This paper not to be cited without prior reference to the authors

International Council for the Exploration of the Sea

C.M. 1993/F:17

Baltic herring-based-feeds might help to diminish the nutrient load from mariculture to the Baltic Sea

by

Ruohonen, K. and Vielma, J.

Finnish Game and Fisheries Research Institute, Mariculture Research Station, 21150 Röölä, Finland

Abstract

Baltic herring stocks are not utilized for fish meal which means that all the fish meal used to manufacture fish feeds in the Baltic Sea region is imported outside the Baltic Sea. Though part of the nitrogen and phosphorus present in the fish meal is bound to the fish growth, inevitably the nutrient pool of the Baltic Sea is increased in the form of fish faeces and uneaten food. If Baltic fish stocks would be used as feed for the Baltic mariculture, the nutrients would recycle and the external nutrient flux to the Baltic Sea might be diminished. In some cases the nutrient balance might even be negative, i.e. more nutrients will be removed from the Baltic Sea (in the form of produced fish) than the external flux (in the form of feed) brings in.

Unless Baltic herring will be used to manufacture fish meal, the most potential way to recycle nutrients is to use semi-moist or moist diets based on Baltic herring or even the plain herring itself. The problem of these diets is higher local nutrient load to the water which might result to local eutrophication near the cage farms. The higher load is a product of high protein-to-energy ratio (PE) and high phosphorus content of the herring if compared to fish meal and commercial dry feeds. Local load could be diminished by balancing the PE by adding fat and carbohydrate to semi-moist and moist diets. If plain herring is used for feed, PE might be balanced by giving extra energy in the form of supplement feeding a low-protein dry feed.

Introduction

Formulated fish feeds consist mainly of fish meal, the amount of which may exceed 40-50% of the diet. Fish meal is the main source of nitrogen and phosphorus in the fish feed, the nutrients which form the most severe discharge problem of the aquaculture industry. In 1989 the nutrient discharge from aquaculture to the Baltic Sea was ca. 1000 tons phosphorus and ca. 6600 tons nitrogen accounting 1.5% of the total phosphorus and 0.4% of the total nitrogen discharge (Enell and Ackefors 1991). Baltic fish stocks are not utilized for fish meal, so all the fish meal used to manufacture fish feeds in the Baltic Sea region is imported outside the Baltic Sea. Though part of the nitrogen and phosphorus present in the fish meal is bound to the fish growth, inevitably the nutrient pool of the Baltic Sea is increased in the form of fish faeces and uneaten food. If Baltic fish stocks would be used as feed for the Baltic mariculture, the nutrients would recycle and the external

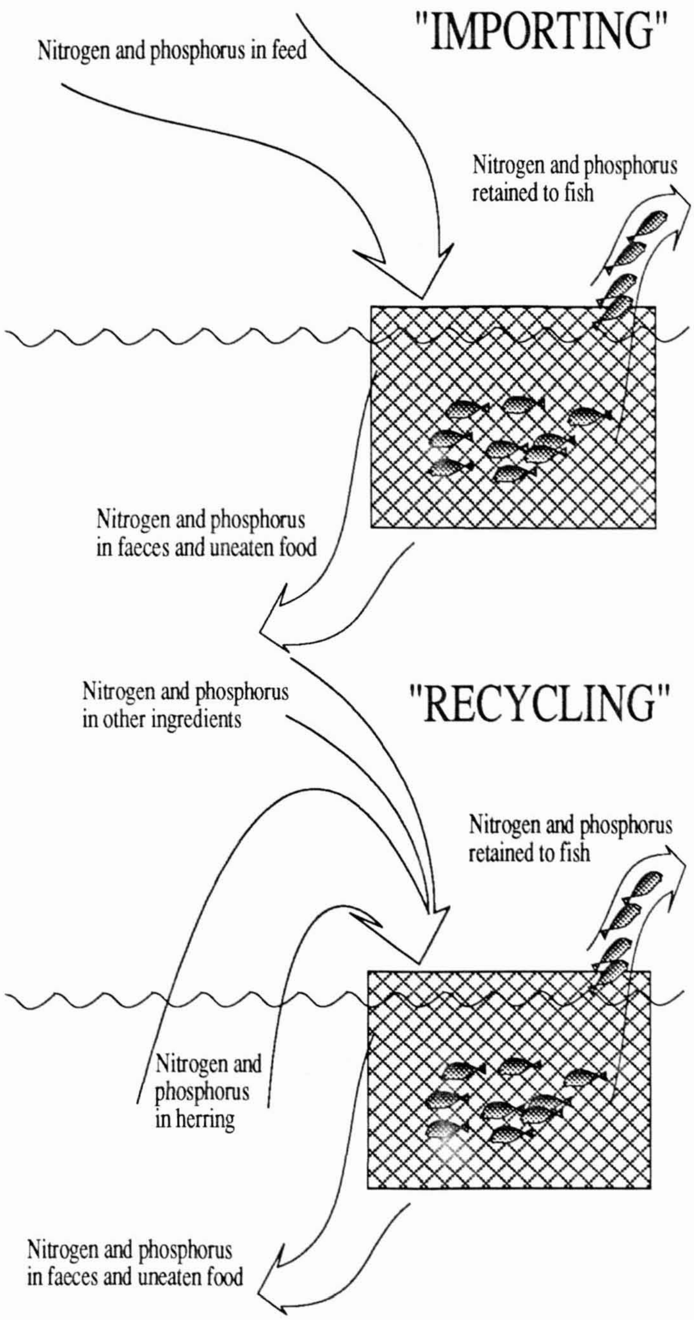


Figure 1. *Schematic illustration of the nutrient fluxes when fish meal-based dry feeds ("IMPORTING") or Baltic herring-based diets ("RECYCLING") are used in mariculture within the Baltic Sea.*

nutrient flux to the Baltic Sea might be diminished (Figure 1).

This paper concentrates on nutrient load to the water from the production and contains preliminary material and discussion of the project "Baltic herring as food for rainbow trout" which has been undertaken in Finland during 1991-1993. The project aims to evaluate the potential of semi-moist and moist diets as well as plain chopped herring in Finnish mariculture, and to solve nutritional and environmental problems inhibiting the increase of Baltic herring use in fish feeds. A practical guide for fish farmers about the use of Baltic herring in semi-moist and moist feeds is intended to be published during 1994.

Table 1. Formulation of the experimental diets in 1991 experiments in addition to commercial dry feed and plain chopped Baltic herring (% of diet).

Ingredient	Diet exp. 1	Diet exp. 2	Diet exp. 3	Diet exp. 4
Baltic herring	49.0	49.0	69.5	84.2
fish meal	37.4	37.4	20.8	8.8
fish oil	11.2	11.2	7.8	5.5
guar gum	1.8	1.8	1.4	1.1
vitamins	0.6	0.6	0.5	0.4
TOTAL	100.0	100.0	100.0	100.0

Diet exp. 1 was prepared by drying diet exp. 2 in warm air flow.

Materials and methods

The material used in this paper consists of preliminary results of experiments undertaken during 1991 and 1992 in Finnish Game and Fisheries Research Institute's Mariculture Research Station located at Finnish south-west archipelago about 30 km west from Turku (Ruohonen and Vielma 1991, 1993). The experiments were undertaken in 48 m^3 net cages in brackish water (salinity 5-6 ‰) with rainbow trouts weighing initially about 0.5 kg. The experiments lasted 3-4 months after which the fish weighed 1-2 kg. 200 fish per cage were weighed individually at the beginning of the experiments. The fish were weighed individually at the end of the experiments, too. 20 randomly chosen fish were gutted from each cage to determine the gutted weight. Five fish per cage were pooled and minced to carcass samples. At the beginning of the experiment a pool of 10 fish was taken for carcass analysis.

In 1991 dietary treatments varied from commercial dry feed to plain chopped Baltic herring. In addition, four isoenergic semi-moist and moist diets with constant protein-to-energy ratio (PE) and varying moisture and Baltic herring content were used Table 1). Experimental dry feed used was Tess Edel and it was delivered by Raision Tehtaat Ltd. All other diets were prepared at the research station. In 1992 the effect of supplement feeding by a low-protein dry feed on the chopped herring feeding was studied. Dry diets were delivered by Finnewos Ltd. In all experiments the fish were fed manually for half an hour untill satiation was achieved. Three replicate cages per treatment were applied in all experiments.

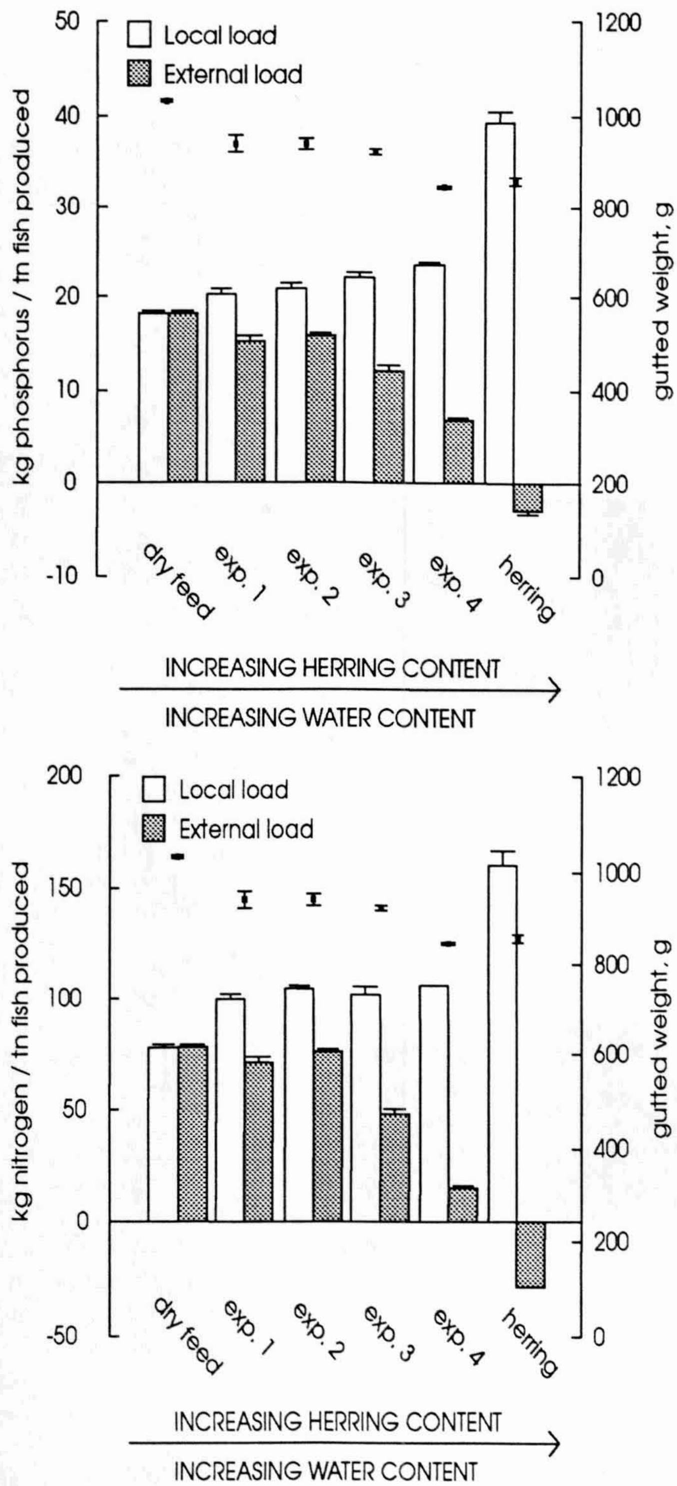


Figure 2. *Phosphorus (a) and (b) nitrogen load to the water in rainbow trout net cage culture when different types of feed are used. Herring-based semi-moist and moist diets (exp. 1 to 4) result to higher local but lower external load than commercial dry feed. Chopped herring results to the highest local load but negative external load. Local load refers to the total amount of nutrients released from the cages and external load to the nutrients originating outside the Baltic Sea, i.e. in the external load the nutrients in the Baltic herring are omitted. Gutted weights after the experiment are shown with small black squares. Error bars refer to standard error of the mean of three replicate cages.*

Table 2. Amount of Baltic herring that could be used in different types of fish feeds. The amount of protein originating from herring is also shown.

Feed type	Herring %	Protein %	FC[1]	Herring usage[2]	Herring protein[3]
dry	12	45	1.5	0.20	4
semi-moist	49	34	2.4	1.20	22
moist	84	19	4.3	3.65	66
chopped	100	15	7.9	7.86	100

[1] feed consumed/fish produced

[2] kg herring used/kg fish produced

[3] % dietary protein from herring

Table 3. Proximate composition of Baltic herring and commercial dry feed (in % unless otherwise stated).

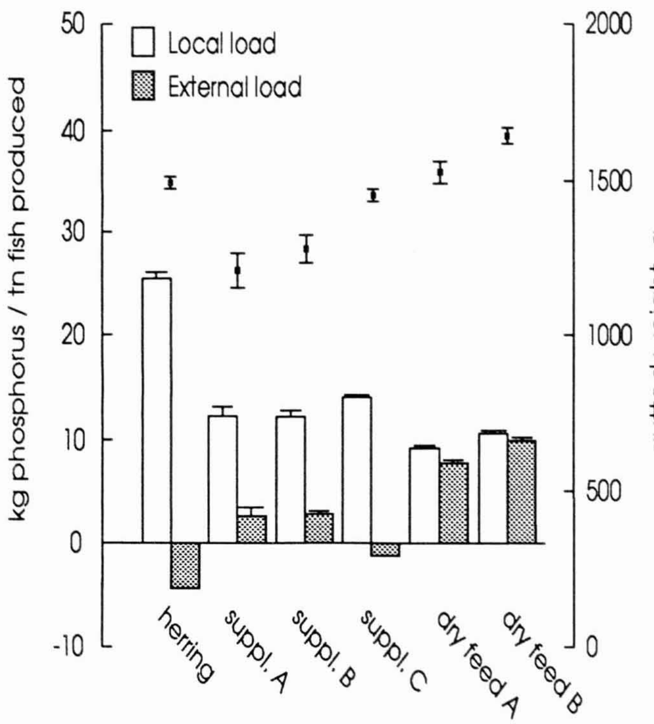
	Baltic herring		Dry feed	
	as fed	dry matter	as fed	dry matter
water	78	-	9	-
crude protein	15	68	41	45
crude fat	2	9	23	25
ash	3	14	6	7
remainder	2	9	21	23
TOTAL	100	100	100	100
phosphorus	0.48	2.18	1.09	1.20
gross energy[1]	4.5	20.5	22.3	24.5
PE[2]	33.2		18.5	

[1] MJ/kg

[2] protein-to-energy ratio (g crude protein/MJ gross energy)

Results and discussion

Unless Baltic herring will be used to manufacture fish meal, the most potential way to recycle nutrients is to use semi-moist or moist diets based on Baltic herring or even the plain herring itself (Table 2). Small amounts of Baltic herring in the form of silage has been used in extruded dry feeds in Finland during the recent years. The problem of semi-moist and moist feeds is that herring-based diets (exp. 1 to 4 in Figure 2) result to higher local load than commercial dry feed. Chopped herring results to the highest local load. The higher local load might result to eutrophication near the cage farms. The higher nutrient load is a product of high PE and high phosphorus content of the Baltic herring if compared to fish meal and dry feed (Table 3). The optimal PE for rainbow trout is estimated to be 22-24 mg protein per kJ digestible energy (Cho 1992).



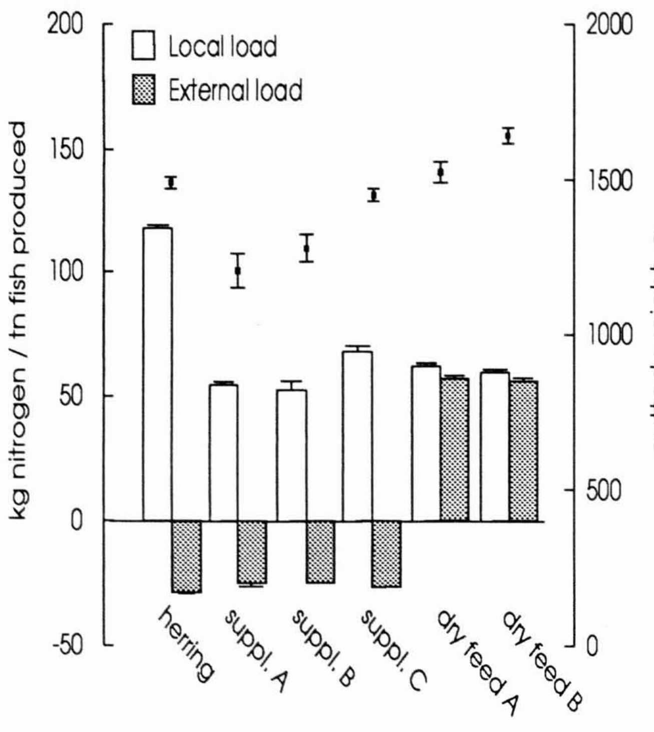


Figure 3. *Phosphorus (a) and nitrogen (b) load to the water in rainbow trout net cage culture when different types of feed are used. Supplement feeding of high energy-low protein dry feed to chopped herring (suppl. A to C) reduces the local load almost to the same level as with commercial dry feeds (dry feed A and B). Local load refers to the total amount of nutrients released from the cages and external load to the nutrients originating outside the Baltic Sea, i.e. in the external load the nutrients in the Baltic herring are omitted. Gutted weights after the experiment are shown with small black squares. Error bars refer to standard error of the mean of three replicate cages.*

Table 3. Formula for herring-based feeds with balanced and unbalanced PE[2] (in % unless otherwise stated).

	PE balanced		PE unbalanced	
	as fed	dry matter	as fed	dry matter
Baltic herring	69	-	69	-
Fish meal	14	-	25	-
Fish oil	9	-	5	-
Wheat starch	7	-	-	-
Guar gum	0.5	-	1	-
TOTAL	100	-	100	-
phosphorus	0.65	1.44	0.87	1.92
dig. energy[1]	10.1	22.5	10.0	22.2
PE[2]	21.2		29.5	

[1] digestible energy MJ/kg

[2] protein-to-energy ratio (g dig. protein/MJ dig. energy)

A negative external load was achieved by feeding the fish with plain chopped herring, *i.e.*more nutrients was be removed from the Baltic Sea (in the form of produced fish) than the external flux (in the form of feed) brought in. A reasonable decrease in the external load of the formulated diets was only achieved when the herring content exceeded 70% of the diet (exp. 3 and 4 in Figure 2).

The local nutrient load might be diminished by adding fat and carbohydrate to semi-moist and moist diets (see Table 3 for an example) which balances the dietary PE. If plain chopped herring is wished to use, supplement feeding with a low-protein diet gave promising results in balancing the PE (Figure 3) and reducing the nutrient load to the water. Supplement feeding of high energy-low protein dry feed to chopped herring (suppl. A to C in Figure 3) reduced the local load almost to the same level as with commercial dry feeds (dry feed A and B). However, to give recommendations about supplement feeding, further studies are needed.

References

Cho C Y: Feeding systems for rainbow trout and other salmonids with reference to current estimates of energy and protein requirements. Aquaculture 100: 107-123, 1992

Enell M and Ackefors H: Belastning av fosfor och kväve, från fiskodlinger i Norden, på omgivande havsområden. Nord 1991(10): 83-101, 1991

Ruohonen K and Vielma J: Baltic herring used as food for rainbow trout. Annual report 1991, 32 p. , 1991 (mimeograph in Finnish)

Ruohonen K and Vielma J: Supplementation of chopped Baltic herring diet with a low-protein dry feed in rainbow trout farming. Baltic herring used as food for rainbow trout. Annual report 1992: 23-42, 1993 (mimeograph in Finnish)