

## Factors affecting different spatial distribution of wintering Tufted Duck *Aythya fuligula* and Goldeneye *Bucephala clangula* in the western part of the Gulf of Gdańsk (Poland)

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### Abstract

Tufted Duck and Goldeneye wintering in the western part of the Gulf of Gdańsk (Poland) were counted in January 1988–1999. In all seasons, the concentrations of the two species were observed in different places. Tufted Ducks gathered in areas well protected against waves and winds (in harbours, near breakwaters, in the river mouths). Goldeneyes preferred areas abundant in food and with shallow water. This distribution difference of the species could be affected by their behaviour. Tufted Duck searched quiet resting places by day when Goldeneye mainly foraged in the same time. During all seasons, adult male ratio of both species was similar. Adult males were the most

numerous group during severe winters (with ice-cover in part of the study area). This could be a result of arrival of birds from frozen wintering areas in northern Europe (predominance of males) and of abandonment of the study area by females and young birds, which are less resistant to bad conditions. In mild winters, individuals in female plumage predominated in the majority of the coastal sectors.

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### Introduction

The Gulf of Gdańsk is an important basin for wintering waterbirds. Relatively shallow water makes this area attractive for Tufted Duck *Aythya fuligula* and Goldeneye *Bucephala clangula*. The populations of both species wintering in the Gulf of Gdańsk periodically make up ca 1% and 1–3,5% of the whole European winter population of these species (Monval & Pirot 1989, Michno et al. 1993, Meissner & Klawikowska 1993, Wetlands International 2002). This winter area is therefore important on the scale of the whole continent.

Data from the southern coast of Sweden (Nilsson 1972) show that wintering Tufted Ducks search for quiet and sheltered places, suitable for resting during day-time, and gather in the flocks of above 1000 birds. They forage at night at sites that may be distant from the daytime roost. On the contrary, the Goldeneye forages by day in smaller, more diffuse flocks and prefers shallow basins with stony bottom.

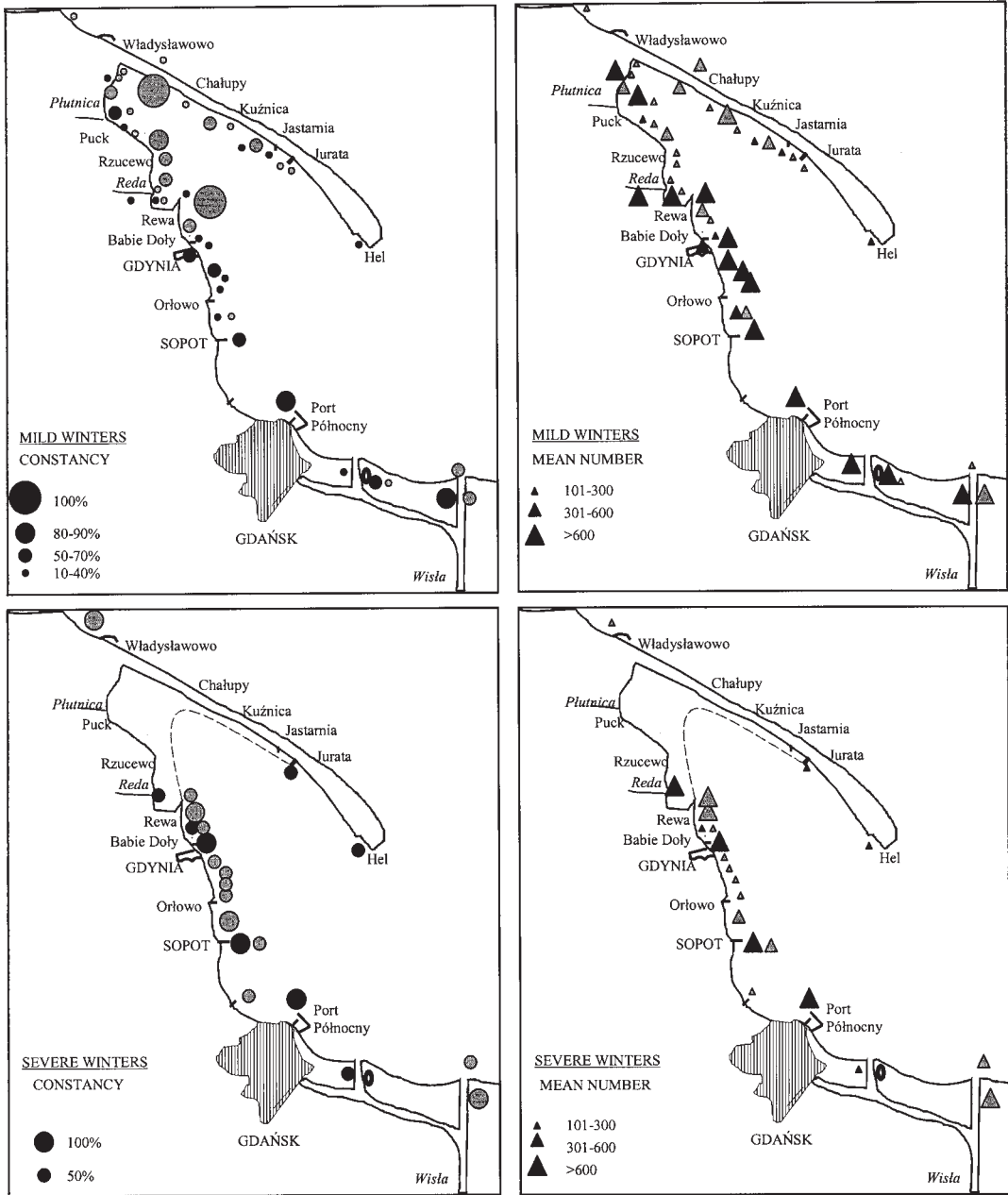
An earlier study on wintering habits of these species in the Gulf of Gdańsk in the seasons of 1984/

1985–1986/1987 (Michno et al. 1993, Meissner & Klawikowska 1993) showed that the two species concentrated in different places.

This paper is an attempt to explain the distribution of Tufted Duck and Goldeneye flocks wintering in the Gulf of Gdańsk, and to explore possible factors that may suggest why they differ in site selection.

### Study area

The surveys were conducted in the area from the Vistula mouth to the Rozewie Cape, an area including the westernmost part of the Gulf of Gdańsk, Puck Bay, and the Hel Peninsula (Figure 1). The southern coast between Vistula Mouth and Sopot is sandy and low. North off Sopot, there are cliffs that are crossed by river valleys (among others Reda and Płutnica rivers). The Hel Peninsula (37 km long) is characterized by a sandy coast on the open sea side and shallow bays with narrow sandy beaches on the inner side. There are a few hydrotechnical constructions in the area – harbours with piers in Gdańsk



Figur. 1. Constancy and long-term mean number of Tufted Duck *Aythya fuligula* (black colour) and Goldeneye *Bucephala clangula* (grey colour) in mild and severe winters. Broken line – approximate border of ice cover.  
 Förekomstkonstans och medelantal för vigg (svarta symboler) och knipa (grå symboler) under milda och kalla vintrar. Streckad linje: ungefärlig gräns för isbeläggning.

Northern Harbour, Gdynia, Hel, and Władysławowo, and coastal breakwaters in the Wisła Śmiała Mouth, in Gdynia, and between Władysławowo and Kuźnica (Meissner 1993).

## Methods

Tufted Duck and Goldeneye were counted during counts of wintering waterbirds, which were performed by the Waterbird Research Group KULING in the seasons 1988–1999. In this paper I use the data from the counts that were carried out in the middle of January from the shore. From 135 km (1988–1997) to 120 (1998–1999) km of the coastline of the Gdańsk Gulf were examined. The small difference of 15 km between the two periods refers to two sections with small bird numbers, which has no effect on the results presented in this paper. The breadth of the surveyed belt was estimated to be about 1000 meters. Both Tufted Duck and Goldeneye dive for food to a depth of a few meters (Tufted Duck 3–5 m, Goldeneye 4 m). The four meters depth line runs within one kilometre from the coast in the southern part of study area.

In the Gulf of Puck that line follows the border of ice cover (Figure 1). A comparison of results of bird counts from ship and coast in the Gulf of Puck has shown that Tufted Duck and Goldeneye gather close to the coast (Strawiński 1990). Counts of these species carried out from land in this area thus give safe estimates of the number and distribution of the whole populations (Cramp & Simmons 1998, Manikowski 1968, Nilsson 1972, Strawiński 1983, Górski & Strawiński 1985).

Due to differentiated shape of the coastline and localisation of the bird feeding places, breakwaters and piers, the study area was divided into 44 basic sectors. 10–15 people have counted birds during 1–2 days. The maximum numbers of birds observed in the consecutive seasons are shown in Table 1. Only

the birds that were distinctly observed feeding or roosting on the water in a given sector were counted. Birds that flew from one sector to another were not recorded.

The twelve seasons were divided into two categories: (1) two severe winters, when ice covered parts of the Gulf of Gdańsk and Gulf of Puck in January 1996–1997, and (2) ten mild winters with little or no ice.

For the analyses of the bird distribution in the 44 basic sectors, I calculated (1) constancy of occurrence (percent of winters with occurrence of more than 100 birds in a given sector), and (2) mean number of birds in seasons when above 100 individuals were observed.

Females and young males cannot be distinguished during this kind of counts (Cramp & Simmons 1998). Therefore I calculated only the adult male ratio. In order to get larger and more reliable samples, this was done for nine bigger areas that were constructed by combining a few neighbouring basic sectors.

## Results

### *Spatial distribution of Tufted Duck*

Constancy of occurrence and mean numbers are shown in Figure 1. During the ten mild winters there were no places, where a concentration of above 100 individuals was observed in all winters. Most often, flocks of above 100 Tufted Ducks were observed in the Vistula Mouth and in the Gdańsk Northern Harbour. These two sites had similar mean number of birds ( $1799 \pm 1242$  sd and  $2289 \pm 2880$  sd; Student t-test;  $t = -0,465$ ;  $df = 15$ ;  $p > 0,05$ ). A little lower constancy of occurrence was observed in the Płutnica mouth, Ptasi Raj lake, and in the parts of coast with hydrotechnical constructions such as the harbour and embankment in Gdynia and Sopot pier. In the

Table 1. Number of Tufted Duck and Goldeneye observed in the consecutive seasons and the proportion of adult males.

*Antal av vigg och knipa som observerats olika vintrar samt andelen adulta hanar.*

Species Art	Year År											
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Tufted Duck	3940	9296	15 211	4231	14 369	6259	8675	8656	18 029	14 347	7464	3572
% adult males	51,5	42,7	42,2	40,9	59,0	57,0	50,4	73,3	54,0	55,3	61,0	–
Goldeneye	2557	3472	5767	5442	2659	3743	3281	15 589	9137	5781	2383	3366
% adult males	38,6	27,5	37,3	48,6	43,5	54,8	36,8	46,7	59,6	64,4	34,5	42,3

rest of the sectors larger concentrations were rare. The Tufted Duck was particularly rare along the Hel Peninsula and in the southern part of the Gulf of Gdańsk.

During the severe winters of 1996–1997, when ice covered the inner, northwestern part of the gulf, the Tufted Duck was concentrated in the southern part and also preferred sectors that were well protected against wind and waves – north off Gdynia (along cliffs), Sopot pier, and Gdańsk Northern Harbour (breakwaters and piers). The number of individuals was similar in these three sectors (Kruskal-Wallis test,  $H(2, N=6)=2$ ;  $p>0,05$ ). During one season birds were observed close to other hydrotechnical constructions – Hel harbour, near Jurata pier, and ice-free areas in the mouths of Reda and Wisła Śmiała rivers. The concentrations were big (above 600 individuals) in four sectors. Concentrations of more than 100 birds were observed in only four sectors in one of the two winters. In the rest of the sectors, as in the mild winters, less than 100 individuals were observed.

#### *Spatial distribution of Goldeneye*

The constancy of occurrence and mean numbers of Goldeneye are shown in Figure 1 in the same way as for Tufted Duck. During the mild winters the Goldeneyes were strongly concentrated in the Puck Bay, northwest of a line between Gdynia and Jurata. During all ten mild winters, concentrations of more than 100 Goldeneyes were found in two sectors – near Rewa and between Władysławowo and Chałupy. The mean number of birds ( $308\pm 237$  sd and  $439\pm 221$  sd) was similar in these places (Student t-test,  $t = -1,276$ ;  $df=18$ ;  $p>0,05$ ). Aggregation of above 100 Goldeneyes during 5–9 winters was observed in the Vistula mouth, along the cliffs of the Gulfs of Puck and Gdańsk (north off Gdynia), and along the flat banks of Hel Peninsula.

During the severe winters, the Goldeneye flocks were observed at other places than in the mild winters, namely between Rewa and Sopot and at the Vistula mouth. More than 100 birds were observed in four sectors in both winters and in nine other sectors in one of the winters. The largest mean concentrations (more than 600 birds) were observed along the border of ice-cover near Rewa and in the Vistula mouth. High concentrations (301–600 birds) were observed also along cliffs between Orłowo and Sopot. In the rest of the sectors concentrations of birds were smaller (less than 300 individuals).

#### *Differences between spatial distribution of the species*

In all studied seasons, the concentrations of Tufted Ducks and Goldeneyes were observed in different places (Table 2 and 3, Figure 1). In the mild winters, the Tufted Ducks gathered in parts of the coast with hydrotechnical constructions like breakwaters, piers, jetties, and in the river mouths. Goldeneyes preferred the shallow water of the Gulf of Puck. During severe winters, when that part of water was covered with ice, both species concentrated in the areas, which were free of ice-cover. But Tufted Duck and Goldeneye preferred different parts of the coast. Tufted Duck gathered in the available parts of the coast that were well protected against waves and winds – near hydrotechnical constructions and in the plots with cliff coast. The majority of Goldeneyes was observed in the Vistula Mouth and in the plot near Rewa (bordered with ice-cover). It was only a few places where both species were noticed in greater concentration (Table 3).

#### *Adult male ratio*

The proportion of adult males and female plumage birds is shown in Figure 2 for each of the nine larger, combined sectors from which data for a sufficient number of birds were available. Proportions were

Table 2. Constancy during the ten mild and two severe winters (number of winters with more than 100 birds in a sector). For each combination the number of sectors is given. T=Tufted Duck, G=Goldeneye.

*Förekomstkonstans under tio milda och två kalla vintrar (antal vintrar med mer än 100 fåglar i en sektor). För varje kombination ges antalet sektorer. T = vigg, G = knipa.*

Number of years <i>Antal år</i>	Ten mild winters <i>Tio milda vintrar</i>			Two severe winters <i>Två kalla vintrar</i>		
	T	G	Both	T	G	Both
10	–	2	–			
8–9	2	1	–			
5–7	5	8	–			
1–4	14	14	3			
Total	21	25	6			
2				3	4	–
1				5	9	1
Total				8	13	2

Table 3. Mean number of birds (in seasons when above 100 individuals were observed). For each combination the number of sectors is given. T=Tufted Duck, G=Goldeneye.

*Medeltalet fåglar (under vintrar då mer än 100 fåglar observerades). För varje kombination ges antal sektorer. T = vigg, G = knipa. Both = båda arterna.*

Mean numbers <i>Medeltal</i>	Ten mild winters <i>Tio milda vintrar</i>			Two severe winters <i>Två kalla vintrar</i>		
	T	G	Both	T	G	Both
101–300	5	16	1	4	7	1
301–600	2	7	1	–	3	–
>600	14	2	–	4	3	–
Total	21	25	6	8	13	2

calculated if the number of birds was larger than 100.

During the mild winters, birds in female plumage of both species predominated in the majority of the combined sectors. In the Tufted Duck, adult males were more numerous in only three of eight sectors, namely in the Gulf of Puck north off Rewa, along city beaches (between Gdynia and Sopot), and in the Ptasi Raj Lake. In some seasons the majority of birds was observed in those three sectors and then the total percentage of adult males was higher than the percentage of individuals in other plumages (Table 1). In the Goldeneye, males predominated in three of seven sectors, namely in the open sea near Władysławowo, south off Reva, and along city beaches between Gdynia and Sopot.

During the two severe winters, a predominance of adult males was observed in the majority of the sectors. In both species males predominated in three of four sectors. In the Tufted Duck, female plumage birds predominated only in the Reda mouth, and in the Goldeneye only at the Vistula Mouth.

## Discussion

### *Spatial distribution*

The very large difference in spatial distribution between the two species could be an effect of their behaviour. The Tufted Duck searches quiet resting areas during the day and feed at night, whereas the Goldeneye mainly forages during day-time. I will therefore first try to explain the spatial distribution of each species separately and then compare them.

For the Tufted Duck, harbours and cliff shores are

attractive since they are well protected against western winds. The importance of harbours for resting Tufted Duck flocks was highlighted in the studies from the Gulf of Gdańsk in the seasons 1984/1985–1986/1987 (Michno et al. 1993), from Denmark (Joensen 1974) and Sweden (Nilsson 1972). Movements among harbour basins were observed in the Gdańsk Northern Harbour. Birds probably wanted to avoid rough waves (Gniotyński 1988).

Data from this study confirmed the importance of the Vistula Mouth for wintering Tufted Ducks (Michno et al. 1993). The concentration of birds was observed in the part of Vistula River close to the mouth. This sector was well protected against wave and wind. Small concentrations of Tufted Ducks in the open parts of the coast were also noticed in Sweden (Nilsson 1972).

Even if sheltered roosting sites was the most important factor determining the distribution of the Tufted Ducks, it is possible that access to nearby foraging sites could be a contributory explanation. For example, Common Mussel *Mytilus edulis*, which is a component of the Tufted Duck diet, occurs on the surface of hydrotechnical constructions (Mańkowski 1975, Michno et al. 1993). Such constructions occurred at several of the concentrations sites – Gdańsk Northern Harbour, Gdynia harbour, and breakwaters near Gdynia. In those places the four metres water depth line runs in a distance of one kilometre from the coast. Tufted Ducks dive only to 3–5 metres, so they can feed in the vicinity of roosting places.

On the other hand they can fly to the shallow waters Gulf of Puck, 15–30 km away. A few evening observations in one sector in the vicinity of Rewa showed that Tufted Ducks flew far away into the Gulf of Puck. This shallow water basin can be attractive for feeding birds. The lack of night data about duck distribution makes it impossible to confirm this presumption.

Since Goldeneyes feed during day-time, when the counts were made, the connection between feeding sites and bird concentrations is more clear than for the Tufted Duck. The shallow shelf zone of the Gulf of Puck was a good place for foraging Goldeneyes. In some areas of shelf zone high values of macrozoobenthos biomass were recorded in the 1990s (Osowiecki 2000). Additionally, the western part of the Gulf is protected against western winds by cliff shore. Western and northwestern winds dominate in the Gulf of Puck (Augustyn 1985). Protection against winds can have positive influence for the water transparency.

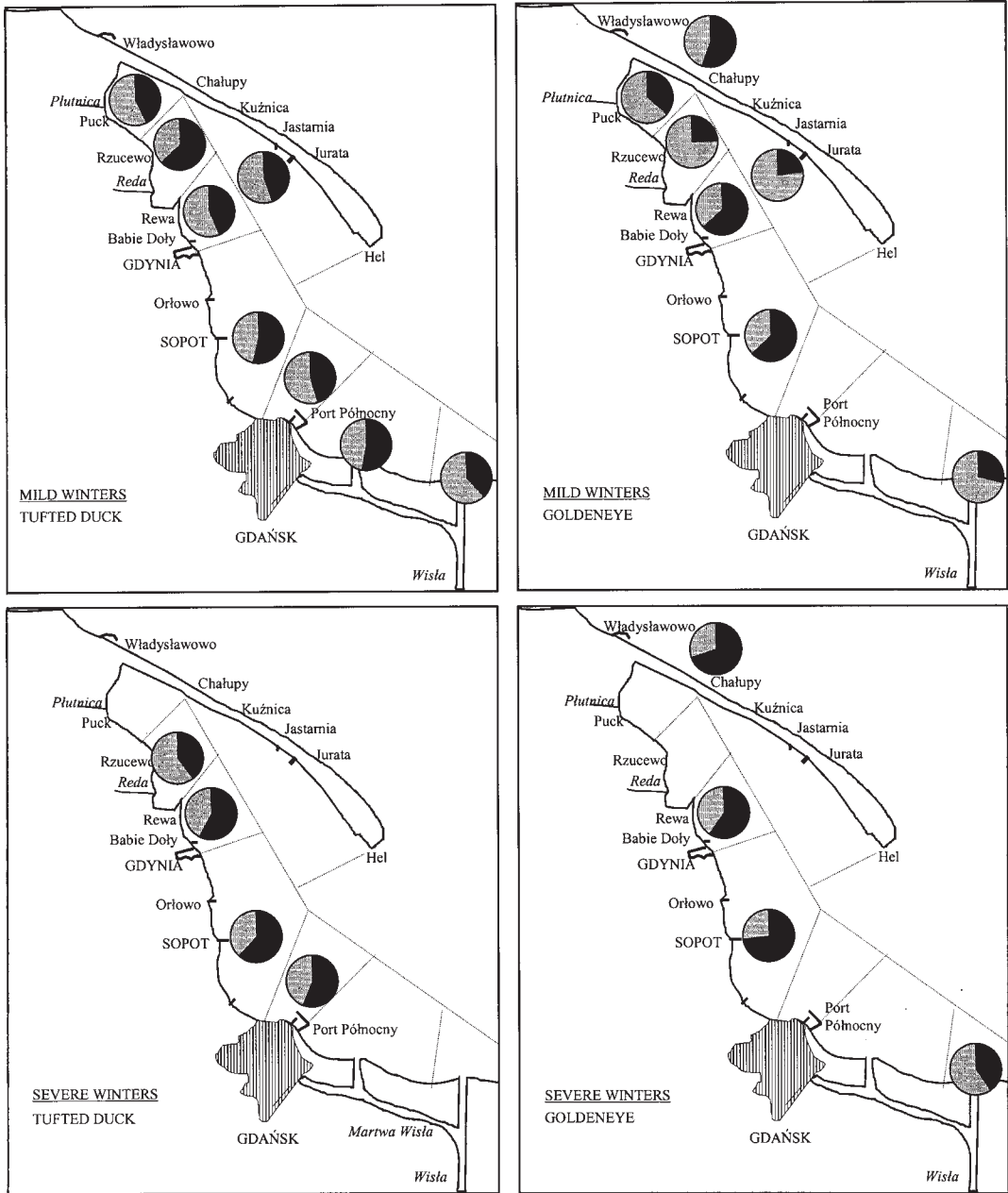


Figure 2. Sex structure (long-term mean in %) of Tufted Duck *Aythya fuligula* and Goldeneye *Bucephala clangula* in mild and severe winters. Black colour – adult males, grey colour – females and immature birds. Sample size for each circle >100 indiv. *Könsfördelning (medeltal i %) för vigg och knipa under milda och kalla vintrar. Svarta sektorer är gamla hanar, grå sektorer honor och unga fåglar. Stickprovsstorleken för varje cirkel är över 100 individer.*

Concentration of Goldeneyes in all studied winters in the Vistula mouth can be explained by lack of ice-cover (it could be attractive for birds coming from frozen, inland water bodies) and good protection against wind and waves.

Sewage in the Vistula River and from a sewage plant outlet near Rewa could be an attractive source of food for foraging Goldeneyes. Sewage may cause increase of zoobenthos biomass in the shelf coastal zone by intensive eutrophication (Ossowiecki 2000). Poles situated on the bottom near the collector mouth can be rich in Common Mussels (Mańkowski 1975).

Low concentration of Goldeneyes in the eastern part of the Gulf of Gdańsk can be caused by low zoobenthos biomass. The bottom sediments there are composed of banks of fine sand, which are shifted by currents and therefore are not overgrown by plants. Such a bottom type is not favourable for intensive zoobenthos colonisation (Osowiecki 1995, 1998).

Goldeneyes wintering in the southern Swedish coast (Scania) concentrated in zones with stony and muddy bottoms and avoided sandy parts (Nilsson 1972). There is stony bottom in the Gulf of Puck near Rzucewo and in the Gulf of Gdańsk near Gdynia. But only in the latter sector were bigger concentrations of Goldeneyes observed. The importance of river mouths for Goldeneye was noticed also in Sweden (Pehrsson 1976). Major concentrations of Goldeneye in Great Britain were noticed at sewage outfalls on the coast (Campbell 1977, Duncan & Marquiss 1993). Goldeneye can forage on wastes from sewage (Pounder 1976, Campbell & Milne 1977, Barrett & Barrett 1985).

There were some plots in the study area, where bigger concentrations of both Tufted Duck and Goldeneye were observed. Those places were well protected against waves and wind, and were good feeding grounds as well. Therefore they were attractive by day for both roosting Tufted Ducks and for feeding Goldeneyes. The two species did not compete about food in such places because of different daily activity rhythm. Additionally, both species are specialised in foraging on somewhat different prey. Both Tufted Duck and Goldeneye forage mainly on mussels (Cramp & Simmons 1998). But the Goldeneye's relatively small and smooth gizzard seems to be specialised in processing small and soft-shelled prey (Suter 1982). In southern Sweden, molluscs were the main food of Tufted Duck in the non-breeding season. The Goldeneye diet consisted of molluscs, crustaceans, polychaets and fish (Nilsson 1972). Such specialisation can limit the interspecies

competition and can make Goldeneye's feeding areas unattractive for foraging Tufted Duck.

But due to lack of complete data about age structure and local distribution of zoobenthos in shelf zone of the Gulfs of Gdańsk and Puck, more precise estimation of the influence of this factor on wintering bird distribution is impossible.

The weather conditions affected the distribution of Tufted Duck and Goldeneye wintering in the Gulf of Gdańsk. Especially ice-cover limited availability of many suitable places for foraging and resting and made birds gather in other places. Movement of Goldeneyes wintering in the Gulf of Gdańsk from the frozen areas to the Vistula Mouth and to the plots situated between Rewa and Gdańsk was also observed in the seasons 1984/1985–1986/1987 (Meissner & Klawikowska 1993).

Human disturbance, tradition and social factors can also influence the distribution of wintering flocks (Joensen 1974, Nilsson 1972). However, in the contrast to the Western Europe, human disturbance was not an important factor influencing distribution of wintering birds in my study area (Meissner & Klawikowska 1993).

#### *Adult male ratio*

During all studied winters, adult male ratio of Tufted Duck and Goldeneye was similar. Birds in female plumage predominated in the majority the sectors in mild winters. During severe winters adult males were the most numerous group.

High percentage of adult males in severe winters could be a result of arrival of individuals from frozen cooler wintering areas in northern Europe, where high rate of adult males was observed (Nilsson 1970, Owen & Dix 1986). Additionally, this effect could be caused by abandonment of the study area by females and young birds. These birds are less resistant to lack of food and bad weather conditions and could leave unsuitable areas faster (Harrison & Hudson 1964, Bennet & Bolen 1978). Predominance of the adult males in the observed flocks of Tufted Ducks and Goldeneye was also noticed in the Gulf of Gdańsk in the severe seasons 1984/1985–1986/1987 (Michno et al. 1993, Meissner & Klawikowska 1993).

In the present study, in the mild seasons, a higher rate of Goldeneye adult males was observed in plots that were not protected against wind and waves (open sea sectors near Władysławowo, along beaches between Gdynia and Sopot). Females preferred shallower water, less exposed for adverse weather. This preference is a consequence of bigger energy

demands, less resistance to low temperatures and food shortage, potential differences in efficiency of foraging under suboptimal condition (e.g. deep and fast flowing water), and intersexual competition for food (Sayler & Afton 1981).

Data from the Swedish coast show that Goldeneye females preferred foraging in shallower water than males (Nilsson 1969, 1970, 1972). In this context predominance of females and young birds in the Gulf of Gdańsk in mild seasons seems to be caused by the big area of the shallow shelf zone (0.5–4.0 m).

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## Sammanfattning

*Faktorer som bestämmer olika rumslig fördelning av övervintrande viggår Aythya fuligula och knipor Bucephala clangula i västra delen av Gdańskbukten, Polen*



Gdanskbukten är ett viktigt övervintringsområde för sjöfåglar. De grunda vattnen är attraktiva för både vigg och knipa. De övervintrande bestånden uppgår till 1% resp. 1–3,5% av hela Europas vinterbestånd. Viggarna och kniporna har olika dygnsaktivitet under vintern. Viggarna vilar dagtid i täta flockar på lugna och skyddade platser men söker föda nattetid på platser som kan ligga ett gott stycke från nattplatserna. Kniporna söker föda dagtid i mindre och glesa flockar på grunda vatten med steniga bottenar. Skillnaderna leder till att de två arterna dagtid koncentreras till olika kustavsnitt. I denna uppsats försöker jag förklara skillnaderna i utbredning och de faktorer som kan spela in.

Undersökningsområdet omfattar kusten från Vistulas mynning till Rozewie udde, ett område som inkluderar västra delen av Gdanskbukten, Puckviken och halvön Hel (Figur 1). Kusten mellan Vistula och Sopot är sandig och låg. Norr om Sopot är kusten klippig med några floddalar. Hel (37 km) präglas av sandkust mot havet och grunda sandstränder in mot bukten. Det finns ett fåtal anläggningar i området, hamnar med pirar samt några vågbrytare.

Det material jag analyserar kommer från de ordinarie vinterfågelräkningar av sjöfåglar som utförts av Waterbird Research Group KULING i mitten av januari 1988–1999. Fåglarna räknades från land och ut till 1000 m från stranden. Viggarna och kniporna söker föda ner till ca fyra meter. I området går linjen för fyra meters vattendjup inom en kilometer från kusten och i Puckviken följer den ungefär isgränsen i Figur 1. Detta innebär att alla fåglar som övervintrade i området räknades.

På grund av kustens struktur och fågelkoncentrationerna delades området upp i 41 sektorer. Räkningarna utfördes av 10–15 personer under 1–2 dagar varje vinter. Det maximala antalet fåglar som räknats varje vinter visas i Tabell 1. De tolv vintrarna delades upp i två kategorier, tio milda och två stränga vintrar (1996 och 1997). De stränga vintrarna var bl.a. inre delen av Puckviken istäckt. För varje sektor beräknades konstanten i förekomsten som andelen (%) år med mer än 100 fåglar och medeltalet fåglar under vintrar med mer än 100 fåglar. Resultaten visas i Figur 1, separat för de milda och stränga vintrarna.

Honor och ungfåglar kan inte skiljas åt. Därför kan endast relationen mellan adulta hanar och övriga beräknas. För att få tillräckligt stora stickprov slogs närliggande sektorer samman till nio större områden, för vilka kvoten adulta hanar beräknades (Figur 2).

För viggarna fanns det ingen sektor där mer än 100

fåglar sågs alla tio milda vintrarna. De flesta registrerades vid Vistulas mynning och i norra hamnen i Gdansk. Andra viktiga områden var Plutnicas mynning, sjön Ptasi Raj samt hamn- och piranläggningar i Gdynia och Sopot. Viggarna var särskilt fåtaliga runt Hel och längs södra kusten. Under de två kalla vintrarna, då inre Puckviken var istäckt, fanns ett fåtal stora koncentrationer med över 600 fåglar i fyra av sektorerna.

Kniporna var starkt koncentrerade till inre delen av Puckviken under de milda vintrarna, nordväst om en linje från Gdynia till Jurata. Mer än 100 knipor alla tio vintrarna noterades i två sektorer. Under de två kalla vintrarna uppträdde kniporna på nya platser, främst mellan Rewa och Sopot och vid Vistulas mynning.

Under alla vintrar observerades koncentrationerna av vigg och knipa nästan alltid på olika platser (Tabell 2 och 3, Figur 1). Under milda vintrar låg viggarna främst vid de kustavsnitt där det fanns vågbrytare, pirar och kajer samt i flodmynningar. Kniporna föredrog i stället de grunda vattnen i Puckvikens inre. Även under de stränga vintrarna, då fåglarna uppehöll sig på andra platser än under de milda, låg arternas koncentrationer på olika ställen. Viggarna låg vid avsnitt som var skyddade från vågor och vind, antingen vid pirar och hamnar eller vid klippkust, medan kniporna koncentrerades till Vistulas mynning och till iskanten utanför Rewa.

Andelen adulta hanar och honfärgade fåglar visas i Figur 2 för de av de nio större områdena som hade mer än 100 fåglar. Under milda vintrar dominerade honor och ungfåglar hos båda arterna. Hos viggarna var det fler adulta hanar än honfärgade fåglar i tre av åtta områden och hos kniporna gällde detsamma för tre av sju områden.

Undersökningen bekräftar tydligt den stora skillnad i platsval som finns mellan viggarna och kniporna. Viggarna uppehåller sig främst på platser där de får skydd mot vågor och vind under sin dagvila. Tyvärr är det inte känt var de uppehöll sig nattetid när de sökte föda, men enstaka observationer kvällstid indikerade att de kunde flyga avsevärda sträckor. Emellertid är det också möjligt att de sökte föda nära nattplatserna eftersom det fanns musslor och annan föda på de pirar, vågbrytare, hamnar och pålar som fanns i anslutning till nattplatserna. Eftersom kniporna söker föda under dagen då räkningarna genomfördes utgör deras uppehållsplatser också deras födoplast. Inre delen av Puckviken var det klart viktigaste området. Tidigare undersökningar har visat att de grunda vattnen i detta område hyser en rik bottenfauna. Området är också väl skyddat från de domine-

rande västvindarna, något som kan vara positivt även för sikten i vattnet, som inte grumlats när det finns skydd mot vågor och vind. En bidragande orsak till koncentrationen av knipor i Vistulas mynning kan ha varit utsläppen av avloppsvatten, som näringsberikar vattnet och ökat mängden bottendjur. Knipornas fåtalighet i övrigt längs södra Gdanskbukten beror på att bottarna här består av rörlig sand som förhindrar riklig förekomst av bottenorganismer.

Andelen adulta hanar var i de flesta sektorer högre än andelen fåglar i honlig dräkt. Vissa vintrar vad

dock andelen adulta hanar högre i ett fåtal sektorer med stora koncentrationer, vilket innebär att andelen i det totala materialet kunde bli hög. Andelen adulta hanar var ofta högst i områden som var exponerade för vind och vågor medan fåglar i hondräkt dominerade på grundare vatten i skyddade områden. En förklaring till skillnaderna i andel adulta hanar kan vara olika tolerans för kalla vintrar genom att de hårdigare adulta hanarna drar sig söderut från nordligare områden i Skandinavien sådana vintrar och de honfärgade fåglarna drar sig ytterligare söderut.

## Foraging and diving patterns of the Great Crested Grebe *Podiceps cristatus* in a fishpond

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### Abstract

Diving and foraging patterns of the Great Crested Grebe *Podiceps cristatus* were studied on Vrbje fishpond in Central Slovenia. Three pairs and their 10 young were studied. The duration of 348 dives of the six adults before hatching, 295 dives of the three pairs of adults with young, and 185 dives of the immature birds were recorded during the breeding season in 1998 (from June through October). Mean dive duration was 31 sec for adults before hatching, 41 sec for adults with young, and 25 sec for immatures.

Diving success varied significantly between groups, the most successful were grebes with young. Adult grebes without young caught a higher proportion of large fish than the other groups did. Fish size was negatively correlated with duration of dives in adult grebes without young and in adults with young but not in immatures.

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### Introduction

Considerable interest has been shown in the diving and foraging patterns of diving birds (see e.g. Cooper 1986, Trivelpiece et al. 1986, Burger & Wilson 1988, Croxall et al. 1988, Wanless et al. 1991). However, most of these studies have focused on marine birds, e.g. penguins and cormorants while data from freshwater birds, e.g. grebes are more scarce.

The Great Crested Grebe *Podiceps cristatus* is a predator that occurs in most freshwaters in Europe. The behaviour and ecology of the Great Crested Grebe have been studied extensively in several countries (e.g. Cramp & Simmons 1977, Glutz von Blotzheim et al. 1987 and references therein), but the feeding habits and foraging patterns were poorly known at the onset of this study (but see Gwiazda 1997 and references therein).

In this paper, I report on the foraging pattern of adult and immature Great Crested Grebes during the breeding season. I show that swallowing the prey under the water by Great Crested Grebe depends on the experience and breeding status.

### Study area

Vrbje pond is situated in the Lower Savinja Valley near the town Žalec (approximately 46°14' 15°09').

The pond area is 13.5 ha and the average depth is about 1.2 m (0.5–2 m). Immersed (*Typha latifolia*, *T. angustifolia*) and floating (*Potamogeton crispus*, *P. natans*, *P. spicatum*, *Myriophyllum spicatum*, *Elodea canadensis*) vegetation covers between 40% and 60% of the surface of the pond (Vogrin 1999). The pond is managed for fish rearing and it is usually discharged once a year (autumn/spring) for about 1 to 5 months. Culturing of carp has always been carried out there and has been done with supplementary feeding. During the whole study period the conditions of the pond (e.g. vegetation, fish stock) were the same; however, we should take into account that fish also grow up during the study period as well as vegetation. For more information about the study area see Vogrin (1996, 1997). Because of the empty pond during early spring, waterfowl start to breed in June.

### Methods

All observations were made from a car on the banks with most observations being made with naked eye, since during a dive the birds frequently moved out of the field of view of the binoculars. However, binoculars and telescope were used to estimate the size of prey.