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Feeding behaviour and diet of goosanders (*Mergus merganser*) in relation to salmonid seaward migration

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Abstract

Foraging activities of goosanders (Anatidae, *Mergus merganser*) were studied in relation to seaward migration of smolt in the River Halselva in northern Norway, 1987-1989. Birds aggregated in the estuary in June, during mass migration of smolts. When present in the estuary males and females spent 28.7 and 35.6% of their time feeding. Only 15% of dives resulted in birds' bringing prey to the surface and about 25% of prey found in goosander stomachs were salmonids. For hatchery-reared smolts released in the estuary, average length taken did not differ from that available; for wild smolts of Arctic char, however, smaller fishes than those available were taken. For 1989, we estimate that goosanders took 1% of the hatchery-reared smolts released in the estuary, and 2% of the wild smolts when smolts passed the estuary during seaward migration. As it is likely that less fit smolts (*e. g.* sick, injured, small) are most prone to predation, we argue that such a level of predation on migrating smolts from goosanders has only a minor impact on salmonid production. Suggestions to reduce predation are discussed.

Keywords: *Mergus merganser*, goosander, feeding behaviour, salmonid migration.

Relations entre le comportement et le régime alimentaire du harle bièvre (Mergus merganser) *et la migration vers la mer des salmonidés.*

Résumé

L'activité des harles (Anatidés, *Mergus merganser*) a été étudiée en relation avec la migration vers la mer des smolts dans le fleuve Halseva, dans le nord de la Norvège, de 1987 à 1989. Les oiseaux se rassemblaient dans l'estuaire en juin, durant la migration en masse des smolts. Lorsqu'ils étaient présents dans l'estuaire, les mâles et les femelles passaient respectivement 28,7 et 35,6 % de leur temps à la recherche de nourriture. Seuls, 15 % des plongées des oiseaux donnaient lieu à une remontée en surface d'une proie, et environ 25 % des proies trouvées dans leur estomac étaient des salmonidés. Pour les smolts provenant d'élevage et relâchés dans l'estuaire, la taille moyenne des prises n'était pas différente de celle des poissons disponibles; pour les smolts sauvages de l'omble chevalier, cependant, de plus petits poissons que ceux disponibles étaient capturés par les harles. Pour 1989, nous avons estimé que les harles prenaient 1 % des smolts relâchés dans l'estuaire et provenant d'élevage et 2 % des smolts sauvages durant leur migration vers la mer. La prédation touchant probablement en priorité les smolts les plus faibles (malades, blessés, petits), nous pensons qu'elle n'exerce qu'un impact mineur sur la production de salmonidés. Des suggestions pour réduire la prédation sont discutées.

Mots-clés : *Mergus merganser*, harle, oiseau piscivore, prédation, comportement alimentaire, migration des salmonidés.

INTRODUCTION

In northern Europe, late spring/early summer is the main period for salmonid smolt seaward migration (Jonsson and Ruud-Hansen, 1985). During this time many smolts appear in estuaries, and they are vulnerable to both fish and bird predators (Hvidsten and Møkkelgjerd, 1987; Reitan *et al.*, 1987; Hvidsten and Lund, 1988). We therefore expect fish-eating birds to respond to such a mass of vulnerable food. Although there is considerable predation on migrating smolts by birds (Mills, 1962; Mace, 1983; Wood, 1985*a*; 1985b, 1987; Ruggerone, 1986; Reitan *et al.*, 1987; Feltham, 1990), it is debatable to what extent this predation has a significant adverse impact on salmonid production (White, 1939, 1957; Huntsman, 1941; Lindroth, 1955; Elson, 1962; Alexander, 1979; Suter, 1991).

Goosanders (*Mergus merganser*) are relatively large (female weight appr. 1.2 kg, male weight appr. 1.7 kg) fish-eating ducks. They respond to activity in their major prey species by changing foraging pattern (Sjøberg, 1985, 1989; Wood, 1987). In this paper, we demonstrate that goosanders selectively utilize mass-occurrences of smolts in an area with 24 h daylight during the smolt migration. We further evaluate the impact of goosander predation on salmonid populations (both wild and hatchery-reared smolts) by studying feeding behaviour and diet of goosanders during smolt migration. As all migrating salmonids were trapped, measured and tagged when leaving this river we are also able to illustrate to what extent goosanders select (i) between the 3 salmonid species present (Atlantic salmon (*Salmo salar*), Brown trout (*Salmo trutta*), Arctic char (*Salvelinus alpinus*)) and (ii) between fish of specific length.

MATERIAL AND METHODS

Field studies were carried out during May-August 1988 and 1989 in areas connected to the River Halselva estuary (70°05'N, 22°55'E), in northern Norway (*fig.* 1). The mean annual waterflow in River Halselva is about 5 $m^3.s^{-1}$. Spring discharge in May reaches 40 $m^3.s^{-1}$. Depth of the estuary-areas used by diving goosanders varied between 0.5 and 5 m. During June-July the area has 24 h daylight giving birds opportunity to feed throughout the 24 h period.

During May-August, goosanders were censused approximately once each week along the coast within 4 km of the River Halselva estuary, as well as in Lake Storvatn (area approximately 1 km^2) (*fig.* 1). Lake Storvatn is not suitable for ducks until the ice pack has melted in late May. Both in 1988 and in 1989, Lake Storvatn had ice free areas after approximately 20 May. In the River Halselva estuary, goosanders

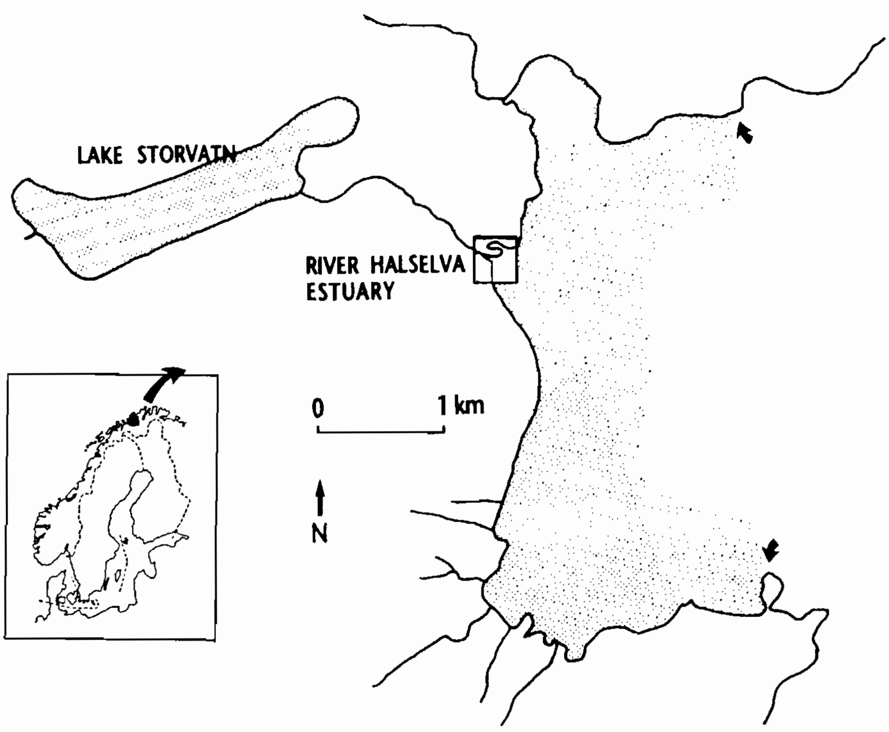

Figure 1. — Study area. Square shows River Halselva estuary, hatched area shows area censused for goosanders.

were censused every day from mid-May until mid-August.

Activity and feeding behaviour of ducks were studied from a hide in River Halselva estuary, using 8× binoculars and 15× telescope during June 1988 and 1989. Activity was calculated from a combination of "focal animal sampling" and "instantaneous sampling" (Altmann, 1974). Activities of all birds (>1-year-old) present in the estuary (2-10 individuals) were recorded simultaneously each minute, and one sampling period lasted 10 min. During this activity sampling the birds' behaviour was transcribed as follows: Feeding (diving or food searching); Swimming (with no indication of food searching); Resting (loafing on water or sitting/lying on the shore, often sleeping); Preening; Agonistic behaviour (birds chasing each other); Flying (birds flying from or to the estuary). A total of 145 such 10 min samples were collected over 26 different days.

To quantify diving frequency, dive duration and catching success, additional samplings were done by continuously recording activity of one randomly-selected food-searching bird during a 5 min sampling period. A total of 34 such 5 min samples were collected over 19 different days.

Fish migration up and down River Halselva was monitored continuously during May-October, 1987-1989. All downstream migrating salmonids larger than 140 mm were trapped and individually tagged with a Carlin tag. They were released downstream from the trap in early morning (08.00-11.00 hours) or early evening (20.00-23.00 hours) after recording total length (mm) and weight (g). Hatchery-reared smolts (all tagged) were released in the river or estuary during June-July (7 600 released in 1987; 9 300 in 1988; 13 700 in 1989).

Data on prey selection in the period of mass occurrence of smolt were obtained from 11 goosanders (shot during 17 June-6 July 1987 ($n=3$) and 1989 ($n=8$)) whose stomach contents were analyzed. When looking at numbers and length of tagged fish taken by goosanders, data from all birds shot in the estuary between 15 June and 1 August (1987, $n=5$; 1989, $n=11$) are included. When testing if goosanders were selectively feeding on fish of specific length, the length group 140-300 mm was used (>95% of tagged smolts taken by goosanders were within this sample).

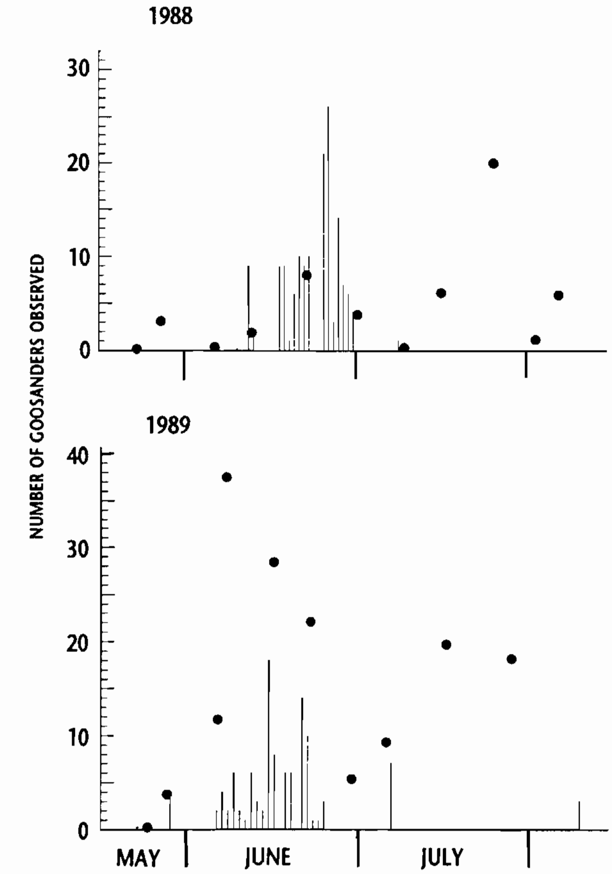

Figure 2. — Number of goosanders observed during census of the total area (black dots) and daily maximum numbers in River Halselva estuary (bars).

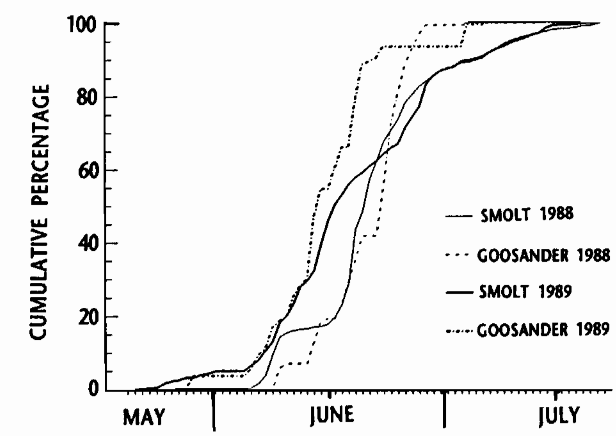

Figure 3. — Cumulative probability distribution for the occurrence of salmonids and goosanders in River Halselva estuary 20 May-20 July, 1988 and 1989.

RESULTS

Distribution of goosanders

In 1988, no goosanders were observed in the study area until 23 May (*fig.* 2). Aggregations of birds were observed in the estuary throughout the period 8-30 June, with a near continuous occurrence from 14 June onwards. During July and August, goosanders mainly used Lake Storvatn and only 1 male was observed in the estuary. The highest number of birds observed simultaneously in the estuary was 13

Table 1. – Time budgets for goosanders observed in River Halselva estuary during June, 1988-1989. Weighted average percentage (%) and standard deviation (sd) for the four 6 h periods, each period containing 12-25 subsamples for each sex.

Activity	Males		Females	
	%	sd	%	sd
Feeding	28.7	14.7	35.6	10.6
Resting	35.4	6.7	34.4	8.3
Swimming	24.4	7.8	19.9	3.6
Preening	8.9	4.3	8.8	6.5
Agonistic	1.9	3.6	0.1	0.2
Flying	0.3	0.4	0.5	0.3

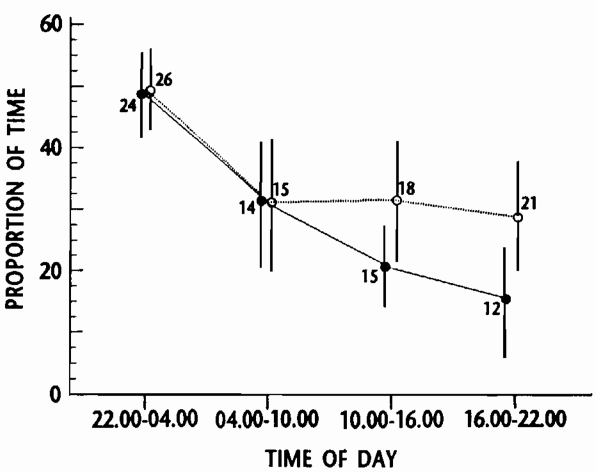

Figure 4. – Proportion of time used for feeding activity for goosanders present in River Halselva estuary. Males – filled circles, females – open circles. Numbers of 10 min sampling periods are shown beside the data point, error bars denote ± 1 standard error.

(24 June), which was also the maximum number observed in the study area that year. A similar trend in distribution of goosanders was found in 1989. The first observation was made on 27 May, and aggregations in the estuary were observed during 5-24 June. Few birds were observed in the estuary in July and August when Lake Storvatn was the most important area for goosanders (*fig.* 2).

Observations of goosanders in the River Halselva estuary correspond well with seaward migration of smolts (*fig.* 3). Both in 1988 and 1989, birds responded by aggregating in the estuary as soon as mass-migration of smolts commenced, and for the period 25 May-10 July there was a significant correlation between daily number of migrating wild salmonids and daily maximum number of goosanders present in the estuary (1988 and 1989 pooled: $r=0.38$, $p=0.0002$, $n=94$). The later occurrence of goosanders in the estuary in 1988 compared with 1989 corresponded to a later mass migration of smolts this year

Table 2. – Stomach contents of 11 goosanders collected in River Halselva estuary, 17 June-6 July, 1987 ($n=3$) and 1989 ($n=8$).

	Frequency ($n=11$)		Number of items ($n=69$)	
	n	%	*n*	%
Teleostei				
Salmonidae	7	64	16	23.2
Gadidae	8	73	19	27.5
Pholidae				
Pholis gunnellus	6	55	20	29.0
Cottidae	5	45	7	10.1
Zoarcidae				
Zoarces viviparus	2	18	2	2.9
Gasterosteidae				
Gasterosteus aculeatus	1	9	2	2.9
Pleuronectidae	1	9	1	1.5
Mollusca				
Gastropoda	1	9	1	1.5
Arthropoda				
Crustacea				
Gammarus sp.	1	9	1	1.5
Carlin tags from wild salmonids	5	45	24	22.0
Carlin tags from hatchery-reared salmonids	8	72	86	78.0
Total tags	9	75	110	100.0

(*fig.* 3) (Kolmogorov-Smirnov test; smolt 1988 versus 1989: $D=0.32$, $p<0.001$; goosanders 1988 versus 1989: $D=0.49$, $p<0.001$). Goosanders used the estuary most intensively during the first part of smolt migration (*fig.* 3).

Feeding behaviour

The average time used for feeding in the estuary was 28.7% and 35.6% in males and females, respectively (data from the 4 different 6 h periods weighted) (*table* 1). No significant differences between the sexes could be documented (Kruskal-Wallis test: $\chi^2=0.41$, $p=0.52$). When data for males and females was pooled a significant variation was found in proportion of time used for feeding between different time periods (Kruskal-Wallis test: $\chi^2=11.93$, $p=0.008$), and most time was devoted for feeding during the period of lowest light intensity (22.00-04.00) (*fig.* 4). Both males and females spent most time resting, followed by feeding, swimming and preening. Very little time was devoted either to agonistic behaviour or flying (*table* 1).

During feeding there were, on average, 0.6 dives/min ($sd=0.38$, $n=34$). There was no significant difference between males and females (ANOVA: $F=0.08$, $p=0.78$). Neither was there any difference between the sexes in time spent under water whilst food searching (males $=10.0\pm4.5$ seconds, $n=62$, females $=9.9\pm5.1$ seconds, $n=37$; ANOVA: $F=0.01$, $p=0.92$).

Table 3. — Numbers of fish (length 140-300 mm) available and numbers found in stomachs of goosanders shot in River Halselva estuary, N-Norway. N gives the number of analysed goosanders that could have been feeding on a specific fish group. Only hatchery-reared smolts released in June are included.

Sample	Available	Taken	%	N
Wild fish 15 June-5 July 1987.				
Atlantic salmon	255	3	1.2	4
Brown trout	196	1	0.5	4
Arctic char	3251	52	1.6	4
Hatchery-reared fish 1987.				
Released 27-29 June				
Arctic char	4997	24	0.5	3
Wild fish 1 June-5 July 1989.				
Atlantic salmon	1205	2	0.2	11
Brown trout	293	3	1.0	11
Arctic char	2114	10	0.5	11
Hatchery-reared fish 1989.				
Released 14 June				
Arctic char	2134	31	1.5	10
Released 27 June				
Atlantic salmon	2700	0	0	5
Atlantic salmon	2452	18	0.7	5
Atlantic salmon	1879	2	0.1	5
Atlantic salmon/Arctic char	200	3	1.5	5
Brown trout	3768	7	0.2	5

Table 4. — Total length (mm) of fishes taken by goosanders and those available for different smolt groups. Tested by Mann-Whitney U test, corrected for ties. No length data are available for hatchery-reared Arctic char released in 1987.

Sample	Available			Taken			
	Length	sd	*n*	Length	sd	*n*	*p*=
Wild fish:							
Arctic char, 1987	230.1	76.8	4365	195.1	54.7	52	0.001
Arctic char, 1989	216.3	48.9	2114	203.8	43.4	10	ns
Hatchery-reared fish:							
Arctic char, 1987				234.6	21.9	24	–
Arctic char, 1989	246.6	23.8	2132	243.3	22.2	31	ns
Arctic salmon, 1989	236.3	27.7	2133	225.5	22.2	18	ns

Diet

Only 15.9% of dives (13 of 82) resulted in goosanders' bringing prey to the surface. All of these prey were fish, but only 6 could be classified (3 salmonids and 3 saltwater fish (2 *Pholis gunnellus* and 1 *Gadus morrhua*)).

Analysis of stomach contents (fish otoliths, bones) of 11 birds showed that a broad spectrum of fish species was taken. Remains from salmonids were found in 64% of the stomachs but these accounted for only 23.2% of the total number of prey. The rest of the prey were made up of several saltwater fishes and some invertebrates (*table* 2).

Salmonids as prey

Both wild and hatchery-reared salmonids were taken (*table* 2) and even relatively few goosanders (<10) were able to take approximately 1% of fishes released in the estuary (*table* 3). For the River Halselva estuary, we can estimate the total number of smolts taken by goosanders by assuming 50% of the food for a bird observed in the estuary was salmonids, and daily consumption in each bird was 400 g (Wood and Hand, 1985, Wood, 1987). For 1989, this gives a total of 107 goosander-days and 21 kg of smolts taken by goosanders. If all birds took the same ratio of wild to hatchery-reared smolts as found in stomachs in 1989 (20% to 80%), about 4.2 kg (2%) of wild smolts and 16.8 kg (1%) of hatchery-reared smolts were taken by goosanders in the estuary in 1989.

For wild fish, we found no significant disproportional predation pessure between salmonid species in the estuary (*table* 3, 1987; $\chi^2 = 1.49$, $p > 0.05$; 1989: $\chi^2 = 4.58$, $p > 0.05$).

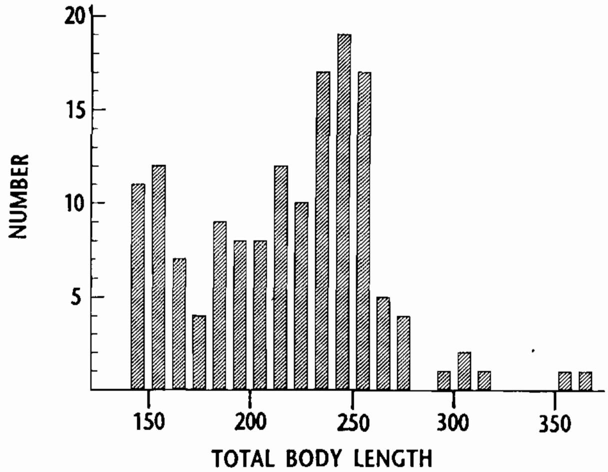

Figure 5. – Length (mm) distribution of tagged smolts (>140 mm) taken by goosanders in River Halselva estuary.

Length of tagged smolts taken by goosanders varied between the minimum size tagged (140 mm) and 364 mm (*fig.* 5). Size selection was tested for *a*) 4 goosanders feeding on wild Arctic char during the period 15 June-5 July 1987, *b*) 11 goosanders feeding on wild Arctic char between 1 June and 5 July 1989, *c*) 10 goosanders feeding on hatchery-reared Arctic char released on 14 June 1989, and *d*) 5 goosanders feeding on hatchery-reared Atlantic salmon released on 27 June 1989. For the 1987 sample of wild Arctic char, goosanders were taking significantly shorter fish than available. The same trend, although not significant, was observed for the 1989 Arctic char sample. No significant differences were found between fish lengths available and taken for the 2 samples of hatchery-reared smolts (*table* 4). Lengths of fish taken by goosanders did differ significantly between these four samples (Kruskal-Wallis ANOVA, corrected for ties $p<0.001$), as longer hatchery-reared smolts were taken compared with wild smolts.

DISCUSSION

Aggregation of goosanders in relation to smolt migration

Goosanders aggregated in River Halselva estuary, apparently to feed on migrating salmonids when these emerged into saltwater. Both the general distribution of goosanders in the census area, and trends in the relative abundance of goosanders and smolts in the River Halselva estuary, especially the delayed appearance of both species in 1988 compared with 1989, support this conclusion. This is in agreement with previous studies showing that goosanders readily respond to changes in the availability of their major prey (Sjøberg, 1985, 1989; Wood, 1985*a*, 1985*b*, 1987).

Feeding behaviour and diet

In the estuary, goosanders seem to feed opportunistically taking prey that are easiest to catch. This conclusion is based on the fact that smolts of very different sizes were taken and there was neither selection among wild salmonid species nor for size of hatchery-reared smolts. The conclusion is corroborated by the fact that goosanders feeding on wild smolts took smaller fish than those available, and that the wild smolts consumed were smaller on average than the hatchery-reared smolts consumed. As smolts are not easy to catch, and even the smallest tagged smolts (140 mm) give a high net energy gain for feeding goosanders, we would not expect "hungry" goosanders to selectively feed on the largest smolts; instead, we would expect them to take those easiest to catch (Sjøberg, 1988).

Impact on salmonid production

Wild smolts seem able to reduce predation risk during migration. Synchronous migration during a short time period should reduce overall predation, and could be adaptive. Occurrence of injured or less smoltified fish in such a "rush" would also reduce predation on fit smolts. Seaward migration during dark periods is also adopted as a typical antipredator strategy in areas with darkness at night (Hansen and Jonsson, 1986). In our study area there is midnight sun, and only small differences between day and night in light levels when smolts migrate. Here no differences in migration of smolts have been observed between day and night (Heggberget, unpubl.). However, this study shows some increase in feeding activity of goosanders during the middle of the night.

Even if goosanders aggregate in River Halselva estuary to feed on migrating smolt, their impact on salmonid production seems to be small. Wild smolts were not readily caught. Only about 15% of the dives resulted in birds' bringing prey to the surface, and a high proportion of their prey (75% based on stomach content) were not salmonids even during the period with mass seaward migration of smolts. Previous studies have also verified that salmonids contributed less to the diet of *Mergus* species feeding in estuaries compared with those feeding in freshwater systems (White, 1939; Wood, 1987).

Our estimates of the total number of smolts taken by goosanders (1-2%) are crude, but do indicate levels of predation pressure. These should not be generalized to other situations as this estuary system was heavily affected by releases of hatchery-reared smolts during the study period. Stocking of high numbers of valuable fish at unnaturally high densities is a situation very different from the normal fish densities in river or lakes and exposes predators to a surplus of food (Draulans, 1988). Such releases will probably reduce predation pressure on wild smolts initially but later on, predation pressure on wild salmonids may be increased if hatchery-reared smolts attract goosanders to the area. This seems to be the case for cormorants (*Phalacrocorax carbo*) feeding on hatchery-reared salmon in Ireland (Kennedy and Greer, 1988). Availability of wild smolts may also be particularly high in our study area as all migrating smolts were caught and handled by man just before being released into the estuary.

Predation on hatchery-reared salmonids could be reduced by keeping fish-eating birds away from the river/estuary for a period after mass releases of such fishes. As goosanders seem to show a functional response to mass occurrences of salmonids (Wood and Hand, 1985; Wood, 1987), a reduction of the period when fish are vulnerable (*i. e.* few large releases rather than many moderate releases, and release of smolt with an optimal migration behaviour), would reduce mortality caused by avian predators.

The present study only analyses predation by goosanders. In addition to goosander a number of other predators exist, for instance mink (*Mustela vison*), gulls (*Larus* sp.), cod (*Gadus morhua*) and saithe (*Pollachius virens*) (Hvidsten and Møkkelgjerd, 1987; Reitan *et al.*, 1987; Heggenes and Borgstrøm, 1988). Overall predation on emigrating smolt in the estuary must, therefore, be higher than reported here.

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REFERENCES

Alexander G. R., 1979. Predators of fish in coldwater streams. *In:* Predator-prey systems in fisheries management. International symposium on predator-prey systems in fish communities and their role in fisheries management. Clepper H. ed. Sport Fishing Institute, Washington D. C., 153-170.

Altmann J., 1974. Observational study of behaviour: sampling methods. *Behaviour*, **49**, 227-267.

Draulans D., 1988. Effects of fish-eating birds on freshwater fish stocks: An evaluation. *Biolog. Conserv.*, **44**, 251-263.

Elson P. F., 1962. Predator-prey relationships between fisheating birds and Atlantic salmon. *Fish. Res. Board Can. Bull.*, **133**, 1-87.

Feltham M. J., 1990. The diet of red-breasted mergansers (*Mergus serrator*) during the smolt run in N. E. Scotland: the importance of salmon (*Salmo salar*) smolts and parr. *J. Zool. Lond.*, **222**, 285-292.

Hansen L. P., B. Jonsson, 1986. Salmon ranching experiments in the River Imsa: Effects of day and night release and of seawater adaptation on recapture-rates of adults. *Rep. Inst. Freshw. Res. Drottningholm*, **63**, 47-51.

Heggenes J., R. Borgstrøm, 1988. Effect of mink, *Mustela vison* Schreber, predation on cohorts of juvenile Atlantic Salmon, *Salmo salar* L., and Brown Trout, *Salmo trutta* L., in 3 small streams. *J. Fish Biol.*, **33**, 885-894.

Huntsman A. G., 1941. Cyclical abundance and birds versus salmon, *J. Fish Res. Board Can.*, **5**, 227-235.

Hvidsten N. A., R. A. Lund, 1988, Predation on hatchery-reared and wild smolts of Atlantic salmon, *Salmo salar* L., in the estuary of River Orkla, Norway. *J. Fish Biol.*, **33**, 121-126.

Hvidsten N. A., P. I. Møkkelgjerd, 1987. Predation on salmon smolts, *Salmo salar* L., in the estuary of the River Surna, Norway. *J. Fish Biol.*, **30**, 273-280.

Jonsson B., J. Ruud-Hansen, 1985. Water temperature as the primary influence on timing of seaward migrations of Atlantic salmon (*Salmo salar*) smolts. *Can. J. Fish Aquat. Sci.*, **42**, 593-595.

Kennedy G. J. A., J. E. Greer, 1988. Predation by cormorants, *Phalacrocorax carbo* (L.), on the salmonid populations of an Irish river. *Aquacult. Fish. Manage.*, **19**, 159-170.

Lindroth A., 1985. Mergansers as salmon and trout predators in the River Indalsälven. *Rep. Inst. Freshw. Res., Drottningholm*, **36**, 126-132.

Mace P. M., 1983. Bird predation on juvenile salmonids in the Big Qualicum estuary, Vancouver Island. *Can. Tech. Rep. Fish. Aquat. Sci.*, **1176**, 1-79.

Mills D. H., 1962. The Goosander and Red-breasted Merganser as predators of salmon in Scottish waters. *Freshw. Salmon Fish. Res.*, **29**, 2-10.

Reitan O., N. A. Hvidsten, L. P. Hansen, 1987. Bird predation on hatchery reared Atlantic salmon smolts, *Salmo salar* L., released in the River Eira, Norway. *Fauna norv. Ser. A*, **8**, 35-38.

Ruggerone G. T., 1986. Consumption of migrating juvenile salmonids by gulls foraging below a Columbia river dam. *Trans. Am. Fish. Soc.*, **115**, 736-742.

Sjöberg K., 1985. Foraging activity patterns in the goosander (*Mergus merganser*) and the red-breasted merganser (*Mergus serrator*) in relation to patterns of activity in their major prey species. *Oecologia*, **67**, 35-39.

Sjöberg K., 1988. Food selection, food-seeking patterns and hunting success of captive Goosanders *Mergus merganser* and Red-breasted Mergansers *M. serrator* in relation to the behaviour of their prey. *Ibis*, **130**, 79-93.

Sjöberg K., 1989. Time-related predator/prey interactions between birds and fish in a northern Swedish river. *Oecologia*, **80**, 1-10.

Suter W., 1991. Der Einfluss fischfressender Vogelarten auf Süsswasserfisch-Bestände-eine Übersicht. *J. Ornithol.*, **132**, 29-45.

White H. C., 1939. Bird control to increase Margaree River salmon. *Bull. Fish. Res. Board Can.*, **53**, 1-30.

White H. C., 1957. Food and natural history of mergansers on salmon waters in the maritime provinces of Canada. *Bull. Fish. Res. Board Can.*, **116**, 1-63.

Wood C. C., 1985*a*. Food-searching behaviour of the common merganser (*Mergus merganser*). II: Choice of foraging location. *Can. J. Zool.*, **63**, 1271-1279.

Wood C. C., 1985*b*. Aggregative response of common mergansers (*Mergus merganser*): Predicting flock size and abundance on Vancouver Island salmon streams. *Can. J. Fish. Aquat. Sci.*, **42**, 1259-1271.

Wood C. C., 1987. Predation of juvenile Pacific salmon by the common merganser (*Mergus merganser*) on Eastern Vancouver Island. I: Predation during the seaward migration. *Can. J. Fish. Aquat. Sci.*, **44**, 941-949.

Wood C. C., C. M. Hand, 1985. Food-searching behaviour of the common merganser (*Mergus merganser*). I: Functional responses to prey and predator density. *Can. J. Zool.*, **63**, 1260-1270.