). The diet of Cormorants at two fish farms in the Warmia and Mazury districts of Poland consisted mainly of carp (92.5-100% of food items) (MELLIN et al. 1997). At two fish farming regions in France, carp consisted c. 50% of fish mass of the Cormorant diet (TROLLIET 2002). Cormorants nesting at a reservoir in South Moravia in the neighborhood of fish ponds also caught carp (ADÁMEK & GUZIUR 1992). The structure of fish in the diet of Cormorants from a colony at Goczałkowice reservoir showed that they foraged mainly in ponds and less in the reservoir.

Fish were most numerous in the diet of Gulls. A study of diet choice during prelaying and incubation periods in Newfoundland showed that 75-80% of Herring Gulls were specialized (on either intertidal organisms, human refuse, or other seabirds) and 20-25% had a generalized diet (PIERROTTI & ANNETT 1991). The diet of herring Gulls in a colony in SW Finland consisted mainly of fish (70% of all feedings) (HILLSTRÖM et al. 1994). Fish were the predominant food in Lakes Ontario, Erie, Huron and Superior (Canada), between mid-April and mid-July (FOX et al. 1990). A study concerning this species in the Great Lakes in Canada in winter and early spring showed mainly fish in the diet as well, and the species varied regionally, probably reflecting local availability (EVINS et al. 1994). The diet of breeding Yellow-legged Gulls was studied in the southwestern Mediterranean and showed that they feed mainly on refuse dumps and on fish (when purse seine fishing) (GONZALES-SOLIS et al. 1997b). A diet analysis of the Herring Gull *Larus argentatus* breeding on an island in the lower river Elbe, northern Germany showed that fish were found in 79% of all pellets, followed by crustaceans (39%) and human refuse (10%). Of (potential) food remains other than pellets, 46% were fish, 19% Gull eggs, 17% crustaceans, 10% small birds and 8% human refuse. The strong tidal rhythm of the adults' attendance at the colony coincided with fishery activities at the river banks and supported their dependence on unwanted bycatches from fisheries (HÜPPOP & HÜPPOP 1999). Pellets of the first two pairs of Yellow-legged Gulls *Larus [cachinnans] michahellis* in Belgium suggest that the diet of their chicks consisted of fish and young rabbits (VERCRUIJSSE et al. 2002). Results of this study also showed mainly fish in the diet of the Yellow-legged Gulls in the upper Vistula river valley. The great number of whole fish placed near nests and the lack of marks on their body, characteristic for the bills of herons or Cormorants, suggests that they could be caught by Gulls. The large frequency of carp in the food of the Yellow-legged Gull showed that Gulls feed in ponds. This is possible because fish ponds are found at a relatively short distance from the breeding colony. The high density of fish and low water level in ponds provided relatively small costs of hunting for birds and a high probability of attack success. The occurrence of rheophilous fish in their food and a high fraction of roach in 2001 was probably the result of catching fish in the Vistula river where reconstruction work was being done. The shores were destroyed and heavy equipment caused water turbidity and disturbed the fish, which was helpful for Gulls by allowing them to hunt from shore. Gulls were observed foraging in a gravel pit near the Vistula. Maybe they search for "easy" prey in different available water bodies around the breeding colony. Apart from this, birds foraged at a close distance from the colony. Probably roach was the main food outside of fish ponds because of its dominance in these habitats.

Cormorants probably foraged mostly in fish-ponds close to the upper Vistula river because the availability of carp is higher there for this diving bird. Gulls are able to catch fish only in surface water. This study shows that carp can be a very important prey item for both studied species. Gulls seem to be the more opportunistic species feeding on a wider spectrum of fish species and foraging in a greater number of habitats, although this may be a result of unequal food samples of the studied species.

Cormorants breeding at the Goczałkowice reservoir caught relatively large prey, greater than in most studies. ADÁMEK and GUZIUR (1992) found that Cormorants in lowland reservoirs in south Moravia caught fish mostly in the size range of 7.0-15.0 cm total length with a maximum of 24-30 cm. The average total length of fish in the diet was 15.8 cm. The most frequently eaten fish in lakes of N-E Poland were 10-15 cm long (body length) (MELLIN 1990, MARTYNIAK et al. 1997), and from fish ponds from the same district -8.0-10.9 cm in length (body length) (MELLIN et al. 1997). Cormorants from the Drawa National Park colony consumed small-sized fish. The mean body length of fish was about 15 cm for roach and perch (WZIĄTEK et al. 2003). Maybe foraging in fish-ponds allowed for catching optimal prey in relation to cost-effect. At fish-ponds, birds can find fish of similar size, easy to catch and swallow. In natural water bodies densities of fish are much lower and the size of fish is more differentiated. A large fraction of fish are too large or too small for a diving predator.

There is no published data on the size of fish caught by Yellow-legged Gulls. They also caught large fish but smaller than the Cormorants'. The prey of Gull can be torn to pieces, while Cormorants swallow the whole fish. Gulls cannot dive so their prey must be in the upper layer of water. They are able to take fish from other fish-eating birds. Fish of greater size can be taken from Cormorants or Grey Herons *Ardea cinerea*, although this was probably not the case here. Higher numbers of Cormorants were observed in autumn at Spytkowice ponds, located near the studied Gull colony. The numbers of Cormorants were very small during the period between May-July (WIEHLE 2002). Catching such great prey as nases 38 or 47 cm in total length by Yellow-legged Gulls seems to be impossible. Foraging at recreational fishing places may explain these records. Nase belongs to the most popular fishes caught by fishermen in the submontane rivers in southern Poland. It is a common practice to remove scales, heads and eviscerate nase immediately on the river bank to maintain good consumption quality of these fishes. Lost offals may be available to foraging Gulls.

Probably Gulls and Cormorants exploited the same cohorts of carp at fish-ponds. No differences between the size of carp and wild fish in the diet of Cormorants in 2001 and of Yellow-legged Gulls shows that these species are able to hunt on large fish in natural water bodies.

Fish are the principal food of both Cormorants and Yellow-legged Gulls during the breeding season in the case of the studied habitats in southern Poland. Therefore, these species may have a great impact on the fish community. A reduction of cyprinids can be positive for environmental quality (biomanipulation theory) with a high density of fish. The expansion of Cormorants and Yellow-legged Gulls and an increase in their numbers can cause conflicts of interest with fish farmers because of these birds' tendencies to forage on carp. The conflict between Cormorants and fisheries (DOBROWOLSKI & DEITROWSKI 1997, SUTER 1997b, TROLLIET 2002) or species conservation (STAUB 1997) is already well known.

REFERENCES

ADÁMEK Z., GUZIUR J. 1992. Food composition of black cormorant (Phalacrocorax carbo L.) in lowland reservoirs Nové Mlýny (south Moravia, Czechoslovakia). *Acta Academiae Agriculturae Technicae Olstenensis*, **19**: 109-120. (In Polish with English summary).

BUKACIŃSKI D., NAWROCKI P., STAWARCZYK T. 1989. Gniazdowanie mew białogłowych (*Larus cachinnans*) na środkowej Wiśle, ich status taksonomiczny oraz problemy z rozpoznawaniem podgatunków *L. c. michahellis, L. c. cachinnans i L. c. omissus*.. *Notatki Ornitologiczne*, **30**: 3-12. (In Polish with English summary).

CRAMP S., SIMMONS K. E. L. (eds) 1977. Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of Western Palearctic, vol. 1. Oxford University Press, Oxford.

CRAMP S., SIMMONS K. E. L. (eds.) 1983. Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of Western Palearctic, vol. 3. Oxford University Press, Oxford.

DIRKSEN S., BOUDEWIJN T. J., NOORDHUIS R., MARTEIJN E. C. L. 1995. Cormorants *Phalacrocorax carbo* sinenesis in shallow eutrophic freshwater lakes: prey choice and fish consumption in the non-breeding period and effects of large-scale fish removal. *Ardea*, **83**(1): 167-184.

DOBROWOLSKI K. A., DEITROWSKI R. 1997. Conflict between fishermen and cormorants *Phalacrocorax carbo* in Poland. *Ekologia polska*, **45**(1): 279-285.

DUBOIS P. J., SKAKUJ M., STAWARCZYK T. 1990. Occurence of Yellow-legged Gull in Poland. *Dutch Birding*, **13**: 14-17.

DUHEM C., VIDAL E., LEGRAND J., TATONI T. 2003a. Opportunistic feeding responses of the Yellow-legged Gull *Larus michahellis* to accessibility of refuse dumps. *Bird Study*, **50**: 61-67.

DUHEM C., VIDAL E., ROCHE P., LEGRAND J. 2003b. Island breeding and continental feeding: How are diet patterns in adult yellow-legged gulls influenced by landfill accessibility and breeding stages? *Ecoscience*, **10**(4): 502-508.

DYRCZ A., GRABIŃSKI W., STAWARCZYK T., WITKOWSKI J. 1991. [Birds of Silesia]. Uniwersytet Wrocławski, Wrocław. (In Polish with English summary).

EVINS P. J., WESELOH D. V., GROOM J. H., DOBOS R. Z., MINEAU P. 1994. The diet of Herring Gulls (*Larus argentatus*) during winter and early spring on the lower Great Lakes. *Hydrobiologia*, **279/280**: 39-55.

FOX G. A., ALLAN L. J., WESELOH D. V., MINEAU P. 1990. The diet of herring gulls during the nestling period in Canadian waters of the Great Lakes. *Canadian Journal of Zoology*, **68**: 1075-1085.

FABER M., BETLEJA J., GWIAZDA R., MALCZYK P. 2001. Mixed colonies of large white-headed gulls in southern Poland. *British Birds*, **94**: 529-534.

GLUTZ VON BLOTZHEIM U. N., BAUER K. M. 1982. Handbuch der Vögel Mitteleuropas. 8/I. Wiesbaden.

GONZALES-SOLIS J., RUIZ X., JOVER L. 1997a. Influence of food availability on interactions between Larus cachinnans and L. audouinii. *Canadian Journal Zoology*, **75**(5): 719-724.

GONZALES-SOLIS J., ORO D., JOVER L., RUIZ X., PEDROCCHI V. 1997b. Trophic niche width and overlap of two sympatric gulls in the southwestern Mediterranenean. *Oecologia*, **112**(1): 75-80.

GRÉMILLET D. 1997. Catch per unit of effort, foraging efficiency, and parental investment in breeding great cormorants (*Phalacrocorax carbo carbo*). *ICES Journal of Marine Sciences*, **54**: 635-644.

HILLSTRÖM L., KILPI M., LINDSTROM K. 1994. Diet of Herring Gulls *Larus argentatus* during chick rearing in the Gulf of Finland. *Ornis Fennica*, **71**: 95-101.

HOROSZEWICZ L. 1960. The Value of Lower Pharyngeal Arches as Species Criteria for Defining Fish of the Cyprinidae Family. *Roczniki Nauk Rolniczych*, **75 B 2**: 237-256. (In Polish with English summary).

HÜPPOP O., HÜPPOP K. 1999. The food of breeding Herring Gulls *Larus argentatus* at the lower river Elbe: does fish availability limit inland colonisation? *Atlantic Seabirds*, **1**(1): 27-42.

JELONEK M., AMIROWICZ A. 1987. Composition, density and biomass of the ichtyofauna of the Goczałkowice Reservoir (southern Poland). *Acta Hydrobiologica*, **29**: 253-259.

LINDELL L., MELLIN M., MUSIL P., PRZYBYSZ J., ZIMMERMAN H. 1995. Status and population development of breeding Cormorants *Phalacrocorax carbo sinensis* of the central European flyway. *Ardea*, **83**(1): 81-92.

MARTYNIAK A., MELLIN M., STACHOWIAK P., WITTKE A. 1997. Food composition of cormorants *Phalacrocorax carbo* in two colonies in north-eastern Poland. *Ekologia polska*, **45**(1): 245.

MARTYNIAK A., WZIĄTEK B., SZYMAŃSKA U., HLIWA P., TERLECKI J. 2003. Diet composition of Great Cormorants *Phalacrocorax carbo sinenesis* at Kąty Rybackie, NE Poland, as assessed by pellets and regurgitated prey. *Vogelwelt*, **124**, Suppl.: 217-225.

MCKAY H. K., ROBINSON K. A., CARSS D. N., PARROT D. 2003. The limitations of pellet analysis in the study of Cormorant Phalacrocorax spp. diet. *Vogelwelt*, **124**, Suppl.: 227-236.

MELLIN M. 1990. Preliminary results of the dissection of cormorants shot in the Mazurian Lakeland in spring 1987. *Notatki Ornitologiczne*, **31**(1-4): 53-60. (In Polish with English summary).

MELLIN M., MIROWSKA-IBRON I. 1997. Results of cormorant *Phalacrocrax carbo* control in north-eastern Poland in 1987-1992. *Ekologia polska*, **45**(1): 305-308.

MELLIN M., MIROWSKA-IBRON I. 2002. Population trend of Great Cormorant in the north-eastern part of Poland with respect to fishponds areas. [In:] Der Kormoran (*Phalacrocorax carbo*) im Spannungsfeld zwischen Naturschutz und Teichbewirtschaftung, 1 (Publisher: Sächsische Landesstiftung Natur und Umwelt Akademie, Dresden, Germany): 51-55.

MELLIN M., MIROWSKA-IBRON I., MARTYNIAK A. 1997. Food composition of cormorants *Phalacrocorax carbo* shot at two fish farms in north-eastern Poland. *Ekologia polska*, **45**(1): 247.

PIEROTTI R., ANNETT C. A. 1991. Diet choice in the herring gull: constraints imposed by reproductive and ecological factors. *Ecology*, **72**(1): 319-328.

PRZYBYSZ J., ENGEL J., MELLIN M., MRUGASIEWICZ A., PRZYBYSZ A., PRZYBYSZ K. 1988. [A quantitative increase of the Cormorant (*Phalacrocorax carbo sinensis* Shaw & Nodder) population in Poland]. *Przegląd Zoologiczny*, **32**: 71-81. (In Polish with English summary).

SEICHE K. 2002. Bestand und Nahrungsspektrum des Kormorans (*Phalacrocorax carbo sinenesis*) in den sächsischen Teichgebieten als Grundlage für eine Schadensbewertung. [In:] Der Kormoran (*Phalacrocorax carbo*) im Spannungsfeld zwischen Naturschutz und Teichbewirtschaftung, 1 (Publisher: Sächsische Landesstiftung Natur und Umwelt Akademie, Dresden, Germany): 38-44.

SNOW D. W., PERRINS C. M. 1998. The Birds of the Western Palearctic. Concise Edition, Oxford.

SOKAL R. R., ROHLF F. J. 1987. Introduction to Biostatistics. W. H. Freeman and Company, New York.

STARMACH J., JELONEK M. 2001 Specjalistyczna gospodarka rybacka w zbiornikach wodociągowych. [Special fishery management at water reservoirs]. *Supplementa ad Acta Hydrobiologica*, **1**: 1-27. (In Polish).

STAUB E. 1997. Cormorant *Phalacrocorax carbo* predation and conflicts with species conservation and fisheries in Switzerland. *Ekologia polska*, **45**(1): 309-310.

STEMPNIEWICZ L., MARTYNIAK A., BOROWSKI W., GOC M. 2003. Fish stocks, commercial fishing and cormorant predation in the Vistula Lagoon, Poland. [In:] I. G. COWX (ed.) – Interactions between fish and birds: implications for management. Blackwell Science Ltd, Oxford: 51-64.

SUTER W. 1997a. Roach rules: Shoaling fish are a constant factor in the diet of cormorants Phalacrocorax carbo in Switzerland. *Ardea*, **85**(1): 9-27.

SUTER W. 1997b. Cormorant *Phalacrocorax carbo* predation on salmonid fish in two Swiss rivers: the use and abuse of fisheries data in impact assesment. *Ekologia polska*, **45**(1): 311-312.

TROLLIET B. 2002. Cormorant and extensive fish-farming in France. [In:] Der Kormoran (*Phalacrocorax carbo*) im Spannungsfeld zwischen Naturschutz und Teichbewirtschaftung, 1 (Publisher: Sächsische Landesstiftung Natur und Umwelt Akademie, Dresden, Germany): 60-67.

VERCRUIJSSE H. J. P., STIENEN E. W. M., VAN WAEYENBERGE J. 2002. First pure pairs of Yellow-legged Gull *Larus* [*cachinnans*] *michahellis* along the North Sea coasts. *Atlantic Seabirds*, **4**(3): 127-129.

VELDKAMP R. 1995a. The use of chewing pads for estimating the consumption of cyprinids by Cormorants *Phalacrocorax carbo*. *Ardea*, **83**(1): 135-138.

VELDKAMP R. 1995b. Diet of Cormorants *Phalacrocorax carbo sinensis* at Wanneperveen, The Netherlands, with special reference to Bream *Abramis brama*. *Ardea*, **83**(1): 143-155.

WOLTER C., PAWLIZKI R. 2003. Seasonal and spatial variation in cormorant predation in a lowland floodplain river. [In:] I. G. COWX (ed.) – Interactions between fish and birds: implications for management. Blackwell Science Ltd, Oxford: 178-186.

WIEHLE D. 2002. Birds of the fishponds in Spytkowice in the years 1995-2000. *Chrońmy Przyrodę Ojczystą*, **58**(1): 25-61. (In Polish with English summary).

WZIĄTEK B., MARTYNIAK A., SZYMAŃSKA U., KOZŁOWSKI J., DOSTATNI D. 2003. Composition of the Great Cormorant *Phalacrocorax carbo sinensis* diet in the Drawien National Park, NW-Poland. *Vogelwelt*, **124**, Suppl.: 291-295.

ZIJLSTRA M., VAN EERDEN M. R. 1995. Pellet production and the use of otoliths in determining the diet of cormorants *Phalacrocorax carbo sinensis*: trials with captive birds. *Ardea*, **83**(1): 123-132.