Contributing Paper

Biodiversity Impacts of Large Dams: Waterbirds

Nick Davidson; Simon Delany
Wetlands International, Netherlands

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For further information see http://www.dams.org/

Biodiversity Impacts of Large Dams: Waterbirds

Nick Davidson & Simon Delany

Wetlands International, PO Box 471, 6700 AL Wageningen, The Netherlands

1. Introduction

Waterbirds[1], both migratory and non-migratory, are important components of the biodiversity of wetlands throughout the world. This is recognised in international conventions and agreements, which place requirements on countries which are party to such instruments to safeguard waterbirds throughout their range and distribution. This is achieved in several ways, notably through the designation of wetlands of international importance for waterbirds through the Ramsar Convention on Wetlands, and the development and implementation of flyway-scale migratory waterbird conservation strategies, notably the Bonn Convention African-Eurasian Migratory Waterbird Agreement (AEWA) and the Asia-Pacific Migratory Waterbird Conservation Strategy. Such flyway-scale initiatives recognise the vital need to safeguard the international networks of key sites upon which these birds depend throughout the year for their survival, and to put in place a range of management measures to maintain these populations.

In support of these measures there is an extensive network of information gathering on waterbird populations, so as to establish their distributions, their population sizes and the location of the key wetlands they use, and to monitor the changes in such distributions and trends in population sizes. Information from waterbird monitoring is made regularly available in support of national and international waterbird conservation activity such as the identification and designation of internationally important wetlands (e.g. Rose & Scott 1997; Scott & Rose 1996; Delany et al. 1999). This report draws on information gathered through such national and international waterbird monitoring schemes to examine the characteristics of waterbird assemblages that utilise waterbodies created by damming rivers in comparison to those on natural open water wetlands.

Since waterbirds are highly mobile they have the capacity to move to and between wetlands so as to capitalise on those systems that provide the most suitable environmental conditions for their survival. The key questions of the influence of dams on waterbirds are therefore:

a. whether wetlands created by dams provide suitable habitat for waterbirds;

b. whether these provide additional or substitute habitats, and whether they are preferred by at least some species to natural open water wetlands;

c. whether such artificial wetlands support similar or different waterbird assemblages to those using natural systems; and

d. whether dammed sites provide habitat largely for common or ubiquitous species and/or for those of conservation concern.

These are in addition to questions concerning the direct and indirect impacts of dams on:

e. the natural riparian waterbird assemblages present prior to dam construction; and

f. those waterbirds affected by changed downstream conditions induced by dam construction and water management.

This report focuses on questions a. - d., and addresses these through case study analyses of waterbird use of natural and dammed wetlands in three countries (Switzerland, United Kingdom and South Africa) with differing patterns of occurrence of natural and dammed open water wetlands. Waterbirds may use such wetlands for breeding, and during their non-breeding seasons for feeding and for roosting. This analysis focuses on wildfowl (divers,

[1] There are no globally accepted definitions of wetland bird terms: terms have often been defined for different purposes. The term “waterbirds” is, however, now increasingly used to cover all wetland bird families (e.g. in the Ramsar Convention), although “waterfowl” has also frequently been used in this broad sense (e.g. Rose & Scott 1997). Waterbirds in this broad sense include “wildfowl”, covering divers, grebes, cormorants, Anatidae (swans, geese, ducks), coots and rails; “shorebirds” (synonymous with “waders”); and some other wetland bird families notably gulls, terns, herons and egrets.

grebes, cormorants, Anatidae (swans, geese, ducks), coots and rails) since these are the species that are particularly characteristic of open water systems, and for the northern temperate countries on assemblages present during the winter period. At this time large numbers of waterfowl migrate south and south-west from arctic, sub-arctic and boreal breeding areas in Europe and Russia to overwinter in the relatively mild climate of western Europe. Other major waterbird guilds such as waders (shorebirds) chiefly utilise the shallow emergent shorelines of such wetlands for feeding during migration staging or wintering.

It is important to stress that the analyses presented in this report are preliminary, particularly since they use only a sample of dammed and natural lakes from which to assess patterns of occurrence. Second, the focus of the analysis is on present patterns of waterbird occurrence and does not address directly the impact of creating the dams on the waterbirds (or other taxa) present before construction. Such largely riparian species can themselves be of considerable conservation significance and in many regions can be under threat through river management removing natural fringing habitats as well as their destruction through inundation. This requires further assessment.

2. Sources of information

Recent (1990s) average numbers of different species of waterfowl in January over a 5-year period on a sample of natural lakes and dammed lakes in Switzerland and the United Kingdom come from Wetlands International's International Waterbird Census, which compiles consistent regular count information from a large number of wetlands throughout the Western Palearctic and South-west Asia (Delany et al. 1999). Additional information on the size and characteristics of waterbird assemblages on United Kingdom wetlands comes from published sources, notably Cranswick et al. (1999). For South Africa information and interpretation of waterfowl use of dams comes chiefly from detailed site information in Taylor et al. (1999).

Additional information on designated Wetlands of International Importance (Ramsar sites) has been supplied from the Ramsar Sites Database, managed by Wetlands International on behalf of the Ramsar Convention Bureau.

3. Ramsar sites of international importance for waterbirds

Of 957 Ramsar sites designated by December 1998 only 10% included artificial wetland types, compared to 25% including natural lake types (Frazier 1999). Many of the designated artifical wetlands are dammed sites: of the almost 100 artificial wetlands designated as internationally important, 78 are listed as having water storage areas (Ramsar wetland type 6) either as a primary or occurring wetland type.

The Ramsar sites database holds information on the criteria used for the designation of the 75 of these 78 sites (Table 1). Of these, 18 have been selected for only non-waterbird criteria; the remaining 57 (76%) being designated either wholly or partly for their internationally important waterbird populations. 10 of these sites are listed only for their waterbird populations.

19 of the Ramsar sites designated for their waterbird populations have been selected for their large waterbird assemblage: they regularly support over 20,000 waterbirds (Ramsar Criterion 5), and a further 13 sites because they regularly support >1% of the biogeographic population of one or more Waterbird species (Ramsar Criterion 6). The remaining 22 sites have been selected for both waterbird criteria.

Conclusions

Although there are, therefore, designated Ramsar sites involving dams that support internationally important waterbird populations, their number is small in comparison to the number of natural wetlands that have already been designated for their waterbird populations: a total of over 800 by December 1998. Interpretation of the true significance of such artifical wetlands for waterbirds is not easy since there is major geographical variation in the pattern of such designations. 38 (69%) of the designated Ramsar sites featuring water storage systems that include waterbird criteria are in Europe, with only 17 elsewhere (chiefly

in Asia and North America). The pattern certainly as much reflects the extent of designations achieved so far in different regions as any true significance of artifical wetlands for waterbirds. The relative overall importance of natural and artificial wetlands of international importance for waterbirds is below explored further for the United Kingdom.

Table 1. Water storage wetlands of international importance, designated for waterbird and other criteria under the Ramsar Convention. Sites are those that identify Ramsar wetland type 6: water storage areas (reservoirs, dams, hydro-electric dams and impoundments), as either a primary or occurring wetland type. 78 Ramsar sites identify wetland type 6 as primary or occurring, but three do not list the selection criteria and are excluded from the analysis. Source: Ramsar Sites Database.

Ramsar criteria	***No. of sites***
A. Type of criteria used:	
Waterbird criteria only	10
Non-waterbird criteria only	18
Both waterbird and non-waterbird criteria	47
B. Waterbird criteria used:	
5 only (regularly supports >20,000 waterbirds)	19
6 only (regularly supports >1% of a biogeographical population)	13
both 5 & 6	22

4. Switzerland

Switzerland provides an example of a country that has many of both natural lakes and dams, and overall supports important numbers of a wide variety of wintering waterbirds. However, as is probably typical for many countries, almost all the natural lakes are no longer wholly natural since all except the Bodensee have their water levels regulated to some extent. Furthermore, many of the dammed reservoirs are in the Alps and are unimportant for waterbirds because they are frozen in winter. The dammed sites use in this analysis are therefore dammed parts of rivers at lower altitudes.

The analysis compares the waterfowl assemblage wintering on eight medium to large natural lakes with six lakes created by damming rivers. The largest natural lakes included are Bielersee, Thunersee and Lac de Neuch↑tel; the others being Griefensee, Hallwilersee, Lac de Morat, Pf←ffikersee and Sempachersee. Dammed lakes are Beznauer Stau, Holderbank, Klingnauer Stau, Niederried Stau, Schiffenensee and Wholensee.

Average total numbers of wintering waterfowl on natural lakes range from 753 birds (Pf←ffikersee) to 88,313 birds (Lac de Neuch↑tel). The size of the wintering populations on dammed lakes are smaller: from 232 birds (Schiffenensee) to 4,272 birds (Niederried Stau). There is, however, little relationship between the size of the lakes and the size of their wintering populations since many of the lakes are deep and it is only the relatively shallow areas close to the shore that are utilised by wintering waterfowl. This is a typical feature of the way in which waterfowl use lakes: the presence of shallow near-shore areas and fringing vegetation are considered to be major factors influencing the size and species diversity using the systems.

General characteristics of the waterfowl assemblages in Switzerland are summarised in Table 2. The overall number of waterfowl species recorded on natural lakes (33 species) is

considerably larger that on dammed lakes (23 species), as is the species diversity on individual sites, although there is considerable overlap in the number of species on the two types of lake.

Table 2. Waterbird species diversity on a sample of natural and dammed lakes in and Switzerland.

	Natural lakes	***Dams***
No. of sites	8	6
No. of species per site	14-30	11-20
Total no. of species	33	23

The average waterfowl assemblage on natural lakes (Figure 1) is dominated by five species (Common Coot[2], Tufted Duck, Mallard, Pochard and Great Crested Grebe) each of which forms over 10% of the total birds present, and together form almost 90% of the assemblage. The most abundant are Common Coot, Tufted Duck and Mallard, all common and ubiquitous species, which each form over 20% of the birds present. The same five species are also the most abundant on dammed lakes, but there are two differences. First the relative abundance differs, with Tufted Duck and Pochard being the most abundant, and a smaller contribution from Mallard, Common Coot and Great Crested Grebe. Second, these species together form a smaller proportion of the overall assemblage on dammed sites (76%) than on natural lakes.

There are other differences in the assemblages, notably the significant present of species such as Goldeneye, Northern Shoveler and Red-crested Pochard on natural lakes; species generally absent from dammed systems. On dammed sites, however, other species such as Green-winged Teal and Gadwall form a larger part of the assemblage, although numbers are small and not of international importance.

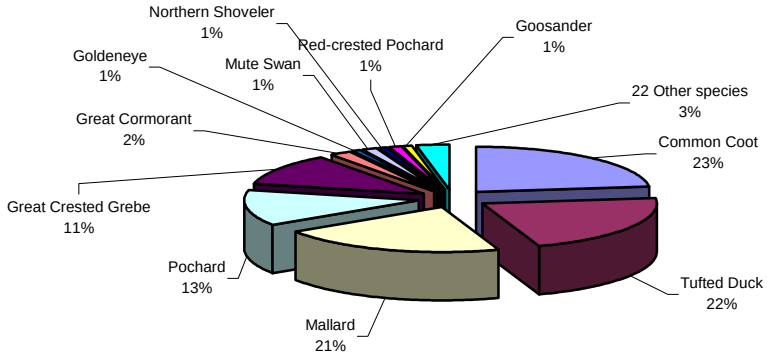
The relative abundance of waterfowl species in the different natural and dammed lake assemblages is further explored in Table 3. On natural lakes, the most abundant species varied, but was always one of the five most overall abundant. These and Mute Swan were amongst the 10 most abundant on all sites. Eleven other species occurred on one or more sites amongst the 10 most abundant species, and notable amongst these were several other species that feed by diving, e.g. Goldeneye, Goosander, Red-crested Pochard, Black-necked Grebe and Little Grebe. On dammed lakes the most abundant was most frequently Tufted Duck, with the most abundant on one site each being Great Crested Grebe and Mallard. Also ubiquitous on dammed sites were Common Coot, Pochard, Green-winged Teal, Mute Swan and Great Cormorant (Table 3). Other species occured in very small numbers.

Conclusions

The wintering waterfowl assemblage on natural and dammed lakes in Switzerland is broadly similar, and the same species occur as most abundant on both types of lake. Dammed lakes, however, support a more restricted range of species and several common and uncommon species of natural lakes were not recorded on this sample of dammed lakes. Although the damming of rivers has increased the number of open water sites available to wintering waterfowl in Switzerland, and provide a more suitable habitat for these birds than the generally fast-flowing stretches of river in between (V. Keller, pers. comm.), they support only relatively small numbers of birds, of mostly common and widespread species, and do not appear to provide as diverse a waterfowl habitat as the natural lakes in the area.

[2] Scientific names are listed in the Tables.

Natural lakes: Switzerland



Dammed sites: Switzerland

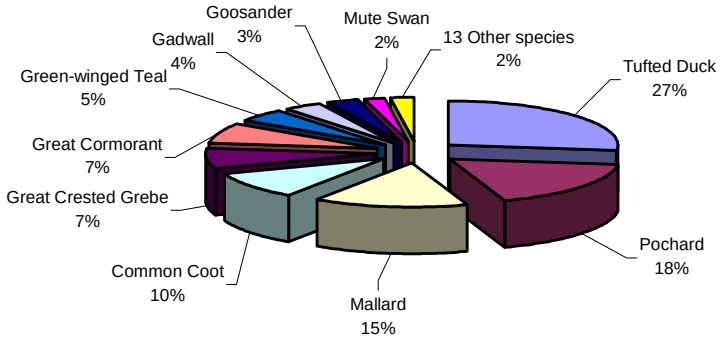


Figure 1. Average waterfowl species assemblages on a sample of eight natural and six dammed lakes in Switzerland.

Table 3. Species abundance on natural and dammed lakes in Switzerland. Figures give the number of sites on which a species occurs amongst the 10 most abundant species present. The most abundant species on natural lakes were: Great Crested Grebe (1 site), Mallard (2), Pochard (1), Tufted Duck (2) and Common Coot (2); and on dammed lakes were: Great Crested Grebe (1 site), Mallard (1) and Tufted Duck (4).

		Natural lakes	***Dammed lakes***
No. of sites assessed		8	6
Species			
Gavia arctica	Black-throated Diver	0	0
Gavia stellata	Red-throated Diver	0	0
Tachybaptus ruficollis	Little Grebe	2	5
Podiceps grisegena	Red-necked Grebe	0	0
Podiceps cristatus	Great Crested Grebe	8	3
Podiceps nigricollis	Black-necked Grebe	1	0
Phalacrocorax carbo	Great Cormorant	5	6
Ardea cinerea	Grey Heron	1	1
Anser fabalis	Bean Goose	0	0
Anser albifrons	White-fronted Goose	0	0
Anser anser	Greylag Goose	1	0
Cygnus cygnus	Whooper Swan	0	0
Cygnus olor	Mute Swan	8	6
Tadorna tadorna	Shelduck	0	0
Anas penelope	Wigeon	0	1
Anas strepera	Gadwall	2	4
Anas crecca	Green-winged Teal	2	6
Anas platyrhynchos	Mallard	8	6
Anas acuta	Northern Pintail	0	0
Anas clypeata	Northern Shoveler	4	0
Netta rufina	Red-crested Pochard	2	0
Aythya ferina	Pochard	8	6
Aythya nyroca	Ferruginous Duck	0	0
Aythya fuligula	Tufted Duck	8	6
Aythya marila	Greater Scaup	0	0
Somateria mollissima	Common Eider	0	0
Melanitta fusca	Velvet Scoter	0	0
Bucephala clangula	Goldeneye	5	2
Mergellus albellus	Smew	0	0
Mergus serrator	Red-breasted Merganser	0	0
Mergus merganser	Goosander	7	3
Fulica atra	Common Coot	8	6

5. United Kingdom

The United Kingdom (England, Scotland, Wales and Northern Ireland) is of major importance for wintering waterbirds using Eurasian-African flyways, particularly because it has a relatively mild winter climate (influenced by the warming effects of the Gulf Stream), and its wetlands seldom wholly freeze over in winter. During periods of severe winter weather in continental Europe it attains additional importance as a cold weather refuge for many waterbird species that move west and south-west to the United Kingdom. It has a number of large and important natural lakes, and substantial numbers of artificial open water systems. The largest, which are as big as the largest natural lakes, are mostly water storage reservoirs. Many others have been created on river flood-plains following aggregate extraction. In some regions, artificial lakes form almost the only open water areas; in others

they have created additional open water systems. A number of dammed reservoirs are in generally steep-sided upland valleys and support rather few wintering waterfowl. However some in lowland regions are shallow basins with extensive shorelines and fringing vegetation, and these often support significant numbers of wintering waterfowl. A sample of this type of lowland reservoir site is used here for comparison with large generally lowland natural lakes. Other lowland reservoirs have largely steep artificial shorelines and these support a lower species diversity of mostly piscivorous species.

The international importance of different types of wetland system in the United Kingdom is summarised in Table 4. The many estuaries and some other coastal systems in the United Kingdom are of particularly great international importance to wintering waterbirds, with 52 supporting at least one species in internationally important numbers, 42 supporting overall populations of more than 20,000 waterbirds, and a higher average number of internationally important populations (4.7) than other wetland types. There are even more (60) inland freshwater wetlands, many being lakes, that support at least one internationally important waterbird population, although the range and average number (2.8) of such species supported by different sites is lower than on the coast. This is largely because coastal sites support large numbers of wintering waders as well as wildfowl, whereas the inland systems generally support only wildfowl in internationally important numbers.

A much smaller number of artificial wetlands are of international importance for wintering waterbirds. Only 11 support one or more (a maximum of three) internationally important populations, and only three (Abberton Reservoir, Rutland Water and West Water Reservoir) have large overall wintering populations of >20,000 waterbirds.

Table 4. Natural and artificial wetlands in the United Kingdom supporting internationally important numbers of wintering waterbirds. Source: Cranswick et al. (1999).

Type of wetland	***Estuaries & coasts***	***Inland (freshwater wetlands)***	***Dams & reservoirs***	***Other artificial wetlands (gravel pits etc.)***
Sites supporting >20,000 waterbirds (Ramsar Criterion 5)				
No. of sites	42	12	3	0
No. of internationally important species present:				
Range	0-15	0-8	1-3	0
Average	4.7	2.8	2.0	0
Other sites supporting 1 or more internationally important species (Ramsar Criterion 6)				
No. of sites	15	49	8	4
Total no. of sites supporting internationally important species	52	60	11	4

Table 5 examines the relative importance of natural and artificial open water wetlands in the United Kingdom for each wintering population. In terms of international importance (i.e. sites regularly supporting >1% of the biogeographic population) natural lakes are of overwhelming importance for almost all species. For only four species do dammed sites support internationally important populations. These are Pink-footed Goose, which uses six dams as well as 27 natural sites, largely as safe night-time roosting sites rather than as feeding areas; and the dabbling ducks Green-winged Teal, Northern Shoveler and Gadwall for which a few dammed lakes have extensive shallow shores with fringing vegetation that provide suitable feeding grounds. Dammed lakes are of most significance for Gadwall (six of eight sites of international importance). The wintering population of this species is rapidly increasing in Great Britain (Cranswick et al. 1999) and artificial wetlands (including many former gravel pits) appear to be providing particularly suitable habitat. The largest wintering population in Great Britain is on the dammed reservoir of Rutland Water.

A similar pattern of national importance of artificial wetlands emerges (Table 5). However, for several additional species a large proportion of nationally important lakes are artificial (although again largely gravel pits rather than dammed sites): 40% or more of important sites are artificial for eight waterfowl: Little Grebe, Great Crested Grebe, Great Cormorant, Gadwall, Northern Shoveler, Pochard, Tufted Duck and Common Coot. These are all widespread and common wintering species in the United Kingdom.

The analysis compares the wintering waterfowl assemblage on five natural lakes: Castle Lochmaben, Hickling Broad, Loch Leven, Upper Loch Erne and Windermere with five dammed reservoirs (Blithfield Reservoir, Cameron Reservoir, Chew Valley Lakes, Grafham Water and Rutland Water). Rutland Water is the largest artifical water body in England.

Total average wintering waterfowl numbers on this sample of sites ranges from 970 birds (Hickling Broad) to 9,490 birds (Loch Leven) on natural lakes, and from 1,986 birds (Grafham Water) to 11,427 birds (Rutland Water) on dammed lakes. In contrast to the situation in Switzerland, each dammed lake in the analysed sample supports as many or more waterfowl species as the natural lakes and the total number of species recorded wintering on the dams is also higher than on the natural lake sample (Table 6).

The average waterfowl assemblage on natural United Kingdom lakes is dominated by five species, each forming 10% or more of the birds present: Common Coot, Mallard, Pink-footed Goose, Grey-lag Goose and Wigeon, and which together 66% of the assemblage. Other species of note are the diving ducks Tufted Duck, Pochard and Goldeneye, the dabbling duck Green-winged Teal, and Whooper Swan.

The dammed lake assemblage is broadly similar to that on natural lakes, but here the assemblage is dominated by Wigeon and Green-winged Teal, with again Pink-footed Goose, Mallard and Common Coot each forming 10% or more of the assemblage. Several important species characteristic of the natural lake assemblage are absent (or occur only in very small numbers), notably Whooper Swan, Pochard, and Goldeneye.

A further feature of the dam site assemblage that is different from that of natural lakes is the presence of Canada Goose and Ruddy Duck as 4% and 5%, respectively, of the assemblage. These are both feral species in the United Kingdom, both with expanding populations, and both of considerable conservation concern. The Ruddy Duck in particular poses a major European conservation threat since it can inter-breed with the closely related endangered and declining White-headed Duck in parts of continental Europe. These two feral species are substantially dependent on artificial wetlands in the United Kingdom.

Relative species abundance is further examined in Table 7. On different natural lakes four species were most abundant (Pink-footed and Grey-lag Geese, Wigeon and Mallard), each being amongst the most abundant on the average assemblage. These, plus Common Coot, Goldeneye, Pochard and Tufted Duck were always amongst the 10 most common species on the natural lakes. 12 other species featured amongst the 10 most common on at least one lake. On dammed lakes the most common were Wigeon, Green-winged Teal and Pink-footed Goose, with Mallard, Pochard, Tufted Duck and Common Coot also ubiquitous. Nine other species species featured amongst the 10 most common on at least one lake.

Conclusions

Some, but not all, dammed lakes in the United Kingdom support substantial and important wintering waterfowl populations, but very few are of international importance in comparison with the major international and national significance of natural lakes and other inland wetlands for many waterfowl species. The waterfowl assemblages of dammed lakes are broadly similar to those of natural systems, and a few large dammed sites support a wide range of species, with some, notably Gadwall, of considerable conservation importance. However, at least in the sample of sites examined in detail, dammed sites do not support significant numbers of some open water species for which the United Kingdom is of major international significance. Furthermore, dammed sites also appear to provide the stronghold for two feral species of considerable national and international conservation concern, and for which control measures are now being undertaken.

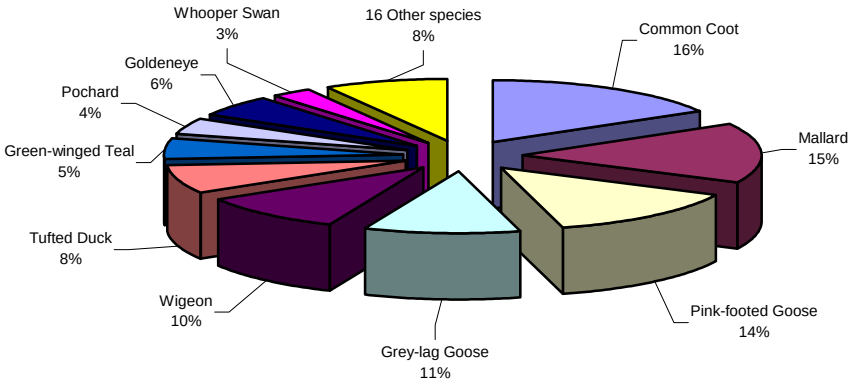
Table 5. Number of natural and artificial (dams, reservoirs, impoundments and gravel pits) in the United Kingdom of international importance and in Great Britain of national importance for different species of waterfowl in the non-breeding season. International importance is defined as regularly supporting >1% of the biogeographical population (Ramsar Criterion 6). Nationally important sites are those regularly regularly supporting >1% of the Great Britain population. Only species for which at least one site was of international or national importance are included. Source: Cranswick *et al.* (1999).

Species		International importance			National importance		
		Natural sites	Artificial sites	% artificial	Natural sites	Artificial sites	% artificial
Gavia stellata	Red-throated Diver				8	0	0
Gavia arctica	Black-throated Diver				5	0	0
Tachybaptus ruficollis	Little Grebe				9	6	40
Podiceps cristatus	Great Crested Grebe	2	0	0	15	19	56
Podiceps auritus	Slavonian Grebe	3	0	0	17	0	0
Podiceps nigricollis	Black-necked Grebe				4	0	0
Phalacrocorax carbo	Great Cormorant				31	23	43
Ardea cinerea	Grey Heron				16	3	16
Anser brachyrhynchus	Pink-footed Goose	27	6	18			
Anser a. albifrons	European White-fronted Goose				14	1	
Anser a. flavirostris	Greenland White-fronted Goose	9	0	0	8	0	0
Anser anser	Greylag Goose (Icelandic popn.)	30	0	0			
Branta leucopsis	Barnacle Goose	10	0	0			
Branta b. bernicla	Dark-Bellied Brent Goose	11	0	0	14	0	0
Branta b. hrota	Light-bellied Brent Goose (Canadian popn.)	7	0	0	1	0	0
Branta b. hrota	Light-bellied Brent Goose (Svalbard popn.)	1	0	0			
Cygnus cygnus	Whooper Swan	9	0	0	20	0	0
Cygnus (columbianus) bewickii	Bewick's Swan	9	0	0	5	0	0
Cygnus olor	Mute Swan				8	2	20
Tadorna tadorna	Shelduck	13	0	0	18	0	0
Anas penelope	Wigeon	6	0	0	28	1	3
Anas strepera	Gadwall	2	6	75	26	39	60
Anas crecca	Green-winged Teal	6	1	14	23	2	8
Anas platyrhynchos	Mallard				9	1	10
Anas acuta	Northern Pintail	14	0	0	12	2	14
Anas clypeata	Northern Shoveler	6	4	40	21	24	53
Aythya ferina	Pochard	2	0	0	16	17	52
Aythya fuligula	Tufted Duck	1	0	0	8	16	67
Aythya marila	Greater Scaup	1	0	0	12	0	0
Somateria mollissima	Eider				18	0	0
Clangula hyemalis	Long-tailed Duck				13	0	0
Melanitta nigra	Common Scoter				13	0	0
Bucephala clangula	Goldeneye	2	0	0	21	2	9
Mergus serrator	Red-breasted Merganser	1	0	0	18	0	0
Mergus merganser	Goosander				10	6	38
Gallinula chloropus	Moorhen				15	7	32
Fulica atra	Common Coot				5	18	78

Table 6. Waterbird species diversity on a sample of natural and dammed lakes in the United Kingdom.

	Natural lakes	***Dams***
No. of sites	5	5
No. of species per site	15-22	15-27
Total no. of species	27	33

Natural lakes: United Kingdom



Dammed sites: United Kingdom

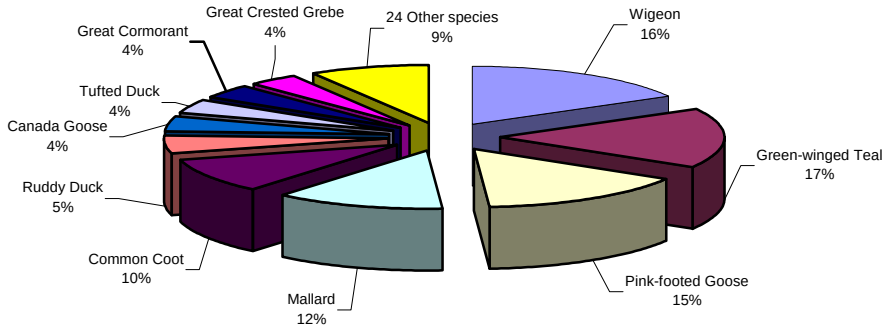


Figure 2. Average waterfowl species assemblages on a sample of five natural and five dammed lakes in the United Kingdom.

Table 7. Species abundance on natural and dammed lakes in the United Kingdom. Figures give the number of sites on which a species occurs amongst the 10 most abundant species present. The most abundant species on natural lakes were: Pink-footed Goose (1 site), Greylag Goose (1), Wigeon (1) and Mallard (2); and on dammed lakes were: Pink-footed Goose (1 site), Wigeon (2) and Green-winged Teal (2).

		Natural lakes	***Dammed lakes***
No. of sites assessed		5	5
Species			
Tachybaptus ruficollis	Little Grebe	1	0
Podiceps cristatus	Great Crested Grebe	0	4
Podiceps auritus	Slavonian Grebe	0	0
Phalacrocorax carbo	Great Cormorant	2	4
Anser brachyrhynchus	Pink-footed Goose	2	1
Anser a. flavirostris	Greenland White-fronted Goose	0	0
Anser anser	Greylag Goose	4	1
Branta canadensis	Canada Goose	2	3
Branta leucopsis	Barnacle Goose	0	0
Cygnus cygnus	Whooper Swan	1	1
Cygnus (columbianus) bewickii	Bewick's Swan	0	0
Cygnus olor	Mute Swan	3	0
Tadorna tadorna	Shelduck	0	0
Anas penelope	Wigeon	4	5
Anas strepera	Gadwall	1	0
Anas crecca	Green-winged Teal	3	5
Anas platyrhynchos	Mallard	5	5
Anas acuta	Northern Pintail	0	0
Anas clypeata	Northern Shoveler	1	1
Aythya ferina	Pochard	5	5
Aythya fuligula	Tufted Duck	5	5
Clangula hyemalis	Long-tailed Duck	0	0
Bucephala clangula	Goldeneye	5	2
Mergus serrator	Red-breasted Merganser	0	0
Mergus merganser	Goosander	1	1
Oxyura jamaicensis	Ruddy Duck	0	2
Rallus aquaticus	Water Rail	0	0
Gallinula chloropus	Moorhen	0	0
Fulica atra	Common Coot	5	5

6. South Africa

The situation in South Africa is very different from those in the northern temperate countries of Switzerland and the United Kingdom. Much of South Africa is arid and lacks natural permanent water bodies, and with only very few large natural lakes - one of the largest being Lake Fundudzi in Northern Province (c. 5 km x 1.2 km in size). There are however a number of palustrine wetlands (vleis and marshes) and flood-plains of considerable conservation significance for waterbirds. In these areas, however, almost all open water wetlands are seasonal pans that dry out progressively during the dry season. Permanent natural water bodies are almost wholly restricted to coastal areas.

In inland South Africa, almost all permanent waterbodies are dammed sites, constructed for water storage purposes – the total capacity of these impoundments amounts to some 52% of annual run-off. These range from large state impoundments kilometres long to many small farm dams. There are at least 517 major reservoirs, constructed by 1986, and many tens of thousands of farm dams of a few hectares each in area (Taylor et al. 1999).

The overall impact of these many artificial open water bodies has been to greatly increase the year-round availability of permanent lakes in inland South Africa (Cowan & van Riet 1998) and this has undoubtedly had very major effects on the distribution and numbers of waterfowl in the region, but the ways in which waterbirds use these wetlands has been little studied in detail (see Taylor et al. 1999). Furthermore, since there are very few natural inland freshwater lakes in the region a direct comparison between similar natural and dammed lakes (as for Switzerland and the United Kingdom) is not possible. Hence for South Africa we make instead some general comments about the nature of waterbird usage of dammed wetlands, and also some comments about impacts on the riparian and palustrine waterbird fauna impacted by dam construction, information drawn largely from Taylor et al. (1999).

Artificial wetlands are included in many Important Bird Areas (IBAs) identified in South Africa (BirdLife International, in prep.), and at least 12 impoundments support major and important concentrations of waterbirds. Overall large dams have provided increased areas of suitable habitat for several species that favour deep open-water conditions. The suitability of such dammed lakes for other species depends, as elsewhere, on the extent to which they provide areas of fringing emergent vegetation and shallow shorelines, features which are generally found in the upper parts of impoundments. Large dams in South Africa have provided generally beneficial conditions for Pelecaniformes (pelicans, darters and cormorants). They provide suitable habitats for moulting sites for waterfowl: for example at least 70% of the global population of the South African Shelduck *Tadorna cana* moults at only 23 localities in South Africa, 21 of which are large dams. Dams also provide dry season or drought refuges for many waterfowl species. Dams also provide breeding sites for many South African waterfowl, including some species of national conservation concern, notably the Pink-backed Pelican *Pelecanus rufescens* and Caspian Tern *Hydroprogne caspia*.

The creation of large numbers of permanent water bodies in a region formerly lacking such year-round habitat is also considered to have substantially altered the patterns of seasonal movement of a number of species including Avocet *Recurvirostra avocetta,* Black-winged Stilt *Himantopus himantopus*, Black-necked Grebe *Podiceps nigricollis* and flamingos *Phoenicopterus ruber* and *Phoeniconaias minor* that formerly were more nomadic during drought periods. The Three-banded Plover *Charadrius tricollaris* which uses the open shorelines of freshwater habitats has also greatly benefited from the presence of the many dams. In addition, the arctic migrant Curlew Sandpiper *Calidris ferruginea* was formerly a passage migrant in inland arid areas, moving through to coastal wetlands to overwinter (during the austral summer). Many birds now remain to spend the austral summer around the fringes of inland dammed lakes, with fewer now reaching coasts (L. Underhill, pers. comm.).

This pattern of some waterbird species formerly scarce or absent from arid areas in Africa benefiting from the creation of dammed wetlands may be typical. Claffey (1999) reports, for example, that the creation of a dam in Benin led to its use not only by waterbirds common in

the region, but also the occurrence of several species either very rare or not previously recorded in the country.

Whilst dams in South Africa have increased the amount of suitable year-round habitat for species of waterbird that prefer open-water habitats, and in some cases species that feed along the shallow margins of the dams, there have been other more negative major impacts on the overall waterbird assemblage that naturally occurs in southern Africa. These (Taylor *et al.* 1999) are known to include:

- the loss, on most river systems, of many of the former natural marshes and riverine habitats, which has impacted on a larger assemblage of species that depend on such habitats than the number of waterbird species that have benefited from the creation of open water dams.
- major changes to downstream riverine habitats, first by reduction of river flow and removing much of its previous seasonal variability, causing changes to sediment movement and stabilising channel morphology. However, poor dam capacity management during major floods can lead to sudden major releases of water, so creating major floods in downstream areas in river systems that have had little or no flood activity for years. This has affected the suitability of the river systems between dams for those species that breed chiefly on unvegetated river banks and sandbanks between river channels.

Few studies have assessed the waterbird assemblage before and after the construction of a large dam. Allan (1999) reported on waterbirds present before and after contruction of the large Katse Dam in Lesotho. Of 13 waterbird species present before inundation, two disappeared (including Black Stork, a Red Data Book listed species), two decreased in abundance, seven showed little change in status and two common species increased in abundance. The species that disappeared or declined were riparian species such as kingfishers and Three-banded Plover. Two widespread open water species colonised the area: Little Grebe and Red-knobbed Coot *Fulica cristata*.

Conclusions

In arid zones lacking natural permanent water bodies, dams can substantially increase the amount of suitable habitat for a variety of open water waterbird species, probably leading to overall increases in numbers. Such dams may also provide suitable year-round habitat for species that use the shallow margins of such lakes, and this can lead to changed seasonal patterns of movement and migration. However, the construction of such dams is at the expense of sometimes larger numbers of riparian and palustrine species, both directly by the destruction of their habitats and indirectly by changing the water regime and morphology of downstream river systems.

7. Overall Conclusions

Unlike organisms that are unable to move in response to the construction of dams, waterbirds are highly mobile and capable of exploiting such new open water systems and their margins if they provide suitable breeding, feeding and roosting conditions. Hence dams are often used by large numbers of waterbirds. On the evidence of this analysis in temperate regions where natural lakes also occur, the waterbird assemblage using dams is broadly similar to those of natural lakes. Although in some situations (e.g. Switzerland) the species diversity is generally lower and artificial sites generally support the more common and ubiquitous species, some dams (e.g. in the United Kingdom) support as large or larger an assemblage than many natural lakes and provide important habitat for internationally important waterbird populations. However even in the UK dams are of overall much less international significance than the natural lake systems, and in this instance are also strongholds of some feral species that are the cause of conservation problems.

In more arid areas such as South Africa, where there are few or no natural permanent water bodies, dams can create substantial suitable habitat for open water species, and for others

that can utilise their shallow margins where these occur. This is, however, at the expense of the loss of much palustrine and riparian wetland habitat depended on by a different guild of waterbird species, and changes to downstream river systems that make them less suitable for waterbirds that use river and sand banks.

The before and after responses by waterbird assemblages to dam construction needs further evaluation, as do the characteristics of dammed (in comparison with natural) lakes that determine their suitability for different waterbird species. Such characteristics are most likely to include water depth, steepness of shoreline and the presence of fringing vegetation.

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