

## **Project description**

### **Working title: Management of Wild Atlantic Salmon (*Salmo salar*) in a bioeconomic perspective**

The Norwegian wild Atlantic salmon is an important resource in its marine habitat as well as along the upstream migration to its spawning grounds. While the benefit of marine harvesting is closely connected to the meat value, the spawning migration gives rise to a number of utilities for different groups. Most important are values connected to fishing permit sales, recreational fishing and various side effects in the local communities related to so-called salmon-tourism.

The number of escaped salmon from Norwegian fish farms has decreased from 1,5 – 2 mill salmon in the late eighties down to just above 0,4 mill individuals in the late nineties (Fiske and Lund, 1999). Salmon escapement gives rise to various negative effects on the wild salmon populations. In this project we want to analyse how the biologic breeding competition wild salmon faces from escaped salmon affects the natural wild salmon production.

Since the first salmon ranches appeared in the early seventies farmed salmon production have increased rapidly and the industry was already in 1987 referred to as one of the most important events in European aquaculture (Ridler and Kabir, 1987). The farming industry sales exceeded 10 mrd NOK for the first time in 1999 (Statistisk Sentralbyrå, 2000). Because of widely use of medicines, eruption of disease's and escapements, this important economic activity is debated. Salmon accidentally escapes from net pens that are wrecked during storms, or damaged by seals, otters, and daily wear and tear (Hindar et al., 1991). The number of accidental escapes has decreased do to safety investments in sea ranches, but still as many as 413 000 salmons escaped from fish farm's in Norway during 1999 (SSB, 2000). The magnitude of the consequences varies, but several studies find unwanted effects of escaped salmon in Norwegian rivers (Hindar et al., 1991, Økland et al., 1991, Lura og Sægrov, 1990). The conflict between wild and ranched salmon production are well known, but the bioeconomic aspect are left unexplored.

Several bioeconomic studies have shown that the behavioural pattern of farmed salmon differs from that of wild salmon, specially when it comes to the timing of the spawning migration (Hansen and Johnsson, 1991, Økland et al., 1991, Fiske and Lund, 1999). While the upstream migration of wild salmon begins in the spring and lasts till late autumn, the farmed salmon tends to migrate in the late autumn in a more uniform pattern. This leads to a high share of farmed salmon in the spawning population, because farmed salmon are not caught by recreational fishermen do to the late migration. In addition, findings suggest that escaped ranched salmon dig up the spawning gravel's of wild salmon, thereby further reducing the number of successful spawning in the wild stock (Lura and Sægrov, 1990). Even if the reproduction success of the ranched stocks are lower than that of wild salmon, the high share of escaped fish in the spawning stock ensures a high degree of alien juveniles and mixed offspring (Hansen and Jonsson, 1991, Økland et al., 1991).

Spawning exogenous salmon may lead to a number of negative effects to the native stock. First, it affects the natural selection process which has given the "fittest" native salmon the most appropriate spawning areas because of the later digging in the same gravel's by ranched spawning salmon. Second, the unique reproduction unit each native population utgjør is directly affected by the interbreeding of escaped and wild salmon (Lura and Sægrov, 1990).

Further, it is shown that the alien juveniles dominate the natives due to rapid growth and more aggressive and risk-willing behaviour (Villaks-utvalget, 1999). If this different behavioural pattern lasts through the remainder of the life cycle, one should believe that offspring of farmed fish would be in the near-cost environment as the farmed salmon tends not to migrate to the offshore like the natives. In this case the amount of hosts to various parasites would increase, and especially the increase in the salmon lice density may be explained by a higher density of hosts through the year cycle (Grimnes et al., 1996). A change in the genes also could contribute to a higher homing failure. A small amount of straying is believed to be a safeguard to ensure genetic variation in respect to save the stock in the case of environmental changes, disease's, to protect the stock against local inbreeding and so on (Hindar et al., 1992). If mixed offspring leads to more or less straying, both cases could give negative side effects. Specially, a higher degree of straying would ease the spread of disease's and make the unique local adaptation less unique.

One further serious impact of farmed salmon reproduction in the rivers is due to the so-called intrinsic value. This existence value of populations is often referred to in connection to threatened species. This value is relevant in our setting because of the threat wild salmon populations face with respect to mixing their genes with genes from escaped fish. Also, in an economic perspective, it is to be expected that the willingness to pay for catching mixed or alien second generation salmon are less than the willingness to pay for wild salmon.

#### Economic problem:

We wish to analyse the economic problem of the fast growing and highly profitable sea ranching industry on the one hand, and the following degradation and negative stock effects on the natives with respect to escaped salmon on the other hand. The problem is to be formulated as a classical problem of externalities. In this case the production of domestic salmon is to be connected to the negative external effects of escapements on the native stock. This external effect will affect the utility of the land owners, the sport fishermen and the local communities along the river through the biological mechanisms. In addition, we have to take into account the intrinsic value since the wild salmon as a unique reproduction unit is threatened.

In our knowledge the wild salmon species is not analysed in this bioeconomic sense yet. The problem of externalities is though one of the most analysed subjects in economic literature, and there is also a sort of consensus with respect to the various possibilities of solving such problems. The most common are taxes, quotas and direct regulation imposed by a social planner and the so-called Coase theorem which predicts that the market under certain assumptions will solve the problem by internalising the externalities on its own (Coase, 1960). The criticism against the Coasian approach and the strict assumptions it requires has led most economists to suggest policies like direct regulation, taxes and quotas. In our bioeconomic framework we would like to discuss to which extent the different management policies would allow us to reach the bioeconomic steady state in our model. Analogous to the traditional literature we would respect the farming industry to increase their investment in preventing escapement until the marginal cost of these investments reach the marginal benefits of less escapements.

Another important subject would as previously mentioned be the intrinsic value of wild Atlantic salmon. In this field the problems of getting exact measurements are large of course. In economic research the emphasis on this question has grown rapidly the last decades (see for example ? for an overview). If this existence value is large enough, it will result in a

bioeconomic optimal escapement rate which approaches zero, and therefore bringing knowledge of this intrinsic value will be an important issue.