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Differences in Waterbird Communities between Years Indicate the Positive Effects of Pen Culture Removal in Caizi Lake, a Typical Yangtze-Connected Lake

Tengteng Liu [1], Lin Cheng [2], Xiangrong Song [1], Hong Zhang [3], Guangyao Wang [1] and Chunlin Li [1,4,*]

[1] School of Resources and Environmental Engineering, Anhui University, Hefei 230601, China; liutt2332@163.com (T.L.); xiangrong056@163.com (X.S.); wgy19980914@163.com (G.W.)
[2] Anhui Vocational and Technical College of Forestry, No.99, Yulan Road, Hefei 230031, China; ly3476034225@163.com
[3] Anqing Forestry Bureau, Anqing 246003, China; suli021777@163.com
[4] Anhui Province Key Laboratory of Wetland Ecosystem Protection and Restoration, Anhui University, Hefei 230601, China
* Correspondence: lichunlin@ahu.edu.cn

Abstract: Considering the negative effects of wetland degradation, various measures have been implemented to restore wetland habitats for aquatic organisms, and their effectiveness levels must be assessed. To reduce the effects of aquaculture on aquatic communities, pen culture facilities, which are widely distributed in Yangtze-connected lakes, were removed in 2018. We surveyed and compared waterbird communities in Caizi Lake during the four months before (2017–2018) and after net pen removal (2021–2022) to evaluate their effect on the diversity and species composition of wintering waterbirds. After net pen removal, the richness and number of individual waterbird species increased, whereas the Shannon–Wiener diversity index did not change because the increase in the bird number throughout the year was mostly associated with a few species. The response of individual numbers of different guilds to the removal of net pens differed. The number of deep-water fish eaters, seed eaters, and tuber feeders increased, whereas that of invertebrate eaters decreased. The species composition also changed, particularly in the northeastern and southwestern parts of the lake. Differences in waterbird communities between the winters of 2017–2018 and 2021–2022 indicated that net pen removal had a positive impact on waterbird communities.

Keywords: net pen; species diversity; community composition; Yangtze-connected lake; waterbird conservation

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1. Introduction

Wetlands are essential and highly productive ecosystems that provide important ecological services to both wildlife and humans [1,2]. However, natural wetlands are disappearing and being degraded, mainly because of frequent human activities [3]. It has been estimated that the area of natural wetlands has declined by 35% worldwide since 1970, with a more extensive loss of inland wetlands compared with coastal wetlands [4]. The remaining wetlands have been degrading to various extents, leading to a decline in the habitat quality for wetland organisms [5]. Global wetland loss and degradation threaten the survival of many wetland-dependent species, resulting in a significant reduction in wetland biodiversity [6,7]. Wetland loss and degradation and the associated decline of many aquatic species populations have attracted widespread attention [8].

As a key component of wetland ecosystems, waterbirds are often recognized as the focus of wetland biodiversity conservation because they play important roles in ecosystem services [9]. Waterbirds are very sensitive to environmental changes and immediately respond to environmental alterations because of their strong movement capabilities [10].

Therefore, they can be used as indicator species. The habitat uses and population dynamics of waterbirds are associated with a series of environmental factors [11,12], and the change in these factors can affect waterbird survival and reproduction [13]. Among these aspects, significant attention has been paid to anthropogenic activities that can lead to complex changes in other variables [14]. Efforts have been made to reduce the direct and indirect effects of anthropogenic factors on waterbirds through conservation plans and practices [15,16]. Furthermore, different guilds of waterbirds may respond differently to environmental changes, depending on their ecological requirements, resulting in changes in the community composition [17]. Therefore, the effects of environmental changes on waterbirds should be investigated for different guilds, and guild-specific conservation plans should be formulated.

Humans are realizing the importance of the protection of waterbirds and their habitats [18]. Various wetland protection and restoration efforts are underway worldwide to reduce the negative impacts of wetland degradation and loss on waterbirds [19–22]. To restore and protect habitats for waterbirds, wetland restoration strategies, such as hydrological management, invasive plant cleanup, and pollution control, have been implemented worldwide in recent decades [23,24]. Habitat restoration measures are expected to benefit waterbirds, from individuals to populations, and at the community level. The results of multiple studies showed that wetland restoration can increase the carrying capacity of waterbirds and the species diversity of assemblages [25–27]. However, some researchers have reported the failure or low efficiency of restoration measures [28]. Therefore, the efficiencies of specific restoration measures should be assessed, and different responses of various guilds should be considered.

Yangtze-connected lakes are vital wintering and staging areas for waterbirds migrating along the East Asian–Australasian Flyway [29]. Each year, these lakes provide diverse foraging habitats for tens of thousands of waterbirds during the low-water period in winter [30]. These lakes are located in a region with a dense human population and rapid economic development in China, in which long-term anthropogenic activities have caused extensive wetland losses and degradation [31]. Among these threats, intense aquaculture has been identified as one of the main contributors to the loss of the ecosystem services provided by wetlands [32]. Specifically, organic matter, such as excrement and feed residues, produced in the course of pen culture, accelerates the process of lake eutrophication [33]. The use of various drugs and additives seriously jeopardizes the safety of aquatic organisms and adversely affects the ecosystem [33]. To manage fish farming activities, pen culture has been constructed in almost all lakes since the 1990s, dividing the lakes into numerous small fragments [34–36]. The negative effects of pen culture on waterbirds have attracted attention, both nationally and globally. It is reasonably well documented that pen culture has serious impacts on seabird survival [37]. Farmers may kill waterbirds to minimize economic losses, and the presence of net pens can make it more difficult for waterbirds to hunt [38]. Wang et al. [39] and Zheng et al. [36] reported that the zooplankton and aquatic plants, are also affected by net pen and aquaculture activities. To resolve the abovementioned problems, net pens were removed from all Yangtze-connected lakes in 2018 in the context of nationwide environmental inspection [40]. It has been observed that submerged aquatic plants and zooplankton populations have recovered to some extent due to improvements in the water clarity and quality after net pen removal [36,39]. However, to date, the effects of pen culture on wintering waterbirds, a priority taxon for conservation in wetlands, have not been investigated [29].

In this study, eight surveys were conducted in 2017–2018 and 2021–2022 to explore the effect of net pen removal on wintering waterbird communities in Caizi Lake. We predicted that (1) the waterbird numbers, species richness, and diversity will increase after net pen removal (2021–2022) because the presence of pen culture may have negative effects on waterbirds [41], and (2) the species composition of waterbird communities will change due to different responses of different guilds to the removal [42]. We predict an increase in the number of waterbirds regarding grass foragers, seed eaters, and tuber feeders because of the restoration of aquatic vegetation. The results of this study have important implications for the management and conservation of wetlands and waterbirds in Yangtze-connected lakes.

2. Materials and Methods

2.1. Study Area

Caizi Lake (117°01′–117°10′ E, 30°43′–30°58′ N) is a typical Yangtze-connected lake in the middle and lower reaches of the Yangtze River in China [43]. The study area has a northern subtropical monsoon climate characterized by high temperatures and abundant rainfall in summer and a mild winter with little rain. The water level of Caizi Lake fluctuates seasonally, resulting in a maximum water surface area of 243.3 km^2 in summer, when the water level is high, and a reduced water surface area of 145.2 km^2 in winter, when the water depth is low [44,45]. The average water depth of Caizi Lake in winter is 1.7 m [45]. Caizi Lake is divided into three subareas (Figure 1): Baituhu, Caizihu, and Xizihu. Caizihu and Xizihu are separated by a dam. Seasonal water level fluctuations enable Caizi Lake to provide important staging and wintering grounds for tens of thousands of waterbirds migrating along the East Asia–Australia Flyway [29]. These waterbirds, particularly threatened species such as the Siberian crane (*Leucogeranus leucogeranus*), Oriental stork (*Ciconia boyciana*), swan goose (*Anser cygnoid*), hooded crane (*Grus monacha*), and falcated duck (*Mareca falcate*), are attracting attention from management and conservation communities.

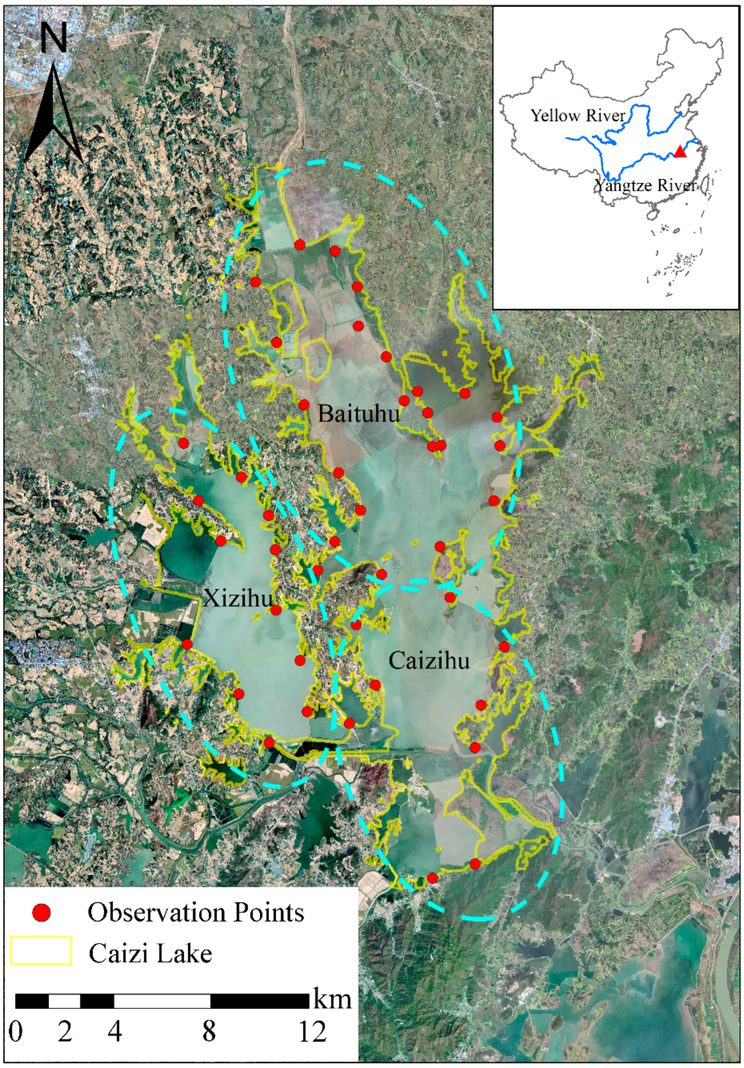

Figure 1. Location of the study area and bird observation points in Caizi Lake.

Caizi Lake has a long history of aquaculture. Net pens were constructed in the lake in the 1990s, covering more than 90% of its area [46]. Intensive aquaculture has destroyed aquatic vegetation, particularly submerged vegetation, throughout the lake. In response to nationwide environmental inspections and the Yangtze River Grand Protection Policy, net pens in Caizi Lake were completely removed in March 2018 to restore the wetland ecosystem [40]. A total area of about 58 km^2 and a length of about 170 km of nets were removed from Caizi Lake [46].

2.2. Bird Survey

We placed 44 fixed observation points along the shores of the Caizi Lake to observe waterbirds throughout the lake. Eight surveys of waterbirds, one each in November, December, February, and March, both before (2017–2018) and after (2021–2022) the removal of net pens, were conducted on clear days, without storms or fog. Each survey consisted of counting waterbirds once each at 44 fixed observation points. To reduce the possibility of counting the same individuals twice, each survey was carried out simultaneously by two teams within two consecutive days. We used the "look-see" counting method to record birds within the observation area of each sampling point but ignored birds flying over it from outside. During the surveys, we used binoculars (10 × 42 WB Swarovski) and telescopes (20–60 × zoom Swarovski: ATM 80) to observe and identify waterbirds. Waterbirds were defined as species that ecologically depend on wetlands [47]. The taxonomy and nomenclature followed those reported in MacKinnon et al. [48]. Based on similarities in resource-sharing and exploitation techniques [49], the recorded species were grouped into six categories: grass foragers (e.g., geese), invertebrate eaters (plovers and snipes), seed eaters (mostly dabbling ducks), tuber feeders (cranes and swans), deep-water fish eaters (gulls and diving birds), and shallow-water fish eaters (egrets, herons, and storks).

2.3. Statistical Analysis

To obtain the water area of Caizi Lake during the waterbird survey, two cloud-free Landsat 8 images (Level 1T of Landsat 8 OLI; https://www.gscloud.cn/ (accessed on 5 April 2020)), acquired in December 2017 and December 2021, were interpreted. Before image classifications, radiometric calibration and atmospheric correction were performed on the Landsat-8 images, which were then reprojected onto the UTM WGS 1984 N50 coordinate system. The water area was identified using the maximum likelihood classification technique in ENVI 5.3.

We used generalized linear mixed models (GLMMs) with negative binomial distributions built, with net pen (presence/absence), months (Oct/Nov/Jan/Feb/Mar), and subareas (Baituhu, Xizihu, and Caizihu) as fixed variables and observation points as random factors to explore the effects of the above influences on indices of the waterbird community, that is, species richness, total bird number, Shannon–Wiener index, and individual number in each guild. We used a backward elimination process to remove non-significant factors, and performed post-hoc comparisons using the emmeans package.

We utilized the multiple response permutation (MRPP) method to separately test changes in the species composition of the waterbird community for the whole lake and for three subareas [50]. MRPP includes a set of distance-based statistical tests that are employed to test the dissimilarity between two groups of sampling units. Based on randomization, MRPP compares compositional dissimilarity within a group and dissimilarity between random collections of sampling units from the entire population. We used the Bray–Curtis distance matrix, calculated using the abundance data from monthly surveys, to run the MRPP with 999 permutations. The species similarity percentage (SIMPER) was used to determine which species contribute significantly to changes in the community composition [51]. In addition, principal coordinate analysis (PCoA) was performed to visualize compositional differences based on the Bray–Curtis distance matrix, weighted by bird abundance data from monthly surveys. PCoA allows for the use of any similarity/dissimilarity matrix representing the relationships between objects or variables by ordering data on axes according to their contributions to the total variance based on eigenvalues. All analyses were performed using R version 4.1.2 [52].

3. Results

3.1. Water Area

The water area in December 2017 was 156 km^2, and in December 2021, it was 170 km^2 (Figure A1).

3.2. Bird Community

Across the entire lake, we counted 57,079 birds of 47 species and 182,878 birds of 48 species in the four monthly surveys, before (2017–2018) and after (2021–2022) net pen removal, respectively (Figure 2, Table A1). Among the recorded species, seven were categorized as globally threatened or near-threatened on the International Union for Conservation of Nature (IUCN) Red List: Siberian crane (critically endangered), Oriental stork (endangered), swan goose (vulnerable), hooded crane (*Grus monacha*; vulnerable), common pochard (*Aythya ferina*; vulnerable), falcated duck (*Mareca falcata*; near-threatened), and northern lapwing (*Vanellus Vanellus*; near-threatened). Three are listed as Class I Key Protected Wild Animal Species in China: the Siberian crane, hooded crane, and Oriental stork. Seven are listed as Class II Key Protected Wild Animal Species in China: common crane (*Grus grus*), White-Fronted Goose (*Anser albifrons*), swan goose, tundra swan (*Cygnus columbianus*), Eurasian spoonbill (*Platalea leucorodia*), Baikal teal (*Sibirionetta formosa*), and smew (*Mergellus albellus*).

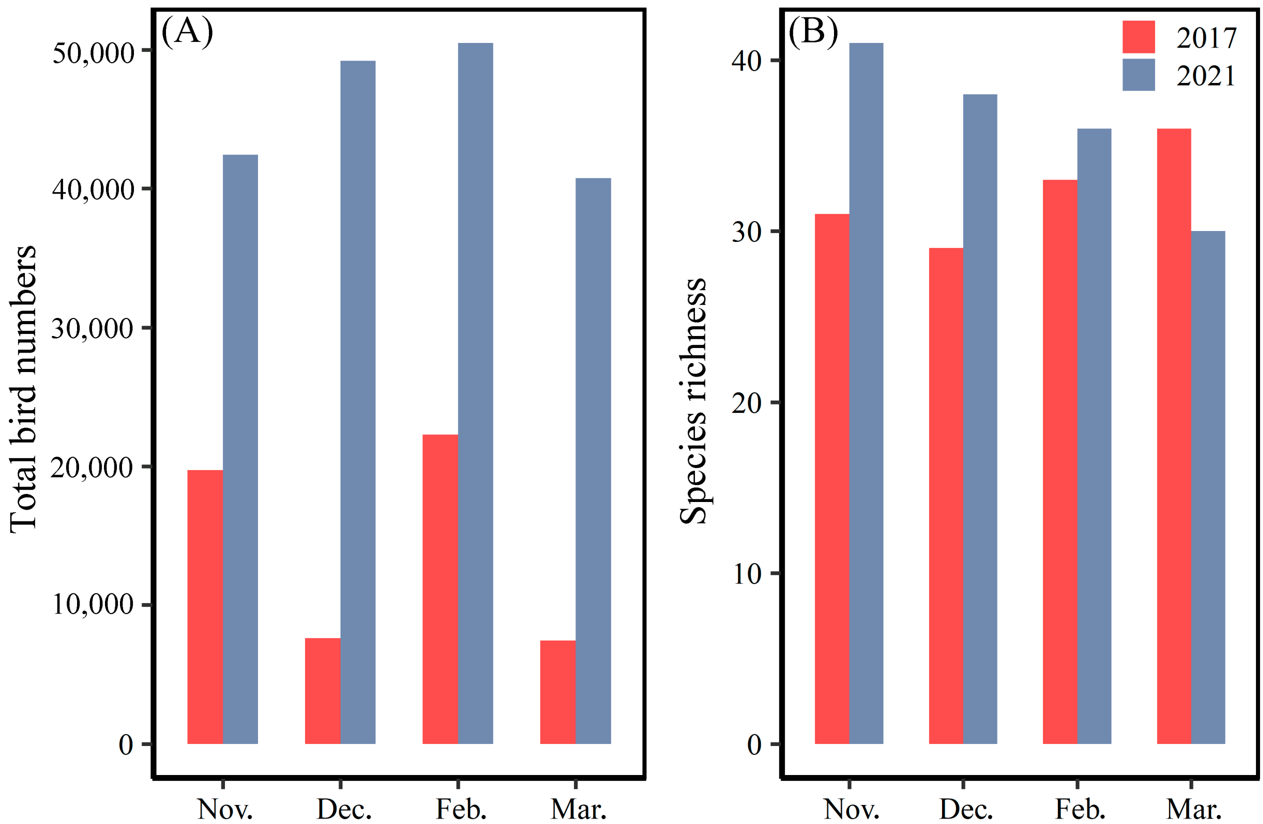

Figure 2. Total bird numbers and total species richness of waterbirds recorded in the months before (2017–2018) and after (2021–2022) net pen removal from Caizi Lake. (**A**) Total bird numbers; (**B**) Species richness.

3.3. Bird Community Index

In 2021, the waterbird species richness (χ^2 = 18.91, df = 1, p < 0.001) and number of individuals (χ^2 = 26.87, df = 1, p < 0.001) increased, whereas the Shannon–Wiener index (χ^2 = 3.021, df = 1, p = 0.082) did not change. The Shannon–Wiener index (χ^2 = 4.140, df = 1, p = 0.042) increased after removing abundance data for taiga bean geese. The waterbird species richness (χ^2 = 29.55, df = 3, p < 0.001), number of individuals (χ^2 = 1772, df = 3, p < 0.001), and Shannon–Wiener index (χ^2 = 12.86, df = 3, p = 0.005) differed in different months. More waterbirds were recorded in November and February in 2021 (p < 0.001; Figure 3). The species richness (χ^2 = 1.929, df = 2, p = 0.381), number of individuals (χ^2 = 3.793, df = 2, p = 0.150), and Shannon–Wiener index (χ^2 = 1.345, df = 2, p = 0.510) in the three subareas of Caizi Lake did not differ.

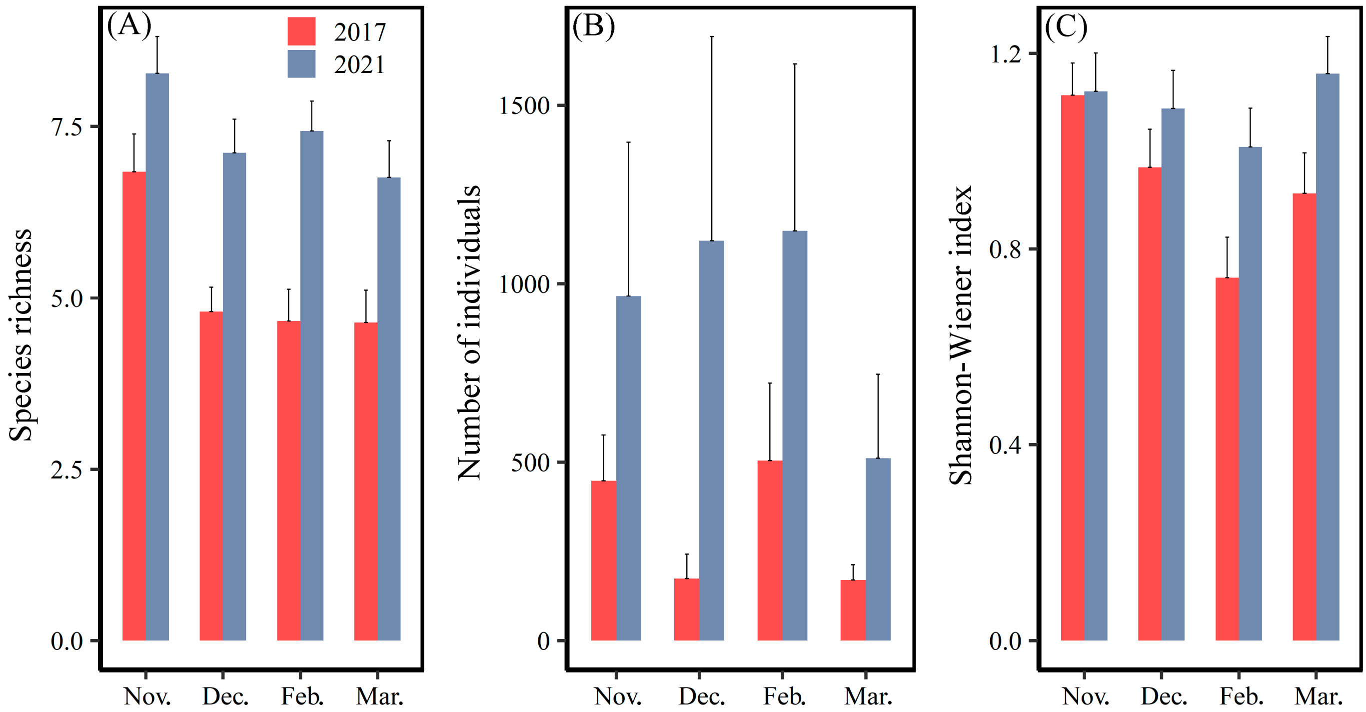

Figure 3. Mean values (with error bars showing standard errors) of waterbird community metrics at each observation point in the months before (2017–2018) and after (2021–2022) net pen removal from Caizi Lake: (**A**) species richness, (**B**) number of individuals, and (**C**) Shannon–Wiener index.

After net pen removal, the number of deep-water fish eaters (χ^2 = 14.75, df = 1, p < 0.001), seed eaters (χ^2 = 28.34, df = 1, p < 0.001), and tuber feeders (χ^2 = 6.632, df = 1, p = 0.010) increased, whereas the number of invertebrate eaters (χ^2 = 6.062, df = 1, p = 0.036) decreased in Caizi Lake (Figure 4). The number of tuber feeders was influenced by the interaction between net pens and month, with a positive effect in December but no significant effect in other months (Figure 4). The number of invertebrate eaters (χ^2 = 9.786, df = 2, p < 0.001) and grass foragers (χ^2 = 7.316, df = 2, p = 0.04) was higher in Baituhu than in Xizihu. The number of deep-water fish eaters was the highest in Xizihu (χ^2 = 8.354, df = 2, p = 0.021, Figure 5). The number of shallow-water fish eaters was not affected by the removal of net pens, the month, or the subareas.

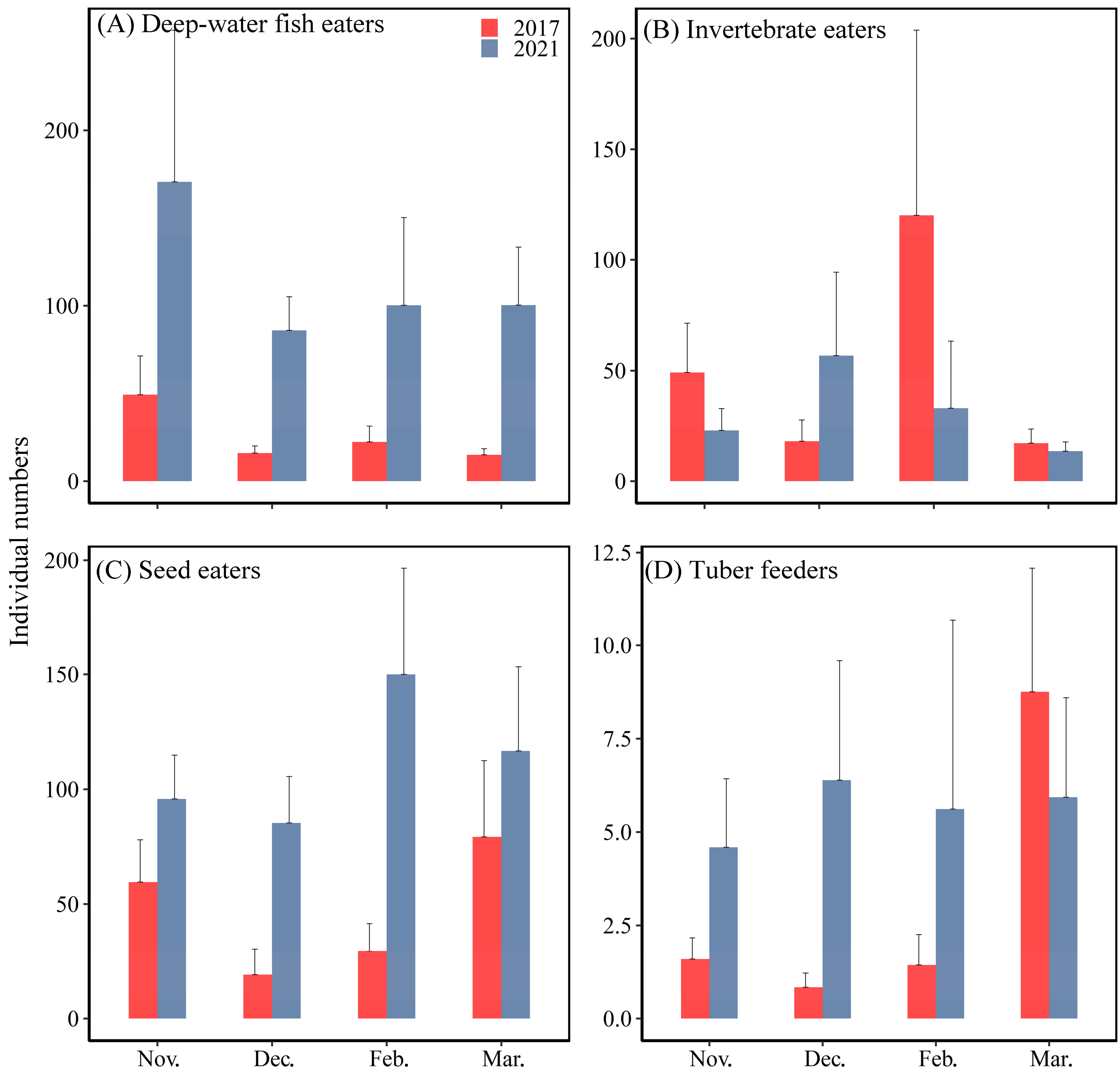

Figure 4. Number (with error bars showing standard errors) of waterbirds in guilds, before (2017–2018) and after (2021–2022) net pen removal from Caizi Lake. (**A**) Deep-water fish eaters; (**B**) Invertebrate eaters; (**C**) Seed eaters; (**D**) Tuber feeders.

3.4. Species Ccomposition

The PCoA plots and MRPP results indicate clear differences in the species composition of the waterbird communities before and after net pen removal (Figure 6A–C). Compositional changes occurred in the entire lake each month and were mostly caused by changes in Baituhu and Caizihu (Table 1).

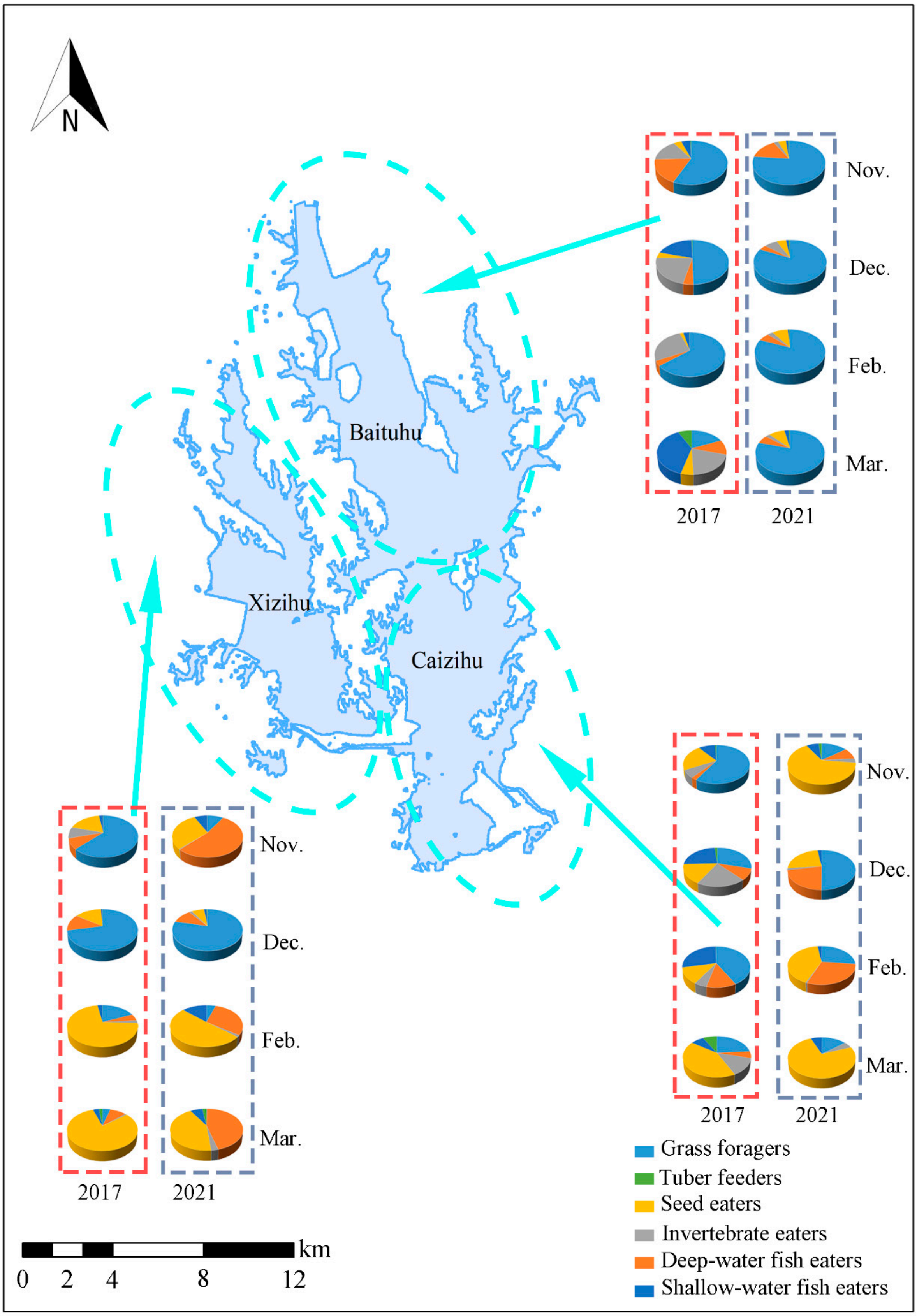

Figure 5. Abundance composition of waterbird guilds in the waterbird communities of the three subareas before (2017–2018) and after (2021–2022) net pen removal from Caizi Lake.

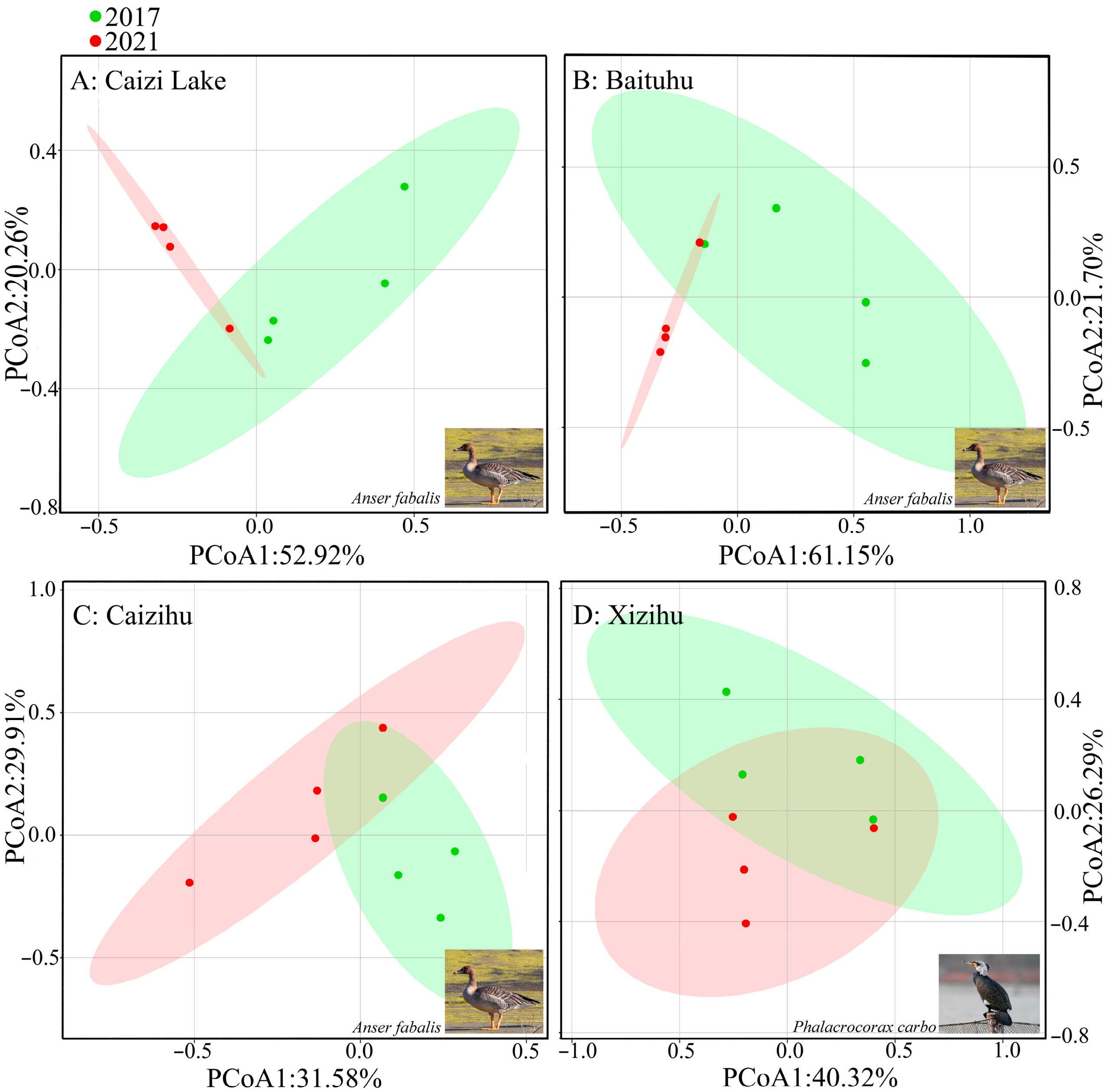

Figure 6. Differences in the species composition of the waterbird community based on principal coordinate analysis (PCoA), before (2017–2018) and after (2021–2022) net pen removal for the whole lake and three subareas. Species with the largest contributions to the changes are displayed in the lower right corner of the panels.

Table 1. MRPP pairwise comparisons of the bird communities before (2017–2018) and after (2021–2022) net pen removal for the whole lake and three subareas.

	The Whole Lake		**Baituhu**		**Caizihu**		**Xizihu**	
	A	*p*	*A*	*p*	*A*	*p*	*A*	*p*
All	0.198	0.026	0.194	0.027	0.065	0.031	0.044	0.198
Nov.	0.010	0.003	0.031	0.001	0.003	0.481	0.030	0.048
Dec.	0.021	0.001	0.038	0.001	0.039	0.005	0.036	0.010
Feb.	0.014	0.003	0.013	0.028	0.009	0.205	0.016	0.058
Mar.	0.024	0.001	0.025	0.001	0.015	0.065	0.027	0.005

Note: *A* was used to evaluate differences within and between groups, with $A > 0$ indicating that the difference between groups is greater than that within groups; $p < 0.05$.

Across the lake, 77.9% of the community composition changes were contributed by changes in the taiga bean goose, Eurasian teal, and great cormorant (Table 2). The main species contributing to compositional changes in the three subareas differ slightly, with taiga bean geese making the greatest contribution. The number of individual species that contributed significantly to compositional changes increased after net pen removal.

Table 2. Species contributions to compositional changes in waterbird communities in Caizi Lake and three subareas.

Species	Whole Lake	Baituhu	Caizihu	Xizihu
Taiga Bean Goose (*Anser fabalis*)	53.1% (+)	71.9% (+)	20.8% (+)	37.4% (+)
Eurasian Teal (*Anas crecca*)	14.7% (+)	<3.0% (+)	<3.0% (+)	8.2% (+)
Great Cormorant (*Phalacrocorax carbo*)	10.1% (+)	4.1% (+)	11.5% (+)	22.0% (+)
Chinese Spotbill Duck (*Anas zonorhyncha*)	5.0% (+)	3.1% (+)	15.3% (+)	6.6% (+)
Dunlin (*Calidris alpina*)	3.4% (−)	3.6% (−)	<3.0% (−)	<3.0% (−)
Greater White-Fronted Goose (*Anser albifrons*)	3.1% (+)	<3.0% (+)	7.8% (+)	<3.0% (−)
Green Sandpiper (*Tringa ochropus*)	<3.0% (+)	<3.0% (+)	<3.0% (+)	3.1% (+)
Mallard (*Anas platyrhynchos*)	<3.0% (+)	<3.0% (+)	4.8% (+)	6.0% (+)
Falcated Duck (*Mareca falcata*)	<3.0% (+)	<3.0% (+)	12.0% (+)	3.9% (+)
Grey Heron (*Ardea cinerea*)	<3.0% (+)	<3.0% (−)	3.4% (+)	3.1% (+)
Eurasian Spoonbill (*Platalea leucorodia*)	<3.0% (+)	<3.0% (+)	4.0% (−)	<3.0% (+)

Note: "+" denotes an increase in the individual number; "−" denotes a decrease in the individual number.

4. Discussion

We recorded a large number of waterbirds in Caizi Lake, including threatened species on the IUCN Red List and Key Protected Wild Animal Species in China, which is consistent with the results of previous studies [29,53]. The results of this study provide further evidence of the importance of Caizi Lake for wintering waterbirds migrating along the East Asian–Australasian Flyway [29]. Consistent with the results of previous studies, we observed that the spatial distribution of the different guilds varied among the subareas of Caizi Lake. This is probably due to the different water level fluctuations in the subareas [30,54,55]. As a typical Yangtze-connected lake, seasonal water level fluctuations of Caizi Lake are affected by the water level change of the Yangtze River and rainfall in the area [29]. The Caizihu and Baituhu areas are directly connected to the Yangtze River, and their water level fluctuations are strongly linked to those in the Yangtze River. However, the dam in the Xizihu Region maintains a high water level in winter [21]. Therefore, large areas of grassland and mudflats are exposed in Baituhu during winter, providing more foraging habitats for grass foragers and invertebrate eaters. In contrast, deep-water fish eaters prefer Xizihu, where the water level is high during winter [29].

Because of intense human activities and overexploitation, the wetlands in the middle and lower reaches of the Yangtze River floodplain have experienced long-lasting degradation and loss, threatening the survival of waterbirds, especially threatened species such as the hooded crane [43,56]. In recent decades, the awareness of the negative effects of wetland loss and degradation on the middle and lower reaches of the Yangtze River floodplain has been growing, and many measures have been implemented to restore wetland habitats for aquatic organisms [25,57]. Several positive effects of restoration measures, such as the restoration of aquatic vegetation and the reduction of human interference, on waterbirds and their habitats have been reported in this region [25,27]. We observed significant differences in waterbird communities between years, which suggests that net pen removal had a positive impact on the waterbird community in Caizi Lake.

We also observed that the species richness and abundance of wintering waterbirds in Caizi Lake increased after net pen removal. The population size is closely related to the habitat carrying capacity. Vital factors affecting the carrying capacity include food quantity and availability [58,59]. The results of previous studies showed that the water quality and zooplankton quickly recover after net pen removal, and conditions are more conducive to the growth of underwater vegetation [36,39,60]. Fox et al. [26] reported that an increase in aquatic vegetation attracts a large number of waterbirds. Therefore, the increase in the waterbird abundance after purse seine removal in Caizi Lake may be attributed to the substantial recovery of aquatic vegetation [46]. The artificial acceleration of the restoration of aquatic vegetation in Caizi Lake is conducive to the increase in the waterbird abundance. Furthermore, wide open space is an important factor affecting the waterbird abundance. Waterbirds must run a certain distance to take off [61–63]. The increase in the area of open water after the removal of net pens has attracted heavier waterbirds (e.g., swans, cormorants) for overwintering.

Human activity is one of the most significant factors threatening bird survival [64,65]. With the cessation of aquaculture in 2018, the effect of human disturbance on waterbirds decreased, and waterbird numbers and species richness increased in Caizi Lake. However, the Shannon–Wiener diversity index did not change because of the particularly high abundance of taiga bean geese and great cormorants [66]. This may be due to their rapid response to net pen removal; they quickly accumulated in Caizi Lake. This indicates that the potential homogenization of the community structure due to the large increase in a few species should be considered in future studies [42]. We also acknowledge that the numbers of taiga bean geese and cormorants are increasing globally or regionally [67], which is one of the reasons for the increase in waterbird numbers in Caizi Lake. As waterbirds are highly mobile, the increase in the number of waterbirds may also be the result of habitat quality enhancement in other Yangtze-connected lakes. However, according to other studies conducted during the same period, the number of waterbirds in Dongting Lake decreased as a result of dam removal, which further supports our speculation [68].

We observed that the community composition changed after net pen removal, mainly due to changes in the number of waterbirds in the guilds [69]. Among the seed eaters, Eurasian teal and Chinese spotbill ducks showed the greatest increase in number, which is associated with the recovery of submerged vegetation [46,70]. The increase in the number of waterbirds among deep-water fish eaters (cormorants and gulls) may be directly related to the reduced risk of diving after net pen removal. For diving water birds, dense underwater seine nets can be obstacles, increasing the risk of entanglement, particularly in winter and spring [71,72]. In. addition to net pen removal, the improved water quality reduces the risk of diving and improves the predation success rate for diving birds [73]. The results of studies prior to net pen removal showed that the foraging grounds of the hooded crane that spent the winter in Yangtze-connected lakes changed from natural mudflats to rice fields close to the lake with the depletion of submerged plants [11,29,43]. We recorded more hooded crane in both rice fields and mudflats, which may be related to their flexible foraging strategy and the recovery of submerged vegetation [43,46]. Therefore, we should pay more attention to endangered species, such as the hooded crane et al., in future wetland conservation and restoration [54]. Note that the number of waterbirds among grass foragers, before and after net pen removal, did not statistically differ, but the increase in the number of taiga bean geese significantly contributed to the change in the community composition.

5. Conclusions

We recorded a large number of waterbirds during field surveys in the winter months of 2017–2018 and 2021–2022 in Caizi Lake. We observed that the spatial distribution of various guilds differed. After net pen removal (2021–2022), the species richness and individual number of waterbirds increased, whereas the Shannon–Wiener index did not change. Net pen removal was the likely cause of the increase in the number of deep-water fish eaters, seed eaters, and tuber feeders and the decrease in the number of invertebrate eaters. The waterbird community composition also changed after the net pens were removed, mainly as a result of the change in the numbers of the great cormorant and the taiga bean goose. The above results indicate that net pen removal in Caizi Lake had a positive impact on the waterbird community, which we suggest is the main reason for the differences in waterbird communities between years. To further improve the habitats for waterbirds, we suggest further restoration measures, such as aquatic vegetation restoration and the reduction of human disturbance.

Author Contributions: All authors contributed to the study conception and design. C.L. conceived the study. T.L., G.W., X.S. and L.C. collected the data. T.L., H.Z. and C.L. performed the analyses. T.L. wrote the first draft of the paper. C.L. revised the manuscript. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

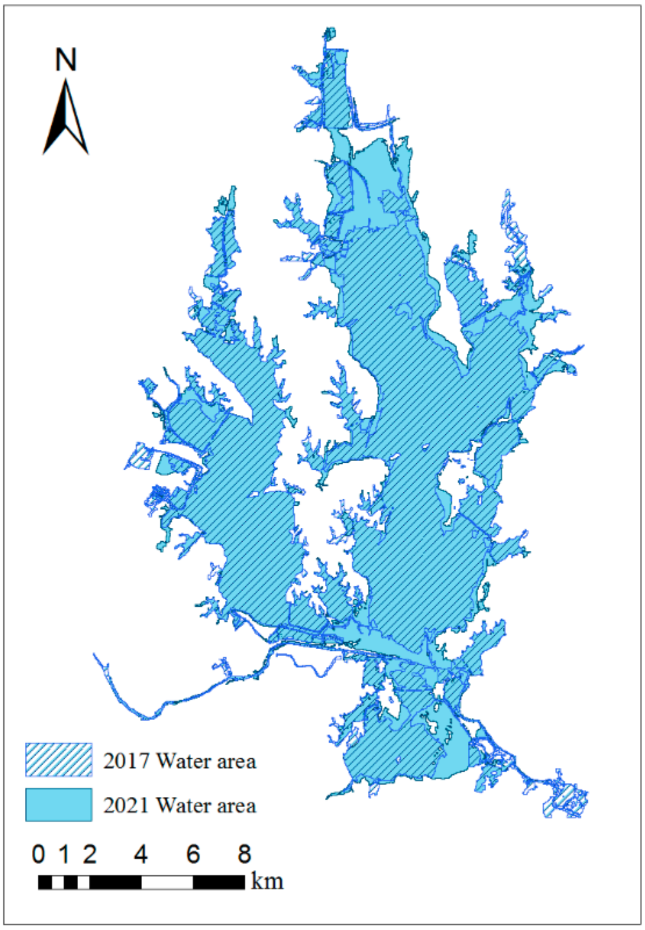

Figure A1. Water areas of the waterbird surveys, before (2017–2018) and after (2021–2022) net pen removal from Caizi Lake.

Table A1. The wintering waterbird species, with minimum, maximum, and mean number of individuals during one survey, recorded at Caizi Lake in eight field surveys during the wintering periods of 2017–2018 and 2021–2022. N: the number of surveys during which the species were recorded.

Common Name	Scientific Name	Mean		N	
		17–18	21–22	17–18	21–22
Great Crested Grebe	*Podiceps cristatus*	203	396	4	4
Little Grebe	*Tachybaptus ruficollis*	156	54	4	4
Eurasian Coot	*Fulica atra*	2	0	1	0
Common Moorhen	*Gallinula chloropus*	4	5	3	3
Siberian Crane	*leucogeranus leucogeranus*	3	9	2	3
Hooded Crane	*Grus monacha*	26	89	4	3
Common Crane	*Grus grus*	0	0	1	0
Greater White-Fronted Goose	*Anser albifrons*	301	1365	4	3
Smew	*Mergellus albellus*	1	4	3	1
Chinese Spotbill Duck	*Anas zonorhyncha*	588	2514	4	4
Eurasian Wigeon	*Mareca penelope*	39	0	1	0
Ruddy Shelduck	*Tadorna ferruginea*	57	36	4	4
Gadwall	*Mareca strepera*	7	121	1	3
Taiga Bean Goose	*Anser fabalis*	7339	27,351	4	4
Tufted Duck	*Aythya fuligula*	0	8	0	2
Common Pochard	*Aythya ferina*	3	25	1	3
Baikal Teal	*Sibirionetta formosa*	1	0	1	0
Swan Goose	*Anser cygnoides*	12	23	3	2
Falcated Duck	*Mareca falcata*	334	669	4	4
Eurasian Teal	*Anas crecca*	347	5183	4	4
Mallard	*Anas platyrhynchos*	647	938	4	4
Northern Shoveler	*Spatual clypeata*	5	1	1	1
Common Merganser	*Mergus merganser*	14	12	3	4
Common Shelduck	*Tadorna tadorna*	0	2	0	1
Tundra Swan	*Cygnus columbianus*	125	121	3	4
Northern Pintail	*Anas acuta*	31	0	1	0
Pied Avocet	*Recurvirostra avosetta*	18	50	3	3
Black-Winged Stilt	*Himantopus himantopus*	0	2	0	1
Northern Lapwing	*Vanellus vanellus*	15	49	4	3
Kentish Plover	*Charadrius alexandrinus*	51	35	3	1
Grey-Headed Lapwing	*Vanellus cinereus*	1	12	1	1
Little Ringed Plover	*Charadrius dubius*	1	17	1	2
Green Sandpiper	*Tringa ochropus*	8	688	2	4
Spotted Redshank	*Tringa erythropus*	174	5	2	2
Dunlin	*Calidris alpina*	1467	10	3	1
Common Redshank	*Tringa totanus*	83	18	2	4
Common Sandpiper	*Actitis hypoleucos*	8	33	2	4
Temminck's Stint	*Calidris temminckii*	0	7	0	1
Common Greenshank	*Tringa nebularia*	55	7	4	4
Common Snipe	*Gallinago gallinago*	0	7	1	4
Marsh Sandpiper	*Tringa stagnatilis*	0	1	0	2
Black-Headed Gull	*Chroicoephalus ridibundus*	1	115	1	3
Pallas's Gull	*Ichthyaetus ichthyaetus*	0	132	1	4
European Herring Gull	*Larus argentatus*	272	77	4	4
Great Cormorant	*Phalacrocorax carbo*	476	4237	4	4
Eurasian Spoonbill	*Platalea leucorodia*	376	446	4	4
Little Egret	*Egretta garzetta*	31	77	4	4
Grey Heron	*Ardea cinerea*	565	571	4	4
Chinese Pond Heron	*Ardeola bacchus*	0	6	0	1
Great Egret	*Ardea alba*	318	130	4	4
Eastern Cattle Egret	*Bubulcus ibis*	0	0	0	0
Black-crowned Night Heron	*Nycticorax nycticorax*	29	38	2	3
Intermediate Egret	*Ardea intermedia*	19	3	4	4
Oriental Stork	*Ciconia boyciana*	60	26	4	4

References

1. Jessop, J.; Spyreas, G.; Pociask, G.E.; Benson, T.J.; Ward, M.P.; Kent, A.D.; Matthews, J.W. Tradeoffs Among Ecosystem Services in Restored Wetlands. *Biol. Conserv.* **2015**, *191*, 341–348. [CrossRef]
2. Mandishona, E.; Knight, J. Inland wetlands in Africa: A Review of Their Typologies and Ecosystem Services. *Prog. Phys. Geogr. Earth Environ.* **2022**, *46*, 547–565. [CrossRef]
3. Meng, W.; He, M.; Hu, B.; Mo, X.; Li, H.; Liu, B.; Wang, Z. Status of Wetlands In China: A Review of Extent, Degradation, Issues And Recommendations For Improvement. *Ocean. Coast. Manag.* **2017**, *146*, 50–59. [CrossRef]
4. Davidson, N.C. How Much Wetland Has The World Lost? Long-Term and Recent Trends in Global Wetland Area. *Mar. Freshw. Res.* **2014**, *65*, 934. [CrossRef]
5. Jeelani, N.; Yang, W.; Xia, L.; Zhu, H.L.; An, S. Ecosystem Threats and Management Strategies for Wetlands in China. *Mar. Freshw. Res.* **2020**, *71*, 1557. [CrossRef]
6. Klemas, V. Remote Sensing of Riparian and Wetland Buffers: An Overview. *J. Coast. Res.* **2014**, *297*, 869–880. [CrossRef]
7. Stroud, D.A.; Davidson, N.C. Fifty Years of Criteria Development For Selecting Wetlands of International Importance. *Mar. Freshw. Res.* **2022**, *73*, 1134–1148. [CrossRef]
8. Kingsford, R.T.; Basset, A.; Jackson, L. Wetlands: Conservation'S Poor Cousins. *Aquat. Conserv. Mar. Freshw. Ecosyst.* **2016**, *26*, 892–916. [CrossRef]
9. Green, A.J.; Elmberg, J. Ecosystem Services Provided by Waterbirds. *Biol. Rev. Camb. Philos. Soc.* **2014**, *89*, 105–122. [CrossRef]
10. Amat, J.A.; Green, A.J. Waterbirds as Bioindicators of Environmental Conditions. In *Wetlands*; LePage, B.A., Ed.; Springer: Dordrecht, The Netherlands, 2011; pp. 45–52, ISBN 978-94-007-0550-0.
11. Li, C.; Zhou, L.; Xu, L.; Zhao, N.; Beauchamp, G. Vigilance and Activity Time-Budget Adjustments of Wintering Hooded Cranes, *Grus Monacha*, in Human-Dominated Foraging Habitats. *PLoS ONE* **2015**, *10*, e0118928. [CrossRef]
12. Li, Y.; Qian, F.; Silbernagel, J.; Larson, H. Community Structure, Abundance Variation and Population Trends of Waterbirds In Relation to Water Level Fluctuation in Poyang Lake. *J. Great Lakes Res.* **2019**, *45*, 976–985. [CrossRef]
13. Watson, H.; Bolton, M.; Monaghan, P. Out of Sight but Not out of Harm'S Way: Human Disturbance Reduces Reproductive Success of a Cavity-Nesting Seabird. *Biol. Conserv.* **2014**, *174*, 127–133. [CrossRef]
14. Quan, R.-C.; Wen, X.; Yang, X. Effects of Human Activities on Migratory Waterbirds at Lashihai Lake, China. *Biol. Conserv.* **2002**, *108*, 273–279. [CrossRef]
15. Carney, K.M.; Sydeman, W.J. A Review of Human Disturbance Effects on Nesting Colonial Waterbirds. *Waterbirds* **1999**, *22*, 68. [CrossRef]
16. Sun, C.; Zhen, L.; Wang, C.; Yan, B.; Cao, X.; Wu, R. Impacts of Ecological Restoration and Human Activities on Habitat of Overwintering Migratory Birds in the Wetland of Poyang Lake, Jiangxi Province, China. *J. Mt. Sci.* **2015**, *12*, 1302–1314. [CrossRef]
17. Katuwal, H.B.; Basnet, K.; Khanal, B.; Devkota, S.; Rai, S.K.; Gajurel, J.P.; Scheidegger, C.; Nobis, M.P. Seasonal Changes in Bird Species and Feeding Guilds along Elevational Gradients of the Central Himalayas, Nepal. *PLoS ONE* **2016**, *11*, e0158362. [CrossRef]
18. Wang, X.; Kuang, F.; Tan, K.; Ma, Z. Population Trends, Threats, and Conservation Recommendations for Waterbirds in China. *Avian Res.* **2018**, *9*, 14. [CrossRef]
19. Lu, Q.; Kang, L.; Shao, H.; Zhao, Z.; Chen, Q.; Bi, X.; Shi, P. Investigating Marsh Sediment Dynamics and Its Driving Factors in Yellow River Delta for Wetland Restoration. *Ecol. Eng.* **2016**, *90*, 307–313. [CrossRef]
20. Mainstone, C.P. Developing A Coherent Narrative for Conserving Freshwater and Wetland Habitats: Experiences in The UK. *WIREs Water* **2017**, *4*, e1189. [CrossRef]
21. Prahalad, V.; Whitehead, J.; Latinovic, A.; Kirkpatrick, J.B. The Creation and Conservation Effectiveness of Statewide Wetlands and Waterways and Coastal Refugia Planning Overlays for Tasmania, Australia. *Land Use Policy* **2019**, *81*, 502–512. [CrossRef]
22. Ribeiro, S.; Moura, R.G.; Stenert, C.; Florín, M.; Maltchik, L. Land Use in Brazilian Continental Wetland Ramsar Sites. *Land Use Policy* **2020**, *99*, 104851. [CrossRef]
23. Abensperg-Traun, M. CITES, Sustainable Use of Wild Species and Incentive-Driven Conservation in Developing Countries, With an Emphasis on Southern Africa. *Biol. Conserv.* **2009**, *142*, 948–963. [CrossRef]
24. Zhao, Q.; Bai, J.; Huang, L.; Gu, B.; Lu, Q.; Gao, Z. A Review of Methodologies and Success Indicators for Coastal Wetland Restoration. *Ecol. Indic.* **2016**, *60*, 442–452. [CrossRef]
25. Fan, J.; Wang, X.; Wu, W.; Chen, W.; Ma, Q.; Ma, Z. Function of Restored Wetlands for Waterbird Conservation in the Yellow Sea Coast. *Sci. Total Environ.* **2021**, *756*, 144061. [CrossRef] [PubMed]
26. Fox, A.D.; Jørgensen, H.E.; Jeppesen, E.; Lauridsen, T.L.; Søndergaard, M.; Fugl, K.; Myssen, P.; Balsby, T.J.; Clausen, P. Relationships Between Breeding Waterbird Abundance, Diversity, and Clear Water Status after the Restoration of Two Shallow Nutrient-Rich Danish Lakes. *Aquat. Conserv. Mar. Freshw Ecosyst.* **2020**, *30*, 237–245. [CrossRef]
27. Zhou, J.; Zhou, L.; Xu, W. Diversity of Wintering Waterbirds Enhanced by Restoring Aquatic Vegetation at Shengjin Lake, China. *Sci. Total Environ.* **2020**, *737*, 140190. [CrossRef] [PubMed]
28. Jiang, H.; Wen, Y.; Zou, L.; Wang, Z.; He, C.; Zou, C. The Effects of A Wetland Restoration Project on The Siberian Crane (*Grus Leucogeranus*) Population and Stopover Habitat in Momoge National Nature Reserve, China. *Ecol. Eng.* **2016**, *96*, 170–177. [CrossRef]

29. Li, C.; Li, H.; Zhang, Y.; Zha, D.; Zhao, B.; Yang, S.; Zhang, B.; de Boer, W.F. Predicting Hydrological Impacts of The Yangtze-To-Huaihe Water Diversion Project on Habitat Availability for Wintering Waterbirds at Caizi Lake. *J. Environ. Manag.* **2019**, *249*, 109251. [CrossRef] [PubMed]
30. Zhao, M.; Cong, P.; Barter, M.; Fox, A.D.; CAO, L.E. The Changing Abundance and Distribution of Greater White-Fronted Geese *Anser Albifrons* in The Yangtze River Floodplain: Impacts of Recent Hydrological Changes. *Bird Conserv. Int.* **2012**, *22*, 135–143. [CrossRef]
31. Hou, X.; Feng, L.; Tang, J.; Song, X.-P.; Liu, J.; Zhang, Y.; Wang, J.; Xu, Y.; Dai, Y.; Zheng, Y.; et al. Anthropogenic Transformation of Yangtze Plain Freshwater Lakes: Patterns, Drivers and Impacts. *Remote Sens. Environ.* **2020**, *248*, 111998. [CrossRef]
32. Tucker, C.S.; Hargreaves, J.A. *Environmental Best Management Practices for Aquaculture*, 1st ed.; Wiley-Blackwell; U.S. Aquaculture Society: Ames Iowa, LA, USA, 2008; ISBN 9780813820279.
33. Wu, R. The Environmental Impact of Marine Fish Culture: Towards a Sustainable Future. *Mar. Pollut. Bull.* **1995**, *31*, 159–166. [CrossRef]
34. Schoelynck, J.; Wolters, J.-W.; Teuchies, J.; Brion, N.; Puijalon, S.; Horemans, D.M.L.; Keirsebelik, H.; Bervoets, L.; Blust, R.; Meire, P. Experimental Evidence for the Decline of Submerged Vegetation in Freshwater Ecosystems by the Invasive Chinese Mitten Crab (Eriocheir Sinensis). *Biol. Invasions* **2020**, *22*, 627–641. [CrossRef]
35. Tsutsumi, H. Impact of Fish Net Pen Culture on the Benthic Environment of a Cove in South Japan. *Estuaries* **1995**, *18*, 108. [CrossRef]
36. Zheng, X.; Chen, J.; Guo, W.; Zhou, Z.; Ye, X. Response of Phytoplankton Community Structure to Vegetation Restoration after Removal of Purse Seine in Shengjin Lake. *Diversity* **2022**, *14*, 178. [CrossRef]
37. Norriss, J.V.; Fisher, E.A.; Denham, A.M. Seabird Bycatch in a Sardine Purse Seine Fishery. *ICES J. Mar. Sci.* **2020**, *77*, 2971–2983. [CrossRef]
38. Kloskowski, J. Human–Wildlife Conflicts at Pond Fisheries in Eastern Poland: Perceptions and Management of Wildlife Damage. *Eur. J. Wildl. Res.* **2011**, *57*, 295–304. [CrossRef]
39. Wang, Y.; Wang, W.; Zhou, Z.; Xia, W.; Zhang, Y. Effect Of Fast Restoration of Aquatic Vegetation on Phytoplankton Community after Removal of Purse Seine Culture in Huayanghe Lakes. *Sci. Total Environ.* **2021**, *768*, 144024. [CrossRef]
40. Department of Ecology and Environment of Anhui Province. Anqing City Begins the Demolition of the Lake Fence. Available online: https://sthjt.ah.gov.cn/hbzx/gzdt/sxdt/111044871.html (accessed on 26 October 2017).
41. Chen, J.-Y.; Zhou, L.-Z.; Zhou, B.; Xu, R.-X.; Zhu, W.-Z.; Xu, W.-B. Seasonal Dynamics of Wintering Waterbirds in Two Shallow Lakes along Yangtze River in Anhui Province. *Dongwuxue Yanjiu* **2011**, *32*, 540–548. [PubMed]
42. Guevara, E.A.; Santander, G.T.; Espinosa, R.; Graham, C.H. Aquatic Bird Communities in Andean Lakes of Ecuador Are Increasingly Dissimilar over Time. *Ecol. Indic.* **2021**, *121*, 107044. [CrossRef]
43. Zheng, M.; Zhou, L.; Zhao, N.; Xu, W. Effects of Variation in Food Resources on Foraging Habitat Use by Wintering Hooded Cranes (*Grus Monacha*). *Avian Res.* **2015**, *6*, 11. [CrossRef]
44. An, L.; Liao, K.; Zhu, L.; Zhou, B. Influence of River-Lake Isolation on the Water Level Variations of Caizi Lake, Lower Reach of the Yangtze River. *J. Geogr. Sci.* **2021**, *31*, 551–564. [CrossRef]
45. Jiang, Z.; Xu, N.; Liu, B.; Zhou, L.; Wang, J.; Wang, C.; Dai, B.; Xiong, W. Metal Concentrations and Risk Assessment in Water, Sediment and Economic Fish Species with Various Habitat Preferences and Trophic Guilds from Lake Caizi, Southeast China. *Ecotoxicol. Environ. Saf.* **2018**, *157*, 1–8. [CrossRef] [PubMed]
46. Zhao, W.; Liu, Z.; Guo, W.; Zhou, Z. Effect of Aquatic Vegetation Restoration after Removal of Culture Purse Seine on Phytoplankton Community Structure in Caizi Lakes. *Diversity* **2022**, *14*, 395. [CrossRef]
47. Gardner, R.C.; Davidson, N.C. The Ramsar convention. In *Wetlands: Integrating Multidisciplinary Concepts*; LePage, B.A., Ed.; Springer: Dordrecht, The Netherlands, 2011; pp. 189–203.
48. MacKinnon, J.R.; Phillipps, K.; Showler, D.; He, F.; MacKinnon, D. *A Field Guide to the Birds of China*; Oxford University Press: New York, NY, USA, 2022.
49. Blondel, J. Guilds or Functional Groups: Does It Matter? *Oikos* **2003**, *100*, 223–231. [CrossRef]
50. McCune, B.; Grace, J.B.; Urban, D.L. *Analysis of Ecological Communities*; MJM Software Design: Gleneden Beach, OR, USA, 2002; ISBN 9780972129008.
51. De Lara, V.C.-F.; Reyes-Bonilla, H.; Serviere-Zaragoza, E. A Tropical Assemblage of Benthic Macroalgae on Rocky Reefs in a Temperate Zone on the Western Baja California Peninsula, Mexico. *Bot. Mar.* **2010**, *53*, 195–203. [CrossRef]
52. R Core Team. R: A Language and Environment for Statistical Computing: R Foundation for Statistical Computing. Available online: https://www.r-project.org/ (accessed on 15 August 2022).
53. Wang, X.; Chen, J.; Zhou, L. Effects of Human Activities on the Diversity of Waterbirds Wintering in a Shallow Lake of the Middle and Lower Yangtze River Floodplain, China. *Diversity* **2020**, *12*, 302. [CrossRef]
54. Jiang, F.; Qi, S.; Liao, F.; Ding, M.; Wang, Y. Vulnerability of Siberian Crane Habitat to Water Level in Poyang Lake Wetland, China. *GIScience Remote Sens.* **2014**, *51*, 662–676. [CrossRef]
55. Wang, Y.; Jia, Y.; Guan, L.; Lu, C.; Lei, G.; Wen, L.; Liu, G. Optimising Hydrological Conditions to Sustain Wintering Waterbird Populations in Poyang Lake National Natural Reserve: Implications for Dam Operations. *Freshw. Biol.* **2013**, *58*, 2366–2379. [CrossRef]

56. Fang, J.; Wang, Z.; Zhao, S.; Li, Y.; Tang, Z.; Yu, D.; Ni, L.; Liu, H.; Xie, P.; Da, L.; et al. Biodiversity Changes in the Lakes of the Central Yangtze. *Front. Ecol. Environ.* **2006**, *4*, 369–377. [CrossRef]
57. Li, C.; Yang, Y.; Wang, Z.; Yang, L.; Zhao, D.; Zhou, L. The relationship between seasonal water level fluctuation and habitat availability for wintering waterbirds at Shengjin Lake, China. *Bird Conserv. Int.* **2019**, *29*, 100–114. [CrossRef]
58. Ferger, S.W.; Schleuning, M.; Hemp, A.; Howell, K.M.; Böhning-Gaese, K. Food Resources and Vegetation Structure Mediate Climatic Effects on Species Richness of Birds. *Glob. Ecol. Biogeogr.* **2014**, *23*, 541–549. [CrossRef]
59. Fino, S.R.; Williams, C.K.; Livolsi, M.C.; Ringelman, K.M.; Coluccy, J.M.; Devers, P.K.; Castelli, P.M. Carrying Capacity of Wintering American Black Ducks in Forested Wetlands. *J. Wildl. Manag.* **2017**, *81*, 943–950. [CrossRef]
60. Fox, A.D.; Balsby, T.J.S.; Jørgensen, H.E.; Lauridsen, T.L.; Jeppesen, E.; Søndergaard, M.; Fugl, K.; Myssen, P.; Clausen, P. Effects of Lake Restoration on Breeding Abundance of Globally Declining Common Pochard (*Aythya Ferina* L.). *Hydrobiologia* **2019**, *830*, 33–44. [CrossRef]
61. Henry, D.A.W.; Cumming, G.S. Spatial and Environmental Processes Show Temporal Variation in the Structuring of Waterbird Metacommunities. *Ecosphere* **2016**, *7*, e01451. [CrossRef]
62. Robert, J.R. Locomotor Mechanisms in North American Ducks. *Wilson Ornithol. Soc.* **1973**, *85*, 295–307.
63. Xia, S.; Liu, Y.; Wang, Y.; Chen, B.; Jia, Y.; Liu, G.; Yu, X.; Wen, L. Wintering Waterbirds in a Large River Floodplain: Hydrological Connectivity Is the Key for Reconciling Development and Conservation. *Sci. Total Environ.* **2016**, *573*, 645–660. [CrossRef] [PubMed]
64. Kirby, J.S.; Stattersfield, A.J.; Butchart, S.H.M.; Evans, M.I.; Grimmett, R.F.A.; Jones, V.R.; O'Sullivan, J.; Tucker, G.M.; Newton, I. Key Conservation Issues for Migratory Land- and Waterbird Species on the World'S Major Flyways. *Bird Conserv. Int.* **2008**, *18*, S49–S73. [CrossRef]
65. Lopez-Darias, M.; Luzardo, J.; Martínez, R.; González, D.; García, E.A.; Cabrera, J. Poaching vs. Patrolling: Effects on Conservation of Cory's Shearwater Calonectris Diomedea Borealis Colonies. *Bird Conserv. Int.* **2011**, *21*, 342–352. [CrossRef]
66. Wang, X.; Zhu, G.; Ma, H.; Wu, Y.; Zhang, W.; Zhang, Y.; Li, C.; de Boer, W.F. Bird Communities' Responses to Human-Modified Landscapes in the Southern Anhui Mountainous Area. *Avian Res.* **2022**, *13*, 100006. [CrossRef]
67. Klimaszyk, P.; Rzymski, P. The Complexity of Ecological Impacts Induced by Great Cormorants. *Hydrobiologia* **2016**, *771*, 13–30. [CrossRef]
68. Zhu, F.; Zou, Y.; Zhang, P.; Zhang, S.; Chen, X.; Li, F.; Deng, Z.; Zhang, H.; Yu, Z.; Zhu, X.; et al. Dyke Demolition Led to a Sharp Decline in Waterbird Diversity due to Habitat Quality Reduction: A Case Study of Dongting Lake, China. *Ecol. Evol.* **2022**, *12*, e8782. [CrossRef] [PubMed]
69. Ding, Z.; Liang, J.; Hu, Y.; Zhou, Z.; Sun, H.; Liu, L.; Liu, H.; Hu, H.; Si, X. Different Responses of Avian Feeding Guilds to Spatial and Environmental Factors Across an Elevation Gradient in the Central Himalaya. *Ecol. Evol.* **2019**, *9*, 4116–4128. [CrossRef] [PubMed]
70. Haas, K.; Köhler, U.; Diehl, S.; Köhler, P.; Dietrich, S.; Holler, S.; Jaensch, A.; Niedermaier, M.; Vilsmeier, J. Influence of Fish on Habitat Choice of Water Birds: A Whole System Experiment. *Ecology* **2007**, *88*, 2915–2925. [CrossRef] [PubMed]
71. Sonntag, N.; Schwemmer, H.; Fock, H.O.; Bellebaum, J.; Garthe, S. Seabirds, Set-Nets, and Conservation Management: Assessment of Conflict Potential and Vulnerability of Birds to Bycatch in Gillnets. *ICES J. Mar. Sci.* **2012**, *69*, 578–589. [CrossRef]
72. Žydelis, R.; Bellebaum, J.; Österblom, H.; Vetemaa, M.; Schirmeister, B.; Stipniece, A.; Dagys, M.; van Eerden, M.; Garthe, S. Bycatch in Gillnet Fisheries—An Overlooked Threat to Waterbird Populations. *Biol. Conserv.* **2009**, *142*, 1269–1281. [CrossRef]
73. Raimo, V. Variation in Population Trends and Spatial Dynamics of Waterbirds in a Boreal Lake Complex. *Ornis Fenn.* **2016**, *93*, 197–211.

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