



The SFI SYSTEM's documented impact on fish welfare

The system is tested with settings up to 10 bar and tests have shown that treatment with the SFI SYSTEM give a low load on fish welfare. However, specific welfare indicators like skin health and fins are significantly affected and some eye damages are also reported (Table 1). Knowing this, one should be attentive to these welfare indicators before, during and after treatment with the SFI SYSTEM. There are no reports on damage to the snout/head, gills, operculum, or open wounds caused by treatment with the SFI SYSTEM. Treatment of fish between 750g and 5kg with the SFI SYSTEM with settings up to and including 10 bar resulted in low mortality, and the fish quickly regained appetite and normal behavior.

Table 1. Schematic overview over welfare indicators, divided into if they are affected by treatment with SFI SYSTEM (Yes=orange, green=no and yellow=possibly) and if increased water pressure from 8 to 10 bar resulted in further damages.

	Affected by the SFI SYSTEM	Affected by increased water pressure
Total score	Yes	No
Scale loss	Yes	Yes
Skin hemorrhages	Yes	No
Fin damage	Yes	No
Eye hemorrhage	Possibly	No
Snout damage	No	No
Head damage	No	No
Gill damages	No	No
Opercular damages	No	No
Lesions/wounds	No	No

Assessments of welfare indicators

Grading of welfare indicators on a scale of 0-3 is a subjective assessment and further interpretation of the welfare score should always be seen in context with behavior, appetite, mortality, and general fish health. While testing the SFI SYSTEM scoring of welfare indicators were performed as described in Appendix IV. When using a similar scoring system, it is recommended that new assessments of the fish welfare are performed if single welfare indicators reach an average of 2. The impact on fish welfare also needs to be assessed against the delousing effect, and adjustments may be necessary.

Documentation

Documentation of fish welfare during treatment with the SFI SYSTEM is obtained through scientific methods and commercial treatments. The following reports make the foundation for the user manual:

- Val FoU, «Fiskevelferd i SFI SYSTEM, rapport». (2020).
- Val FoU, «SFI SYSTEM Treatment results, February – May 2021». (2021).
- Val FoU, «Fiskevelferd i SFI SYSTEM – rapport 2021». (2021).



Table 2. This table shows delousing treatment performed using the SFI SYSTEM, on fish of different weights, at different sea temperatures and pressure settings (Bar) in the SFI SYSTEM from May 2020 to September 2021. Dark green fields represent commercial treatments based on average fish weight, including CV 20 %. Orange fields represent treatments performed as part of the scientific testing described in Val FoU, «Fiskevelferd i SFI SYSTEM – rapport 2021». (2021). (Norwegian).

	Fish size (kg)	0,75	1 -2					2-3					3-4					4-5				
Bar	Temp (°C)	13 - 14	5- 6	7- 8	9- 10	11- 12	13- 14	5- 6	7- 8	9- 10	11- 12	13 - 14	5- 6	7- 8	9- 10	11- 12	5- 6	7- 8	9- 10	11- 12		
	5,5																					
	6																					
	7																					
	7,5																					
	8																					
	8,5																					
	9																					
	9,5																					
	10																					

For Norwegian users: Should the user choose to deviate from the SFI system manual, the user is responsible for documenting that the use is in line with good fish welfare.

Risk assessments

Fish health professionals responsible for fish welfare need to ensure that the health status of the fish is good enough for fish to withstand treatment in regards to the above mentioned impacts the SFI SYSTEM has shown to have on fish welfare, in addition to the general stress of being crowded, handled and pumped. Current health status, disease history, and previous treatments are factors that need to be considered before any delousing treatment.

Environmental conditions

The SFI SYSTEM is tested under the following conditions: field of depth above 5m; oxygen levels above 70% before, during and after treatment.

Recommendations regarding environmental conditions:

- Field of depth should be measured before treatment start
- Oxygen levels should be monitored at all times and maintained at stable levels under crowding and pumping. Low oxygen will increase the fish's stress levels and could be fatal.
- Oxygen should be supplied if needed
- Temperature should not fluctuate ($\pm 2^{\circ}\text{C}$) in the days before treatment



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- Treatment should be done when environmental conditions are stable to avoid treating fish that are already experiencing heightened levels of stress.

Handling

The most critical step during treatment with the SFI SYSTEM is handling of the fish, including crowding in advance. Caution should be advised in this step as mistakes can have a large impact on fish welfare.

Welfare evaluations during treatment

Welfare indicators should be evaluated before and right after treatment with the SFI SYSTEM to be able to adjust system settings to achieve an optimal treatment. A continuous evaluation of the delousing effect and impact on welfare is also recommended.

The following adjustment- and stop criteria are based on the previous tests performed on the SFI SYSTEM (based on Appendix IV and V).

If one or more of the following points are reached, adjustments to the SFI SYSTEM settings should be made.

- Unacceptable fish welfare
- Individual welfare indicators with high score (2-3)
- Behavior score above 1 (see Appendix V)
- Insufficient delousing effect

If one or more of the following points are reached, treatment with SFI SYSTEM should be terminated.

- Unacceptable fish welfare even after adjustment to the SFI SYSTEM settings
- Individual welfare indicators with high score even after adjustment to SFI SYSTEM settings (score 2-3)
- Systematical lesions or wounds
- Behavior score above 2 (see Appendix V)
- High acute mortality
- Large fluctuations to environmental conditions (see “Environmental conditions”)
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After treatment with the SFI SYSTEM

After treatment with the SFI SYSTEM the following recommendations for follow-up are given

- Behavior should be monitored after treatment. Tests show that the fish achieve normal behavior within 24h after treatment with the SFI SYSTEM (Appendix V)
- It is recommended to follow-up on fish health and welfare in the time after treatment using the SFI SYSTEM.
- Appetite should be monitored after treatment. Tests show that the appetite is stable and normalized 48h after treatment with the SFI SYSTEM
- Mortality should be monitored after treatment. Tests have shown that mortality is low and stabilized 1 week after treatment with the SFI SYSTEM
- If there is an acute high mortality that is suspected to be from treatment with SFI SYSTEM, the supplier should be noted so that steps may be taken to avoid similar situations.



APPENDIX IV – WELFARE INDICATORS USED DURING TESTING OF THE SFI SYSTEM

The system used for scoring of welfare indicators under testing of the SFI SYSTEM are based in the operative welfare indicators described in Noble et al.(2018) “Welfare Indicators for farmed Atlantic salmon: tools for assessing fish welfare”.

All welfare indicators were score from 0-3, except for gill damages. Score 0 were given to fish with no flaws and score 3 were given fish with large damages the individual welfare indicator. Score 1 were given fish with minimal damages while score 2 includes a large scale of damages from minimal to large damage. Damages to gills were scored 0 or 3, where 0 represent no gill bleeding and 3 represent gill bleeding.

The following individual welfare indicators were assessed before, under and after treatment with the SFI SYSTEM: snout and head damages, eye damages, operculum damages, gill damages, scale loss, skin hemorrhages, fin damages and lesions/wounds.



APPENDIX V – EVALUATION FISH BEHAVIOR DURING TREATMENT/HANDLING

	0	1	2	3
Description	Untreated and undisturbed fish. Normal swimming pattern with fish in equilibrium.	Up to 20% the fish behave in an unnormal manner (unnormal swimming pattern and showing signs of stress), but with the behavior moving towards normal within a short amount of time. The latter fish have a normal swimming pattern, with fish gulping air and fish in equilibrium. Score 1 is considered normal behavior after treatment/handling.	20%-50% the fish behave in an unnormal manner (unnormal swimming pattern and showing signs of stress). Individual fish show problems with equilibrium and/or deviant swimming speed. The activity should return to normal within a few hours. The latter fish have a normal swimming pattern, with fish gulping air and fish in equilibrium. Score 2 is considered normal behavior after treatment/handling.	Over 50% the fish behave in an unnormal manner (unnormal swimming pattern and showing signs of stress). Fish show problems with equilibrium and deviant swimming speed. The latter fish have a normal swimming pattern, with fish gulping air and fish in equilibrium. Score 3 is considered as reduced welfare after treatment/handling.
Measures	No need for further measures. Treatment/handling can continue as planned.	No need for further measures. Treatment/handling can continue as planned.	Halt treatment, continue observation and new score of behavior after 1 hour. If the behavior is stabilized towards score 1 further treatment/handling can continue/is acceptable.	The fish group should be monitored closely and a new score of behavior should be done after a few hours. Termination of treatment should be considered. The fish group should be evaluated again before new treatment/handling is started.

