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Estimating costs of sea lice control strategy in Norway

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ABSTRACT

This paper explores the costs of sea lice control strategies associated with salmon aquaculture at a farm level in Norway. Diseases can cause reduction in growth, low feed efficiency and market prices, increasing mortality rates, and expenditures on prevention and treatment measures. Aquaculture farms suffer the most direct and immediate economic losses from diseases. The goal of a control strategy is to minimize the total disease costs, including biological losses, and treatment costs while to maximize overall profit. Prevention and control strategies are required to eliminate or minimize the disease, while cost-effective disease control strategies at the fish farm level are designed to reduce the losses, and to enhance productivity and profitability. Thus, the goal can be achieved by integrating models of fish growth, sea lice dynamics and economic factors. A production function is first constructed to incorporate the effects of sea lice on production at a farm level, followed by a detailed cost analysis of several prevention and treatment strategies associated with sea lice in Norway. The results reveal that treatments are costly and treatment costs are very sensitive to treatment types used and timing of the treatment conducted. Applying treatment at an early growth stage is more economical than at a later stage.

1. Introduction

This paper explores the costs of prevention and control strategies of sea lice associated with salmon aquaculture in Norway. Disease is a primary threat to the continued growth in aquaculture due to its extensive effects on the sector (Hjelt, 2000; Moran and Fofana, 2007; Asche et al., 2010; Aunsmo et al., 2010) and other resource users such as wild fisheries (Liu et al., 2011; Olaussen et al., 2013). Among various diseases associated with salmon aquaculture, sea lice (e.g., *Lepeophtheirus salmonis* and *Caligus* ssp.) have become one of the main challenges in the major farmed salmon producing countries, especially in Norway and British Columbia, Canada (Revie et al., 2009). Therefore, this paper conducts a cost analysis of sea lice control strategies by comparing different treatment costs of sea lice and examining the impacts of sea lice treatment on farm profits based on a case study in Norway.

Sea lice are small marine parasites and naturally occur on wild fish, especially wild salmon (Tully and Nolan, 2002). They have a life cycle consisting of five phases which are divided into non-parasitic and parasitic stages (Tully and Nolan, 2002; Johnson et al., 2004). Sea lice feed on fish skin, mucus and blood especially on the head, back and perianal region. High infestation pressure very likely results in severe damages to the host and even death from serious erosion and exposure of subcutaneous tissues, secondary bacterial infections, osmotic imbalance and extreme chronic stress (Johnson et al., 2004). The degree of damage depends on the developmental stages of sea lice, the density of sea lice on a host fish and host fish size. Studies indicated that more than 0.1 lice per gram of

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fish body weight can have lethal effects on host fish which are bigger than 10 grams (Costello, 2006; Wagner et al., 2007). Due to treatment measures applied to curb sea lice level, sea lice rarely have negative impacts on the health of farmed salmon (Revie et al., 2009). However, farmed fish are affected by chemotherapeutant treatments through increased mortality and reduced growth. During salmon growout phase at sea, smolt are more vulnerable to sea lice infestations due to its smaller size and lower physiological tolerance to environmental stress (Finstad et al., 2000; Costello, 2006). Therefore, high infestation level of sea lice can impact the fish's welfare and growth, and reduce productivity at the farm.

Sea lice represent a significant challenge for the salmon aquaculture industry and a concern for the wild salmon stock. Because of the potential effects of sea lice on wild salmon stocks Norwegian authorities have imposed strict regulations on the number of sea lice per treated fish. The latest regulation implemented in 2009 includes a limit of 0.5 adult female or 3 mobile lice per fish on average from January 1 to August 31, and 1 adult female or 5 mobile per fish from September 1 to December 31. A routine monitoring with sampling is compulsory, and the treatments are required when the lice number exceeds these limits. A treatment may have to be synchronized by all the farms in a region to meet the whole regional planning, for instance in Trøndelag area – Mid-Norway.

The salmon growout stage is defined as the rearing and feeding of salmon smolt in sea cages to market size, normally a 14 to 22 month period dependent on salmon genetics, environmental conditions and management strategies. Smolt averaged 60–100 g are transferred to net pens generally in the spring or autumn, then graded by size after several months until around one year in the sea. They are harvested when they reach market size, averaged around 4.5–6 kg. Salmon are usually raised in dense net pen systems which is uncommon in their natural environment. This makes farmed fish more exposed to diseases and parasites. If one fish contracts a contagious disease in a farm, the disease may then rapidly infect the whole farm, and might even be transferred or spread to neighboring farms if they are close enough to each other.

Diseases in general can cause direct and indirect production losses through reduction in growth, low feed efficiency and increasing mortality rate. The economic impacts of diseases can be substantial (e.g., Fofana and Baulcomb, 2012), and aquaculture farms suffer these direct and immediate economic losses (Mustafa et al., 2001; Menzies et al., 2002; Costello, 2009; Asche et al., 2010; Aunsmo et al., 2010). Costello (2009) indicated that the global economic costs of sea lice to the salmon farming industry are estimated to be around US$ 423 million. For instance, the cost of sea lice was estimated to be about 0.79 NOK[2] per kg of salmon produced in Norway in 2011 as a result of direct losses due to mortality and slow growth, treatment costs and extra manpower (Anon, 2012). If this estimate was applied to all the producers in Norway, sea lice could have cost the whole Norwegian salmon industry approximately US$130 million (790 million NOK) in 2011. A recent report in Norway revealed that the cost of sea lice has gradually increased, and could be up to 2.45 NOK/kg salmon produced (Jensen, 2013), three times that estimated in 2011 due to an increasing level of sea lice occurrence and treatment.

High infestation levels of contagious diseases may also decrease the quality of marketable products, potentially resulting in lower market price (Mustafa et al., 2001; McVicar, 1997; Aunsmo et al., 2010). If a severe reduction in production occurs due to high mortality rates, the dynamics of market (i.e., supply and demand) may change resulting in high demand relative to supply and subsequently a higher market price may emerge. It may also potentially cause changes in consumption pattern and behavior if consumers are very concerned about environmental impacts, seafood safety, and human health. This may eventually lead to a decline in demand (Israngkura and Sae-Hae, 2002). The net effect on demand and supply depends on which of these two factors is greater. Moreover, combating diseases requires additional resources, in other words, prevention and treatment measures require additional effort and investment which likely increase production cost and undermine production. Therefore, the economic effects of diseases on the aquaculture sector, especially at a farm level, can be measured through changes in productivity and profitability.

Total eradication of sea lice on salmon farms is not very likely, if not impossible, but salmon are required to minimize the abundances of sea lice through a combination of treatments and management strategies. In addition to chemotherapeutant treatments, a variety of management decisions can be made which can have impacts on sea lice control at salmon farms. Integrated pest management (IPM) in farming operations has been proposed and developed in major producing nations. One of the IPM is regional management coordination which may include coordinated stocking of single year-classes, fallowing of farm sites, and synchronized treatment strategies within the fjords and between different aquaculture companies. For instance, mandatory and synchronized delousing during late autumn and early spring are proposed and implemented along most of the Norwegian coastline to reduce the overall sea lice infestation pressure during wild salmonids spring run. As a decision supporting tool, economic evaluation would thus become an important part of the IPM plan to assess the economic performance of different sea lice control strategies.

2. Treatment types

Prevention and treatment measures and management strategies are the core steps in reducing the abundance of sea lice at salmon farms. Especially when sea lice level exceeds the threshold level salmon farms are obligated to take treatment measures immediately. Currently, in Norway, three main types of prevention and treatments have been used in salmon farms: (1) medicine: in-feed pellet – oral treatment; (2) chemical: bath delousing and (3) biological: Wrasse (Labridae) – cleaner fish. In in-feed treatment anti-parasitic medicines are administered into feed pellets and fed to infected salmon. *Ememectinbenxoate*

[2] US$ = 6.07 NOK, accessed in March 2014.