Conflicting Interests of Fisheries and Predators at Kerkini Lake, Greece

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Introduction

At many Greek coastal and inland wetlands there is much discussion among fishermen about the impact of fish eating birds on fishery. Due to the catches' decrease of the most commercially important fish species, fishermen regard many fish eating birds and especially Great cormorants (*Phalacrocorax carbo sinensis*) as competitors. According to short time studies carried out in Greece, the impact of Great cormorant on fishery seems to be of low importance. Its diet consists of fish species of low or medium commercial value (Goutner et al. 1997, 1998, Liordos et al. 2002, Kazantzidis and Naziridis 2003). They may also reduce the commercial value of certain fish species by injuring them mainly at fishfarms (Dimitriou et al. 2003). However, in many wetlands (lakes, lagoons or fish farms), a lot of frightening techniques are applied from fishermen in order to minimize the number of birds feeding at their fishing sites and their negative effect on fishery. The majority of these techniques are of limited or temporal effectiveness.

During the 90s at Kerkini Lake the yield of the most commercially important fish species decreased, due to various reasons (e.g. illegal fishing, water management etc.). On the other hand, the population of Great cormorant has increased dramatically during the last 13 years reaching to the maximum number ever recorded at the lake (Crivelli et al 1995, Kazantzidis and Naziridis 2003). The breeding population of Great Cormorant at Kerkini Lake at 2002 represented a percentage of 81.4% of the total breeding population of this species in Greece (Liordos and Goutner 2003). Fishermen believe that Great cormorant is among the reasons of the yield decrease and they have strong negative feelings especially for this species and not for other fish eating birds like pelicans or herons (Pyrovetsi and Daoutopoulos 1991). In order to minimize the negative effects and to prevent damages from this species they apply a special (non-lethal) frightening technique with a considerable effectiveness in relation to other techniques applied elsewhere in Greece.

The aims of this study are a) to study the population changes and the diet of Great cormorants at Kerkini Lake in order to estimate fish consumption and to compare it with the fish

catches by fishermen and b) to study the population changes and the diet of Pygmy cormorant (*Phalacrocorax pygmaeus*), a globally threatened species that a few fishermen confusing it with the Great one believe that is also harmful to fishery.

The study area

Kerkini Lake is an artificial reservoir and is situated in northern Greece at Serres Prefecture and close to the Greek-Bulgarian border (41^{o} 13' N, 23^{o} 08'E, map 1). The main water supplier of the reservoir is Strymon River that comes from Bulgaria where is the larger part of its drainage basin. The area of the lake ranges from 5,500 to 7,300 ha according to the height of the water surface. When the dam is closed – usually from February to September- the surface of the lake expands to the north whereas when the dam is open the water surface shrinks at its smallest extend.

The dam was first constructed in 1932 for irrigation and flood control purposes. In 1982 a new much bigger dam was constructed next to the former one in order to increase the carrying capacity of the reservoir for irrigation. Today, the situation after the raising of the second dam is characterized by seasonal changes in the water level with amplitude ranging from 31 to 36 m. above sea level. Apart from the dam, a long dyke (embankment) was constructed along the eastern coast of the lake.

The most significant change after the construction of the second dam is the increase of water level that caused the total loss of the reedbeds. Furthermore, the forest at the northern part of the lake, most islands and mudflats are flooded during spring and early summer. On the other hand, new wet meadows (but of lesser extent now) are created at the north lakeside providing foraging areas to many bird species (e.g. waders).

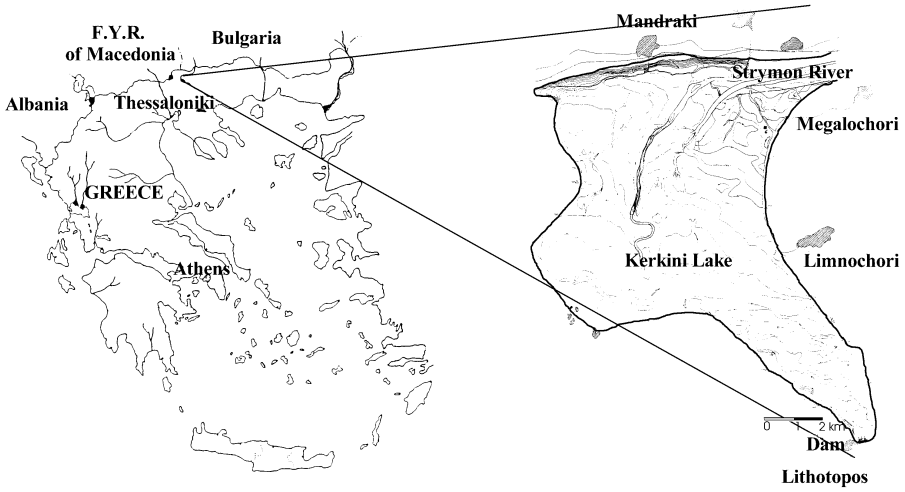
The wetland is of international importance (according to the Ramsar Convention) and a Special Protected Area (according to EU Directive 79/409). About 300 bird species were recorded at the lake and the surroundings. The richest (regarding the number of species) and biggest colony in Greece with more than 5,500 pairs of eleven bird species is found at Kerkini Lake. Great Cormorants *Phalacrocorax carbo sinensis*, Pygmy cormorants *Phalacrocorax pygmaeus,* Herons (Grey Herons *Ardea cinerea*, Night Herons *Nycticorax nycticorax,* Squacco Herons *Ardeola ralloides* and Purple Herons *Ardea purpurea*), Egrets (Little Egrets *Egretta garzetta* and Great White Egrets *Egretta alba*), Ibises (Glossy Ibis *Plegadis falcinellus),* Spoonbills *Platalea leucorodia* and Great crested grebes *Podiceps cristatus* form the colony. The colony is located at the north side of the lake, in a forest formed mainly by willow trees - Salix spp., which is flooded during the breeding period (Crivelli et al. 1995, Naziridis and Papageorgiou 1996). Additionally, Kerkini Lake is among the most important wintering sites in Greece for waterfowl with large numbers of wintering ducks, geese and pelicans. At least two

globally threatened fish eating bird species are found in the Lake: The Pygmy cormorant that breeds and winters and the Dalmatian pelican *Pelecanus crispus* that only winters.

Although Kerkini Lake is mainly used for irrigation purposes, it also supports fishery. At least 30 fish species live in the system "lake and river", four of which have been introduced while there are two endemic sub-species as well. Carp *Cyprinus carpio* is the fish with the highest economical value followed by Perch *Perca fluviatilis.* Goldfish *Carrasius gibelio* (an introduced species) although of low market value is the most abundant in the lake and is fished in high quantities. The rest of the species are of less commercial importance (Tatarakis 1995). Some fish species (like Eel *Anguilla anguilla* or Tench *Tinca tinca*) disappeared from the wetland many years ago and after the construction of the second dam (Tatarakis 1995). The number of fishermen at the lake seems to be in decline during the last years but there are no data concerning their number (no fishing licenses are issue any more).

Apart from fishery, cattle's raising is another source of income for people who live in the surrounding villages. The meadows around the lakeshore support one of the last and the biggest herd of water buffaloes in Greece (about 1000 animals). A large number of sheep and goats are also grazing in the area (Naziridis 2003).

At least 27.000 ha of maize, alfalfa and cotton that are the main agricultural products, are irrigated from the water of the lake. Wheat and tobacco are also cultivated (Naziridis 2003).



Map 1. Kerkini Lake (right) with its position in Greece.

Methods

In order to estimate the Great cormorants' fish consumption we monitored on a monthly basis the changes of the Great cormorants' numbers feeding in the lake. The counts during the non-breeding season were carried out at their night roosting sites. The number of Great cormorants feeding outside the lake was also estimated on a monthly basis and was subtracted from the number of birds found at the roosting sites. This number was found by counting all these individuals that, after leaving the roosting site during the morning, fly westwards to Doirani Lake (about 30 km at the west of Kerkini Lake). The breeding population was found by counting all occupied nests in the colony. At least two nest counts were carried out during the nesting season. Great cormorants start egg laying gradually from early March until early May and incubate their eggs for 28-31 days (Cramp and Simmons 1977, Naziridis 2003). The chick-rearing (fledging) period lasts approximately 50 days. According to Naziridis (2003) the number of nestlings hatched and survived until the age of approximately three weeks was 2.64 (data from 1990). Using this value of the breeding success the total number of nestlings in the colony was estimated.

The population changes of Pygmy cormorants were recorded in the same way as of Great Cormorant during both breeding and non-breeding season. Pygmy cormorants start egg laying gradually from late March or early April until mid late May and incubate the eggs for 27-30 days (Cramp and Simmons 1977, Naziridis 2003). The chick-rearing (fledging) period lasts approximately 70 days. According to Naziridis (2003) the number of nestlings hatched and survived until the age of approximately three weeks was 3.7 chicks per nest (data from 1990). Using this value of the breeding success the total number of nestlings in the colony was estimated.

Data concerning the breeding population of both study species were taken during the breeding seasons of 2001 and 2002. Counts at the night roosting sites were carried out from August 2001 to March 2002 for Great cormorant and from August 2001 to January 2002 for Pygmy cormorant.

In order to study the diet of the two study species we collected regurgitations from both species nestlings during repeated visits in the colony (at least twice a month from April to July). In order to collect as intact (not digested) items as possible from the regurgitations, visits in the colony for regurgitations' collection was taking place only during morning hours. Only fresh regurgitations were collected below the nests and only those whose origin was known were taken into account. Each regurgitated fish was identified and its body length was measured (digested fish were not measured after the identification). The biomass (fresh weight) of each fish species was found using the given by Kleanthidis et al. (2000) and the FishBase (see at

www.fishbase.org) equation of body length – body mass of each species. Regurgitations were collected during two successive breeding seasons (2001 and 2002). Data of both years are examined together due to their small sample size.

In order to find the yearly consumption by Great cormorants two assumptions were made: a) the diet of Great cormorant does not change during the year and b) the mean daily food intake of an adult Great cormorant during the non breeding period was 396 g (with 95% confidence limits: 250 g – 577 g) while the total consumption of each bird during the breeding period (totally 80 days) was 57.8 kg (with 95% confidence limits: 46.4 – 70.8 kg) (Gremilet and Argentin 1998, Carss and Ekins 2003).

The yield data for Kerkini Lake are based on the official fishery statistics given by Fishery Department of Serres Prefecture (Tatarakis pers.comm.). The yield (kg/ha/year) from Kerkini Lake has been calculated from an area equivalent to the mean annual area of the lake (6.400 ha).

Results

Great Cormorant

a) Population changes

The number of Great cormorants at Kerkini Lake increased remarkably during the last 13 years. From 500 breeding pairs in 1990 the population reached 3500 pairs in 2002 (fig. 1, Crivelli & Naziridis unpublished data). In 2002 the breeding population reached the maximum number ever recorded at Kerkini, attaining an increase of 40% in relation to the population of 2001 and 600% in relation to the population of 1990 (fig.1).

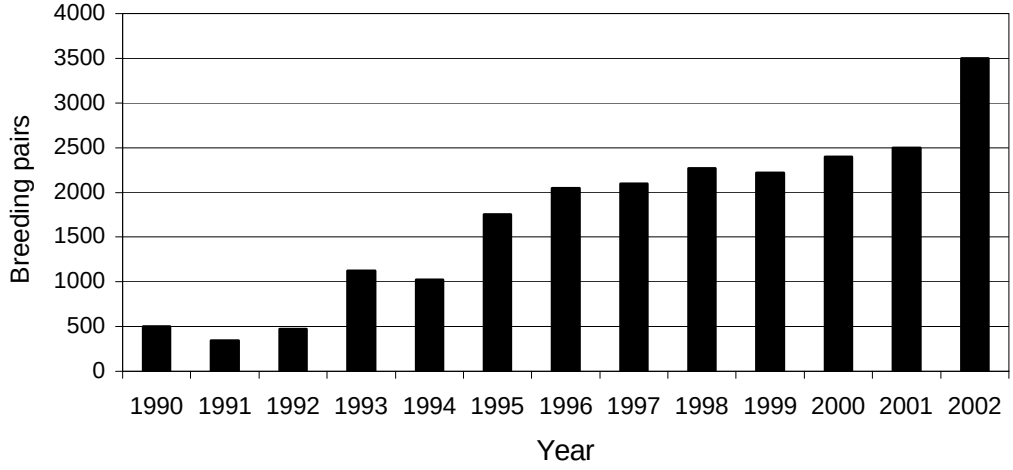


Figure 1. Great cormorant's breeding population changes at Kerkini Lake since 1990.

The number of Great cormorants at Kerkini Lake varies during the year according to the season (fig. 2). The highest number (approximately 11,600 individuals including nestlings) was recorded during the breeding period, a period during which almost all nestlings are fledging and are fed by their parents. After the breeding period the majority of the population dispersed at the neighboring wetlands so, the population that remained at the lake was much lower (approximately 3,000 birds). During winter the population varied from 900 to 3,000 birds and was on the increase in February with the arrival of birds that would start nesting (from February).

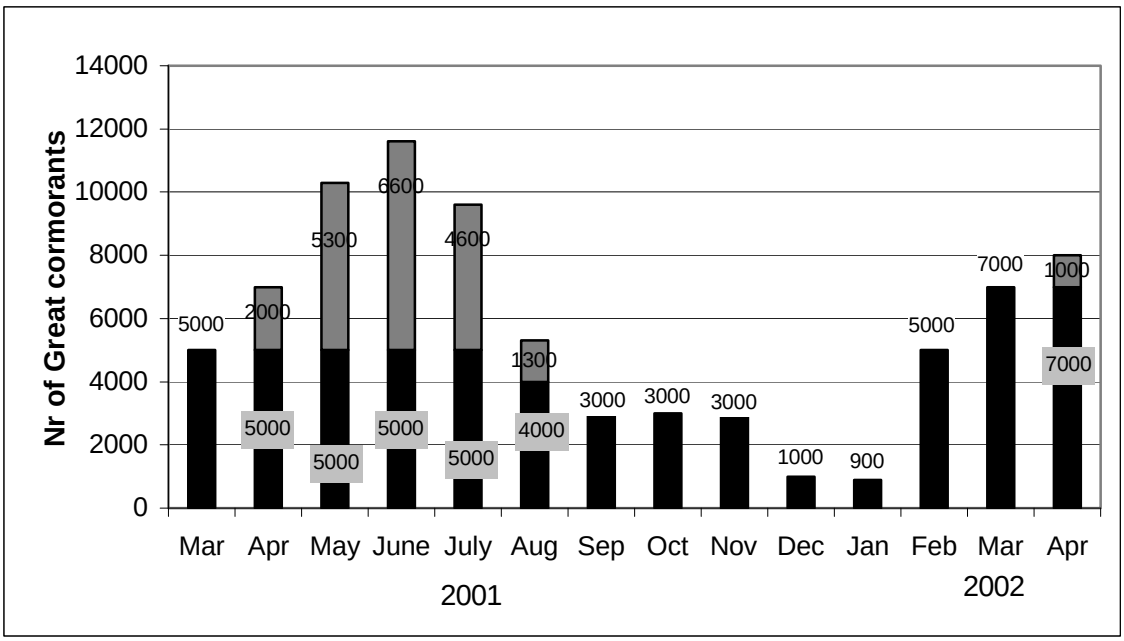


Figure 2. Population changes of Great Cormorant at Kerkini Lake (black bars: number of adults, gray bar: estimation of nestlings' number).

b) Diet

A total of 138 regurgitations were collected and analyzed during the two breeding periods of the study. Totally 697 fish were found belonging to five species (Table 1). The most common fish species found was Bleak *Alburnus alburnus* followed by Roach *Rutilus rutilus* and Goldfish (Table 1). The rest of the species (Chub *Leuciscus cephalus macedonicus* and Vimba *Vimba melanops*) were found in very low proportions (only one specimen of each species was found during the study).

Table 1. Species, number (N), percentage (%) and somatometric characteristics of fish found in nestlings' regurgitations.

Species	N	%*	**Mean body length (cm) ± SD**	**Minimum length (cm)**	**Maximum length (cm)**	**Mean body mass (g)**
Alburnus alburnus	478	68.6	8.0±1.2	4.1	12.6	5.1
Rutilus rutilus	126	18.1	9.0±1.3	4.2	13.1	11.2
Carassius gibelio	91	13.1	16.9±4.3	9.1	25.0	131.2
Leuciscus cephalus	1	0.1	15.8	15.8	15.8	64.6
Vimba melanops	1	0.1	9.7	9.7	9.7	8.3
Total	**697**	**100**	**9.4±3.6**			

* Percentage by number of prey items identified in all regurgitations.

The mean body length of the prey was 9.4±3.6 cm ranging from 4.1 cm to 25.0 cm (Table 1). The longest and heavier fish species was Goldfish (the maximum recorded body length of this species was 25.0 cm with a mean biomass of 131.2 g) while the smallest and lightest was Bleak (mean body length: 8.0±1.2 cm, mean biomass: 5.1g, Table 1).

Pygmy cormorant

a) Population changes

The number of breeding Pygmy cormorants at Kerkini Lake in 2002 was 350 pairs. This number was the second lowest during the last 13 years (fig. 3). The maximum breeding population was recorded in the lake in 1994 (645 pairs, Crivelli and Naziridis unpublished data) followed by a

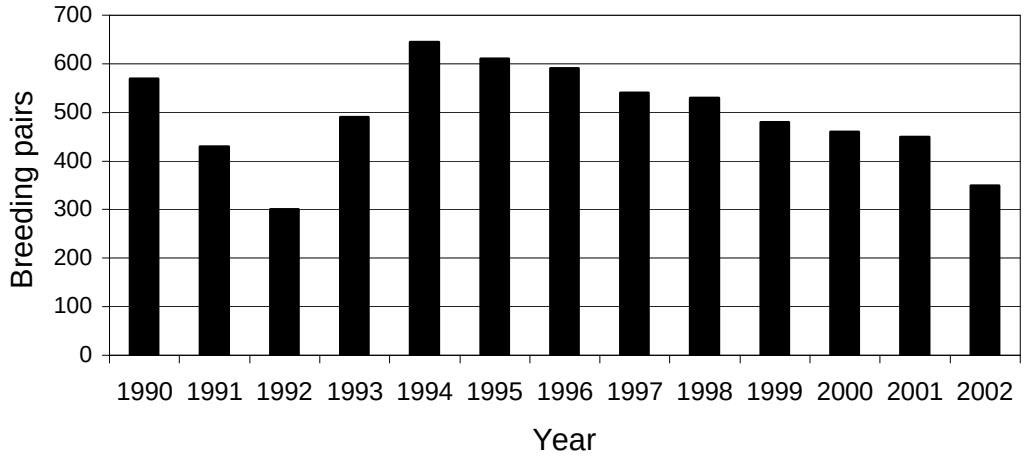


Figure 3. Pygmy cormorant' breeding population changes at Kerkini Lake since 1990.

continues gradual decrease (fig. 3). The number of Pygmy cormorants at Kerkini Lake varies during the year according to the season (fig. 4). The highest number (approximately 2,600 birds) was recorded during the summer and after the nestling hatching (fig. 4). After the nestlings' fledging the majority of the population disperse in neighboring wetlands. During the winter the population ranges from 350 (November 2001) to 1600 individuals (Jan 2002).

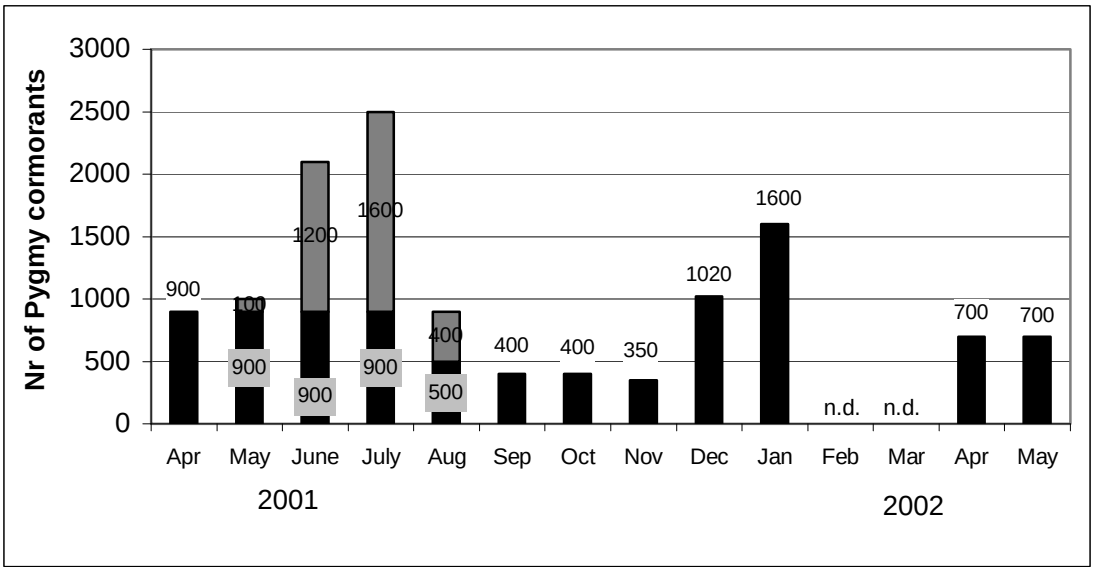


Figure 4. Population changes of Pygmy cormorant at Kerkini Lake (black bars: adults, gray bars: estimation of nestlings' number).

b) Diet

A total of 17 nestling regurgitations were collected and analyzed during the two breeding periods of the study. Totally 66 fish were identified belonging to five fish species. These were Bleak, Roach, Pumkinseed *Lepomis gibbosus*, Goldfish and Chub. The most common fish in the diet was Bleak followed by Roach and Pumkinseed (Table 2).

The size of fish found in regurgitations was much smaller than these found in Great cormorants' regurgitations ($F=18.45$, $p<0.001$) and varied from 3.5 to 10.3 cm (mean 7.2 cm). The biomass (fresh weight) of each species varied from 2.4 g to 4.7 g (Table 2).

Table 2. Species, number (N), percentage (%) and somatometric characteristics of fish found in Pygmy cormorant nestlings' regurgitations.

Species	N	% *	Mean body length (cm) ± SD	Minimum length (cm)	Maximum length (cm)	Mean body mass (g)
Alburnus alburnus	39	59.1	7.5 ± 0.9	5.6	10.3	4.3
Rutilus rutilus	9	13.6	7.4±0.8	6.6	10.0	3.2
Lepomis gibbosus	8	12.1	7.7 ± 0.7	6.0	8.1	4.7
Carassius gibelio	6	9.1	5.3 ± 2.1	3.6	9.3	2.5
Leuciscus cephalus	4	6.1	7.2±1.2	3.5	9.0	2.4
TOTAL	**66**	**100**	**7.2±1.5**			

* Percentage by number of prey items identified in all regurgitations.

Fishery

Kerkini Lake is the most productive lake in Greece regarding fishery (Crivelli et al. 1995). There are approximately 100 fishermen (all of them are part time fishermen) that fish during the whole year apart from April when fishing is not allowed (according to the local low restrictions).

The annual average fish yield during the late 80's was estimated at 25-35 kg/ha (Crivelli et al. 1995). The annual average fish yield from 1990 to 2002 was 20.88 kg/ha (Fig. 5).

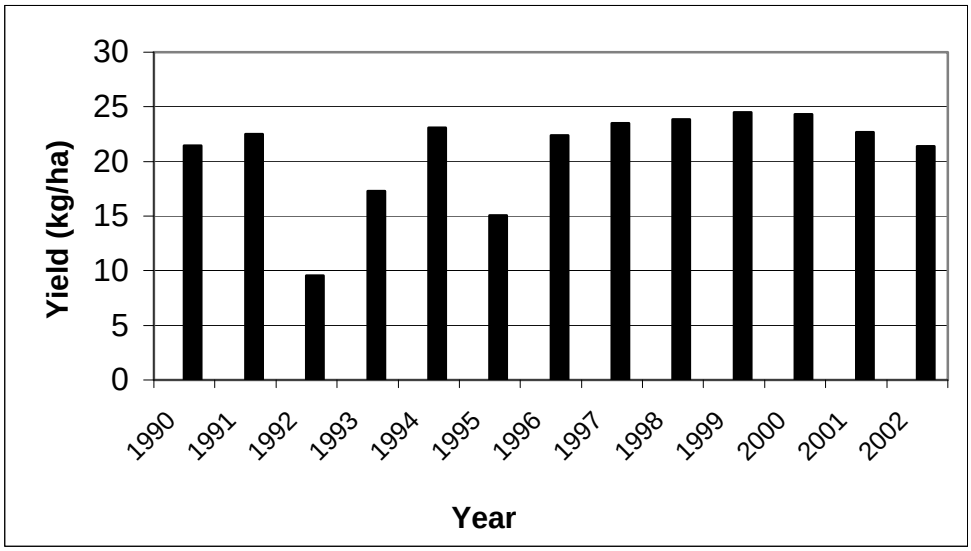


Figure 5. Fish yield (kg/ha) at Kerkini Lake since 1990.

From seven fish species fished by fishermen in Kerkini Lake (fig. 6) the most important (from economical point of view) is Carp and Perch as well (their selling price is about 3 €/kg and 1.4 €/kg respectively). The most abundant fish in the lake (as in the fishermen' nets) was Goldfish

(price 0.23 €/kg). Although the catches of certain fish species and especially Goldfish are on the increase, the yield of Carp gradually decreases (fig. 6) and especially after 1994. The other species like Bleak, Asp, Roach and Common Rudd whose yield seem to be on the increase after the middle of 90s are also of less economic importance (their market prices ranges from 0.20 to 0.50 €/kg).

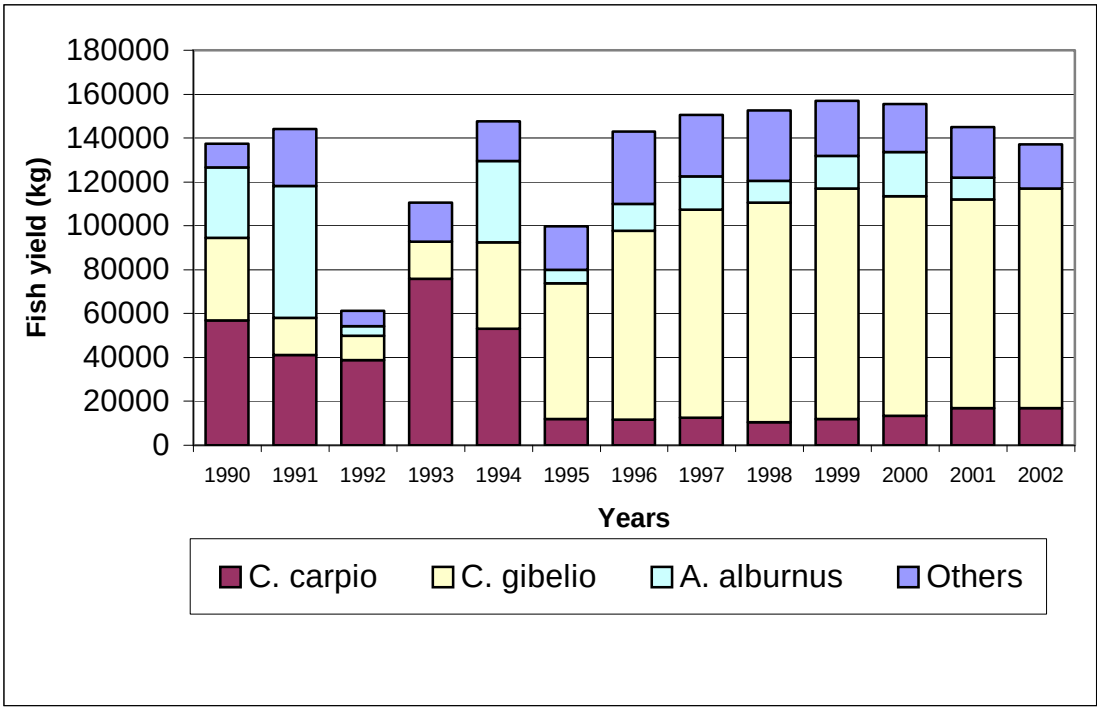


Figure 6. The fish yield of each of the main fish species at Kerkini Lake during the last 13 years. In "Others" are included: Asp *Aspius aspius*, Roach, Perch and Common Rudd *Scardinius erythrophtalmus.*

The total fish consumption of all Great cormorants that are feeding at Kerkini Lake in 2001 was estimated at approximately 681,400 kg (ranging from 479,727 kg to 925,755 kg). Their consumption per ha (kg/ha) was 106,5 (ranging from 74.9 to 144.6 kg/ha). On the other hand the fishery yield in 2001 was only 145.000 kg (22.6 kg/ha) (fig. 7). A percentage of 75.3% by weight was Goldfish. Although the number of Goldfish in Great cormorants' diet was relatively small compared to the rest of prey, it contributed in high percentage in the total consumption estimated by weight due to their high weigh compared to the rest of the fish species. Fishermen' and Great cormorants' catches were similar by weight concerning Goldfish (χ^2 =2.77, p=0.096). The only one remarkable difference between fishermen and cormorants' catches was the absence of the Carp in the latter's catches (fig. 7).

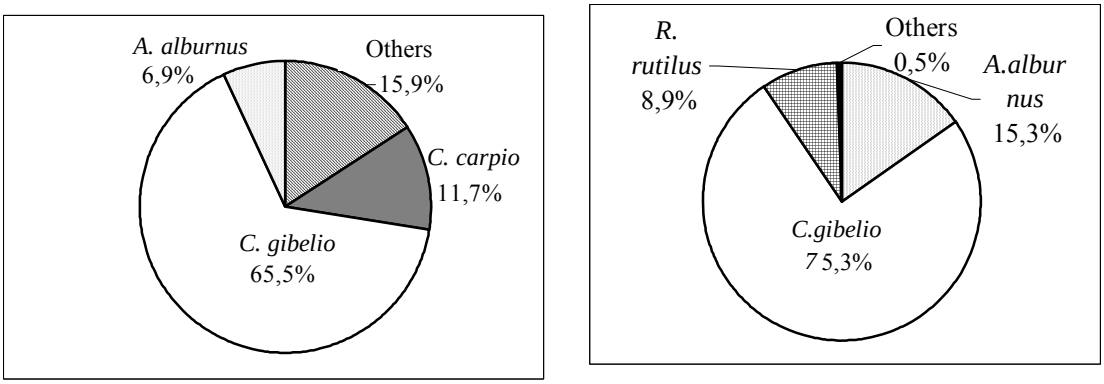


Figure 7. Fish species and percentage (of the weight) that has been fished during 2001 by fishermen (left) and Great cormorants (from nestlings' regurgitations) (right). In "Others" at the fishermen pie (left) Asp, Roach, Perch and Common Rudd is included while in the Great cormorants' pie (right) in "Others" only Chub and Vimba is included.

Discussion

The breeding population of Great cormorants at Kerkini Lake has increased remarkably during the last 13 years. At the other three Great cormorant colonies in Greece the breeding population was stable or was on the decrease (Liordos and Goutner 2003). Concerning Pygmy cormorant the breeding population is on a small decrease after 1994 when the highest number of the species was recorded. One of the reasons for the Pygmy cormorants' decline could be the limitation of the nesting sites, especially after the 1994 when the number of Great cormorants started increasing, and as the latter species starts nesting earlier to the former, occupies all available nesting sites. The breeding population of Pygmy cormorant at Kerkini is the second biggest in Greece in out of four colonies while the wintering population is among the highest in Greece (Kazantzidis and Naziridis 1999).

Fishermen and cormorants in Kerkini Lake fish at least three common fish species (Goldfish, Bleak and Roach). All these species are of low commercial interest. The rest of fish found in nestlings' regurgitations (Pumkinseed, Chub and Vimba) were also of no economic value. Not any Carp was found in both study species nestlings' regurgitations during the two study years. According to Crivelli et al. (2000) during the breeding season of 1990 Great cormorants at Kerkini Lake had taken only few Carps. Furthermore, no Carp was found at the same breeding period at Pygmy cormorants regurgitations (Crivelli et al. 2000). So, we could state that there is an antagonism between Great cormorants and fishermen at Kerkini Lake but concerning only species of low economical importance. At the Axios Delta (northern Greece) was found that the diet of Great cormorants' nestlings was consisted of fish species either unimportant (gobiids) or of secondary importance (mullets) to fishermen (Goutner et al. 1997). Additionally, according to

Liordos et al (2002) only a percentage of 3.8% of the diet of Great cormorant at Amvrakikos Bay (western Greece) was consisted of species of high commercial value (e.g. Flat headed grey mullet *Mugil cephalus* and Sea bass *Dicentrarchus labrax*). A percentage of 5.1% was of medium commercial value (mullets) while the rest was insignificant to fishermen. On the other hand, Great Cormorants were a serious threat to fishery during the winter in a small lagoon at the western Greece that is used as a fish farm. High numbers of Great cormorants (up to 5000) during the winter of 2001-2002 injured a lot of fish of high commercial value. For certain fish species (like Gilthead seabream *Sparus auratus* and Sea bass *Dicentrarchus labrax*) the percentage of injured individuals was up to 70% of these caught by fishermen (Dimitriou et al. 2003).

Between Pygmy cormorants and fishermen it seems that there is no competition because, apart from the fish species consumed by the former (that are also of low economic importance) their size is small to be considered of commercial interest.

On the other hand, the fishery at Kerkini Lake did not present a remarkable difference regarding the total amount of fish yield. The most noticeable difference was observed after 1994 when the weight of Carp in fishing nets was reduced. The most probable reason of the Carp's decrease seems to be the mean water level increase (by closing the dam) that took place for first time in April 1992. The water level increased approximately half a meter (from 34.5 m asl to 35.0 asl). This resulted in the gradual deepening of all available swallow marshes at the northern part of the lake. All these shallow waters are very valuable for Carps because there, they lay their eggs. Furthermore, this increase of the water level took place during April that is the month of egg laying. Usually a successful breeding year of the Carp appears in the fishermen's nets after three years (this is the Carp's age with commercial value). The water level was "established" at the new level in all the following years, not permitting the recovery of the Carp's breeding success at the previous level. Some other factors that probably affected the Carp breeding success were the increase of the cattle grazing in the area that destroy the vegetation at the shallow water areas where the Carp lays its eggs. Additionally, illegal fishing was on the increase during the '90s and the over-fishing as well. These factors did not affect the population of other fish species like Goldfish that increased in high numbers today.

So, the low population of Carp in the lake gives smaller chances to Cormorants to prey upon them. Apart from that, there are two more possible reasons that no Carp was found at the Great cormorants diet. a) Fishermen especially during the winter patrol the area where they put their nets and use a scaring system consisted of many noise-making devices (bells or empty cans) hanged on a rope supported on poles across the lakeshore. When cormorants approach, fishermen drag the rope producing noises (from cans or bells) that scares cormorants that leave the area. They may

approach later on with the same reaction from fishermen that watch the area. b) A big part of Great cormorants during the breeding season forage at the entrance of Strymon River in the lake where there are no Carps (although this does not explain the absence of Carp at Pygmy cormorant diet).

Regardless of our results, the conflict between fishermen and cormorants is still continuing in Kerkini although, due to legal limitations, no actions against cormorants were undertaken. In other wetlands in Greece only sporadically fishermen shoot at Great cormorants killing nestlings (at the Axios Delta, Goutner et al. 1977) or wintering birds (at the Amvrakikos bay, Liordos et al. 2002). Since the current study was limited we suggest that a further study concerning the diet of at least Great cormorant should be carried out during the whole year. Study on fish stock and fish dynamic in the system River – Lake should also be carried out. In order to find a solution, all related parties as fishermen, ichthyologists and ornithologists must work together in order to plan the most appropriate strategy for a sustainable fishery in the lake alongside with a wealthy wildlife.

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