

Short report on results to NRC “Matprogrammet” 2009: Capture based aquaculture around fish farms: developing a small scale fjord fishery (NRC contract 178306).

1) Description of aims, background and achieved results in the project:

There has been no comprehensive approach to investigating the effects of sea-cage farms on marine wild fish populations in Norway). In a newly funded NRC project, “*Artificially created ecosystem (ACEs) in coastal waters: developing technical methods to assess their effects on wild fish assemblages in cold-water environments (CoastACE, NRC contract nr 173384, 2006-2007)*”, this lack of techniques and ecological knowledge have been addresses. Another hot issue at the moment is the question of a possible quality and taste reduction in saithe and cod aggregating around fish farms and feeding on excess salmon food and faeces. This topic was not addressed in the *CoastAce* project, and even less is known about this. Skog et al. (2003) have, however, documented that saithe aggregated at a single farm were in better condition but tasted worse than fish caught at distant control locations. Another pilot experiment by Fiskeriforskning (now Nofima) have indicated no obvious differences in processing quality in farm aggregating compared to control cod. Overall, it is therefore reason to believe that substantial amounts of wild fish may aggregate around Norwegian fish farms. They may however have inferior quality and taste compared to wild fish in areas without fish farming activity, but details about this is scarce. On the other hand, this behaviour also opens possibilities for small-scale fisheries and marine aquaculture to coexist in the same waters. This study describes quality of wild fish around fish farms and in controls areas in a Norwegian wide context. Furthermore, we have developed and tested methods to capture alive, and possibly improve quality, of wild fish in such a way that a small-scale fishery of high quality food can be developed in intensively farmed Norwegian fjords. This have been accomplished in close collaboration with the above mentioned *CoastACE* project, and through two closely linked workpackages (WP):

Main Objective

- To assess quality of wild fish aggregating around fish farm in Norway, and to develop methods and equipment for live capture, storage and quality improvement in such a way that a sustainable small-scale fishing can be developed in areas of intensive aquaculture production.

Sub-goals

- To describe quality of wild fish aggregating around fish farms and in control areas in a Norwegian wide context (WP 1)
- To develop methods for live capture and recovery of fish captured around fish farms (WP 2, task 1)
- To study if short time storage without food can improve quality of fish captured around fish farms (WP 2, task 2).

Quality and taste of fish aggregating around fish farms, WP 1

The *CoastACE* project has generated baseline ecological data of wild fish aggregation at farms from the north to the south of Norway. To do this *CoastACE* have sampled wild marine fish at a total of 9 locations: Three in southern-Norway (Ryfylke), three in mid-Norway (Hitra) and three in north-Norway (Øksfjord). At each location, farming sites and control sites have been sampled during summer of 2007. In this project we have partly used the infrastructure and extensive sampling programme of the *CoastACE* project to include studies of processing quality of fish and taste of the fish fillet from these three fish farming sites and control areas. In addition we have follow quality changes with time at one selected locality

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(Ryfylke) during a one year cycles. To investigate the processing quality and taste of the fish from the fish farming sites and control areas, different methods have been used. The ecological and biological data from cod and saithe in these areas have been collected as part of, or similar, as the *CoastACE* project. This, combined with further registration of the appearance of the fish, like colour, shape, belly size, hepatosomatic index (HIS), body lipid content, fillet processing quality and taste, will give an answer if there are significant differences in quality and taste between wild fish aggregating around fish farms and in control areas in a Norwegian wide context. During autumn 2007, in collaboration with NINA, University in Alicante and SINTEF, an extensive sampling program was conducted all along the Norwegian Coastline: The intensively farmed Øksfjord was chosen as the northernmost locality. Both cod and saithe were sampled directly below the net pens by “jukse-fishing (jigging)”. A similar control sample was gathered from Sørøysundet. Similar samples were also gathered from Hitra and in Ryfylke. In Ryfylke (se above), the sampling program was furthermore increased: Three localities were investigated; directly below a fish farm, inside the intensively farmed area but 1-2 km away from the nearest farms and in outer coastal control areas without farms (> 20 km away from nearest farm). In addition, we have followed quality changes with time at these localities and sampled fish both in autumn 2007, winter (both gill-netting and “jukse”) and spring 2008.

Results shows that there were few differences in filet processing quality between cod in the intensively farmed Øksfjord (northern Norway) and in control areas. The fillet index (based on a grading of colour, shape, gaping, smell, softness etc) were close to 1 both below farms and in control areas. This indicated a fillet of good processing quality. The saithe had a bit higher fillet index, (around two), but there was no difference between the farmed exposed and control saithe, and quality was acceptable. However, a few of especially the saithe captured below the farms in Øksfjord, clearly indicated feeding on fish pellets both through stomach content (35 % pellets), increased hepatosomatic index, and increased condition factor. In addition, small differences in the fatty acid (FA) muscle composition in saithe from Øksfjord, confirm pellets eating. The sensory panel found however very few differences in taste and flesh consistence both in cod and in saithe. At Hitra, the fillet index of both exposed and unexposed cod (around one) were similar to Øksfjord, and indicate good processing quality. Unexposed saithe also showed good quality (fillet index ca 1,5). A larger difference was found between control saithe and fish farmed exposed saithe. The latter showed a fillet index above 4 and indicate less good quality. A 53 % content of food pellets in the saithe stomach, indicated heavily feeding upon pellets around the fish farms of Hitra. Also, differences in hepatosomatic index, increased condition factor and a different FA profile, were found between exposed and unexposed saithe. The sensory panel could, however, not discriminate between exposed and unexposed saithe. In cod, a higher amount of food pellets (48 %) were consumed compared to Øksfjord, and the taste panel generally evaluated the exposed cod to be more similar to farmed cod, especially through textural attributes of the flesh. In Ryfylket, it showed to be impossible to capture cod, and indeed also very difficult to capture saithe. During autumn 2007 an intensive sampling programme was conducted. Results show quite large differences in process fillet quality between our three localities. At the distant control area (> 20 km away from farms), fillet index was around 1 and quite similar to unexposed saithe at Hitra and in Øksfjord. Saithe directly below fish farms in Ryfylke showed also similar properties, although more than 60 % of their feed consisted of pellets. However, the saithe caught in intensively farmed areas, although not directly below a farm, showed very bad fillet processing quality (fillet index close to 7), and also had very high condition factor, high hepatosomatic index as well as a significantly changed FA profile. In addition, the sensory panel evaluated the saithe group from Finnøy (intensively farmed area but 1-2 km

away from nearest farm) to have inferior taste and especially textural quality (less juicy, less tender, needs more chewing) than both control saithe and saithe directly below fish farms. Of all three groups, the one furthest away from fish farms was therefore evaluated the best. Furthermore, a similar sampling programme during winter 2008, also found significantly worse fillet processing quality in fish farming areas (both below farm and 1-2 km away from farms) than in control areas. However, a comparison of gill captured and “jukse” captured saithe showed that much of the fillet quality could be improved by live (“jukse”) capture. In conclusion, our sampling program has been performed in general accordance with the proposal, and we have studied quality differences in wild cod and saithe aggregating around fish farms as well as in control areas in a Norwegian wide context. Results shows, in short, that only relatively small differences exist, but also that the observed differences are more significant in saithe and in the middle- and southernmost part of Norway. However, much of this quality reduction, especially fillet quality, seems to be improved by live capture.

Methods for live capture and quality improvement of fish around fish farms

Already in 1993, Bjordal and Johnstone (1993) indicated that fish farms act as aggregation devices for wild fish. Furthermore, it has been suggested that such behaviour provides and ideal opportunity for cost-effective capture of wild fish. In the present project we have used input from WP 1 and *CoastACE*, to develop “Methods for live capture and quality improvement of fish around fish farms” (WP 2). WP 2 consisted of two closely linked tasks:

WP 2, task 1: Develop methods for live capture of fish around fish farms.

Capture of fish around fish farms must be done in such a manner that it doesn't conflict with normal production routines or damage the farm. We have developed and tested two promising methods of capturing live fish around fish farm; the first is a large version of a “fish pot”, the second is modified net pens (“smart net pens”). During spring 2008 two large “fish pots” were made at Nofimas processing plant. The fish pot was made of knotless mesh on a collapsible frame of aluminium, measure 2 x 2x 2 meters, had modified entrance openings and a second storage chamber on top of the capture chamber. During spring and autumn 2008, the new “fish pot” was compared to an older non-collapsible version (“net pot”) as well as against commercial available “REFA pots”. The test fishing program showed that both the new “fish pot” and the older “net pot” both fished much better (two to four times) than the commercial product. During both fishing periods (30 days) the first two pots fished between 300-500 kg cod, 20-50 kg saithe and few other species. The new “fish pot” however tended to capture bigger cod (also a halibut of more than 40 kg), probably because of the newly designed capture entrance. Interestingly, both during spring and autumn, capture per unite effort (CPUE) did not decrease during the fishing trial, indicating that new cod continuously occupy the farm habitat. In addition, the fisherman preferred the easy handling and storing of the new “fish pot”. Used in the correct way, it was not in conflict with, or danger towards, the fish farm. Overall, developing and testing the “fish pot” was a success, and may also have the potential to be included in a capture based aquaculture after cod around fish farms and in intensively farmed areas.

WP 2, tasks 2: Methods to improve quality of fish captured around fish farms.

In addition, we have also developed and tested modified net pens (“smart pens”) to capture especially saithe around fish farms. This was done by modifying a net pen as a large, floating purse by attaching a modified version of the “fish pot” to the bottom of a 40 m. PolarCircle net pen. This was done at Karmsund Redskap during spring 2008, and was tested around Marine Harvest's experimental farm in Ryfylke from June to October 2008. Unfortunately, the “smart pen” were not capable of capturing saith, although considerable effort was taken.

The reason for this was a general lack of saithe around the fish farm in Ryfylke and because the few saithe present were deeper than 50 meter and thereby not accessible for live capture. Task 2, methods to improve quality of fish captured around fish farms through short time storage without feeding therefore had to be terminated and this was decided done in November 2008. In conclusion, task 1 (developing live capture tools) in WP 2 was performed with success and in accordance with the project plans. The smart pen planned used to capture saithe alive for storage and quality improvement, was however, a failure and implemented severely on task 2.

2) Evaluation of project accomplishment and use of resources

The project has generally been performed in accordance with the plans. However, design, accomplishment and use of resources have been modified in accordance with results and challenges. WP 1 was, to large extends, performed in accordance with the plans and with success. We had, however, to use much more resources to fieldwork (sample fish) than we had expected because the sensory lab at Nofima Marine was not available at the same time as *CoastAce* did its sampling. SINTEF, University of Alicante and NINA helped with the sampling programme, and goals were therefore achieved. In addition, it showed indeed very difficult to sample saithe in Ryfylke, even though a huge effort was taken. We succeeded in autumn 2007 and winter 2008, but not in spring 2008. The developing and testing of the “fish pot” and “smart net pen” in WP 2 (task 1), was also a success, especially the “fish pot for cod”. The “smart net pen for saithe” was a failure, and impended severely upon WP 2 (task 2) which had to be terminated. Instead, we increased the testing effort of the promising “fish pot for cod” and performed twice as much fieldwork on this (spring and autumn testing period) than planned.

Our results are assumed to impact both on the research field, industry and management. Firstly, research on fish farms as fish aggregating devices are a growing field in EU, and EU FP7 has already implemented call text on this issue. The constellation of this project (Nofima Marine, SINTEF, NINA, University of Alicante) has just succeeded in a large EU-proposal (PreventEscape). We will probably follow up on a EU-proposal on fish farms as fish aggregating devices in northern Europe and the Mediterranean, as well as towards NRC and FHF. Secondly, quality reduction of wild marine fish around fish farms has been, and still are, an area of heated debate between fish farmers, local fishermen and management. We have provided new, objective and important knowledge in this field. Thirdly, fishing around fish farms may be a promising method for fjord fishery in intensively farmed fjords and coastal areas. We have showed that this is possible through “fish pots for cod”, and that quality, economy and practical feasibility are acceptable. “The smart pen” for saithe was, however, a failure, and have to be developed as saithe fishing may be even more promising, and sustainable, that fishing for cod.

In conclusion, the project has been quite successful, and results will be followed up in new initiatives. Results will in addition be presented through Nofima Marin’s channels (internet and news letters) as well as in other media. In addition, Nofima Marin, SINTEF, NINA and University of Alicante are working on a scientific paper on our results.